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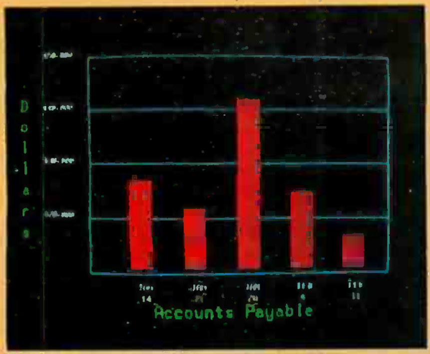
BYTE®

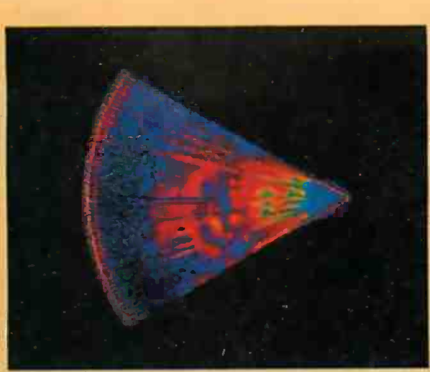
the small systems journal

A McGRAW-HILL PUBLICATION

HOMEBREWING



Management Information Display



Ultrasonic heart sector scan

High-resolution display with alphanumerics

Get the professional color display that has BASIC/FORTRAN simplicity

LOW-PRICED, TOO

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.

The SDI then maps computer display memory content onto a convenient color monitor to give high-quality, high-resolution displays (756 H x 482 V pixels).

When we say the SDI results in a high-quality professional display, we mean **you can't get higher resolution than this system offers in an** NTSC-conforming display.

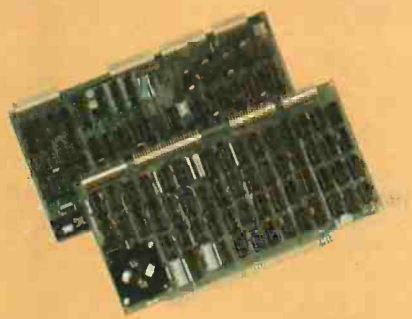
The resolution surpasses that of a color TV picture.

BASIC/FORTRAN programming

Besides its high resolution and low price, the new SDI lets you control with optional Cromemco software packages that use simple BASIC- and FORTRAN-like commands.

Pick any of 16 colors (from a 4096-color palette) with instructions like DEFCLR (c, R, G, B). Or obtain a circle of specified size, location, and color with XCIRC (x, y, r, c).

*U.S. Pat. No. 4121283



Model SDI High-Resolution Color Graphics Interface

HIGH RESOLUTION

The SDI's high resolution gives a professional-quality display that strictly meets NTSC requirements. You get 756 pixels on every visible line of the NTSC standard display of 482 image lines. Vertical line spacing is 1 pixel.

To achieve the high-quality display, a separate output signal is produced for each of the three component colors (red, green, blue). This yields a sharper image than is possible using an NTSC-composite video signal and color TV set. Full image quality is readily realized with our high-quality RGB Monitor or any conventional red/green/blue monitor common in TV work.

Model SDI plugs into Z-2H 11-megabyte hard disk computer or any Cromemco computer

DISPLAY MEMORY

Along with the SDI we also offer an optional fast and novel **two-port** memory that gives independent high-speed access to the computer memory. The two-port memory stores one full display, permitting fast computer operation even during display.

CONTACT YOUR REP NOW

The Model SDI has been used in scientific work, engineering, business, TV, color graphics, and other areas. It's a good example of how Cromemco keeps computers in the field up to date, since it turns any Cromemco computer into an up-to-date color display computer.

The SDI has still more features that you should be informed about. So contact your Cromemco representative now and see all that the SDI will do for you.

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Tomorrow's computers today

Circle 1 on inquiry card.

Here's the state of the art in low-cost hard-disk computers

11 MEGABYTES OF FAST HARD-DISK STORAGE

Yes, the Cromemco Model Z-2H is in a class by itself in the computer field.

These Z-2H features tell you why:

- **11 megabytes of hard-disk storage**
- **64 kilobytes of fast RAM**
- **Two dual-sided floppy disk drives**
- **Z-80A type processor**
- **Fast 4 MHz operation—150 nanosecond access time**
- **Fast hard-disk transfer rate of 5.6 megabits/second**
- **Low cost**

And that's not all you get. Not nearly.

BROAD SOFTWARE SUPPORT

You also get Cromemco software support—the broadest software support in the microcomputer field. Software that Cromemco is known for. Like this:

- **Structured BASIC**
- **FORTRAN IV**
- **RATFOR (RATional FORtran)**
- **COBOL**
- **Z-80 Macro Assembler**
- **Word Processing System**
- **Data Base Management**

And more all the time.

FIELD PROVEN

The Z-2H is clearly in a class by itself. We introduced it last summer. It's field proven. It's reliable.

And it's rugged. Housed in a sturdy, all-metal cabinet.

EASILY EXPANDABLE

As always with Cromemco, you get expandability. The fast 64K RAM in this Model Z-2H can be expanded to 512 kilobytes. That amount of RAM combined with 11 megabytes of hard-disk storage gives you enormous computer power—the equal or even beyond what much larger computers sometimes offer.

What's more, this computer gives you a 12-slot card cage. That's to plug in your special circuits as well as additional RAM and interface cards.

This expandability is supported by still more Cromemco value — the Z-2H's heavy-duty power supply that gives you 30A at 8V and 15A at ±18V to support plug-ins.

LOW COST — SEE IT NOW

The Z-2H is real. It's been in the field for many months. It's proven itself.

You should see the Z-2H now. Contact a Cromemco representative and arrange for a demo. Learn that Cromemco is a survey-winner for reliability.

And learn that the Z-2H is under $10K.

In the long run it always pays to get the best.

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In The Queue

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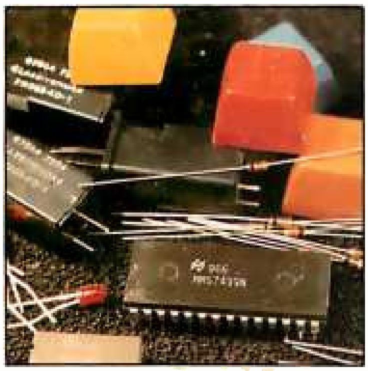
BYTE September 1980
Volume 5, Number 9

Foreground



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86 PENNY PINCHER'S JOYSTICK INTERFACE *by Steven Wexler*
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116 APL CHARACTER GENERATOR *by John W Langer*
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126 CONSTRUCTION OF A FOURTH-GENERATION VIDEO TERMINAL, Part 2 *by Theron Wierenga*
Part 2 helps you to complete the construction of the terminal and learn to use the built-in debugging features.

242 KHACHIYAN'S ALGORITHM, Part 2: Problems with the Algorithm
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A practical BASIC program can be used to explore the power and limitations of this new algorithm.

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About This Issue

BYTE is five years old this month, and we're taking the opportunity to discuss one of our favorite subjects: *homebrewing*. Much of the personal computer hardware sold today is already assembled; even so, many of our readers like to build or modify their own equipment, and even "homebrew" it from scratch. The cover photograph by Raoul Hackel, Stock Boston, shows some colorful wiring harnesses inside a computer chassis, a familiar sight to the intrepid do-it-yourselfer.

Theme articles in this issue include a build-it-yourself, low-cost, remote data-entry terminal (from Steve Ciarcia); exploring the TI Speak & Spell; a pennypincher's joystick interface; and the beginning of a multipart article on building an 8088 processor for the S-100 bus. Along with these are features on threaded code; FCC regulations and your personal computer; machine problem-solving; some tax hints for personal computer owners; and much more.

You've probably noticed that this issue of BYTE is on the large side. In fact, it's the biggest issue we've ever printed. The extra space allows us to bring you even more articles and features in this issue and in the coming months. . . . CM

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Editorial

Intellectual Ethics and Software

An Inquiry Into the Nature of Ideas, Academia, and Commerce

Carl Helmers

Recently, I encountered an old problem again. A problem in this sense is a body of questions and my tentative answers. An old problem is like an old jacket. You get familiar with the intricacies of its individual creases, wrinkles, and holes. It may not be currently stylish, or even in the best of conditions. Yet it is hardly worth throwing out because of a shared body of experience. So, I had long ago packed this problem away in my mental baggage.

The problem I refer to is ethical in nature; it has epistemological attributes as well. It is the problem of interfacing the world of ideas with the world of commerce. In its simplest form it is a two-part question: "who originated an idea?" and "what is the value of that idea?" The problem, which has great practical implications in our technological civilization, is that of encouraging innovation by means of rewards in the worlds of ideas and commerce. The ethical position implicit in my viewpoint is simple honesty. Its intellectual expression is that credit should be given where credit is due in a freely operating world of ideas. In a laissez-faire world of commerce, its expression is that value in the marketplace should be given where value is due, in a framework of freely chosen relationships.

We humans have two worlds of activity: the intellectual world and the world of commerce. Each has its own characteristics. One deals with ideas and thoughts freely expressed. The other deals with material goods freely traded in the marketplace. We can engage in both of these very natural human pursuits to the extent that we are politically free of arbitrary laws and interference.

What, you might ask, brings about a discussion of ethics in the marketplace at this time? The particular impetus to this discussion is an incident that came to my knowledge at a recent trade show. Inasmuch as the incident is far from closed, I will not disclose the names of the parties involved. But the situation in its abstract form is worth using to explore some of the ethical problems of commerce in ideas, particularly software for small computers.

Several years ago, a small group of academics began pursuing a particular line of inquiry that related to the nature of computer design for human interaction. The charter of this group of researchers might have been expressed as: "Find the problems of human interaction with computers, and experiment with any solutions you may find." As in any academic pursuit, the inquiry generated many published papers over more than a decade. The fact that these papers also generated some exciting hardware and systems software entered the picture along the way.

Both the software and hardware developments of this group's research have been and are generously underwritten by the sponsoring organization where the activity takes place. In fact, the sponsoring organization did not expect the research to have any immediate practical expression in the marketplace, because it was basic research.

"For reliable data storage, I recommend systems with Shugart disk drives."

Tom Knight, President–
Nycom, Los Altos, California

"The last thing you need when you put your personal computer or small business system to work is a disk drive that you can't rely on. If the drive quits, your system is out of business."

That's why more and more manufacturers and dealers depend on Shugart disk drives for reliable data storage. These professionals don't want disk drive problems any more than you do. Shugart has a large family of drives, too—in all sizes and capacities to suit your system storage needs. For the smaller system, the original 5¼-inch Minifloppy™ stores 250 to 500 kilobytes (single or double-sided)—that's about 50 to 100 pages of printed material. Our single and double-sided 8-inch floppys store 800 to 1600 kilobytes. And for systems that need a larger data base, our 8-inch or 14-inch fixed disk drives store from 5 to 58 megabytes. No other manufacturer offers such a wide variety of disk storage for personal computer and small business systems.

Word processing, general business, accounting—big system or small, you can rely on Shugart drives. We're known as the Headstrong company for good reason. We're Headstrong about reliability, quality, and value. Ask your dealer. He knows us.

Rely on the Headstrong Company.

Shugart

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Naturally, the members of the group communicated with others at similar academic and industrial research laboratories of the land, by means of conversations at conferences and meetings, as well as written communications of academic professional organizations. This type of communications between peers is an essential part of any productive research field. In short, word of their ideas got out.

Enter the publicist.

Now, intellectually and ethically we cannot argue with the following thought: when an opportunity is available to pursue some perceived value, we should go ahead and pursue it. There is no way one could complain about this kind of action since it is the essence of human activities. This attitude is a prelude to all research and innovation.

The publicist had all the *right* words. He was fluent in the jargon of computers. He perceived the enthusiasm with which the researchers described their activities personally and in print. He thought it would be good to tell the world about what was going on. And that is what he proceeded to do by means of a self-published work which was indeed ahead of the technology of practical general-purpose microcomputers.

Up to this point, our publicist had done nothing to which we could object. He was taking published works, analyzing them and pointing out the implications that these works have. But having caught the enthusiasm, he was beginning to grow impatient. After all, our researcher friends are involved in research, not in entrepreneurial activities. What our publicist had done, however, was create among people stimulated by small computers an intellectual and commercial demand for an excellent concept.

Enter the entrepreneurial programmer. He is the archetypal programmer who, given a challenge, immediately proceeds to code. Probably as a result of the ballyhoo created by the publicist, the entrepreneurial programmer proceeded to dig up the published works of our thinker friends.

These works were indeed complete, and can be found in the technical journals published during the 1970s. They even include all the information necessary for the entrepreneurial programmer to implement a version of one of the crude, early approaches our researcher friends investigated in their pursuit of the problem. Now, as a published work, these documents were intended for use by other researchers and anyone else with a programming problem.

The problem arises when we examine the manner in the which the publicist was going to use the published works of our researchers. It is one thing to implement a version of a program and sell the particular example as a toy. But it is quite another thing to name it the same as our researchers' ongoing project, imply in advertising that it is the same (when it is not), and generally imply that its use is sanctioned by its original authors at the research establishment. This is not the same as simply crediting the source in a published work and proceeding to implement a version under a different name and with particular variations.

Here, we find the complicity of the publicist and the entrepreneurial programmer as a pair. The publicist now had an opportunity to reach for the brass ring of the software that our research friends had not yet made available to him. He found the ring in the entrepreneurial programmer's product. So, the publicist has recently been pushing the entrepreneurial programmer's product at whatever forum he can find. This situation had been fermenting for some time when all parties showed up at a recent convention.

The situation came to a head at the convention when our researcher friends arrived on the scene. I became involved to the extent of providing a sympathetic ear in conversation with one of my friends from the laboratory in question. By all reports, the entrepreneurial programmer later became involved in some heated discussion of these points with the publicist, my research friends, and several individuals well aware of the issues involved (not including myself).

As of this writing, the matter remains unresolved. The entrepreneur still has not decided whether to change the name of his program or not, but I hope that, through the mediation of several individuals who know the facts of the matter, he will recognize the error of his ways and, in so doing, learn a bit about the in-

tellectual versus commercial realms of endeavor. I have learned that some sort of decision will probably have been made by the time you read this.

As for the publicist, he continues in his inimitable style to spin wheels of fancy.

In the intellectual marketplace of ideas, the coin of the realm is thought. He or she who owns a reputation as a result of careful thought has a purse full of golden coins ready for the bazaar of ideas. A marketplace of ideas or commerce is a human activity where all parties benefit as a part of trade. One cannot expect willing and bountiful trading when one party plays by a set of rules different and incompatible from the other's set.

The productive results of innovation and thought carry a requirement for the respect of the rules of the game. One of these rules in the intellectual world could be stated "thou shalt not take thy neighbor's reputation as thine own." When you use an idea, credit its source where appropriate, but do not pretend to imply that your version of the thought is the same.

It is perfectly fine to use an inspiration from someone's published thought in a commercial product of your own. But be sure that you make clear that the product is your own! Credit the inspiration to be sure. However, if you do not have an endorsement from the source of the inspiration, do not attempt to advertise that thought in any way as a product endorsed by the source of the inspiration.

Naturally, the ideal state is that in which the researcher is also able to capitalize directly on the results of his or her innovation. By being the first to it and the best able to understand the problem, an inestimable advantage is gained over the nonoriginal machinations of those who merely implement the published designs.

The main rewards of research must be understood for what they are: an appreciation of difficult problems and the satisfaction of seeing them through to a better understanding.

Occasionally in research a commercial gold mine is found that exudes some of its wealth on the innovator. But this is a small part of motivation for a life of ideas. The innovator's reputation is based on a mutual trust and fascination with ideas. Entrepreneurs with a long-term point of view respect this trust by avoiding any semblance of potential violation of that trust. End of commentary.

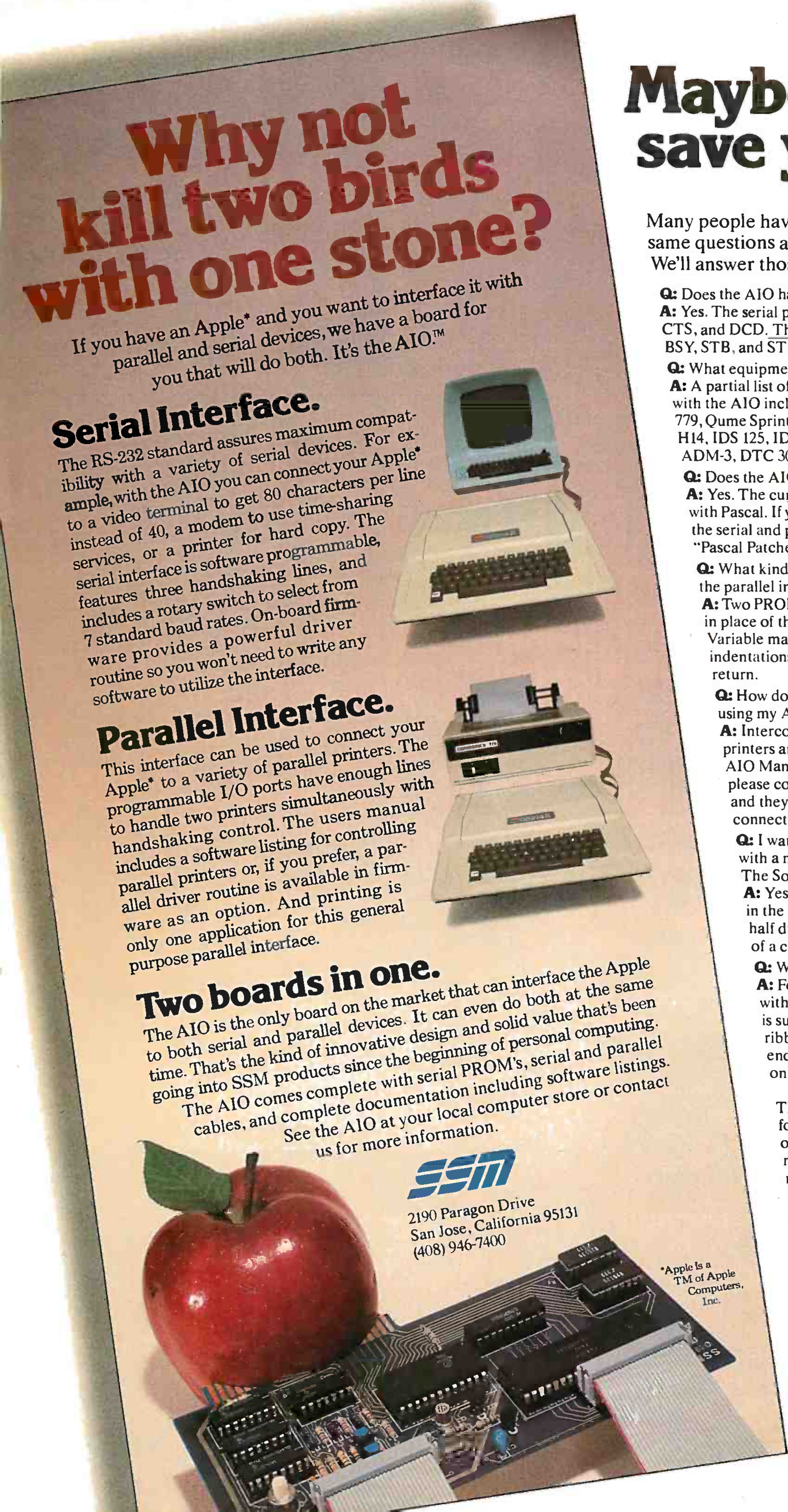
* * *

A Note

The lives of individuals are marked by a series of changes through growth. Enterprises evolve in much the same way. BYTE has gone through many such changes. It began as an idea in the minds of my associates and me five years ago. After much hard work it matured to the point where it now has a circulation in excess of 160,000 and an assured future as a member of the family of magazines published by McGraw-Hill. This issue marks the fifth anniversary of BYTE's first issue, published in September 1975.

Since BYTE has matured to the point where a founder's day-to-day input is no longer a requisite to the continued health of the venture, I am now in the fortunate position of being able to indulge in my other interests and goals. While continuing with many of the functions at BYTE that have occupied me over the last five years, I will be able to engage in consulting activities related to the technology of, and markets for, small computer systems. Such activities have always been of great interest to me. Only with the evident maturity of BYTE and the cooperation of McGraw-Hill am I now able to spend about half of my time on such ventures.

The day-to-day operations of the magazine will be in the very capable hands of my successors, Chris Morgan and the technical editors of BYTE's staff. My new relationship with BYTE is reflected in a new title on the masthead: "Founding Editor." With my continued intimate involvement with BYTE, I shall truly have the best of both worlds. . . .CH■



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.

SSM

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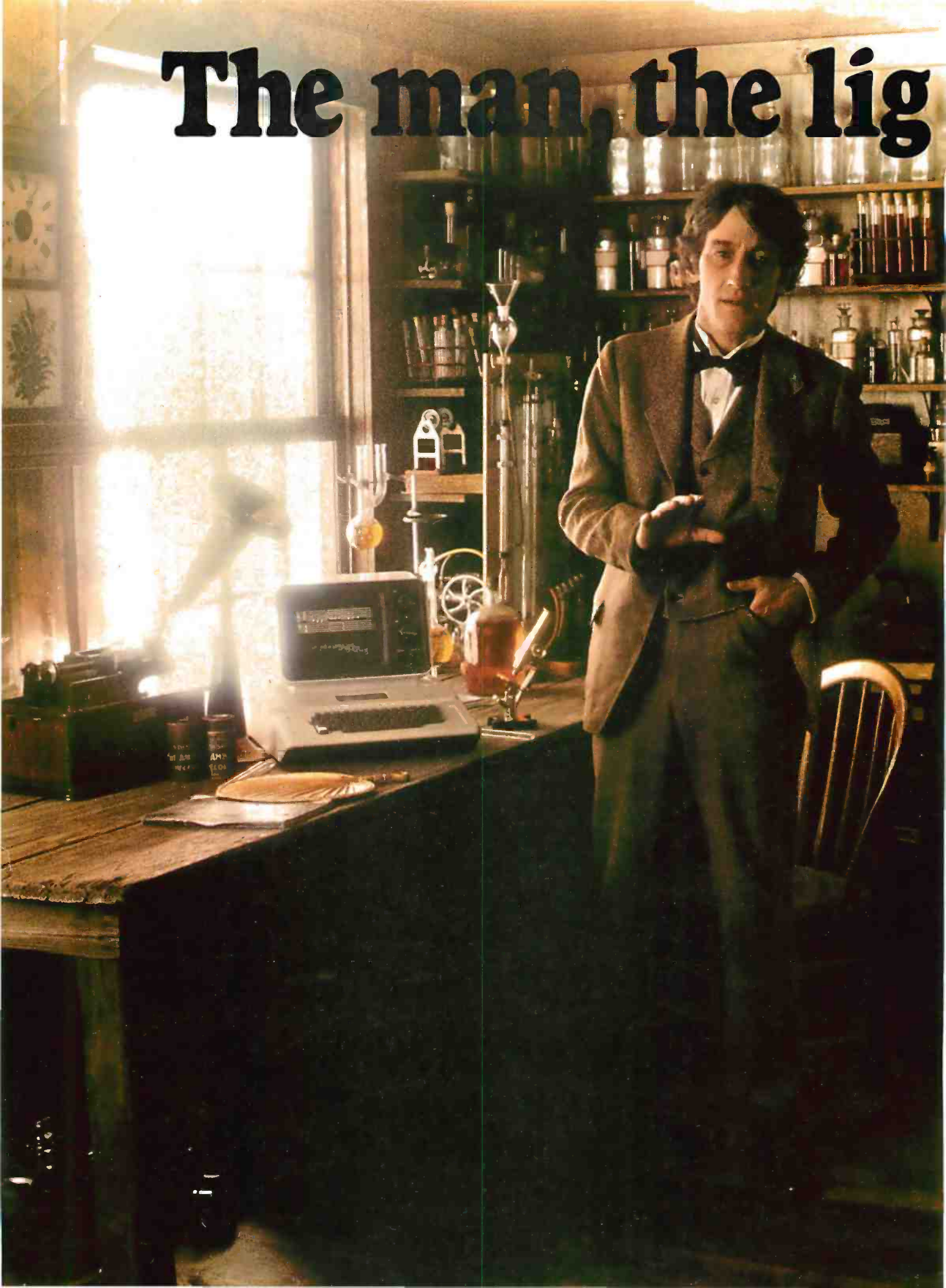

The man, the lig

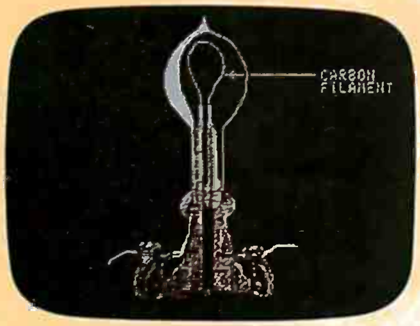
ht and the Apple.

If you could talk to Thomas Edison, he'd tell you what it was like to turn the lights on in 1879. You could tell him about some bright ideas of the 20th century... particularly, a technological phenomenon that can handle everything from solar heat control to lighting your home via voice command. The Apple personal computer.

Expand your own inventiveness with the always-expandable Apple.

Take a look inside your local computer store. There's a range of Apple systems for you... whether you want expansion capabilities of four or eight accessory slots... or memory expandable to 64K bytes or 128K bytes. With this kind of flexibility, the possibilities for creating your own computer system are endless.

Want to add an A to D conversion board? Apple makes it happen. Want to plug into time sharing, news and elec-



With Apple, Edison could've written a program to determine why some filaments burned longer than others.

tronic mail services? Apple does it all. Because Apple is the most popular personal computer with the least complicated interface, over 100 companies supply peripherals for the Apple family... including an IEEE 488 bus for instant control.

Disk drives, a tool kit and creativity in color.

Apple was one of the first to use disk drives for increased performance and application versatility. Today, our $5\frac{1}{4}$" disk drive offers high density (143K bytes), high speed and low cost. No wonder this drive is the most popular on the market.

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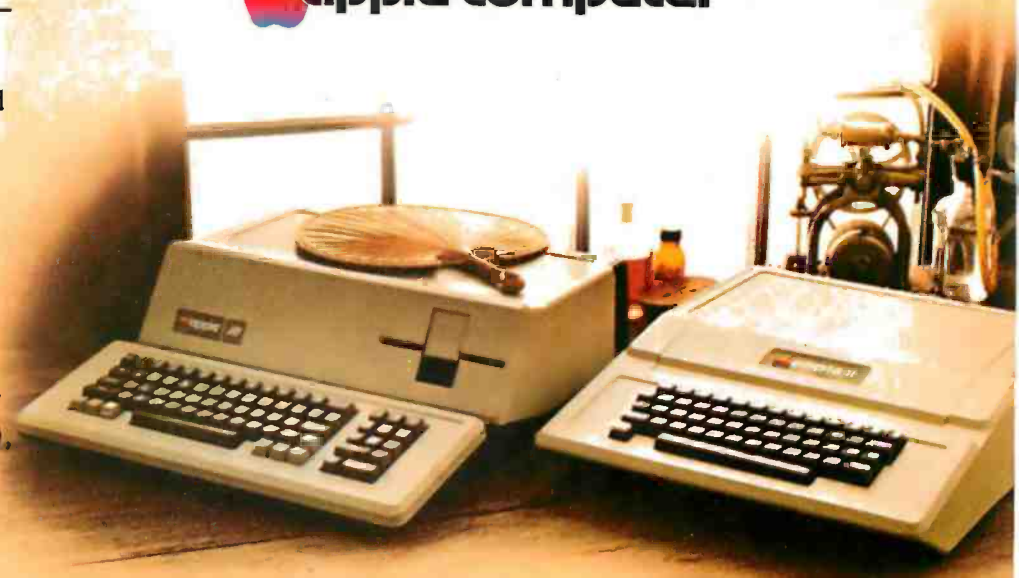

Circle 4 on Inquiry card.

Cromemco Lauded

After reading of the many horror stories of poor documentation and service within the microcomputer industry, I want to point out the excellent treatment I have received from Cromemco Inc.

In July, 1979, I purchased a System III with four disk drives and most of Cromemco's available software. Lately, I have added the 3102 Terminal and the 3355A Printer. I have found the documentation very complete. The manuals for the above products form a pile 10 inches high.

When I first received the System III, I had some difficulty using the third and fourth disk drives. Because I was not too familiar with the system, and the drives worked in certain situations, I concluded that the drives were probably OK, and that I did not understand some detail of the system's operation. Several weeks ago I was forced to conclude that the drives were defective, and I called Cromemco. Even though the warranty on the drives had expired six months earlier, they accepted the responsibility for the defect and had the repaired drive back to me within two weeks.

In addition, I have begun receiving updated software on disks. The software has been considerably enhanced. There is no charge for the additional features. I don't even have to pay for the disks.

Finally, though I had done a lot of programming on large systems and am quite knowledgeable about electronics, I had never worked with FORTRAN or COBOL, and initially I was not up to speed on the system aspects of microcomputers, especially the use of the disk drives. My questions were always answered courteously, even when they were naive, and my telephone calls were always returned.

The equipment is conservatively designed and well constructed. The software and operating system are capable and straightforward to use.

I have never been more pleased with all aspects of a purchase than I am with my Cromemco system.

Wil Schuemann
Sage Instruments
501 Maple St
Parkersburg WV 26101

Making Music

Hal Chamberlin's article on "Advanced Real-Time Music Synthesis Techniques" (April 1980 BYTE, page 70) was timely and informative. Since I have been experimenting with similar techniques for several years, I can vouch for the viability of his procedures, but I would also like to comment on several points raised in the article.

I agree that most digital synthesizers on the market do not have sufficient control for either education or serious musical work. A recent informal poll of musicians showed that the majority desired at least four voices, and complete control over envelope, timbre, loudness, and pitch for these purposes.

While Mr Chamberlin's technique provides for the important change of timbre with time that is so often neglected, his sequence table is stepped through at a rate determined by the tempo setting, so a voice will behave differently at slow

and fast tempi. Most musical instruments, however, vary their amplitude (tremolo), pitch (vibrato), and timbre (we need a word for this—tambolo?!) at a rate almost independent of the score tempo, but in a manner suited to the instrument and type of music played. This could be accomplished by adding one more counter for vibrato-tremolo-tambolo update independent of the tempo counter.

The computation of signal/noise (S/N) ratios for synthesizers can be misleading. If the intent is to *reproduce* a musical sound, then a resolution of 60 to 80 dB is a necessity. However, if the intent is to *produce* music from scores, a much lower S/N ratio can be tolerated if the distortion partials are harmonic. After all, the "noise" content of flutes or harpsichords can be very high, but is considered part of the natural sound of the instrument. Eight-bit D/A (digital-to-analog) converters and 256-byte wave tables do seem adequate for music-synthesis experimentation, at least until computer memory and power become somewhat cheaper.

Mr Chamberlin's method of generating up to 8 K bytes of waveform tables is well suited to single D/A output but requires extensive dedicated storage, plus time spent in creating the wave tables. This can be markedly reduced by noting that the *ratios* of the harmonic amplitudes remain nearly constant for a considerable fraction of the note duration for many instruments. This suggests that if the envelope amplitude were provided by a separate D/A converter and its output were multiplied by a waveform multiplying D/A converter, that many fewer waveform tables would be necessary since they would contain only waveshape information, not envelope information, and they could better be reused for other voices. The additional $10 for a multiplying D/A converter would be more than offset by the savings in memory. Incidentally the envelope "volume control" must *precede* the waveform D/A converter, not follow it as implied in the text, so that the required envelope filter does not cut off the harmonics of the waveform.

Finally, there is a very serious problem with the low sampling rates (6.9 kHz to 8 kHz) mentioned in the article. Suppose that the highest fundamental desired is C_6 ($\approx$2100 Hz) and that at least four harmonics are necessary to produce the desired timbre (both of these figures are very conservative). Then the highest frequency present in the sampled waveshape is $\approx$8400 Hz, and since a "headroom" of at least 10% is needed for the anti-aliasing low-pass filters, the filter stop-band edge can be no lower than $\approx$9300 Hz. So for these requirements, the sampling frequency must be at least 18,600 Hz by the Nyquist criterion. A lower sampling frequency will:

1) produce aliasing distortion, or
2) limit the highest fundamental to a smaller value, or
3) force you to accept fewer harmonics in the waveform (at least at higher pitches) if aliasing is to be prevented.

A solution might be to use different waveform tables with fewer harmonics for the higher pitches, but this further complicates the algorithm, requires more waveform storage, and introduces pitch breaks into a voice's timbre like that of an organ mixture stop.

The length of my comments reflects favorably on the thought-provoking nature of this article. Mr Chamberlin's work should be of great help to new experimenters in the field of music synthesis, and will, I hope, stimulate discussion on this topic.

Donald L Shirer
Director, Computer-Based Instruction Laboratory
University of Arizona
Tucson AZ 85721

Suspected Brain Malfunction Disables Op Code Equivalence

My article in the June 1980 BYTE "Z80 Op Codes for an 8080 Assembler" (page 64) contains a monumental goof, which I can only explain in terms of brain malfunctions and the like.

To define a symbol such as XAF as being equivalent to hexadecimal 08, one doesn't write "XAF DB 08H"; obviously one writes "XAF EQU 08H". Table 2 on page 70 makes sense only if you put EQU statements between the columns, not DBs and DWs as I said.

Judging from letters I have received, BYTE readers aren't dumb enough to believe everything they read, thank goodness. My intelligence seems to have gone down about 10 DB or if you like, 10 DW. Sorry, people.

Bill Powers
1138 Whitfield Rd
Northbrook IL 60062

Z80 Op Codes...The Continuing Saga

There is an error in the article "Z80 Op Codes for an 8080 Assembler" which appeared in the June issue of BYTE. On page 64 the statement "XAF DB 08H" should read "XAF EQU 08H". As writ-

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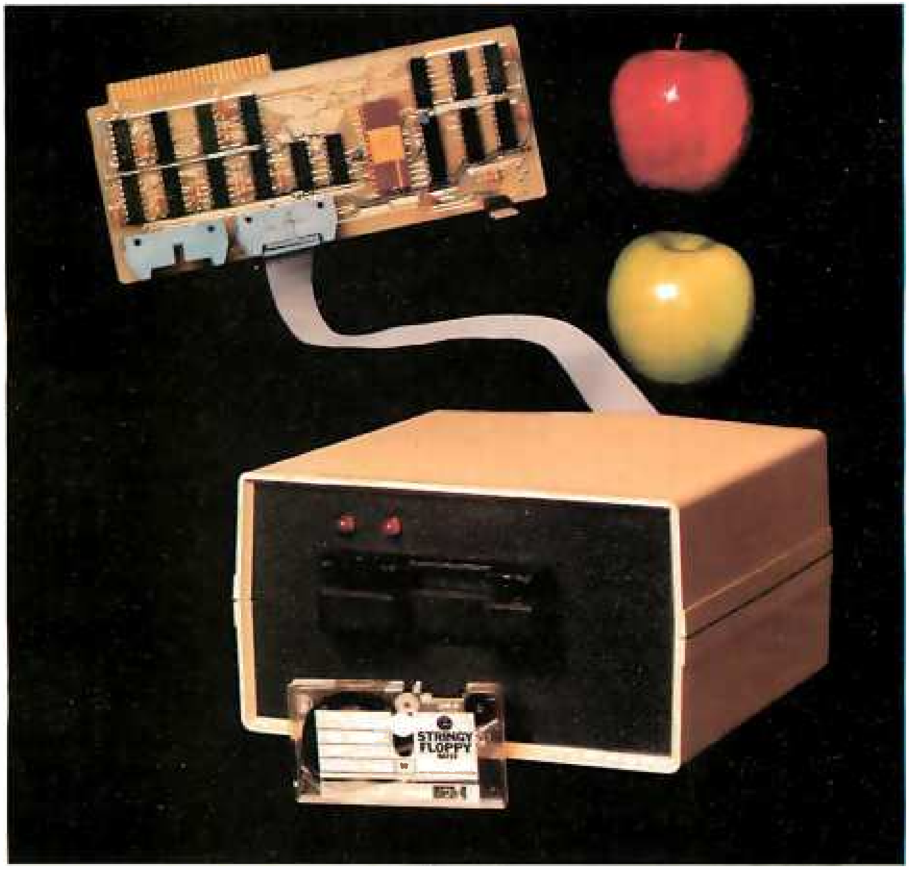

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Circle 8 on inquiry card.

ten, XAF is assigned the address to which a byte of value 8 is assembled. The actual intent is to assign XAF the value 8. The pseudo-operation EQU serves the function of an "equivalence statement."

Using mnemonic conventions such as those developed in this article, it is simpler to use Z80 code on an 8080 assembler. However, the readability of the resultant programs will be poor. I would suggest the use of macroinstructions in lieu of the DW...DB sequences. If a macroassembler is not available, then a preprocessor could be created to expand the Z80 instructions into sequences understandable to an 8080 assembler. Either way, the source code will retain readability and will probably be less error-prone.

I believe that the basic software tools make a tremendous difference to the quality of software produced. Every Z80 computer should have at least one good Z80 assembler.

Lest I seem too critical, I did enjoy this article very much.

Anthony Skjellum
1695 Shenandoah Rd
San Marino CA 91108

Information Please

Are any of my fellow BYTE readers willing to share information with me on interfacing microcomputer systems to the IBM Models 50 or 60 electronic typewriters? I would like to use my Model 60 as an output printer, and I would appreciate some advice, if any is to be had. Thanks very much.

Michael Pinneo
3757 Vienna Dr
Aptos CA 95003

Selectric Information Sought

Do any readers of BYTE know of any commercial devices that can interface a Radio Shack TRS-80 to an old model of an IBM Selectric typewriter (a Model 71)? I would also like to hear from anyone who has bought an already-interfaced Selectric from McClain and Associates or from Worldwide Electronics. Thank you.

N Vijayan
1332 Notre Dame Dr
Davis CA 95616

Performance Improvements

I have studied the article "TRS-80 Performance Evaluation by Program Timing," by James Lewis (March 1980 BYTE, page 84) with interest. I am only concerned here with the Level II BASIC program.

The largest number a figure is divisible by without becoming redundant is its square root. If we include the statement:

```
20 C=INT(SQR(A))+1
```

and change the second FOR-NEXT loop to:

```
30 FOR B=3 TO C STEP 2
```

we will find the program runs much faster. For example, in the original program 9901 goes through the inner loop roughly 4500 times. Using the modified program, the second loop is only used 50 times which is ninety times faster. I find this version will run in about 25 minutes.

Here is a listing of the modified program:

```
1    CLS:PRINT"1 2 3";
10   FOR A=5 TO 10000 STEP 2
20   C=INT(SQR(A))+1
30   FOR B=3 TO C STEP 2
40   D=A/B
50   IF INT(D)=D THEN NEXT A
60   NEXT B
70   PRINT A;
80   NEXT A
```

Brian Glover
POB 2102
Inuvik, Northwest Territories
X0E 0T0, Canada

More Improvements

Mr Lewis, in his article in the March 1980 BYTE, seems to compare two dissimilar computers. It was unclear to me what could be gained by this kind of comparison. The run time of a program is not only sensitive to the computer being used, as well as the programming language, but also to many other seemingly trivial factors.

For instance, Mr Lewis wanted to find all the prime numbers less than 10,000. His method was to divide by successive odd numbers. If division occurred without a remainder, then the number being divided is not a prime. The problem was that he kept dividing until the divisor was half of the dividend. For example, to check a number that was almost 10,000 he would keep dividing by numbers until he has used up all those less than 5000. It is easy to show that the time to stop is at the square root of the number, not half the number. He could have stopped after checking numbers up to 100 instead of 5000.

This is true because, if some number greater than 100 is divided without a remainder, the quotient would be some number less than 100 and this would have been revealed before ever reaching 100.

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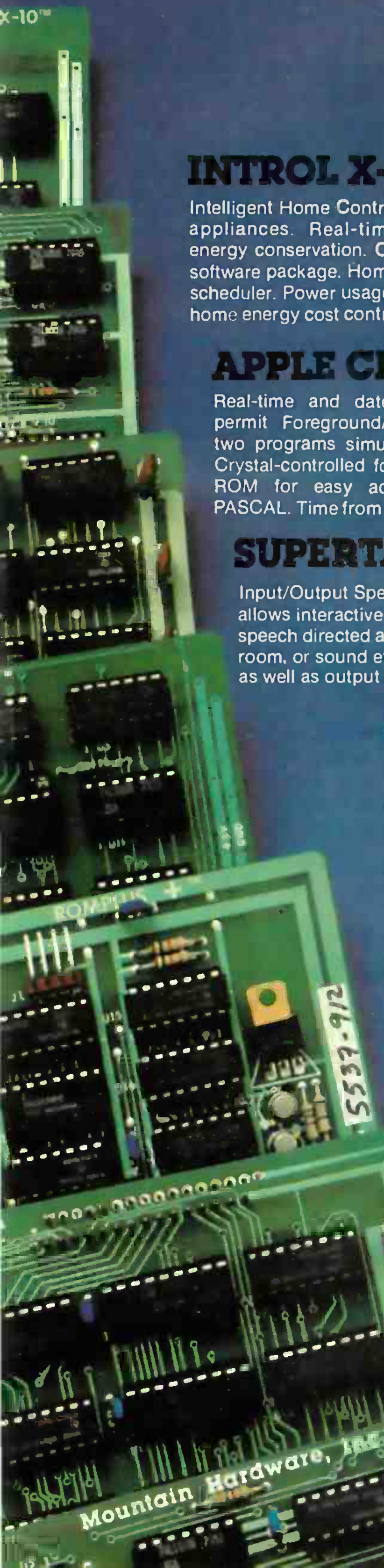

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I wrote the following short program, PRIME, and ran it on my North Star computer in about 24 minutes:

```
10 REM PRIME
20 FOR K=5 TO 10000 STEP 2
30    I=3
40    IF INT(K/I) = K/I THEN 80
50    I=I+2
60    IF I ↑ 2< =K THEN 40
70    !K
80 NEXT
90 END
```

Division for a conventional microcomputer for which double precision is necessary is slow, and the fewer occurrences in a program the quicker the program will run. When I eliminated one division in my program to produce PRIME 2, the running time was reduced to 17 minutes:

```
10 REM PRIME 2
20 FOR K=5 TO 10000 STEP 2
30    I=3
40    X=K/I
50    IF INT(X)=X THEN 90
60    I=I+2
70    IF I ↑ 2< =K THEN 40
80    !K
90 NEXT
100 END
```

But the most important consideration is how the translator works; an interpreter is devilishly slow. A computer will run considerably faster because machine code is actually executed. I wrote a short Pascal program for my North Star, *primes*, and was surprised to find that it executed in 1 minute and 46 seconds. (See listing 1.)

Mr Lewis' results for the large IBM computer was 1 minute and 19 seconds using a PL/I compiler. Does this mean that my microcomputer is almost equivalent to this huge IBM machine? I think not.

Comparisons of this sort do not prove much; they just show how many variables are involved in determining the time it takes to run a program!

Ivan Flores
Flores Associates Computer Consultants
108 8th Ave
Brooklyn NY 11215

Comparisons of this sort may not prove much, but you (and many other readers) found the idea interesting enough to experiment with. Evaluation of performance encourages programmers and designers to work their crafts with efficiency, and to search for the elegantly simple solutions that improve .... CPF

Listing 1

```
program primes; {writes out a number of primes}
var i,j,k, n : integer;
begin
  k := 2;
  while k < = 5000 do begin
      n := 2*k + 1;
      j: =1; i := 3;
      while (i * i < = n) and (j = 1) do
        begin
        if n mod i = 0 then j: =0 else    i: =i+2;
      end;
      if j=1 then write(n, ' ');
      k := k + 1;
    end;
end.
```

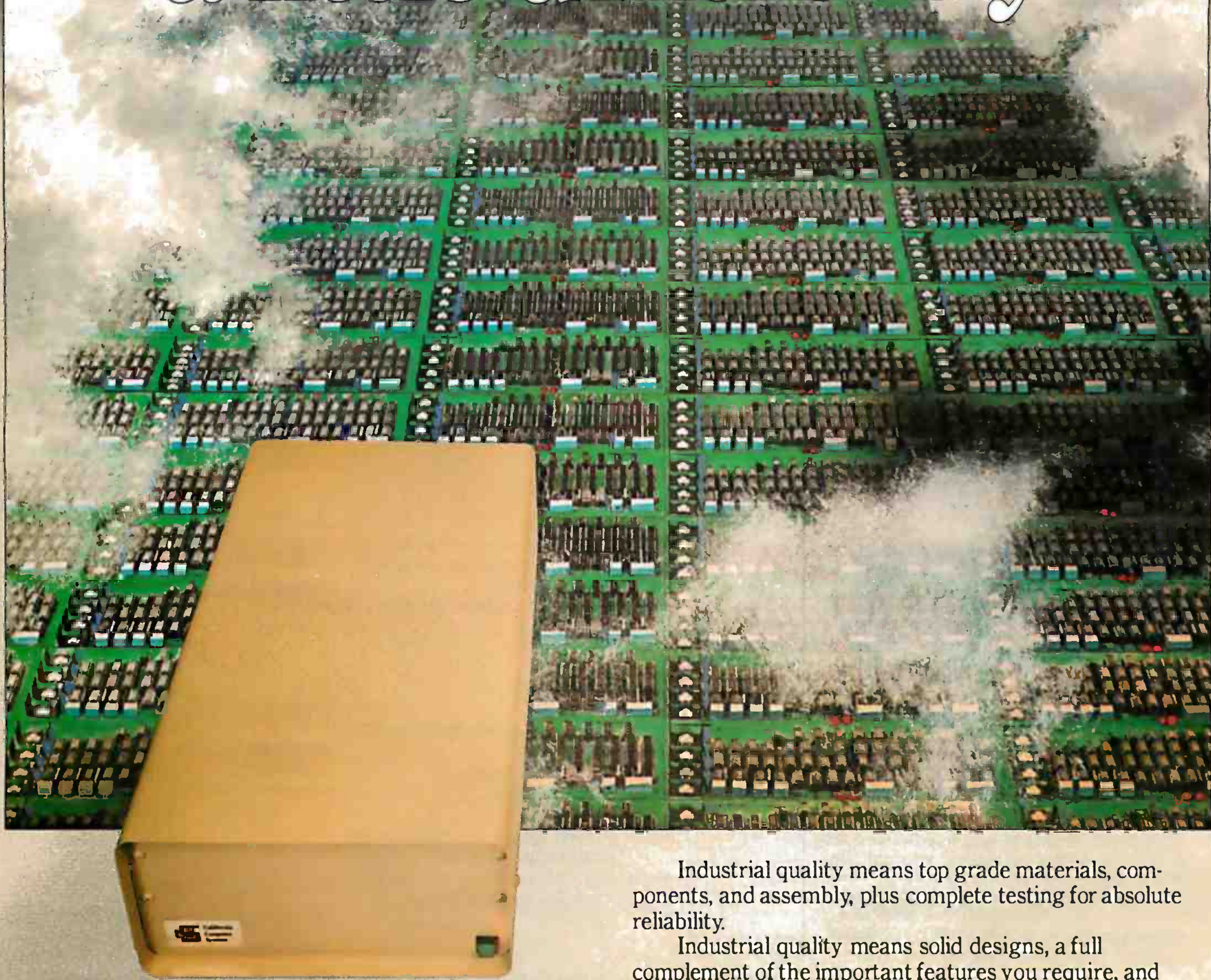
Pascal Precision

The letter from Martin Berman concerning numerical precision in UCSD Pascal (BYTE, June 1980, page 17) struck one of my current concerns. The actual precision available in UCSD Pascal is 7.2 decimal digits; ie: the data type *real* will accommodate integer values as large as 16,777,216 (2^{24}) exactly. However, the output routine is limited to six significant digits. To print the remaining available 1.2 digits will require either a revision to the system-output routine or an output routine custom-made for the application.

I am not privy to the design process at UCSD, but suspect that this is an attempt to "protect" the user from round-off error. I, for one, deplore such attempts at protection since the user who actually knows what he is doing is forced to "program around" the system. A reasonable precaution is to give no more precision than the system has (eight digits in the case of UCSD Pascal), although even this is open to question—a fellow programmer was once caught by this type of "protection" even though he was using only powers of two which are exactly represented throughout the range of the system.

Incidentally, there is a routine available for determining the actual precision of floating-point routines. It may be found in *Pascal News,* number 13 (December 1978). I enclose a copy of the code as I ran it on my UCSD Pascal system, along with the output it generated.

We see the S-100 a little differently.



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Listing 1

```
program representation;

var base, numberofdigits, i     : integer;
    rounding                    : boolean;
    epsilon                     : real;

procedure enquiry (var radix, digits : integer;
                         var rounds : boolean);
  var number, increment          : real;
begin
          (*find large integral value just beyond integer limits*)
  number :=2;
  while (((number+1)-number) = 1) do
   number := number * 2;
  (*end while*)
          (*manufacture the next largest real value*)
  increment := 2;
  while ((number+increment) = number) do
   increment := increment * 2;
  (*end while*)
          (*subtract these to give radix of representation*)
  radix := trunc((number+increment)-number);
          (*see if it rounds or truncates by adding (radix-1)*)
  rounds := ((number+(radix-1)) NEQ number);
          (*work out how many digits in mantissa*)
  digits := 0;
  number := 1;
  while (((number+1)-number) = 1) do begin
   digits := digits +1;
   number := number * radix;
  end; (*while*)
end; (*enquiry*)

begin
          (*find out basic properties*)
  enquiry(base,numberofdigits,rounding);
  writeln(' Base = ',base);
  writeln(' Number of digits = ',numberofdigits);
  if rounding then
   writeln(' Rounded')
  else
   writeln(' Truncated');
  (*end if*)
          (*compare the precision bounds*)
  epsilon := 1;
  for i := 1 to numberofdigits do
   epsilon := epsilon/base;
  (*end for*)
  if rounding then epsilon := epsilon/base;
          (*print the best and worst precision*)
  writeln(' Best and worst precisions are ',
               epsilon,(epsilon*base));
end.
```

My hard-copy terminal does not have greater-than or less-than symbols. Thus "NEQ" is inserted for the Pascal "not equal" symbol.

Base = 2
Number of digits = 24
Rounded
Best and worst precisions are
  2.98023E−8 5.96046E−8

Fred Crary
7750 31st Ave NE
Seattle WA 98115

May We Suggest a Gasp Mask?

Philip K Hooper is not alone. I too noticed the foul odor of the magazine. (See Letters, April 1980 BYTE, page 16.) Not only do I love computer science, but I love my body, and my health is paramount. I therefore abstain from the inhalation of foul vapors and fumes.

A Healthy Minority
Jon Dattorro
1379 Kingstown Rd Apt 1A
Kingston RI 02881

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Steve Ciarcia
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There is no formal definition of what constitutes a remote data-entry terminal. The application defines the classification. While a regular video-display terminal can be used for data entry, remote data-entry terminals are usually specially fabricated to fit the application and environment. Remote data-entry terminals almost always communicate in duplex mode, and are capable of displaying computer directives to the operator as well as sending operator input to the computer.

A further refinement is that the buttons on the panel frequently have function/numeric nomenclature rather than the character set we normally associate with keyboards. A key bearing the label "START" may in fact transmit an ASCII (American Standard Code for Information Interchange) "A" when pressed. Application software running on the control computer is used to recognize that a letter "A" means "initiate the process." The transmission length and protocol should be preset to reduce operator error and entry-panel complexity.

Remote data-entry terminals are usually specially fabricated to fit the application and the environment.

For example, an entry terminal associated with a dip-plating line in a factory would probably have a panel with a numeric keypad and function buttons labeled "Bath 1", "Bath 2", "Anode Current", "Voltage", "Time", and "Temperature". If the operator has to set the anode current in the plating tank, he presses the "Anode Current" button and then enters a four-digit value on the numeric keypad. When the control computer detects the anode-current function button being pressed, it reads the next four characters as numeric information pertaining to the anode-current function. Other function keys could have entirely different entry sequences.

To minimize error, most industrial data-entry terminals rely on considerable handshaking. At the very least, they include an accept/reject indicator for the operator. If the numeric portion of the anode-current entry did not fit within the limits prescribed for the process, a reject signal must be given to the operator so the data can be reentered.

In the more sophisticated units, the data-entry panel often incorporates an alphanumeric display. Usually, it is unnecessary to display textual material to the operator, and these

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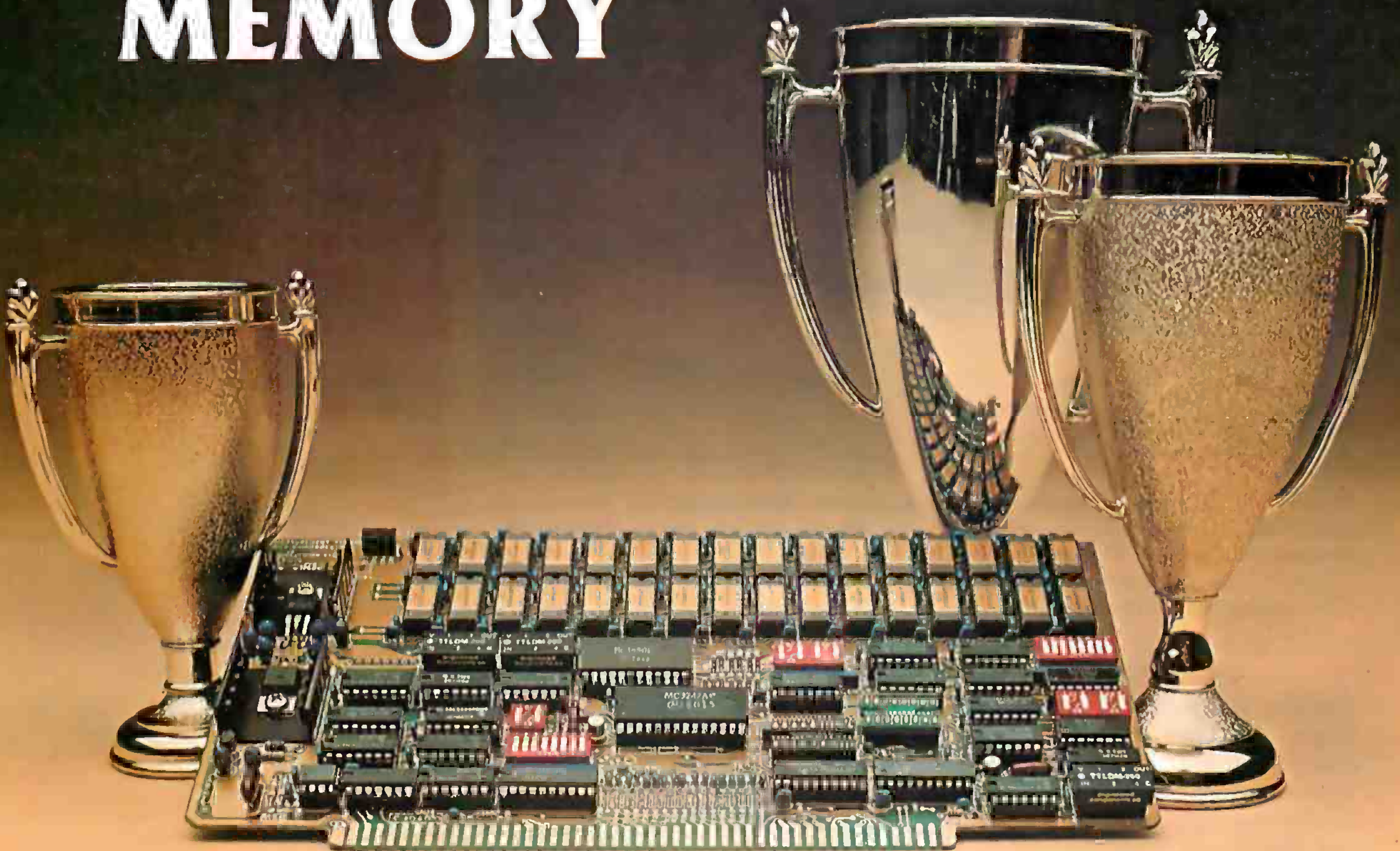

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Photo 1: *Deluxe remote data-entry terminals, intended for industrial use, often contain specialized equipment to read card-badges, or control unusual functions. Many are constructed with a hazardous environment in mind, and are waterproof or blast-proof. This particular unit is a function/numeric panel (FNP) manufactured by General Digital Corporation in East Hartford CT.*

displays are generally limited to a single line of sixteen to eighty characters. Gas-plasma displays or alphanumeric LED (light-emitting diode) matrices work well and are cost-effective in these applications.

Since the panel can communicate in both directions, it is possible for the operator to interrogate the process data base in the computer for specific information. Pressing the "Bath 1" and "Temperature" buttons could result in the appearance of "#1 TEMP =192 C" on the sixteen-character display for example.

The entire remote data-entry terminal can be constructed with only two integrated circuits.

Entry Panels for Personal Computers

Deluxe industrial data-entry terminals include numeric keypads, function buttons, badge readers for operator identification, Hollerith-card readers for part identification, alphanumeric displays, and elaborate self-test features. A typical unit is shown in photo 1. They can be made waterproof, blast-proof, and idiot-proof as required by the application. These are hardly attributes that suggest their use in the home. However, the concept of remote data-entry panels connected to a personal computer is not as alien as it once seemed.

In the past few months I have been presenting articles on various aspects of home control. If you have attached any control devices to your computer and have it controlling the lights and appliances around your home, you undoubtedly are using a program which manipulates logic outputs based on time, status of input sensors, and operator commands. What you have is in fact a practical, even if rudimentary, process-control system. It has fundamental similarities to the dip-plating system previously discussed.

There seems to be considerable interest in home control these days. Many new systems and peripheral devices have been introduced to meet the demand. In my opinion, however, they address only half the problem. They all seem to be limited to central-system use with no facility for remote data entry or effective *human engineering*.

The handheld remote-control devices I detailed in my July article

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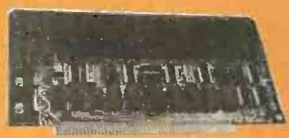

+ Works with the following Z-80 CPU Boards: Cromemco Systems, S.D. Systems, SSM (CB2A), Jade (Big Z), Q.T. (Z+80) and many others + Uses 3242 Refresh Chip with delay line + Four layer PC Board insures a quiet board + Supports 16K, 32K, 48K or 64K of memory + 24 Address lines per IEEE specifications + Optional M1 Wait state allows error-free operation with faster processors + Optional PHANTOM disable + Uses Z-80 Refresh signal + Bank on/off signal selected by I/O port 40 (Hex) per industry standard. + Bank in use determined by convenient DIP switch selection of data bus bits. + Low power consumption – 5 watts. + Convenient LED indication of bank in use

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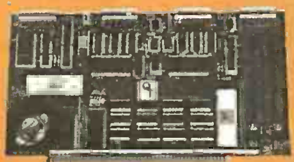

+ Two Independent SYNC/ASYNC Serial Ports + One Strobed Eight Bit Parallel Input Port With Handshaking + Three Eight Bit Parallel Ports (Undedicated, User Configured) + Three Independent Sixteen Bit Timers + Eight Level Priority Interrupt Controller + Large Prototyping area has regulated +5VDC, +12VDC,–12VDC + Two software programmable baud rate generators with crystal controlled frequencies (±.01%)

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Photo 2: *The remote data-entry terminal. Using a new serial keyboard-interface integrated circuit, construction is simple and inexpensive.*

were only one part of the solution. They facilitate operator feedback, to a limited degree, but like any transmit-only wireless device, they cannot be relied upon in critical applications. Consistent success in control can be obtained only with closed-loop communications hard-wired directly between the operator and the control computer. If you press a button on the entry panel, the computer signifies acceptance of the command by flashing an LED or displaying "HEY, GOOD BUDDY."

The easiest way to satisfy the requirements of direct communication is to use a standard video-display terminal at each remote location. The environment in the average home is not as hazardous as a factory plating line. With video terminals at $700 each, it is at least worth thinking about.

Limitations of Video Terminals

However, one problem is that most video-display terminals have an RS-232C serial output which is not supposed to be used for communication line lengths over 50 feet. Before you throw out the terminal you were saving to put in the bedroom at the end of the hall (51 feet from the computer), I should point out that this specified limitation becomes significant only at a data rate of 19,200 bps (bits per second). At 300 bps, the problem is of less concern. I have personally driven 1000 feet of transmission line at 300 bps through an RS-232C port. This is a little unorthodox so don't tell anyone I told you.

There are many computer owners like me who don't particularly care to put a $700 terminal in the garage. If your garage is anything like mine, you'd either have to keep it wrapped in plastic or periodically wipe the oil off, and dump the leaves and the dirt out of it. The average open-chassis video terminal would last about a week. Terminals specifically designed for these extremes would be very expensive and probably come in NEMA 4 or NEMA 10 (National Electrical Manufacturers Association specifications) oil- and water-tight enclosures.

Build a Low-Cost Data-Entry Terminal

The personal computer applications which would warrant using a $5000 submersible data-entry panel are limited in number. I prefer instead to build something that is less expensive. A remote-entry panel, in the garage for instance, might only require functions such as lights on and off, alarm on and off, and maybe a few heating-system functions. A unit installed in the bedroom might have a couple additional functions.

For my own use, I felt I could be satisfied with a combination of ten numeric digit codes (0 thru 9) and ten function inputs. Control-system response could be handled adequately with an 8-bit display. Proper choice of components used in construction (with regard to temperature and voltage ranges, etc) would allow use of the panel in a slightly heated garage as well as the bedroom, and make it inexpensive enough to almost be considered disposable.

Thanks to a new serial keyboard-interface integrated circuit from National Semiconductor, the entire remote data-entry terminal, shown in photo 2, can be constructed with only two integrated circuits. The entry panel, which communicates with the host computer in standard 1200 bps serial format, can be placed as far away as 2 miles from the control computer with the addition of a line driver and receiver. With the exception of the hexadecimal display shown on the prototype, the entire

D I S C U S

terminal can be built for under $50.

The heart of my entry panel is the MM57499 serial keyboard-encoder circuit. This device bears some similarity to other scanning keyboard-encoder read-only memories sold by many manufacturers. It scans a 12 by 8 key matrix and produces the ASCII code for each key. However, using an inexpensive color-burst (3.579 MHz) crystal and an internal data-rate generator, it transmits the characters serially at 1200 bps. In addition, it has the capability to receive serial data (1200 bps) as well. This information can be displayed 1 byte at a time using a single 8-bit shift register. The communications protocol in either case is fixed at 1 start bit, 8 data bits, 1 stop bit, and no parity bit. The data rate can be changed by selecting a different crystal or injecting a TTL (transistor-transistor logic)-level clock signal into pin 2 of the MM57499.

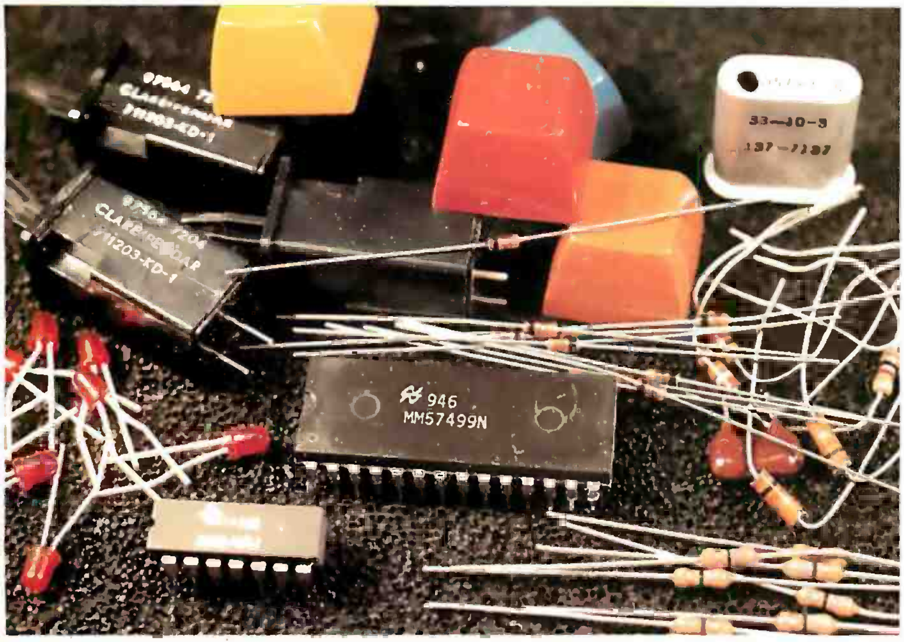

Photo 3: *It is amazing what can be done with so few parts. Most of the components shown here are quite common and easily available. The use of such materials as a color-burst crystal and a standard hexadecimal keypad make this project reliable and nearly bulletproof.*

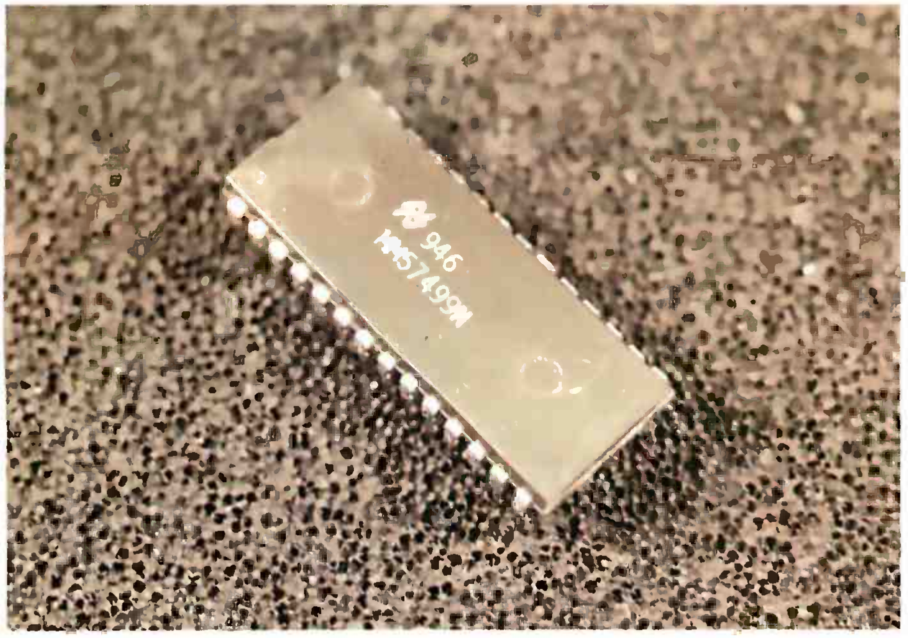

Photo 4: *This twenty-eight-pin integrated circuit keeps things simple by performing the keyboard encoding and transmitting resulting data serially. It also takes care of display functions, with the addition, in figure 2a, of a single shift register.*

A block diagram of the interface is shown in figure 1, and the schematic diagram is illustrated in figure 2. The keyboard I used is a standard twenty-key hexadecimal pad. The keys are individually connected across the X and Y matrix inputs as shown. When the A key is pressed, it will short Y_8 and X_1 together sending out the ASCII code for lowercase "a". Pressing the shift key and the A key together will send an uppercase "A". The ten letters A thru E and a thru e constitute our primary function keys. The numeric-digit keys 0 thru 9 are wired into the matrix in a similar manner. Pressing the shift key and a digit can provide ten more ASCII symbols as function indicators if needed. The key codes corresponding to the cross points of the matrix are outlined in figure 3. To change a particular key, simply determine which scan and strobe lines produce the desired code and wire the key between those points.

Three keys, F, H, and L in my unit, are given operations that are different from what their nomenclature might indicate. The F key is wired as a semicolon ";", the L key is wired as a Control "CTL" key and, the H key is now an Escape "ESC". These three keys facilitate using the programmable phrase feature of the MM57499.

During normal use, pressing the A key will send an "a". This could be interpreted by the host computer as the set-alarm signal to the home security system. To reduce potential problems, a numeric code or password could be required with all entries. Fortunately, frequent transmission of a lengthy password is not a problem.

The MM57499 contains a fourteen-character programmable memory. Pressing a Control-Escape enables this function and automatically transmits a hexadecimal FA to tell the control computer that the panel is in the program mode. The next one to fourteen keystrokes (character or control) will be stored in memory. To halt the entry process, for instance after entering a password of "abAB", we just type a Control-semicolon. This will transmit the stored message

Circle 18 on inquiry card. ➞

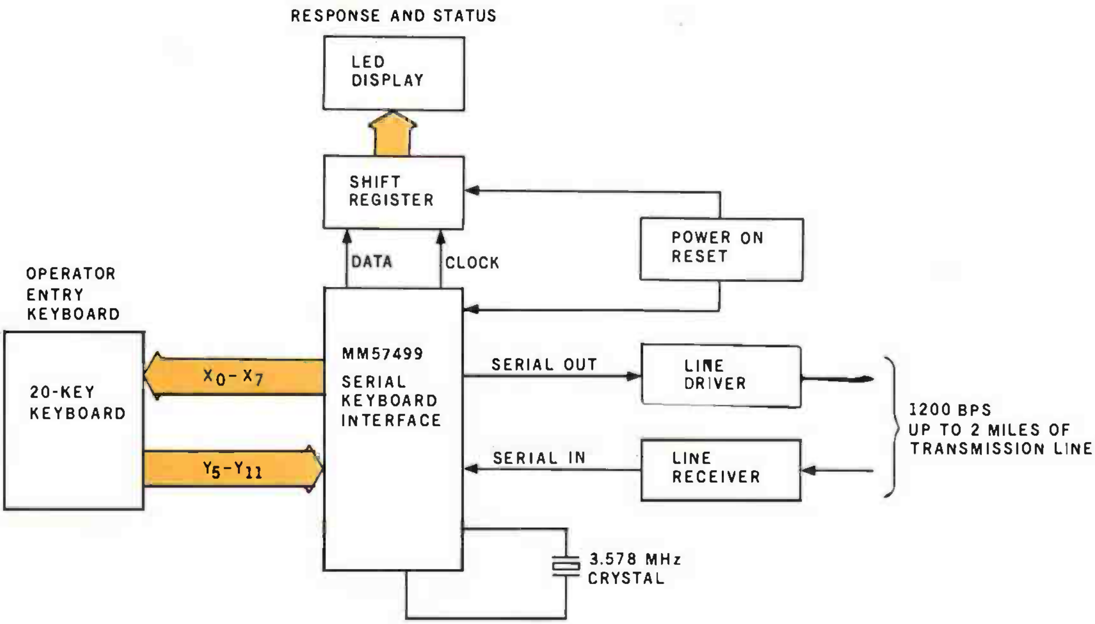

Figure 1: *Block diagram of a minimal-component remote-entry panel, capable of serial communication with most host computers.*

to the computer. The first time it is transmitted, a hexadecimal F9 is affixed to the beginning of the message to tell the computer that the terminal is no longer in the programming mode. At any time after this point, whenever a Control-semicolon is pressed, the stored password will be transmitted. Reprogramming this phrase is accomplished by simply pressing Control-Escape again and repeating the sequence.

Receiving data from the control computer in response to an operator input is where the real power of this interface becomes apparent. The computer can signify the acceptance or rejection of a command input, or the completion of a task by turning on one of the LEDs connected to IC2.

Text continued on page 42

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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.

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Matrix Connections X	Matrix Connections Y	Standard Code	With Control Key Pressed	With Shift and Control Pressed	With Shift Key Pressed	Key
0	0	80	80	80	80	FN1
1	0	81	81	81	81	FN2
2	0	82	82	82	82	FN3
3	0	83	83	83	83	FN4
4	0	84	84	84	84	FN5
5	0	85	85	85	85	FN6
6	0	86	86	86	86	FN7
7	0	87	87	87	87	LS
0	1	88	88	88	88	IC
1	1	89	89	89	89	ADM
2	1	8A	8A	8A	8A	DE
3	1	8B	8B	8B	8B	BTAB
4	1	8C	8C	8C	8C	SC
5	1	8D	8D	8D	8D	CLEAR
6	1	8E	8E	8E	8E	EOS
7	1	8F	8F	8F	8F	EOL
0	2	90	90	90	90	BS
1	2	91	91	91	91	DL
2	2	92	92	92	92	DC
3	2	93	93	93	93	IL
4	2	94	94	94	94	FMT
5	2	95	95	95	95	↑
6	2	96	96	96	96	↓
7	2	97	97	97	97	→
0	3	98	98	98	98	←
1	3	09	09	09	09	TAB
2	3	08	08	08	08	BS
3	3	7B	7B	7B	7B	{
4	3	7C	7C	7C	7C	:
5	3	7D	7D	7D	7D	}
6	3	7E	7E	7E	7E	~
7	3	5F	1F	1F	1F	—
0	4	30	30	30	30	0
1	4	31	31	31	31	1
2	4	32	32	32	32	2
3	4	33	33	33	33	3
4	4	34	34	34	34	4
5	4	35	35	35	35	5
6	4	36	36	36	36	6
7	4	37	37	37	37	7
0	5	38	38	38	38	8
1	5	39	39	39	39	9
2	5	0A	0A	0A	0A	LF
3	5	1B	1B	1B	1B	ESC
4	5	20	20	20	20	SP
5	5	0D	0D	0D	0D	RTN
6	6	2E	2E	2E	2E	.
7	5	FF	FF	FF	FF	BREAK

Matrix Connections X	Matrix Connections Y	Standard Code	With Control Key Pressed	With Shift and Control Pressed	With Shift Key Pressed	Key
0	6	30	30	30	30	0
1	6	31	31	21	21	1
2	6	32	32	22	22	2
3	6	33	33	23	23	3
4	6	34	34	24	24	4
5	6	35	35	25	25	5
6	6	36	36	26	26	6
7	6	37	37	27	27	7
0	7	38	38	28	28	8
1	7	39	39	29	29	9
2	7	3A	3A	2A	2A	:
3	7	3B	3B	2B	2B	;
4	7	2C	2C	3C	3C	,
5	7	2D	2D	3D	3D	-
6	7	2E	2E	3E	3E	.
7	7	2F	2F	3F	3F	/
0	8	40	00	00	60	@
1	8	61	01	01	41	A
2	8	62	02	02	42	B
3	8	63	03	03	43	C
4	8	64	04	04	44	D
5	8	65	05	05	45	E
6	8	66	06	06	46	F
7	8	67	07	07	47	G
0	9	68	08	08	48	H
1	9	69	09	09	49	I
2	9	6A	0A	0A	4A	J
3	9	6B	0B	0B	4B	K
4	9	6C	0C	0C	4C	L
5	9	6D	0D	0D	4D	M
6	9	6E	0E	0E	4E	N
7	9	6F	0F	0F	4F	O
0	10	70	10	10	50	P
1	10	71	11	11	51	Q
2	10	72	12	12	52	R
3	10	73	13	13	53	S
4	10	74	14	14	54	T
5	10	75	15	15	55	U
6	10	76	16	16	56	V
7	10	77	17	17	57	W
0	11	78	18	18	58	X
1	11	79	19	19	59	Y
2	11	7A	1A	1A	5A	Z
3	11		ON→FC			Cap Loc
4	11		ON→FE			Shift Loc
5	11					RPT
6	11		No Code			CNTR
7	11					SHIFT

Table 1: *Hexadecimal key-code assignments. Using this set of assignments, the computer can reply to data entered at the terminal. The data received at the remote terminal is displayed on eight LED indicators or an optional two-digit hexadecimal readout.*

Circle 21 on Inquiry card.

Circle 22 on inquiry card. →

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Number	Type	+5 V	GND
IC1	MM57499	11	1
IC2	74164	14	7
IC3	75114	16	8
IC4	75115	16	8
IC5	75115	16	8
IC6	75114	16	8

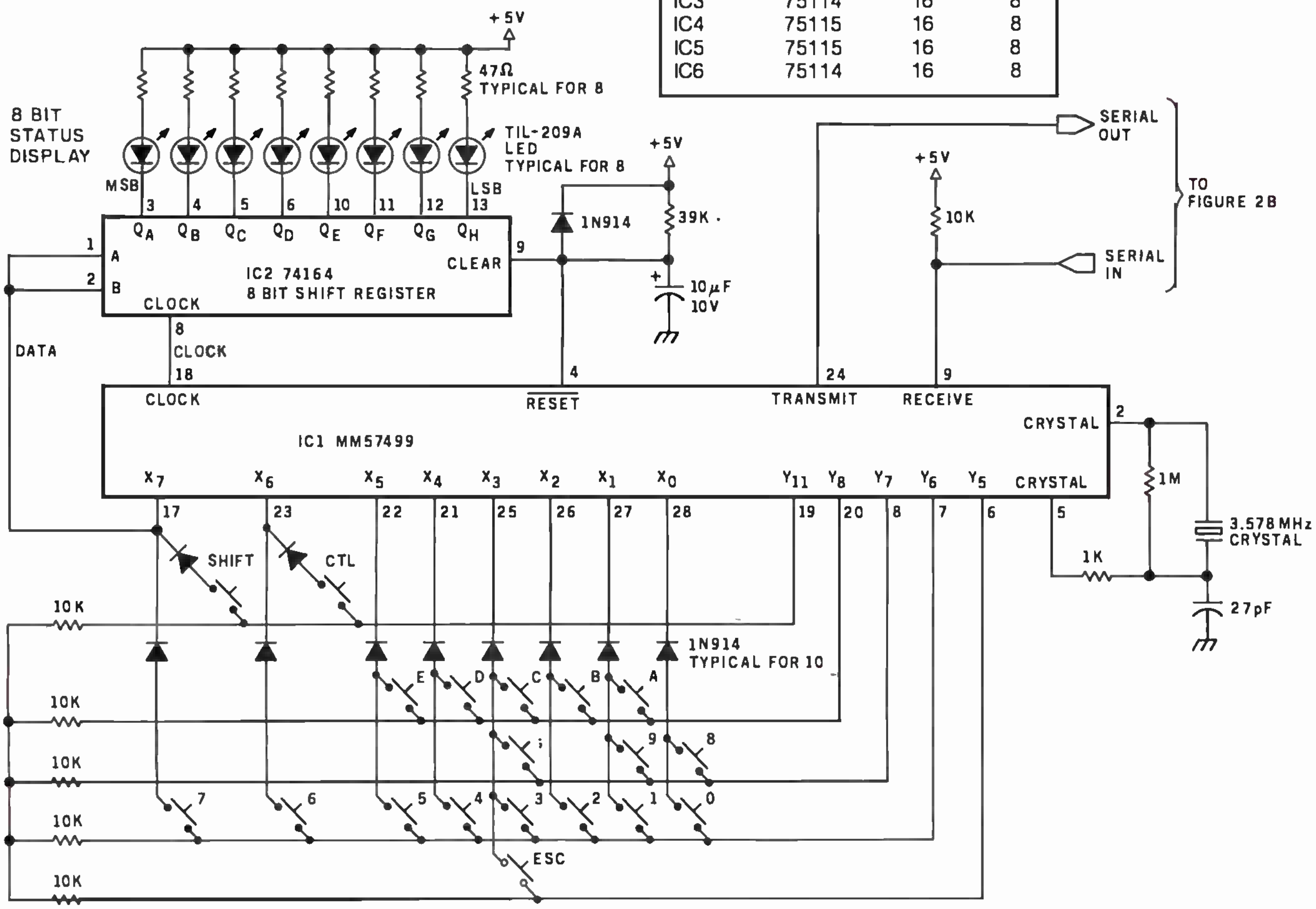
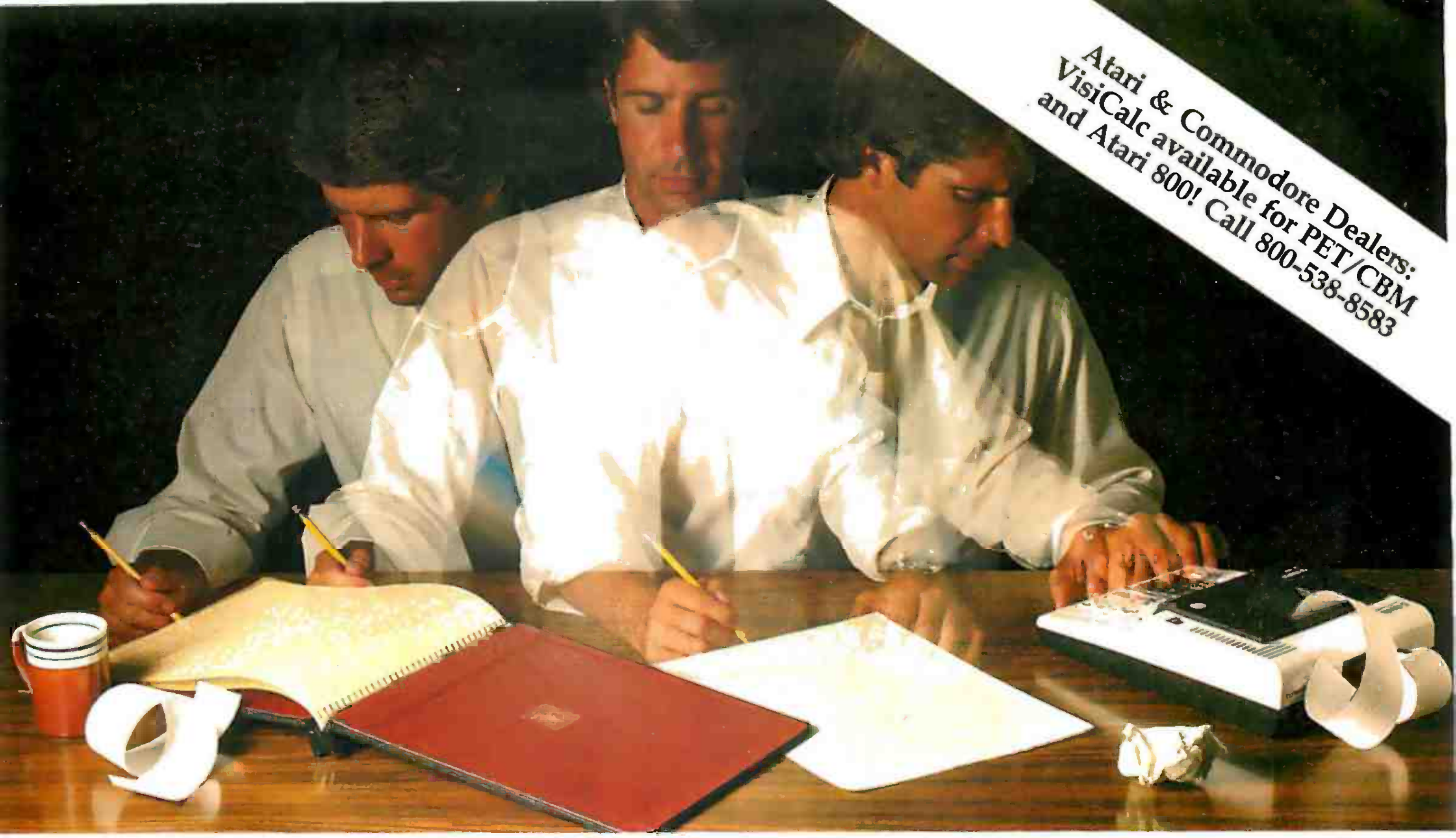


Figure 2a: *Schematic of the remote data-entry terminal. Use of the MM57499 serial keyboard-interface circuit allows for simple construction. Data is entered via a standard keypad, and encoded by the interface circuit. Data may then be sent serially at 1200 bps to the computer over any of a number of types of transmission line.*

In this circuit, all diodes are 1N914s, and not all Yn lines are used since a hexadecimal keypad does not require them. Holding any key down causes a 15-cps automatic repeat.



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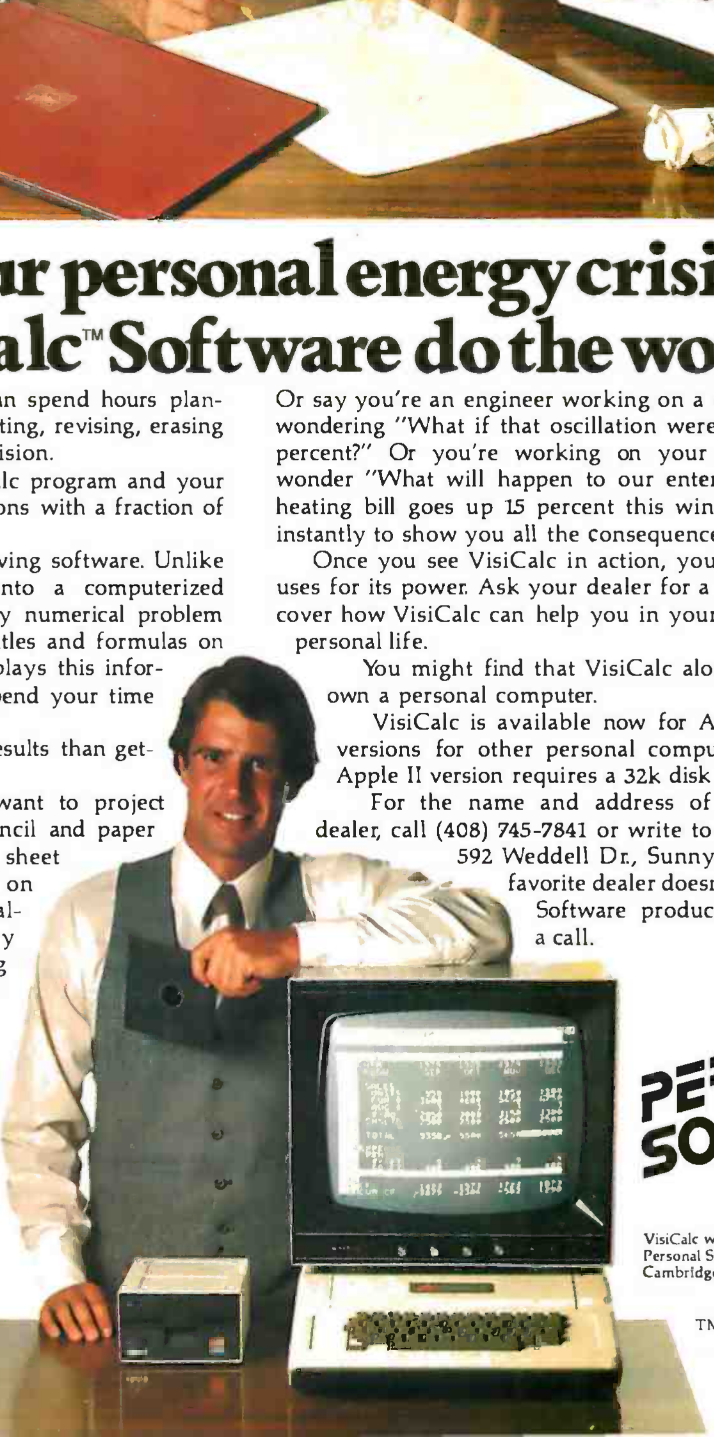

PERSONAL SOFTWARE

VisiCalc was developed exclusively for Personal Software by Software Arts, Inc., Cambridge, Mass.

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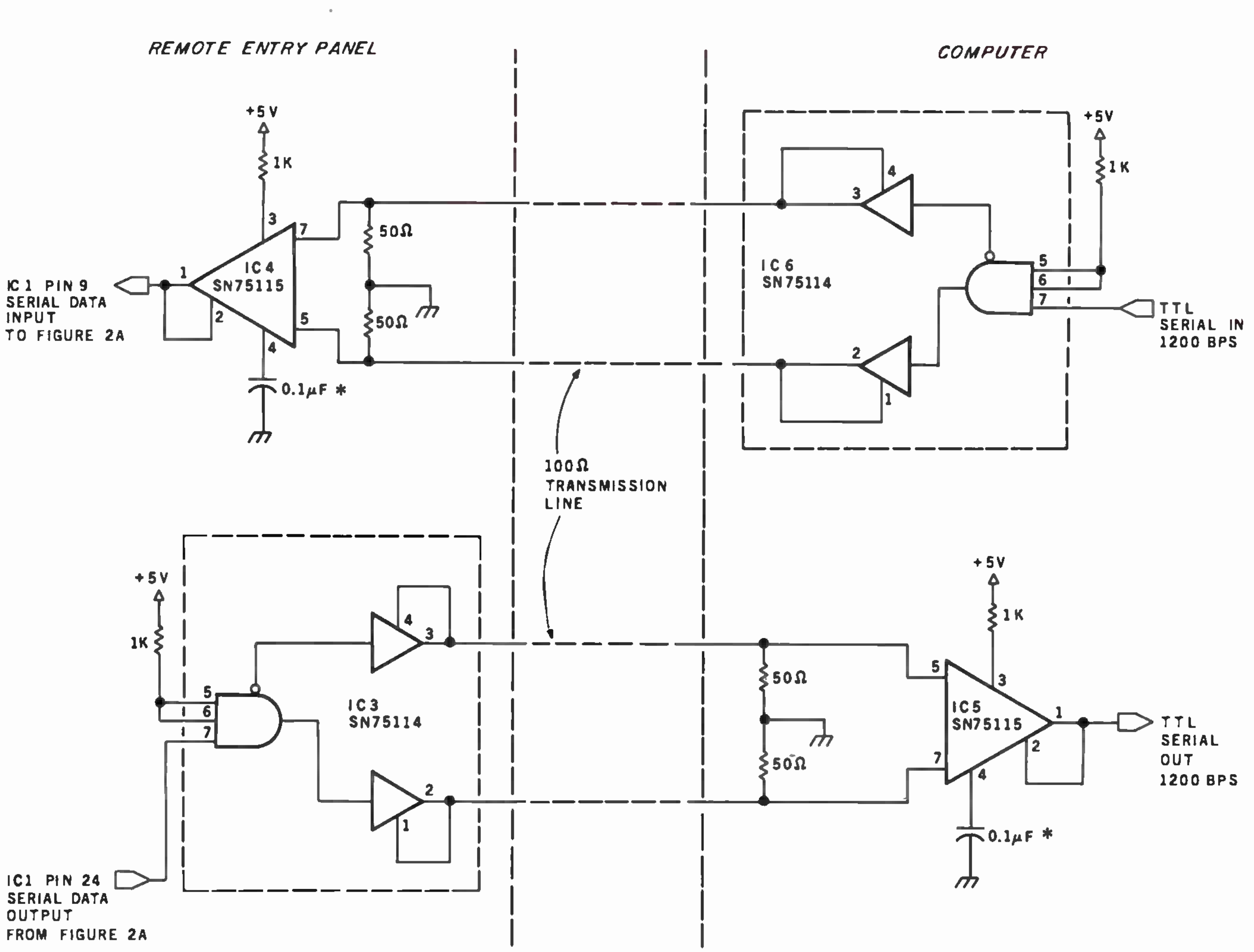
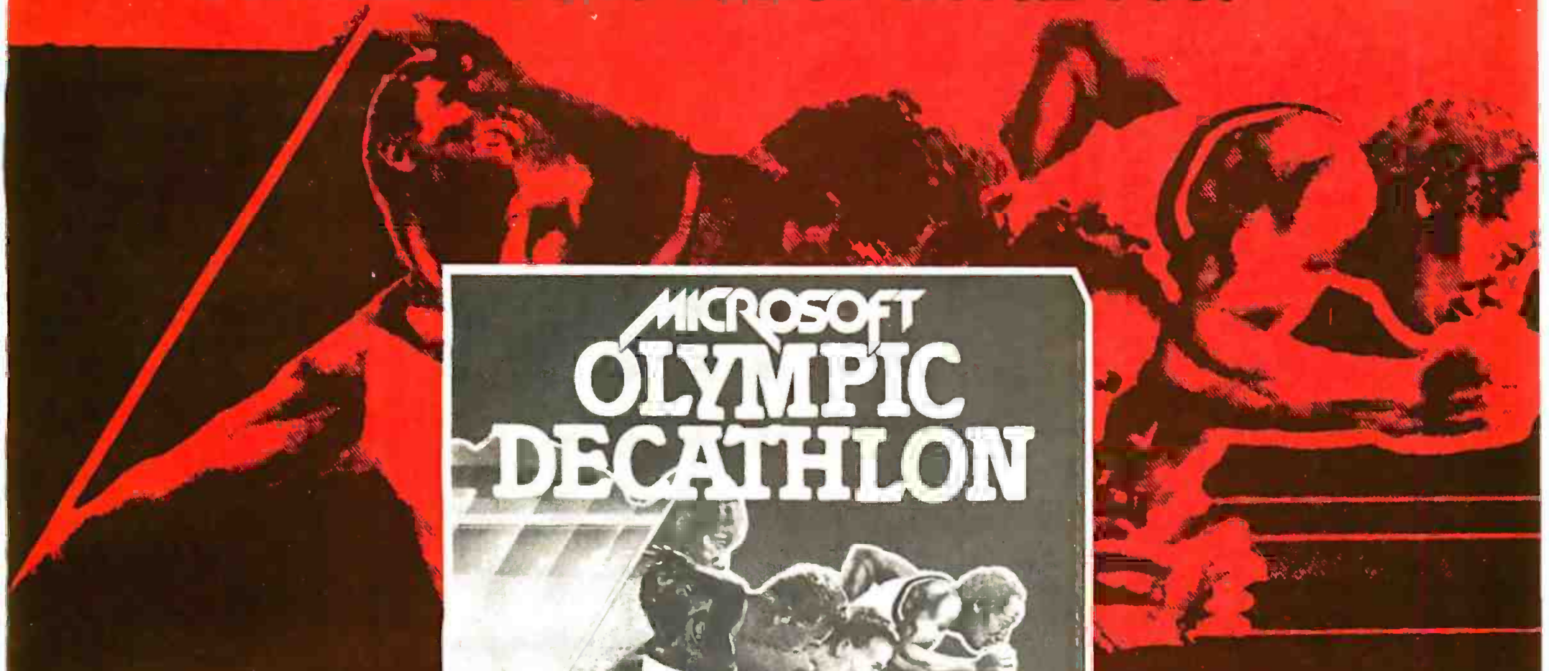
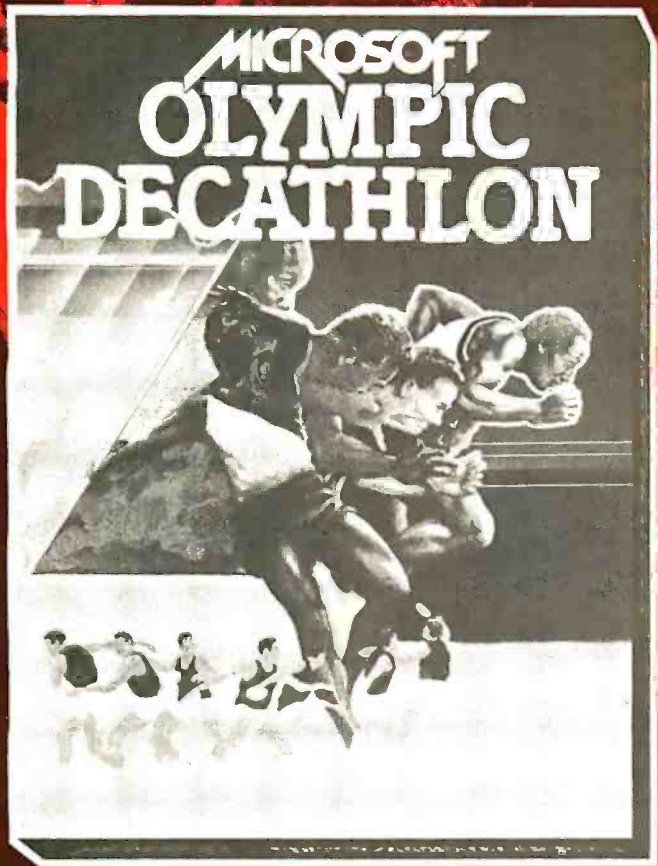


Figure 2b: *Transmission-line drivers for the terminal are capable of transmitting over 10,000 feet of 100-ohm line. The capacitors at pin 4 of IC4 and IC5 help to reduce noise pick-up by decreasing the frequency response of the receiver.*

After you've broken the pole vault record, see if you can outsmart the killer dwarves.





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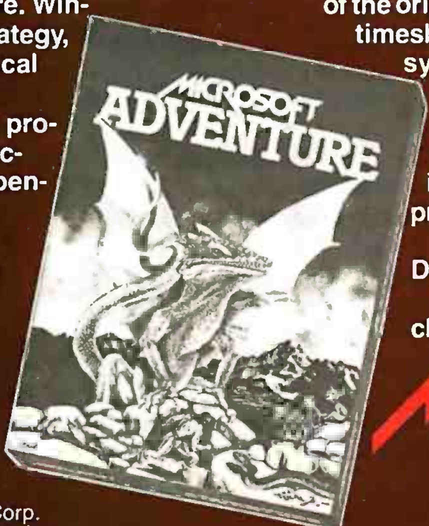
There's never been a program that tests your reflexes and coordination like Olympic Decathlon. Just like the real one, Microsoft's has 10 events, including shot put, pole vault, long jump, javelin throw, and six more. Winning takes a combination of strategy, timing, coordination, and physical endurance (really!).

When you jump or throw, the program calculates the actual trajectory, and shows you what's happening with exciting animated graphics. After each event, the scores of all competitors (up to 8) are displayed. It's the ultimate party game to show off your computer!

Disk-based Decathlon runs on a 32k TRS-80. The cassette version requires a 16k Level I or Level II system.



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If you've ever been lucky enough to play Adventure on a big computer, you know how addictive it is. Fantasy, deduction, and magic all come into play as you explore the chambers of Colossal Cave, collecting treasure while avoiding pitfalls and hostile creatures. There are surprises around every corner, and even veteran players keep discovering new things and improving their scores.

Microsoft has the complete microcomputer version of the original FORTRAN Adventure that runs on large timesharing systems. It runs on TRS-80 and Apple II systems with at least 32k memory and one disk.

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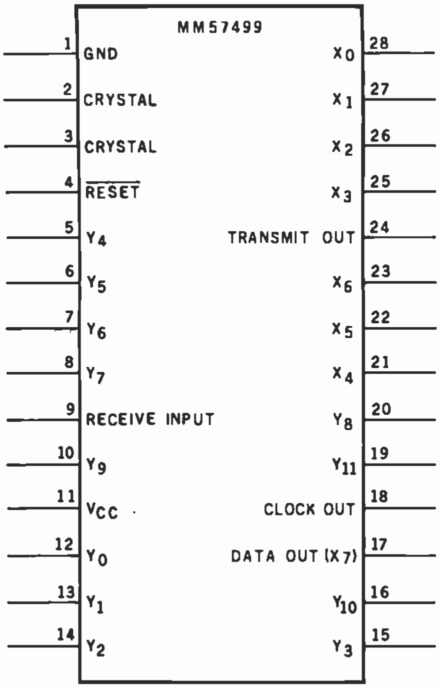


Figure 2c: *The MM57499 serial keyboard-encoder integrated circuit, which scans a 12 by 8 matrix and produces the appropriate ASCII code for each key.*

SCAN LINES	X_7	X_6	X_5	X_4	X_3	X_2	X_1	X_0
Y_{11}	SHIFT KEY	CONTROL	REPEAT	CAP LOCK	SHIFT LOCK	Z / z	Y / y	X / x
Y_{10}	W / w	V / v	U / u	T / t	S / s	R / r	Q / q	P / p
Y_9	O / o	N / n	M / m	L / l	K / k	J / j	I / i	H / h
Y_8	G / g	F / f	E / e	D / d	C / c	B / b	A / a	□ / @
Y_7	? / /	> / .	= / -	< / ,	+ / ;	* / :	) / 9	(/ 8
Y_6	' / 7	& / 6	% / 5	$ / 4	# / 3	" / 2	! / 1	o / 0
Y_5	BREAK	.	RTN	SP	ESC	LF	9	8
Y_4	7	6	5	4	3	2	1	0
Y_3	DEL / —	^ / ~	] / }	\ / ¦	[/ {	BS	TAB	←
Y_2	→	↓	↑	FMT	IL	DC	DL	FS
Y_1	EOL	EOS	CLEAR	SC	B TAB	DE	ADM	IC
Y_0	LS	FN7	FN6	FN5	FN4	FN3	FN2	FN1

STROBE LINES

Figure 3: *Key function chart. Although not all scan lines are used for the hexadecimal keypad, the MM57499 circuit is capable of encoding the full ASCII character set. In the unit described, shorting X_3 and Y_5 produces an ESC (Escape) code, while shorting X_5 and Y_5 gives the code for 5.*

Text continued from page 34:

This is accomplished by sending an ASCII character to the entry receiver that has a key code corresponding to the bits we wish to light. These codes are listed in table 1.

For example, to light the LSB (least-significant bit) of the display, a hexadecimal 01 is sent. This corresponds to a "Control-shift-A". The Break key code FF would turn on all the indicators. To successfully use these LEDs, a lookup table and bit map should be included in any software driver for the terminal. My prototype included both an 8-bit LED display and a two-digit hexadecimal display. They are wired in parallel and display the same information.

Long Distance Transmission

No one bothers to construct a remote-entry terminal for placement next to the control computer. In most cases you will not have to resort to extraordinary means to communicate a couple hundred feet. Should you need to communicate long distances, such as 3000 feet to the barn, the line-driver circuitry of figure 2 should be used. It is capable of driving 10,000 feet of 100-ohm transmission line. For short distances it isn't absolutely necessary to use this wire or circuit. A pair of MC1488 and MC1489 RS-232C drivers can be substituted for short runs and twisted-pair wiring used instead of 100-ohm cable. The degree of leeway allowed depends upon the electrical noise between the terminal and the computer. If in doubt, use the heavy-duty driver I've outlined.

Whether you build this interface or not is immaterial so long as you recognize the advantages it presents for those readers interested in control applications. I've only scratched the surface concerning the capabilities of the MM57499. We could also have used it as a single-chip remote-status transmitter, or we could have expanded the receiver section for full message displays. Trying to cover all potential applications is impossible in a single article. I assure you that I am not through with this device, and I'll think up a few more gadgets that use it. If in the meantime you have any brainstorms concerning home control, I'd appreciate hearing about them.

For information on the MM57499 write to:

Mike Van Slack
Product Marketing Engineer
National Semiconductor
2900 Semiconductor Dr
Santa Clara CA 95051

Next Month: *We will explore some ways to use LCDs (liquid-crystal displays).* ■

Your vehicle for com
The Challenger 8P DF.

The general purpose microcomputer was first introduced as a computer for hobbyists and experimenters. However, as the industry has grown, microcomputers have become specialized for personal use or for small business use. There is virtually no computer for the serious experimenter with one important exception, the Ohio Scientific Challenger 8P.

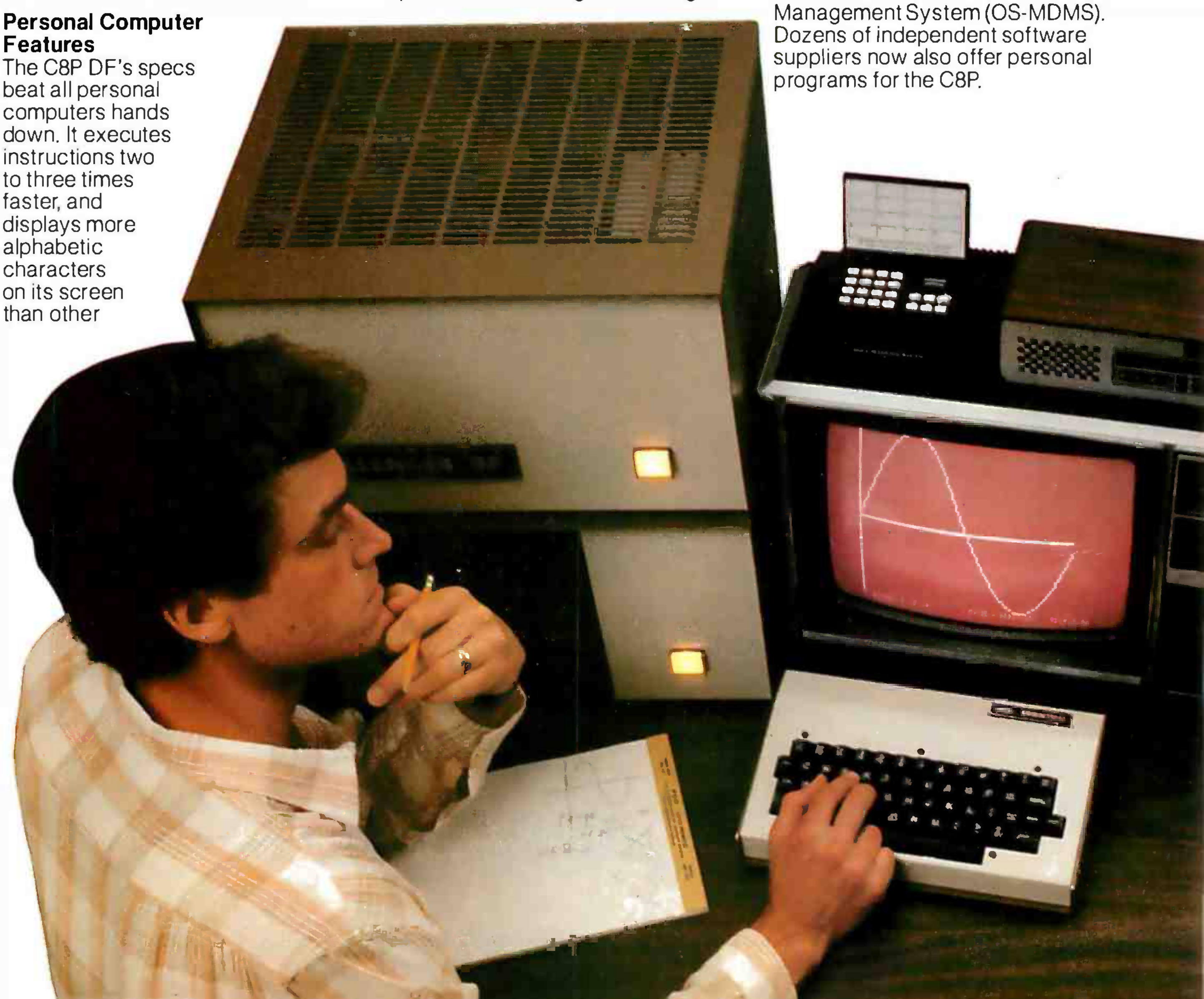
The C8P is unique in that it incorporates the features of state-of-the-art personal computers, with the memory and disk storage capacity of business computers, along with the "mainframe" bus architecture and open ended expansion capability of industrial control computers.

Personal Computer Features

The C8P DF's specs beat all personal computers hands down. It executes instructions two to three times faster, and displays more alphabetic characters on its screen than other models. It has upper and lower case and graphics in 16 colors. The C8P's *standard* I/O capabilities are far more extensive than any other computer, with joystick and keypad interfaces, sound output, an 8-bit D/A converter, 16 parallel I/O lines, modem and printer interfaces, AC remote control and security monitor interfaces and a universal accessory port that accepts a prom blaster, 12-bit analog I/O module, solderless prototyping board and more.

Ohio Scientific offers a large library of personal applications programs, including exciting action games such as Invaders and Star Trek, sports simulations, games of logic and educational games, personal applications such as biorhythms, calorie counter, home programs such as checking and savings account balancers and a home budgeter just to name a few. A new Plot BASIC makes elaborate animations easy, and music composition program allows you to play complex multi-part music through the computers DAC.

At the systems level the machine comes standard with OS-65D, an advanced disk operating system with Microsoft BASIC and an interactive Assembler Editor. Optional software includes UCSD PASCAL and FORTRAN and an Information Management System (OS-MDMS). Dozens of independent software suppliers now also offer personal programs for the C8P.



puter explorations.

Business Computer Features
The C8P DF utilizes dual 8" floppy disk drives which store up to eight times as much information as personal computer mini-floppies, and an available double-sided option expands capacity to 1.2 megabytes of on-line storage. The C8P DF is compatible with Ohio Scientific's business computer software, including OS-65U an advanced operating system, and an Information Management System (OS-DMS) with supplementary inventory, accounting, A/R-A/P, payroll, purchasing, estimation, educational grading and financial modeling packages. The system also supports word processing (WP-3) and a fully integrated small business accounting system (OS-AMCAP V1.6). The C8P DF's standard modem and printer ports accept high-speed matrix printers and word-processing printers directly.

Home Control and Industrial 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 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.

For process control applications, a battery back up calendar clock with automatic computer restart capabilities is available. Ohio Scientific's unique accessory ports allow the connection of a nearly unlimited number of 48 line parallel I/O cards and 12-bit high speed instrumentation quality analog I/O modules to the computer by inexpensive 16-pin ribbon cables.

Exploring New Frontiers
Ohio Scientific's vocalizer software processes normal BASIC print statements with conventional spellings and speaks them clearly in real-time on computers equipped with the UTI (CA-15B or CA-14A). This voice output capability, combined with the C8P's remote control, remote sensing, telephone interface capabilities and reasonable cost open up new frontiers for computer applications.

Documentation
The C8P DF is not a beginner's computer and doesn't come with beginner's documentation. However, Ohio Scientific does offer detailed documentation on the computer which is meaningful for experts, including a Howard Sams produced hardware service manual that includes detailed block diagrams, schematics, parts placement diagrams and parts lists. Ohio Scientific is now also offering fully documented Source Code in machine readable form for OS-65D, the Challenger 8P's operating system allowing experimenters and industrial users to customize the system to their specific applications.

What's Next?
Ohio Scientific is working on a speech recognizer to complement the UTI system, with a several hundred word vocabulary. The company is also developing an 8 megabyte low-cost, add-on hard disk for use in conjunction with natural language parsing to further advance the state-of-the-art in small computers. The modular bus architecture of the C8P assures system owners of being able to make use of these new developments as they become available just as the owner of a 1976 vintage Challenger can directly plug in voice output, the UTI and other current state-of-the-art OSI products.

The C8P DF with dual 8" floppies, BASIC and two operating systems costs about $3000, only slightly more than you would pay for a dual mini-floppy equipped personal computer with only a fraction of the capabilities of the C8P.

For more information and the name of the dealer nearest you, call 1-800-321-6850 toll free.

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An 8088 Processor for the S-100 Bus

Part 1

Thomas Woodward Cantrell
2475 Borax Dr
Santa Clara CA 95051

The 16-bit microprocessor has definitely arrived. No one doubts that this new wave of high-performance processors will soon be operating on the familiar S-100 bus. In fact, Seattle Computer Products is already shipping its Intel 8086-based processor card, along with a support card that includes vectored-interrupt control, hardware mathematical operations, and miscellaneous timer/counters.

Godbout Electronics has designed a card containing two microprocessors and the logic allowing transfer of control between them by software. One of the processors on this board is an Intel 8085A-2, which allows the board to be placed in 8080A/8085A/Z80A-based S-100 systems with a minimum amount of hassles.

Using various existing or soon-to-be-developed cross-software products, programs can be developed for the other processor on the board, the Intel 8088. When the new software is developed and loaded, control can be transferred from one microprocessor circuit to the other for checkout and debugging. This is a novel solution to the problem of bootstrapping a system consisting of both new hardware and new software.

Microsoft and Digital Research, both highly renowned producers of quality software, are making their contributions to the processor revolution. Microsoft is already shipping an 8086/8088 version of its popular BASIC interpreter as well as an 8086/8088 cross-macroassembler which runs under Digital Research's CP/M. A disk operating system and other system software are to follow.

Digital Research has an 8086/8088 based version of CP/M in the works. Expect this to be followed with new versions of MP/M and PL/I. The multitude of vendors who supply software to run under CP/M should already be converting their software for use with the new CP/M.

Photo 1: *A wolf in sheep's clothing. The panel may say "8080," but the processor card in this system is based on Intel's high-performance 8088.*

Problems Remain

Be that as it may, the S-100/16-bit processor picture is not as bright as it may seem. The fundamental problem is that the S-100 bus was originally designed by MITS (of Altair fame) for the Intel 8080, an 8-bit microprocessor. To "upgrade" the S-100 bus to the higher levels of performance offered by the new machines, certain problems must be addressed. The IEEE (Institute of Electrical and Electronics Engineers) Standards Committee, through its S-100 bus standard definition, has assured a future for the S-100 bus in two ways.

First, the problem of incompatibility between different "S-100" modules will be laid to rest. Woe be unto today's computerist who attempts to use a Brand X DMA color video-display board with a Brand Y

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Z80 processor card and a Brand Z dynamic memory board. If they *all* work together it's a miracle! By more clearly defining things like DMA (direct-memory access) protocols and timing, as well as eliminating some of the archaic or abused S-100 signals, board compatibility can more likely be assured.

Second, provisions have been made to ease the adaptation of new, higher-performance processors to the bus. This expandability has been achieved in three distinct ways:

- 16-Bit Data Transfers — MITS chose to split the 8080's bidirectional 8-bit data bus into separate input and output data buses. While the wisdom of this was often questioned, it has proven to be a saving grace. The IEEE S-100 standard adds two signals (SXTRQ*, Sixteen Request, and SIXTN*, Sixteen Acknowledge) to allow 16-bit data transfers by ganging the input and output data bus. (Note that throughout this article I will use the "*" notation to designate active low signals; this is the accepted usage in the IEEE standard.)
- Extended Memory Addressing — Eight of the unused S-100 bus lines have been designated as address lines A16 thru A23. With 24 address bits (A0 thru A23), 16 megabytes of memory can be addressed directly.
- Extended I/O (input/output) Addressing — The 8080 was capable of addressing 256 I/O ports. The 8-bit I/O port address was placed on both the low byte (A0 thru A7) and high byte (A8 thru A15) of the 16-bit address bus. The IEEE standard allows this echoing of the port address on both halves of the address bus, but recommends that A0 thru A15 be used for I/O addressing. The 16-bit I/O address gives S-100 systems the ability to directly utilize up to 64 K I/O ports.

These standardization efforts will allow a controlled evolution of the S-100 bus. However, I realize that of the dozens of S-100 boards I have (including some of very recent vintage), probably none meets the IEEE standard. I cannot afford to replace them

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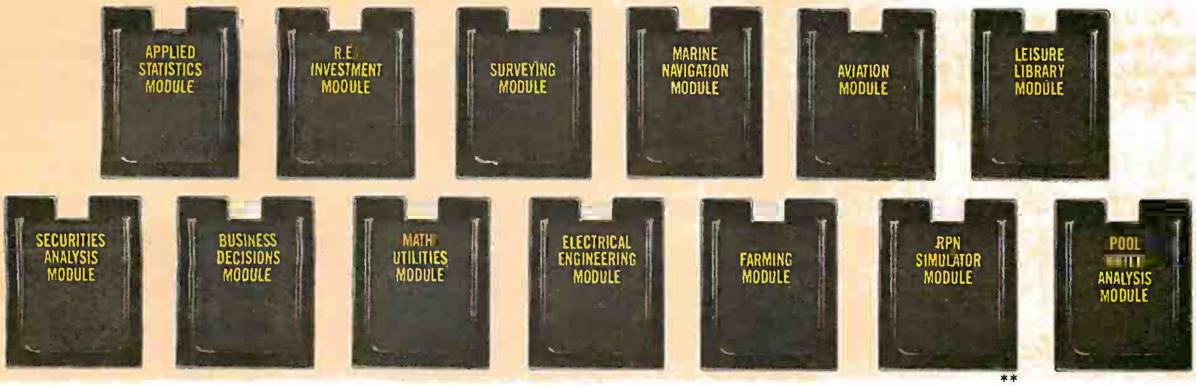

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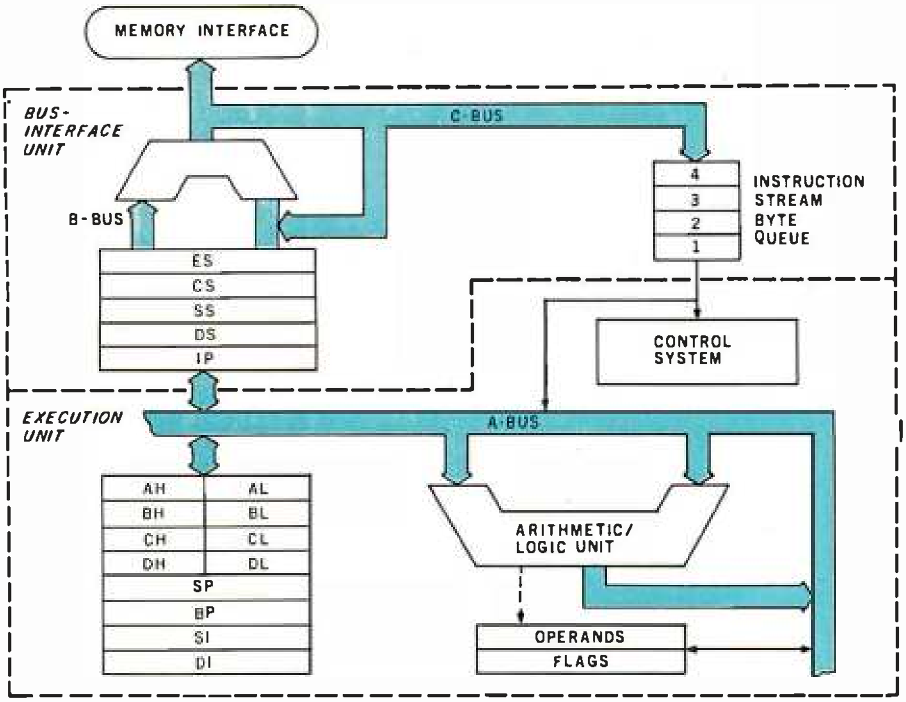

Figure 1: *The internal architecture of the 8088. By combining a 16-bit execution unit with an 8-bit bus-interface unit, the 8088 can use a powerful instruction set and still remain compatible with most existing hardware. The functional division of processing allows the 8088 a speed advantage by performing* fetch *and* execute *concurrently.*

all. In fact, my IMSAI computer's front panel does not meet the standard either.

A Solution

Intel's 8088 microprocessor is a remarkable machine. By combining a 16-bit execution unit with an 8-bit bus interface, the 8088 can represent the best of both worlds for many users. (See figure 1.) In particular, the 8088 allows you to reap the benefits of a powerful new architecture while preserving your investment in 8-bit hardware. In addition, many data-handling-oriented applications (such as intelligent terminals, data concentrators, and small business computers) are more naturally implemented with a machine that communicates using 8-bit characters.

New Architectures

The microprocessor revolution is fascinating because it represents a microcosm of the computer revolution. In the last 5 years we have seen computers on silicon follow the footsteps of 30 years of computing history. The effort of the computing pioneers has not been in vain, for it has served to chart our course.

Consider current VLSI (very large scale integration) processing technologies. Semiconductor manufacturers have the capability of placing 30,000 transistors on a chip of silicon today, with as many as 100,000 in the near future. Now imagine a second-generation mainframe computer of the 1960s. It fills an air-conditioned room and consists of large metal boxes and massive power supplies. Inside some of the metal boxes are large racks filled with circuit cards. These circuit cards are covered with transistors, resistors, and capacitors. Today, the computing equivalent of these metal boxes is a small group of integrated circuits.

The user may be initially impressed by the complexity of the computer being used, but he will ultimately judge the machine on the basis of its power and ease of use; therefore, the challenge for the manufacturers is not as simple as maximizing the number of devices. The problem is designing microprocessors that respond to the needs of the user.

The high-performance solution is to implement mainframe architectures that contain tried and proven virtues. Concepts like *attached coprocessors, concurrent I/O processing, pipelining, memory segmentation* and *hardware mathematical operations* are being adopted and put on silicon. When I say the architecture of the 8088 is "new and revolutionary," I am really saying that the day of the "mainframe-on-a-chip" has arrived.

The Best of Both Worlds

The 8088 contains two processors in its 40-pin package. One is called the EU (execution unit) and the other is the BIU (bus-interface unit). The BIU is optimized for communicating with the rest of the computer system, while the EU is optimized for executing programs.

The EU most closely resembles what is conventionally considered the processor; it contains the working registers, the status flags, and the ALU (arithmetic/logic unit). As its name implies, this is where programs are executed.

The EU of the 8088 is the same as the one in the 16-bit 8086 processor. All the registers (twelve of them) are 16 bits wide, though some of them can be treated as two separate 8-bit registers by the programmer. In addition, all math operations (addition, subtraction, multiplication and division) can utilize 16-bit operands.

The 8-bit BIU manages much of the work associated with the address, data, status, and control bus interfaces. The BIU of the 8088 uses an 8-bit data bus for receiving and transmitting data, as opposed to the BIU of the 8086, which uses a 16-bit data bus. An example of the bus-handling optimization of the BIU is that the speed requirements placed on the rest of the system (ie: memory and I/O devices) are very easy to deal with. An 8088 running at 5 MHz can use relatively slow memories (ie: 450 ns access time) with no wait states. Save those old, slow memory boards.

The connection between the BIU (which fetches and stores data) and the EU (which processes the data) is the *queue* or *pipeline*. The BIU keeps the pipeline filled with instructions fetched from memory, while the EU draws instructions from the queue as it needs them.

In less sophisticated computers, the rest of the system (especially memory) might sit idle, waiting for the processor to finish a long instruction. To eliminate this waste of

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system resources, the BIU of the 8088 will fetch more information and put it in the queue for later use by the EU. Similarly, when the BIU tries to read some extra-slow memory and encounters a wait state, the EU can continue reading instructions from the queue and executing them. All the EU ever "sees" is the queue, regardless of differences in the BIU that feeds it.

This powerful internal architecture, combined with the simple 8-bit I/O, makes the 8088 a natural for the S-100 and other 8-bit buses.

Design and Interfacing

My S-100/8088 board is designed as a simple, yet powerful, base computer with the support logic necessary to interface to the S-100 bus. I will explain the design accordingly by first discussing the design of the minimal system, and then the techniques for interfacing to the S-100 bus.

Several years ago it would not have been uncommon to overhear: "My computer's got a microprocessor, 2 K bytes of EPROM, 1 K bytes of programmable memory, and a couple of I/O ports." Today, the same machine can be created using four integrated circuits. In fact, such a system is shown in figure 2.

This system uses a 5 MHz 8088 processor, driven by an 8284 clock generator, with an 8185-2 1-K-by-8-bit static memory circuit and an 8755A-2 2-K-by-8-bit EPROM (erasable programmable read-only memory). The 8755A-2 also includes two 8-bit parallel ports.

Notice how simple the basic system is. Each part was designed with compatibility in mind, so the interfacing task is essentially "connect the dots."

The 8088 Microprocessor

In the following section, detailed hardware aspects of these key components will be discussed. My reference is Intel's *8086 Family User's Manual*, which contains a wealth of information on the 8088, 8086, and other high-performance members of

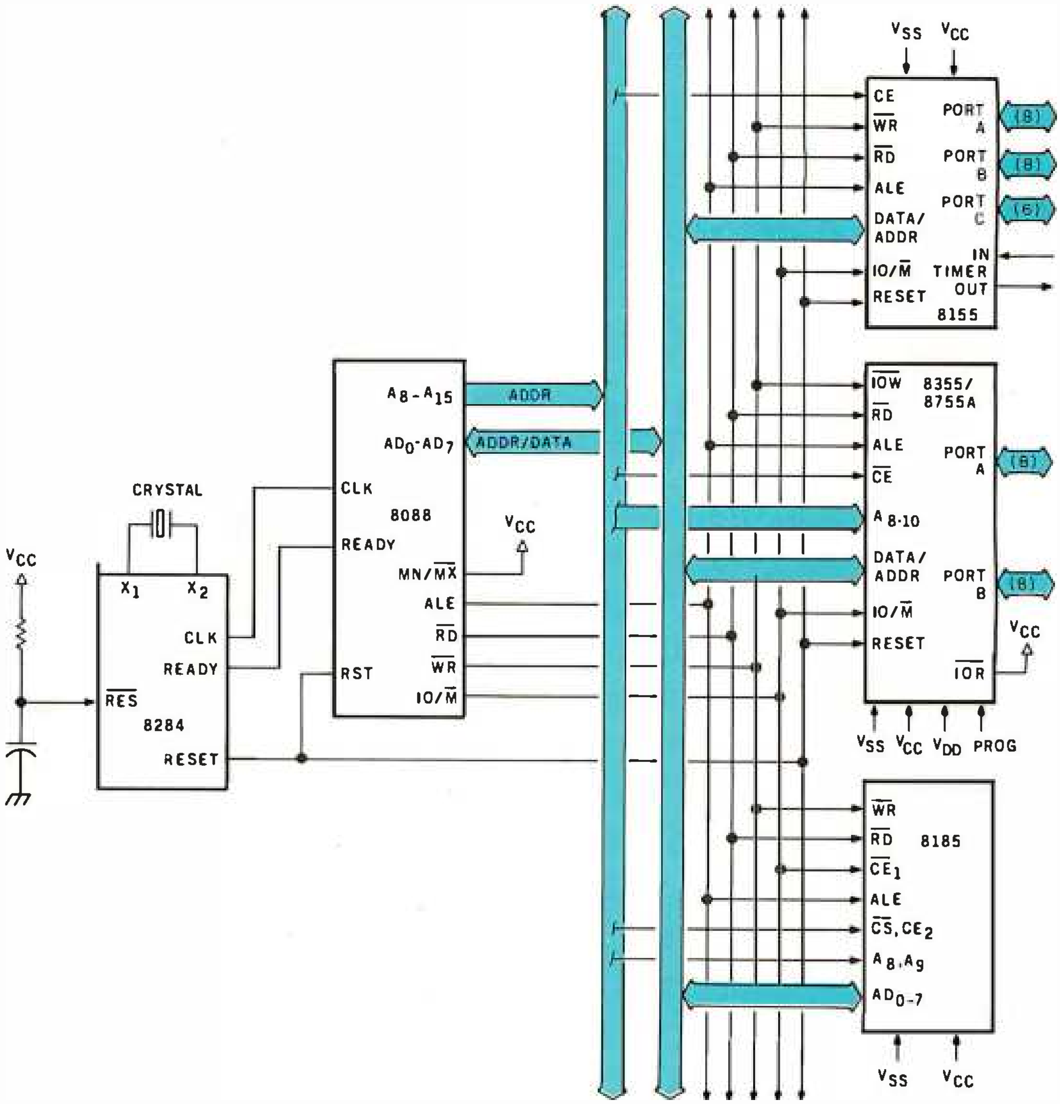

Figure 2: *A minimum system is possible with the 8088 family using only four dual-in-line packages. This system uses a 5 MHz 8088 central processor, driven by an 8284 clock generator. An 8185-2 1-K-by-8-bit programmable memory and an 8755A-2 2-K-by-8-bit EPROM provide system memory and two 8-bit parallel I/O ports. Active-low signals are shown in the figures using the overbar notation, rather than asterisks.*

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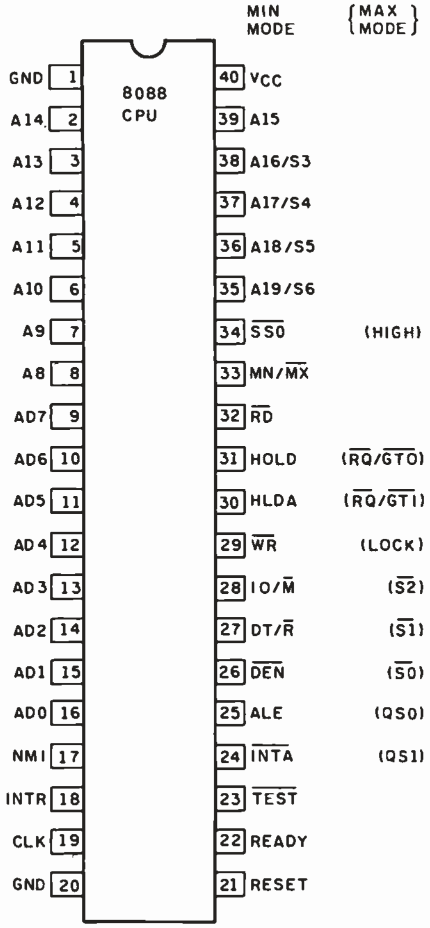

Figure 3: *The pinouts assigned to the 8088 microprocessor package. Notice that many pins serve dual functions depending on the mode selected (either* minimum *or* maximum*). Maximum mode is designed to facilitate concurrent processing, using the I/O processor and arithmetic processor also available in the 8088 family.*

the family. See figure 3 for the 8088 pinouts.

The following paragraphs describe the function of the 8088 pins:

AD0 thru AD7: These form the time-multiplexed address and bidirectional data bus. In other words, they sometimes contain address information (A0 thru A7) and other times contain data (D0 thru D7). The obvious benefit of multiplexing is that eight fewer pins are needed on the package.

ALE (Address Latch Enable): The 8088 asserts ALE whenever the multiplexed address/data bus contains valid address information. ALE serves two fundamental purposes.

- When connected to other multiplexed-bus components (as in figure 2), ALE is a signal to them that the processor has address information on its address/data bus.
- We may want to demultiplex the bus—in other words, the rest of the system may want to see a separate address bus and a separate data bus (the S-100 standard requires two separate buses). ALE can be used to *strobe* address information into a *latch* (hence the "latch enable" part of its name) (see figure 4).

A8 thru A15: These are address lines; they are not multiplexed.

You may note that the multiplexed bus and many of the following hardware-interface facets of the 8088 are the same as those of the popular 8085A. The 8088 is upward compatible with many existing 8085A designs, and the 8088 can easily use all the peripheral components designed to support both the 8080A and the 8085A

A16/S3 thru A19/S6: The upper four address lines (A16 thru A19, also known as S3 thru S6) extend the addressing capability of the 8088 to 1 megabyte. This is a very real perfor-

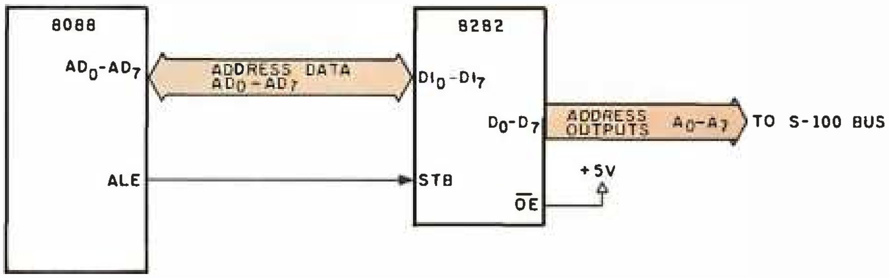

Figure 4: *The ALE signal from the 8088 microprocessor is used to latch address information into an 8282 buffer. The buffer output is demultiplexed address information which has been separated from data that appears on the same pins.*

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mance improvement over most 8-bit processors (usually limited to a 64 K-byte address space). These address lines are multiplexed with status information. During the early part of a bus cycle (T1, the first clock period of the four-clock bus cycle), a valid address is present. Then from clock cycles T2 to T4, each of these pins contains status information as follows:

- S6: This signal is always low.
- S5: This signal reflects the state of the EU's interrupt-enable flip-flop. If this signal is high, it indicates that the processor can accept interrupts. If it is low, interrupts are currently disabled.
- S3 and S4: These two pins can encode four possible states. These states reflect the segment register used in forming the address for the current bus cycle. (See table 1.) This information can be used for monitoring program execution or for analyzing program performance. There is also the potential for implementing a memory *bank-switching scheme*, where the two lines are used to choose one of four areas (banks) of memory.

MN/MX*: Reflecting the needs of different users, the 8088 can be operated in two different modes. If MN/MX* is high, the processor is in *minimum* mode; if this input is low, the processor is in *maximum* mode. Depending on the mode (*min* or *max*), certain pins on the processor will serve different purposes. In *min* mode the processor is responsible for generating all bus-control signals. In *max* mode, control signals are generated by an 8288 bus controller.

The control signals put out by the 8088 in *min* mode are then replaced with other signals that facilitate the design of higher-performance (and generally more expensive) systems. These *max* mode signals include a hardware *bus lock*, *queue status* information and the implementation of a memory access *request/grant* protocol used in multiprocessing.

The *max* mode gives a computer the ability to use multiple processors (eg: an 8088 processor with an 8089 concurrent-I/O processor and an 8087 ultra-high-performance numeric-data processor). Note: both *min* and *max* modes allow the 8088 to address the full megabyte of memory.

My S-100/8088 board is implemented in *min* mode, so when a signal that differs for *min* or *max* mode is defined, the *min* mode definition will be used.

RD*: This is the general-purpose read signal that latches data from memory or an I/O device (the device involved depends on the state of IO/M*) into the 8088.

WR*: This is the general-purpose write signal. The 8088 uses WR* to output information to memory or I/O devices.

IO/M*: This line indicates whether the processor is communicating with I/O devices or

S4	S3	Segment
0	0	EXTRA
0	1	STACK
1	0	CODE or none (ie: I/O)
1	1	DATA

Table 1: *Possible interpretations of information on pins S3 and S4 of the 8088. Each of the four states is associated with the segment register that helped form the current address.*

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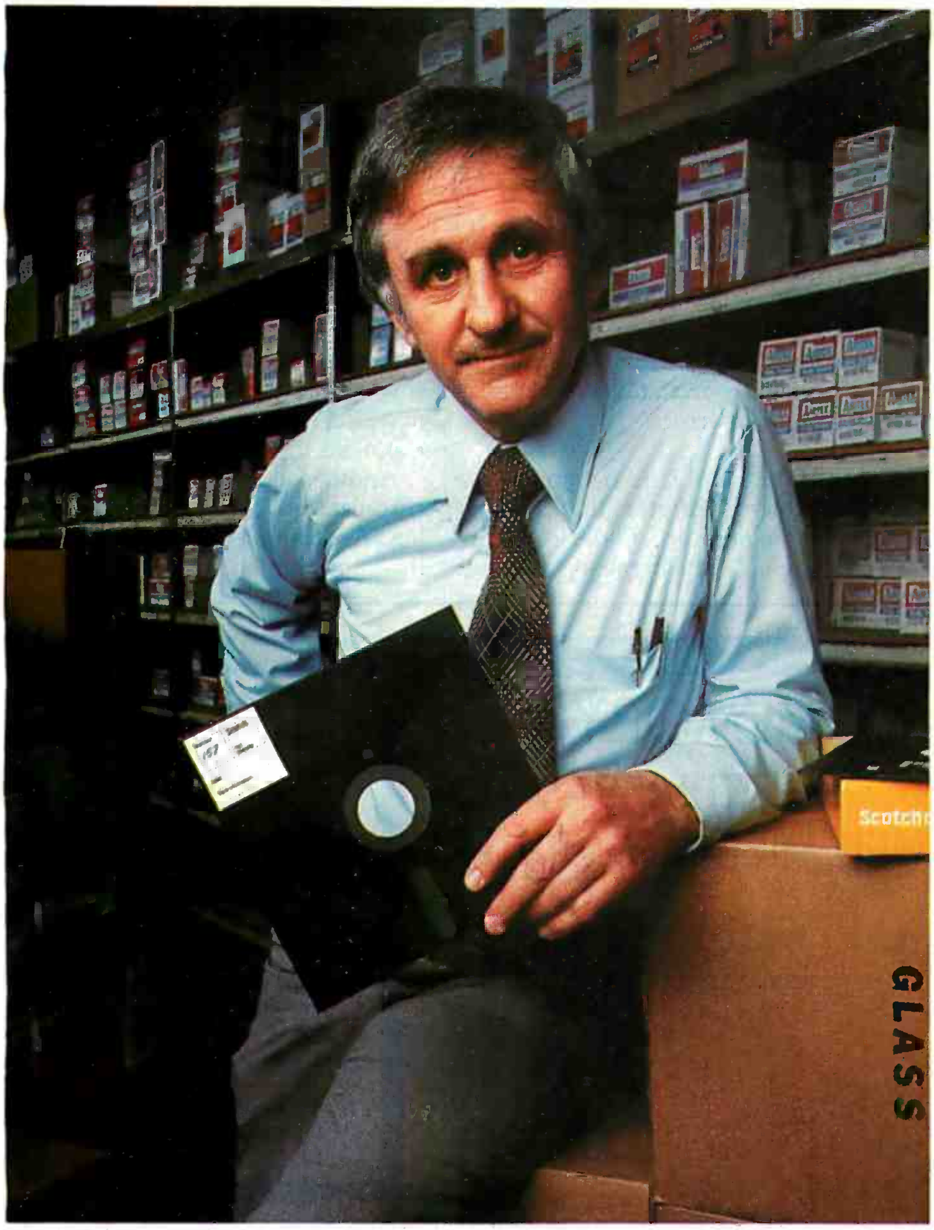

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memory.

DEN* and DT/R*: The data enable (DEN*) and data-transmit/receive (DT/R*) signals are primarily for use with the 8286 and 8287 bus transceivers. These devices serve to buffer the information going to or from the 8088 processor. DT/R* configures the transceiver for either the transmission or reception of data. DEN* is used to enable the 8286 or 8287 at the correct time. Since my system does not use these transceivers, DEN* and DT/R* are not used.

INTR: This interrupt-request line is the general-purpose interrupt input. The ability to receive interrupts can be masked via software using the clear interrupts (CLI) instruction, (similar to the 8080A DI instruction). If interrupts are not disabled, the processor will vector (ie: jump) to an appropriate interrupt-handling routine (see INTA*, below).

INTA*: Upon receipt of an INTR instruction, the 8088 will begin an (INTA*) *interrupt-acknowledge* sequence. The INTA* signal is used to read an interrupt *type vector.* Without going into details, this type vector is used by the 8088 to determine the actual address of the appropriate interrupt routine. Commonly, INTA* and INTR are connected directly to an 8259A programmable priority-interrupt controller, allowing an easy implementation of powerful and flexible interrupt-driven systems.

NMI: The nonmaskable interrupt line NMI is an input similar to the more general INTR except for two fundamental differences:

- Receipt of NMI does not generate an INTA* sequence; rather, a fixed location (stored at hexadecimal address 08) is immediately vectored to.
- NMI interrupts cannot be masked (ie: via the CLI instruction, as for INTR); NMI interrupts are usually reserved for catastrophic events such as imminent power failure or recurrent bus errors.

READY: READY is an input to the 8088 which indicates that an addressed memory or I/O device is currently capable of completing an input or output data transfer. The 8088 will enter and execute *wait states* (idle clock cycles with all control and address lines valid) until READY is brought high. This signal is normally used to allow operation with slow memories or I/O devices. It is also handy for implementing hardware single-step capability via a front panel switch.

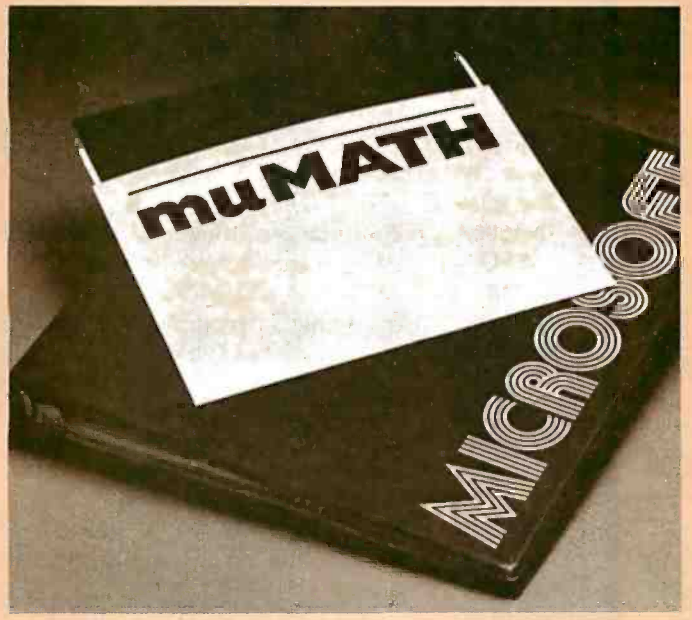
TEST*: This unique input line, in combination with an associated software instruction, yields a powerful hardware/software debugging capability. It works like this: when the 8088 executes a WAIT (wait for TEST*) instruction, it immediately examines the state of the TEST* input line. If TEST* is low, execution simply continues with the next instruction; however, if TEST* is high, the processor waits in an idle state. TEST*, combined with the above mentioned READY-signal-based single-stepping capability, provides a powerful debugging aid that I have exploited in my design.

Another use for TEST* is the synchronization of concurrent processing. An example will serve to explain this more fully.

PROBLEM.

INT(X^N+X*SIN(X^2),X)

SOLUTION.



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However, in some cases, the 8088 must wait for the 8089 to finish its I/O task. For example, the user's program may not be able to continue processing until data is retrieved from a disk. In this case, the 8088 will command the 8089 to perform the read operation and will then execute a WAIT instruction. Meanwhile, the 8089 pulls the 8088's TEST* input high until the I/O operation is complete. When the operation is finished, the 8089 will bring TEST* low and the 8088 can continue executing.

SSO*: This is a status output line which, combined with IO/M* and DT/R*, allows complete decoding of the current 8088 status. (See table 2.)

RESET: A high-logic state on this input causes the 8088 to terminate its present activity and restart execution. The CS (code-segment) register is set to hexadecimal 0FFFF and the IP (instruction pointer) is reset to 0, resulting in an absolute restart address of hexadecimal 0FFFF0. (See figure 5.)

CLK: This is the clock input to the processor and is normally driven by the 8284 clock generator. It is a 5 MHz, 33% duty-cycle signal.

The 8284

The 8284 clock generator is used to generate an optimal clock signal for the 8088 and condition some of the basic processor-control signals. (See figure 6.) Some of its functions are more directed towards *max*-mode multiprocessing bus control and will not be discussed here.

The following paragraphs describe the functions of the 8284 pins.

X1 and X2: These pins are attached to the crystal that generates the fundamental clock frequency. Note that the crystal frequency is three times the desired operating frequency (ie: 15 MHz for a 5 MHz 8088). It is also recommended that a 3 pF to 10 pF capacitor be connected in series with X2.

CLK: This is the optimized clock output that is directly connected to the 8088 CLK input.

PCLK and OSC: The peripheral clock line (PCLK) is a TTL (transistor-transistor logic)-level, 50% duty-cycle clock output of the 8284 with a frequency of half that of the CLK output. The OSC line is similar but operates at the crystal frequency (eg: a 15 MHz crystal gives a 15 MHz OSC signal, which drives a 5 MHz 8088 CLK signal and a 2.5 MHz PCLK signal).

F/C*: The frequency/crystal select line allows generation of a clock signal using either a crystal or an external frequency input (see EFI below). Since I use a crystal, F/C* is tied low in my system.

EFI (External Frequency In): If F/C* is high, the 8284 will use the EFI input line to generate the CLK and PCLK signals. Once again, the CLK output will be one-third the frequency present on EFI (OSC and PCLK act the same too).

AEN1*, AEN2*, RDY1, and RDY2: These signals are primarily used in multiprocessor systems; however, I do use RDY2 to condition the system READY signal for use by the 8088. AEN1*, AEN2* and RDY1 are not used in my system.

READY: As mentioned previously, this 8284 output line is a conditioned and synchronized reflection of the in-

IO/M*	DT/R*	SSO*	Status
1	0	0	Interrupt Acknowledge
1	0	1	Read I/O port
1	1	0	Write I/O port
1	1	1	Halt
0	0	0	Code Access
0	0	1	Read Memory
0	1	0	Write Memory
0	1	1	Passive (idle)

Table 2: *The status of the 8088 processor is completely encoded by the three signals above.*

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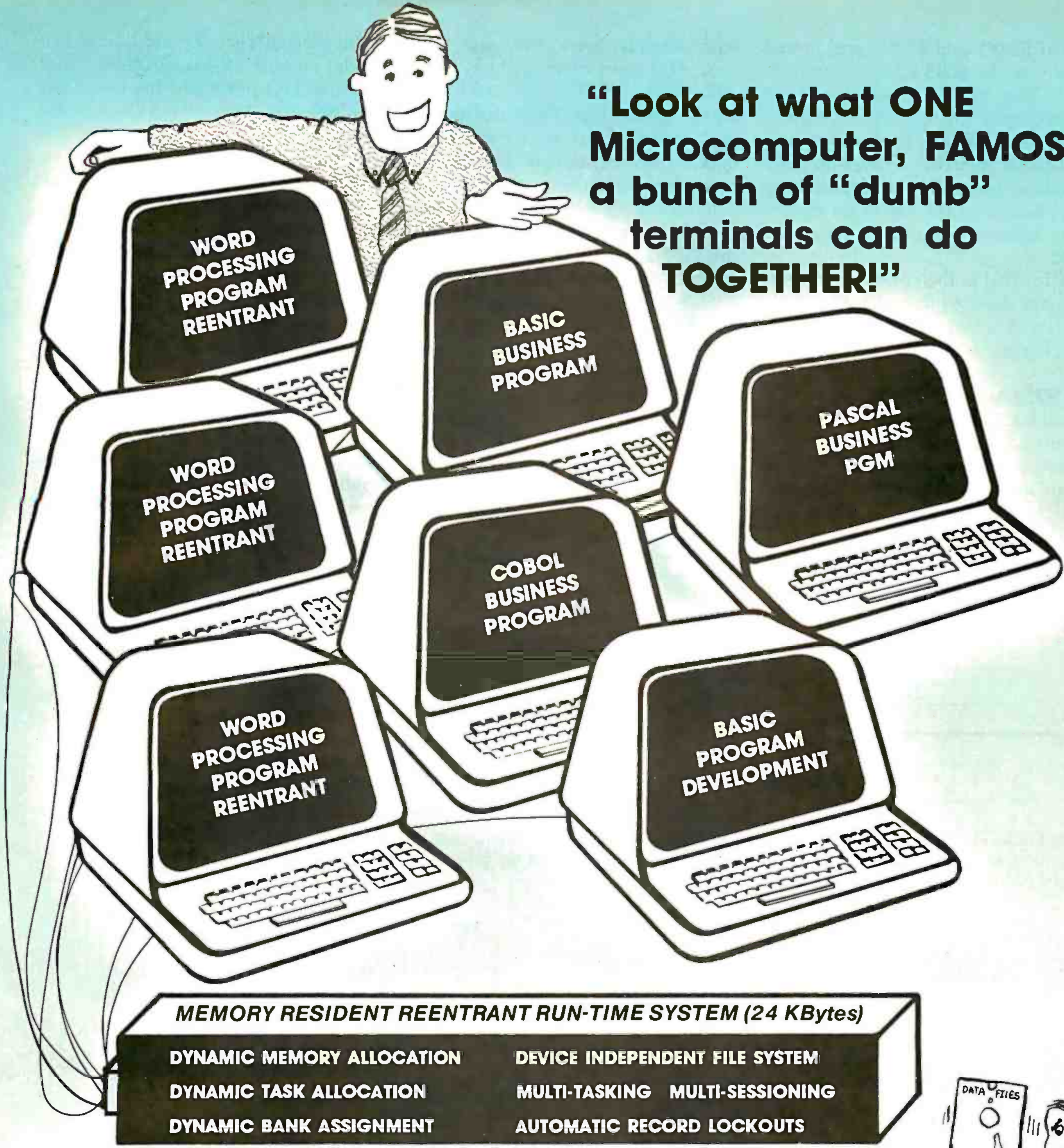

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puts at RDY1 and RDY2 and is tied directly to the 8088 READY input.
RES*: The reset-in signal (RES*) is an 8284 input line that is connected to the system RESET line (through a front-panel switch). *Power-on-reset* as well as proper input conditioning are obtained by the use of an appropriate resistor/capacitor timing network.
RESET: This is the conditioned reset output of the 8284 (based on the RES* input) and is tied directly to the 8088 RESET input line.

The 8755A-2 and the 8185-2

Looking at the 8755A-2 and 8185-2 pinouts (see figures 7a and 7c), we immediately notice that a lot of the signals are common to the 8088 and have already been discussed. AD0 thru AD7 (and other address lines), ALE, IO/M*, RD*, WR* and RESET are all used. This illustrates what I said earlier about the "connect the dots" ease of design using these multiplexed-bus components. Simply connect the 8088 pins AD0 thru AD7 to 8755A-2 pins AD0 thru AD7 and the 8185-2 pins AD0 thru AD7. Then connect the 8088 ALE pin to the 8755A-2 ALE pin and the 8185-2 ALE pin, etc.

The 8755A-2 is a 2-K-by-8-bit EPROM (erasable programmable read-only memory) much like the familiar 2716. The "−2" suffix means that it can run reliably at 5 MHz, compared to the 3 MHz rating of the standard 8755A. Two useful enhancements are the addition of two independent 8-bit bidirectional parallel I/O ports and the use of the multiplexed bus; these make the system-design task much easier. The 8755A-2 is programmed in much the same way as the 2708 and the 2716, but differences do exist. Also, most EPROM programmers do not have 40-pin sockets. I hope some enterprising experimenter will develop an 8755-2 "byteburner" for the S-100 bus. This might be as simple as a "pin-scrambler" adapter (with a little extra circuitry) for existing EPROM programmers.

The 8185-2 is a 1-K-by-8-bit static memory circuit that is quite easily interfaced to the multiplexed bus. The byte-wide organization, low power and small physical size (only eighteen pins) make this a natural for minimal systems.

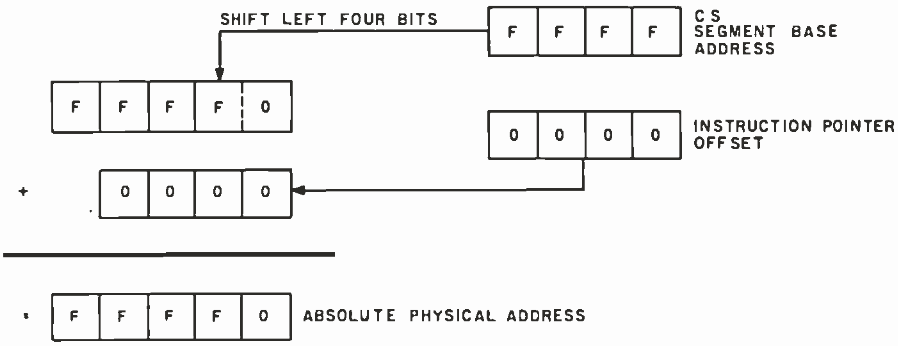

Figure 5: *Calculation of the reset address on the 8088. The 8088 reset address is derived from the code-segment register, which is set to hexadecimal 0FFFF, and the value in the instruction pointer, which is reset to 0.*

A Base on Which to Build

The front panel on my IMSAI computer has many functions that are irretrievably tied to the 8080A instruction set. As an example, when I enter an address on the front panel address switches and push the Examine switch, the front panel "jams" an 8080 JMP (jump, hexadecimal C3) instruction onto the processor's data bus; allows the processor to execute the jump while jamming the address I entered on the switches onto the data

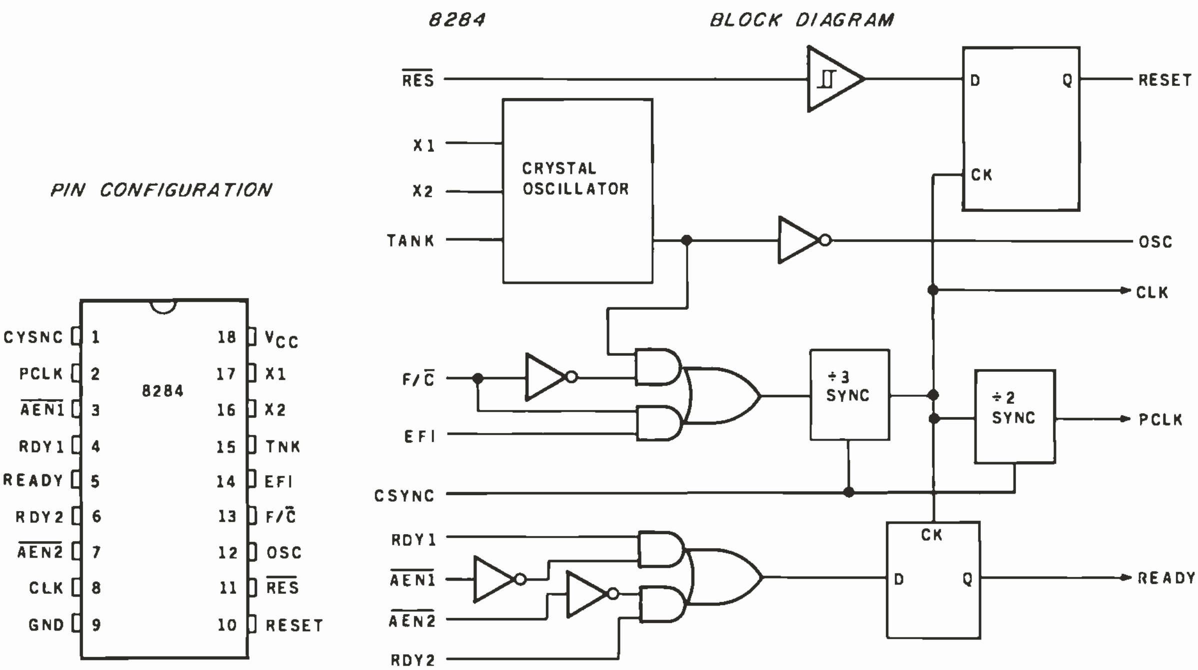

Figure 6: *The 8284 clock generator. This device provides an optimum clock signal and serves to buffer and condition some of the basic processor signals. Figure 6a shows the pin labeling for the device, while figure 6b shows a block diagram of its internal structure.*

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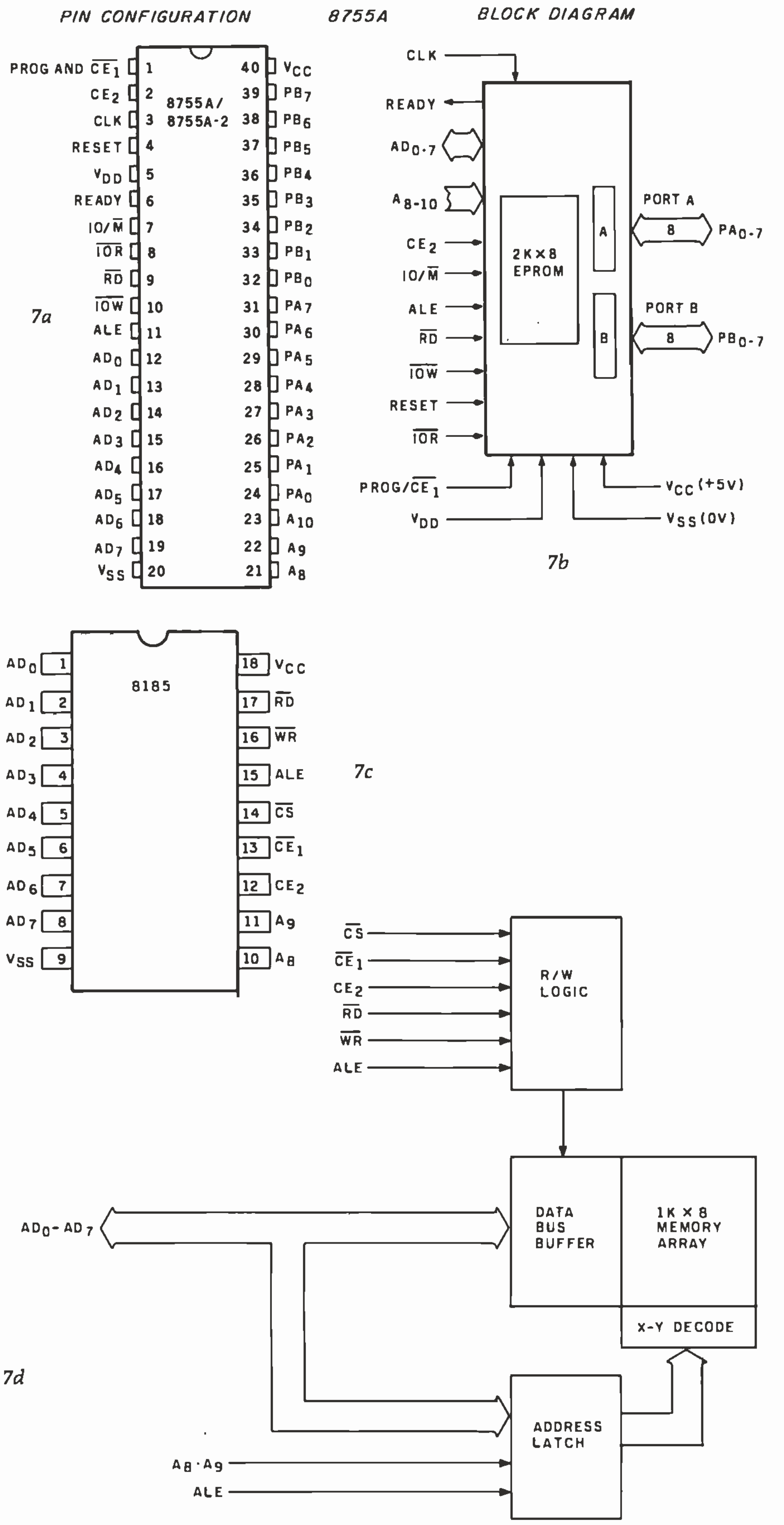

Figure 7: *Pinouts and block diagrams of the 8755A-2 EPROM (figures 7a and 7b) and the 8185-2 user programmable memory (figures 7c and 7d). These circuits were designed specifically to work with the 8088 multiplexed bus lines; they provide two 8-bit parallel I/O ports without any additional hardware.*

bus; and finally stops the processor once the jump is completed.

Similarly, for Examine-Next and Deposit-Next functions, the front panel jams and executes a NOP (no-operation, hexadecimal 00) instruction to move on to the next location.

The JMP and NOP instructions for these switch functions are hard-wired into the front-panel circuitry; circuit traces must be cut to change them. Since the operation codes for the 8088 are completely different, every attempt at front-panel operation would produce bizarre results. Other difficulties include the two's-complement representation of 8088 JMP addresses and the IMSAI's use of S-100 control signals that have been outlawed by the IEEE standard.

Because of these difficulties, I decided to base my 8088 project on a different S-100 system. Fortunately, I was able to scrounge a vintage BYT-8 S-100 box at the local electronic flea market for a good price. The box did not contain any circuit boards, but the metal panel on the front did have cutouts for various LEDs (light-emitting diodes) and switches, which I used to implement a minimal front panel (see photo 1). While I agree with the principle of turnkey systems, which have only power and reset switches, a front panel is a useful tool for debugging any new hardware design. The front panel is a "window" into the machine, one that is needed in case the system does not work perfectly the first time.

Next Month

Next month's installment will cover some of the more interesting aspects of interfacing to the S-100 bus, including the amount of TTL "glue" necessary to emulate the control and status signals of the S-100 standard and the construction of the actual processor board. ■

References

Both the 8086 and 8088 microprocessors have been discussed by Steve Ciarcia in "Ciarcia's Circuit Cellar" articles in BYTE, as follows:

1. "The Intel 8086", November 1979 BYTE, page 14.
2. "Ease Into 16-Bit Computing: Get 16-Bit Performance from an 8-Bit Computer", March 1980 BYTE, page 17.
3. "Ease Into 16-Bit Computing, Part 2: Examining a Small Multi-User System", April 1980 BYTE, page 40.

Programming Quickies

Time Your Tape

John O'Flaherty, St Louis Veterans Administration Medical Center, St Louis MO 63125

Recently I was involved in a research program that required long-term recording (eight hours) of physiological data on an analog instrumentation recorder. We needed a quick method of searching the tape for information occurring at certain times. Although a time marker was recorded on one channel, it could not be played back during fast-forward operation. Unfortunately, although the take-up-reel turns counter indexed unique locations on the tape, the readings obtained did not correlate simply with time. Obviously, one turn on a fully wound reel contains at least twice as much tape as one turn on a bare hub.

I developed a computer solution to the problem. Given the diameter of the take-up-reel hub, the length of the tape, and the turns-counter reading at the end of the tape, the program of listing 1 prints a table relating turns-counter reading, elapsed time, remaining time, footage used, and footage remaining.

The method used is simple (now!): the single datum needed is an accurate value for tape thickness *as wound*, and it is found by considering the side of the tape first as a very long, very thin rectangle, and then as a circle. The area of the side of the tape (ie: what is seen as you face the reel on its axis) can be approximated by a linear function of tape thickness:

$$\text{Area} = \text{Tape Thickness} \times \text{Tape Length}$$

or by a nonlinear function of tape thickness:

$$\text{Radius} = \text{Tape Thickness} \times \text{Turns Count} + \text{Hub Radius}$$
$$\text{Area} = \pi \times (\text{Radius})^2 - \text{Hub Area}$$

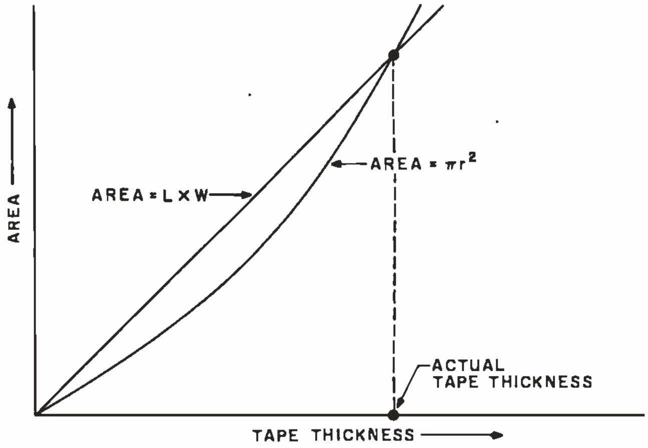

Figure 1: *Area occupied by the side of a given length of tape as tape thickness is changed. The X-axis value at the nonzero intersection of area calculated by two different methods must be the actual tape thickness.*


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Lines 30 thru 80 of listing 1 find the intersection of these two functions by iteration for a fully wound reel of tape. (See figure 1.) Then lines 95 thru 230 generate a table by finding area through radius, and length and time from area for turns-counter increments of ten.

It has not been possible to test the routine on the instrumentation recorder yet, but I have applied the method to my own cassette recorder with very good results. For a C-60 cassette, which actually runs 32 minutes, 23 seconds per side, the tape length was precalculated to be (1943 s × 1⅞ ips/12) = 303.6 feet. By carefully disassembling the cassette, the hub diameter was found to be 0.8525 inches (five cassettes from different manufacturers were found to be identical in this respect). The ratio of indicated to actual turns of the takeup reel was found by turning the reel one hundred turns by hand (an index mark helps), and noting the turns-counter reading.

Then the program was run and table 1 (see page 74) was printed, and its accuracy was tested by actually running the tape and noting the times for turns-counter increments of ten.

The test results are printed as the last two columns in the table. As can be seen, the worst case error is 5 seconds, or 0.3% of the total time, which is surprisingly good, in view of tape counters' reputed inaccuracy, and the fact that no empirical trimming was done—the algorithms simply try to represent the physical realities of the situation.

One might also use the formulas above to program a portable calculator to find time for turns count or vice versa, without consulting a table.

Listing 1: *An Applesoft BASIC program for correlating turns-counter readings with time. All documentation statement line numbers end in 5, and they may be ignored when keying in the program.*

```
5   REM SET CONSTANTS & MENTION VA
      RIABLES FOR EFFICIENCY
10 PI = 3.141592654:TW = 2:W = 1:
      TV = 12:DO = .000001:HS = 0:
      TT = 0:ITC = 0:HH = 3600:MM =
      60:HF = 0.5:TC = 0
20  HOME : GOTO 1000
25  REM  FIND ACTUAL TAPE THICKNE
      SS
30  PRINT "CALCULATING TAPE THICK
      NESS AS WOUND..."
35  REM AREA BY PI(R^2) MUST EQUA
      L
40 A1 = PI ◆ ((MTC ◆ TT + HS) ^ T
      W - HS ^ TW)
45  REM AREA BY L◆W
50 A2 = ML ◆ TT ◆ TV
60 CR = A1 / A2:TT = TT / CR
65  REM  SO TRY NEW TT TILL IT DO

70  IF  ABS (W - CR) > DO THEN 40

80  PRINT : RETURN
95  REM  GENERATE TABLE
100  FOR ITC = 0 TO MIT STEP 10
```

Listing 1 continued on page 70

Listing 1 continued:

```
110 TC = ITC * IR
120 R = TC * TT + HS
130 A = PI * (R ^ TW - HS ^ TW)
140 L = A / TT
150 T1 = L / SPD
160 T2 = MXT - T1
170 F1 =  INT (L / TV + HF)
180 F2 =  INT (ML - F1 + HF)
190  PRINT ITC; TAB( 8);:TM = T1:
     GOSUB 300
200  PRINT  TAB( 18);:TM = T2: GOSUB
     300
210  PRINT  TAB( 29)F1 TAB( 35)F2

220  IF CL = W THEN 260
230  NEXT
235  REM  220,240,250 TO CLOSE TA
     BLE NEATLY
240  IF  INT (MIT / 10) = MIT / 1
     0 THEN 260
250 CLOSE = 1:ITC = MIT: GOTO 110

260  END
295  REM  CONVERT SEC TO HR,MIN,S
     EC    AND PRINT
300 TM =  INT (TM + HF)
310 H =  INT (TM / HH):TM = TM -
     (H * HH)
320 M =  INT (TM / MM):S = TM - (
     M * MM)
325  REM  PRETTYPRINTING
330 Q = H: GOSUB 380: PRINT ":";
340 Q = M: GOSUB 380: PRINT ":";
350 Q = S: GOSUB 380
360  RETURN
380  IF Q < 10 THEN  PRINT "0";
390  PRINT Q;: RETURN
995  REM  INPUT NECESSARY INFORMA
     TION
1000  INPUT "HUB DIAMETER(INCH)?
     ";HS:HS = HS / 2
1010  INPUT "TAPE LENGTH LESS LEA
DER(FEET)? ";ML
1020  INPUT "TURNS COUNT AT END O
     F TAPE? ";MIT
1030  PRINT "TURNS COUNT READING
     FOR"
1035  REM  MTC WILL BE ACTUAL
TURNS COUNT
1040  INPUT "100 ACTUAL TAKE-UP T
URNS? ";IR:IR = 100 / IR:MTC
      = MIT * IR
1050  PRINT "1...15/16   IPS"
1060  PRINT "2...1-7/8   IPS"
1070  PRINT "3...3-3/4   IPS"
1080  PRINT "4...7-1/2   IPS"
1090  PRINT "5...15      IPS"
1100  PRINT "6...30      IPS"
1110  INPUT "WHICH TAPE SPEED? ";
SPD
1115  REM  KLUGE TO FIND SPEED
      FROM TABLE ENTRY
1120 SPD = .9375 * 2 ^ (SPD - 1)
1125  REM  FIND MAX. TIME
1130 MXT = (ML * 12) / SPD
1135  REM  SET START VAL FOR   TT
      AND FIND ACTUAL VALUE
1140 TT = .001: GOSUB 30
1145  REM  PRINT COLUMN HEADS
1150  PRINT "TURNS" TAB( 8)"ELAPS
ED" TAB( 18)"REMAINING" TAB(
29)"FEET" TAB( 35)"FEET"
1160  PRINT "COUNT" TAB( 8)"TIME"
      TAB( 18)"TIME" TAB( 29)"USE
D" TAB( 35)"LEFT"
1170  PRINT
1175  REM  GENERATE TABLE
1180  GOSUB 100
2005  REM TT=TAPE THICKNESS
2015  REM HS=HUB SIZE
2025  REM ML=TOTAL TAPE LENGTH
2035  REM MIT=MAX INDIC. TURNS
2045  REM MTC=MAX ACTUAL TURNS
2055  REM ITC=IND. CURRENT T.C.
2065  REM TC=ACT. CURRENT T.C.
2075  REM IR=ACT./IND. RATIO
2085  REM R,A,L.RAD,AREA,LENGTH
2095  REM MXT=TOTAL TIME
3005  REM TM,Q..TEMP VAR FOR TIME
      CONV
3015  REM T1,T2.TIME USED,LEFT
3025  REM F1,F2.FEET USED,LEFT
9999  END
```


Circle 46 on inquiry card. →

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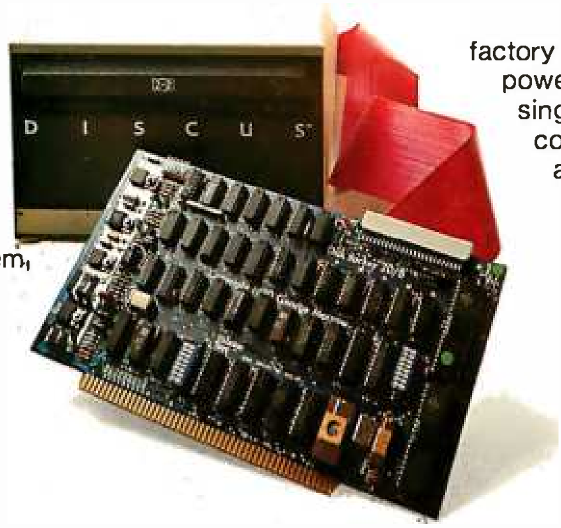

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Table 1: *A tape counter/time table (produced by the program in listing 1) for a cassette recorder using C-60 tape. The last two columns were not printed by the program, but are a check value from an actual test of the program's accuracy.*

```
]

]RUN
HUB DIAMETER(INCH)? .8525
TAPE LENGTH LESS LEADER(FEET)? 303.6
TURNS COUNT AT END OF TAPE? 641
TURNS COUNT READING FOR
100 ACTUAL TAKE-UP TURNS? 77.3
1 . . . 15/16        IPS
2 . . . 1-7/8        IPS
3 . . . 3-3/4        IPS
4 . . . 7-1/2        IPS
5 . . . 15           IPS
6 . . . 30           IPS
WHICH TAPE SPEED? 2
CALCULATING TAPE THICKNESS AS WOUND . . .
```

TURNS COUNT	ELAPSED TIME	REMAINING TIME	FEET USED	FEET LEFT	TIME BY TEST	ERROR (SEC)
0	00:00:00	00:32:23	0	304	0:00	0
10	00:00:19	00:32:04	3	301	0:19	0
20	00:00:38	00:31:45	6	298	0:39	−1
30	00:00:57	00:31:26	9	295	0:58	−2
40	00:01:17	00:31:06	12	292	1:18	−1
50	00:01:37	00:30:46	15	289	1:38	−1
60	00:01:58	00:30:26	18	286	1:59	−1
70	00:02:18	00:30:05	22	282	2:20	−2
80	00:02:40	00:29:43	25	279	2:42	−2
90	00:03:01	00:29:22	28	276	3:04	−3
100	00:03:23	00:29:00	32	272	3:26	−3
110	00:03:46	00:28:37	35	269	3:48	−2
120	00:04:08	00:28:15	39	265	4:11	−3
130	00:04:31	00:27:52	42	262	4:34	−3
140	00:04:55	00:27:28	46	258	4:58	−3
150	00:05:19	00:27:04	50	254	5:22	−3
160	00:05:43	00:26:40	54	250	5:46	−3
170	00:06:07	00:26:16	57	247	6:11	−4
180	00:06:32	00:25:51	61	243	6:36	−4
190	00:06:58	00:25:25	65	239	7:01	−3
200	00:07:23	00:25:00	69	235	7:27	−4
210	00:07:49	00:24:34	73	231	7:53	−4
220	00:08:16	00:24:07	77	227	8:20	−4
230	00:08:43	00:23:40	82	222	8:47	−4
240	00:09:10	00:23:13	86	218	9:14	−4
250	00:09:37	00:22:46	90	214	9:41	−4
260	00:10:05	00:22:18	95	209	10:09	−4
270	00:10:34	00:21:50	99	205	10:37	−4
280	00:11:02	00:21:21	103	201	11:06	−4
290	00:11:31	00:20:52	108	196	11:35	−4
300	00:12:01	00:20:23	113	191	12:04	−3
310	00:12:30	00:19:53	117	187	12:34	−4
320	00:13:00	00:19:23	122	182	13:05	−5
330	00:13:31	00:18:52	127	177	13:34	−3
340	00:14:02	00:18:21	132	172	14:05	−3
350	00:14:33	00:17:50	136	168	14:37	−4
360	00:15:04	00:17:19	141	163	15:08	−4
370	00:15:36	00:16:47	146	158	15:40	−4
380	00:16:09	00:16:14	151	153	16:12	−3
390	00:16:41	00:15:42	156	148	16:45	−4
400	00:17:15	00:15:09	162	142	17:18	−3
410	00:17:48	00:14:35	167	137	17:51	−3
420	00:18:22	00:14:01	172	132	18:25	−3
430	00:18:56	00:13:27	177	127	18:59	−3
440	00:19:30	00:12:53	183	121	19:33	−3
450	00:20:05	00:12:18	188	116	20:08	−3
460	00:20:41	00:11:42	194	110	20:44	−3
470	00:21:16	00:11:07	199	105	21:19	−3
480	00:21:52	00:10:31	205	99	21:54	−2
490	00:22:29	00:09:54	211	93	22:31	−2
500	00:23:05	00:09:18	216	88	23:07	−2
510	00:23:43	00:08:40	222	82	23:44	−1
520	00:24:20	00:08:03	228	76	24:21	−1
530	00:24:58	00:07:25	234	70	24:59	−1
540	00:25:36	00:06:47	240	64	25:37	−1
550	00:26:15	00:06:08	246	58	26:16	−1
560	00:26:54	00:05:29	252	52	26:54	0
570	00:27:33	00:04:50	258	46	27:33	0
580	00:28:13	00:04:10	265	39	28:13	0
590	00:28:53	00:03:30	271	33	28:53	0
600	00:29:33	00:02:50	277	27	29:33	0
610	00:30:14	00:02:09	283	21	30:13	+1
620	00:30:55	00:01:28	290	14	30:54	+1
630	00:31:37	00:00:46	296	8	31:35	+2
640	00:32:19	00:00:04	303	1	32:17	+2
641	00:32:23	00:00:00	304	0	32:28	0 ■

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Dissecting the TI Speak & Spell

Michael A Rigsby
5164 Sunburst Dr
Norcross GA 30092

There is now an economical way to provide limited voice output for computer-controlled devices. TI (Texas Instruments) provides most of the hardware in its familiar toy called the "Speak & Spell."

Because I am fascinated by toys (my system is a hand-wired 1802 processor used in a self-contained, maze-solving mouse), it was only natural that I should procure my own birthday present—a toy—and immediately tear it apart.

Speak & Spell is an educational aid designed for children aged seven or older. It contains a vocabulary of greater than 230 words in addition to the letters of the alphabet. Asking questions and playing games with electronic speech, it expects answers to be entered on its 40-switch keyboard. Each entry evokes an audible response, and the machine even keeps score. Plug-in modules are available to expand the vocabulary. Suggested retail price for the toy is $65, though I bought mine for less than $40 at a major Atlanta department store.

Operation of the electronic portion of the Speak & Spell involves many unknowns. I am sure that the manufacturer would probably prefer to keep these unknowns secret, but I can provide some insight into the operation of the Speak & Spell.

The first great obstacle encountered when opening the machine is the back cover. Removing the two Phillips-head screws is a good step, but not good enough. There are still four slots, each containing a plastic hook over a plastic ledge. Take a thin-bladed screwdriver and push the hook toward the outside edge of the case, at the same time pull the front and back of the case apart with substantial force. Continue until all four hook slots are free. Take care not to allow any backsliding. I have done this three times, each time expecting to destroy it, but everything is still intact.

After reaching the inside, there is not much to see except the back of a double-sided printed-circuit board. To turn the board over, the matrix switch cards (figure 1) must be released from the front of the case. This involves springing delicate plastic hooks. If one of these hooks should break, the toy is lost. Somehow I slipped the cards out and turned the main board over. (See photo 1 and figure 2 on page 82.) On the opposite side of the main board are a circuit board (with a little black round thing on it) on top of the main circuit board, an 8-character alphanumeric display, and four integrated circuits, each with a distinctive proprietary number. The small circuit board appears to be a power supply.

The toy operates from a 6 V supply (four C cells), but +6 V, −6 V, and −20 V may be found throughout the board. The processor has five input lines from the switches; five lines seem to interconnect most of the circuits. The five input lines from the switches are activated upon contact closure by −20 V pulses generated within the processor.

At this point I will refer to figure 1. Eight bits from any processor may be used to control each of thirty-two lines by means of the 74154 binary-to-hexadecimal decoder. Each output line must go to a PNP transistor capable of switching a −20 V signal. The drawing in figure 1 indicates which wires go with which letters,

Text continued on page 84

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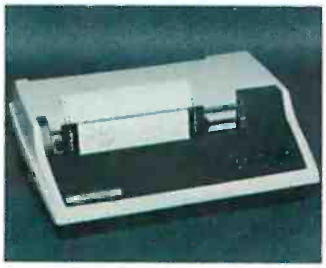

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1a

1b

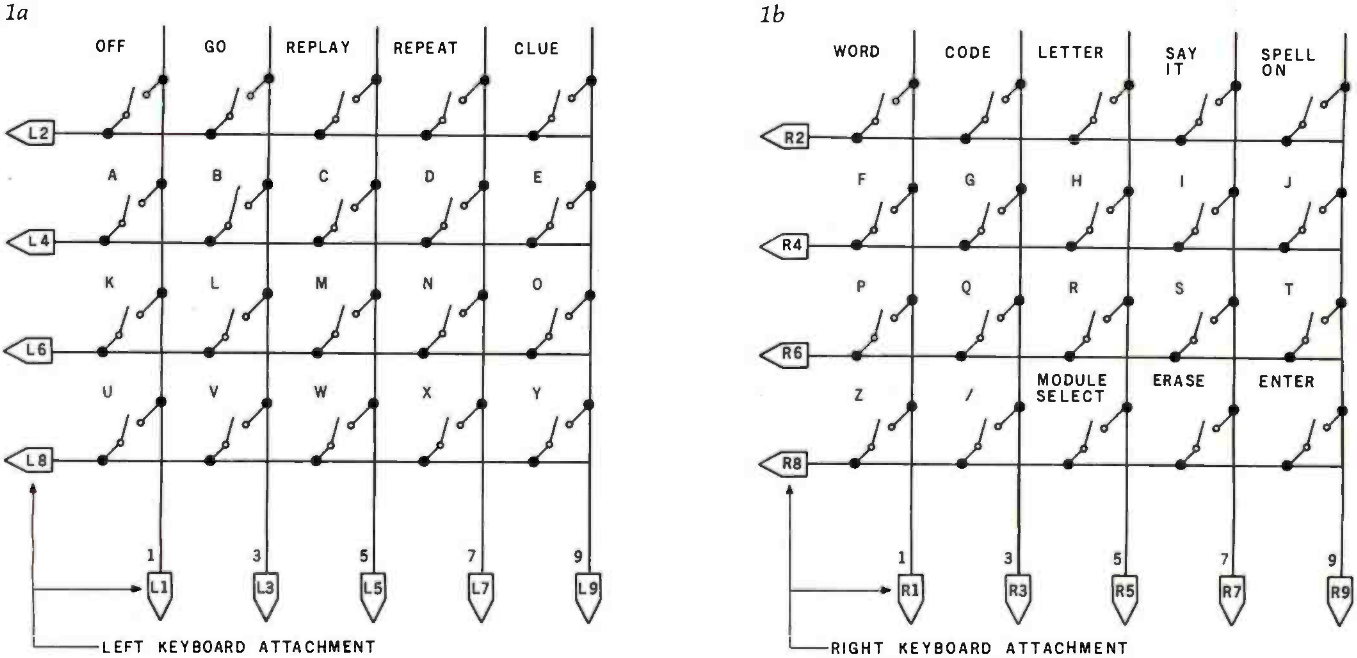

Figure 1a and 1b: *During normal operation, the Speak & Spell will voice a phoneme (letter sound) after a key is pressed on one of the keyboards. The Speak & Spell can be controlled by a microprocessor interfaced to the keyboard lines as shown in figure 1c.*

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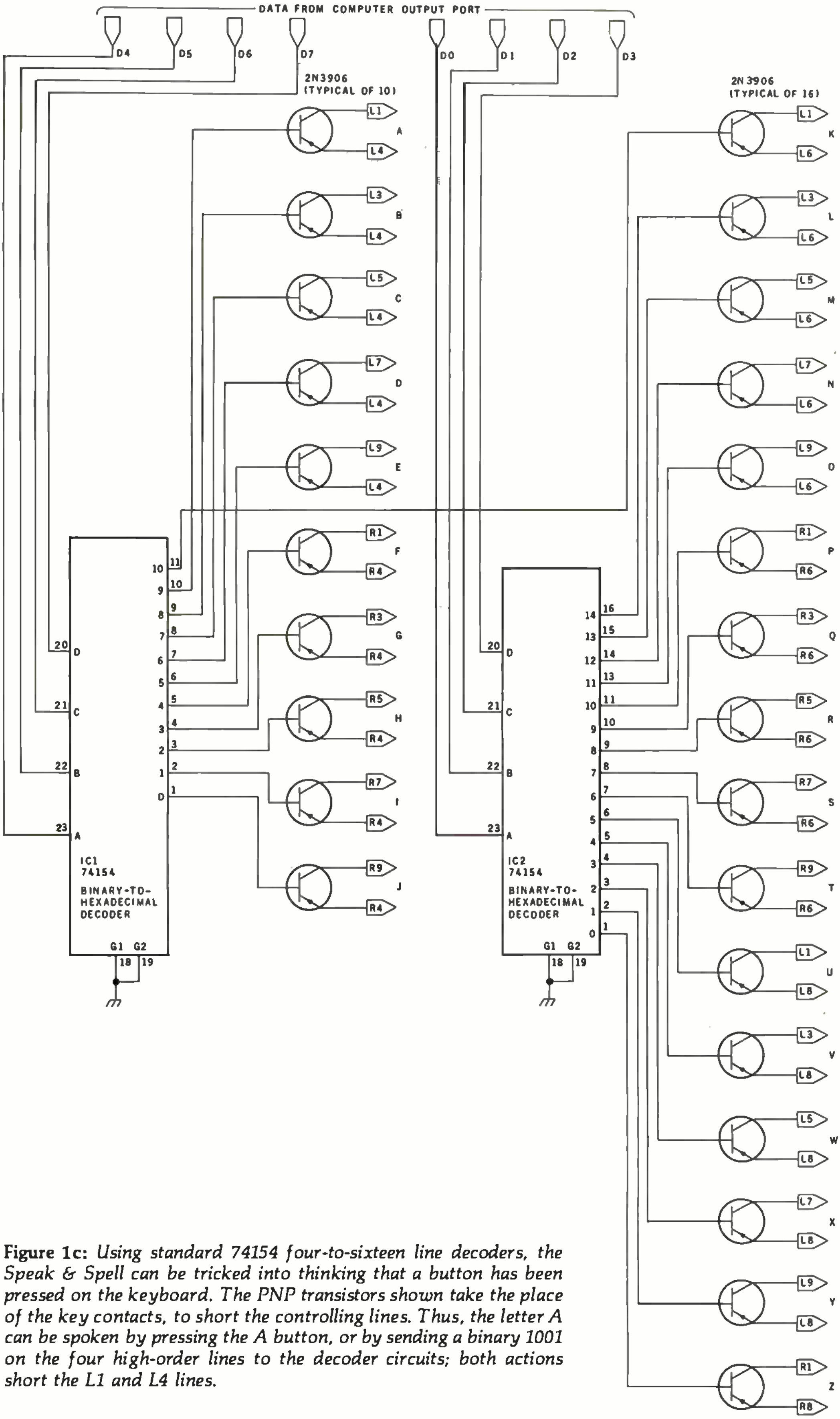

Figure 1c: *Using standard 74154 four-to-sixteen line decoders, the Speak & Spell can be tricked into thinking that a button has been pressed on the keyboard. The PNP transistors shown take the place of the key contacts, to short the controlling lines. Thus, the letter A can be spoken by pressing the A button, or by sending a binary 1001 on the four high-order lines to the decoder circuits; both actions short the L1 and L4 lines.*

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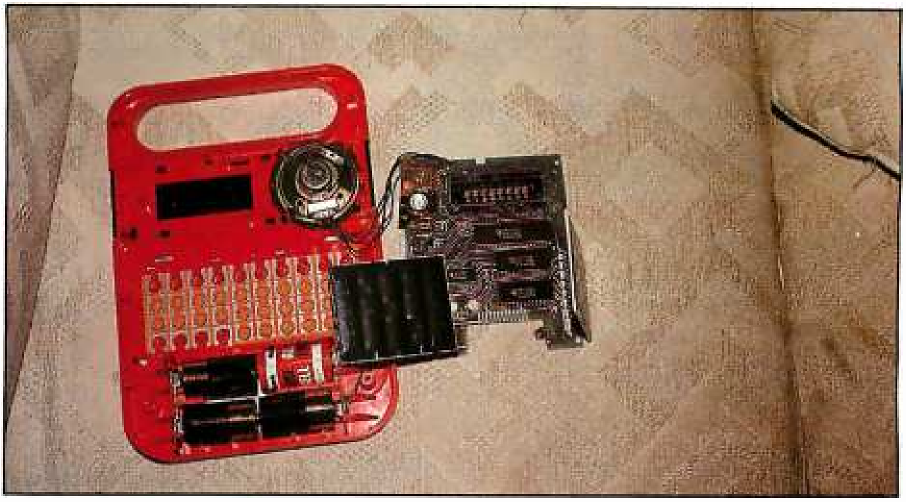

Photo 1: *Detailed photograph of the disassembled Speak & Spell. The main circuit board is shown in the same position as in figure 2; the board in the upper left-hand corner is the power supply. The black box at bottom center is one of the two keyboard assemblies.*

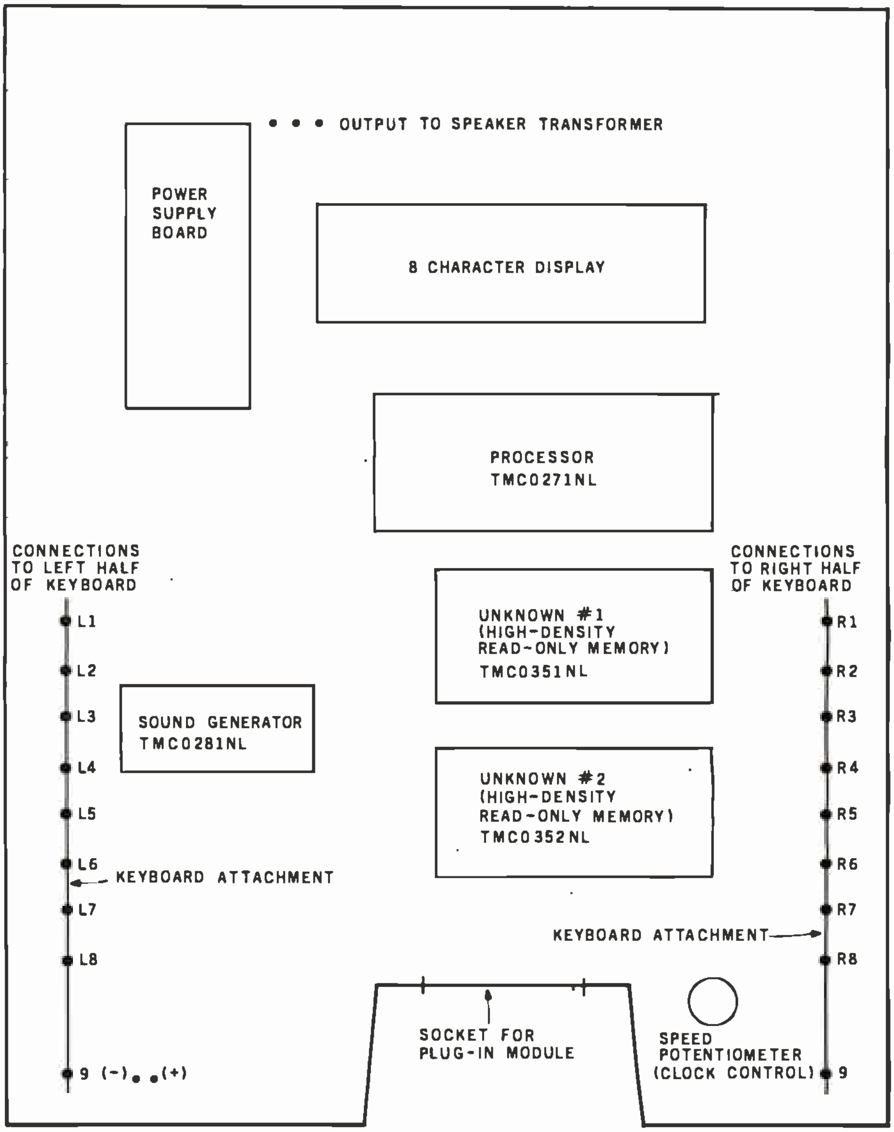

Figure 2: *Layout of the Speak & Spell main circuit board, viewed from the front of the toy.*

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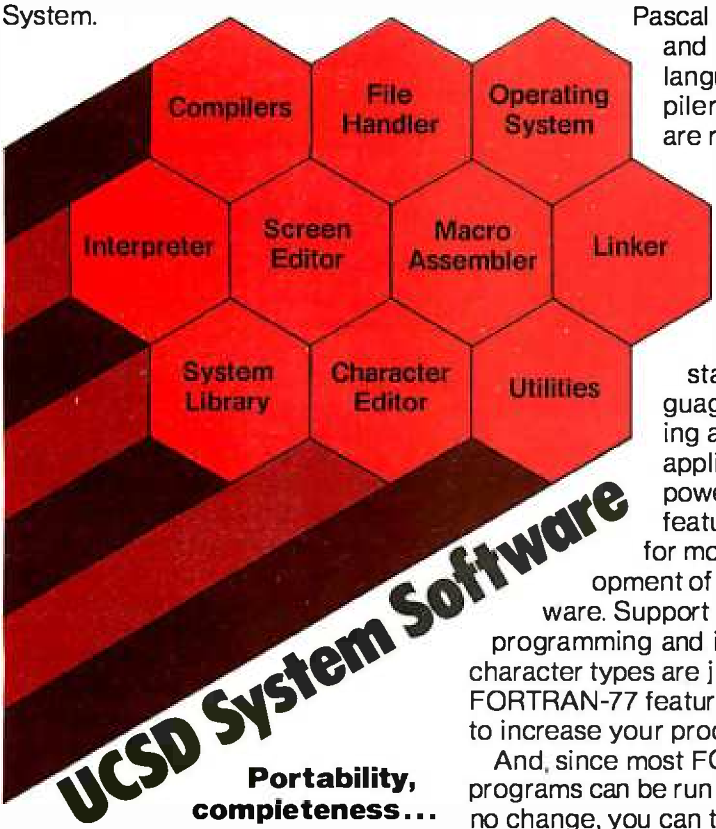

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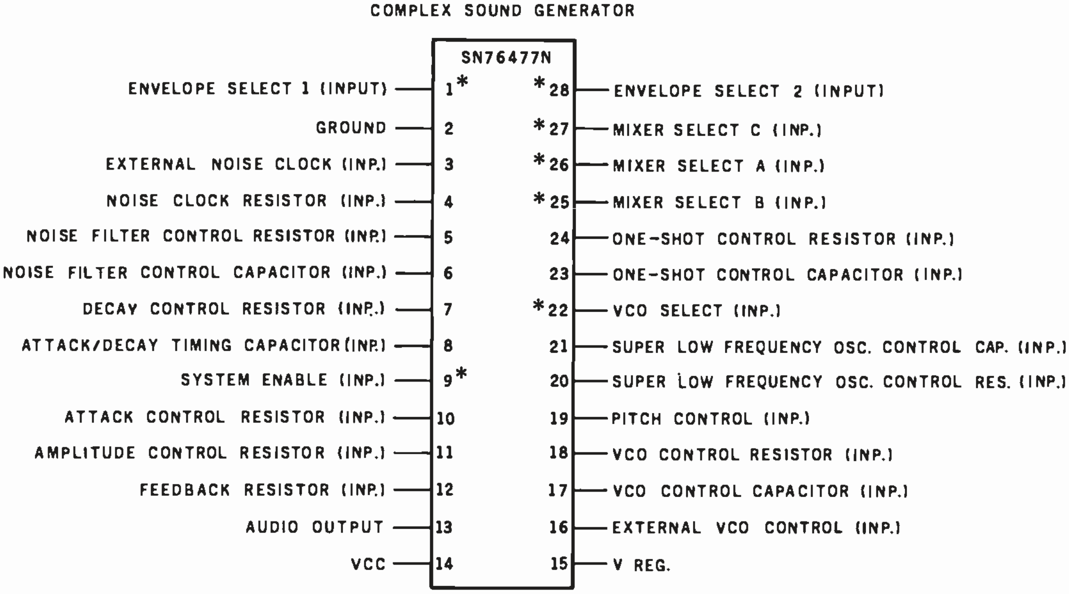


Figure 3: *Pin assignments for the SN76477N complex-sound generator. It is suspected that this well-known device is marked TMC0271NL in the Speak & Spell. The pins marked with asterisks are in a logical low state unless they are pulled up by an external voltage.*

Behavior	Pin # of TMC0271NL	Connected To		
		Pin	Device #	Informal Name
steady pattern when letters are pronounced, variable pattern for all words	22	4	TMC0351NL	Unknown #
	25	11	TMC0271NL	Processor
	27	14	TMC0271NL	Processor
variable pattern for all speech	26	6	TMC0351NL	Unknown #1
	28	36	TMC0271NL	Processor

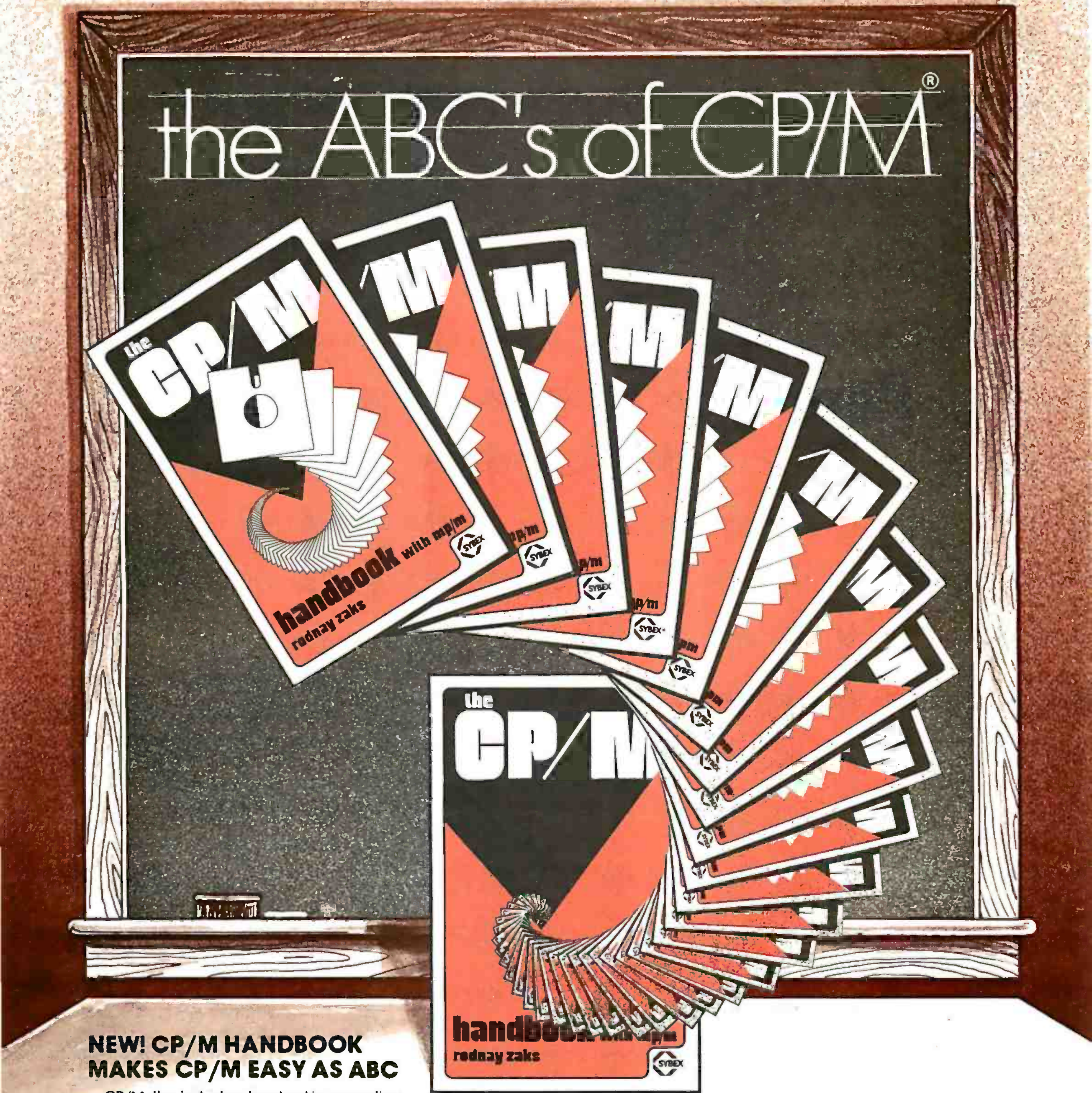
Table 1: *Experimental behavior of selected logic lines coming from the TMC0271NL device on Speak & Spell circuit board.*

Text continued from page 76:
while figure 2 shows the location of these wires in the toy. Each line must be released before the processor will accept another input command.

Returning to the operation of the device, the 40-pin circuit is undoubtedly a processor. There are two integrated circuits which I have labeled as high-density read-only memory (however, this is only a guess). They contain the information for the 230 spoken words; the processor (TMC0271NL) appears to contain the spoken letters and a few brief words. Of the forty pins on the processor, five are input lines from the switches, seven are pulsed output lines to the switches, fifteen or more are output lines to the display, and three are output lines to the sound generator. Three of the lines that go to the display are part of the five lines that connect the processor to unknown circuit #1 (mentioned above as possibly being a high-density read-only memory). If the unknown circuits *are* memory devices, the individual byte locations are not addressed by the processor (there is an insufficient number of interconnecting lines for that purpose), but are possibly left to be sequenced by a clock and stopped by processor control.

I am reasonably certain that the sound is generated by a complex sound generator, SN76477N. This circuit is controlled by numerous resistor-capacitor combinations and seven digital-control lines. (See figure 3 and table 1.) If this device is the chip marked TMC0271NL in the Speak & Spell, then it is two of the seven control lines (pins 1 and 9) that are tied to ground all of the time. Five of the lines have varying signals, though three of these maintain a constant pattern when letters are being pronounced. The narrowest spike in a pulse train that is connected to a control line is 0.1 ms long. With a 230-word vocabulary, there is a controlled speech time of well over 100 seconds. Five lines multiplied by 100 seconds multiplied by 10,000 pulses per second yields 5,000,000 bits of information stored somewhere in the Speak & Spell—providing one assumes that each word is composed of individually stored pulses. There are probably subroutines that cause the production of phonetic elements. I can see no way to access these phonetic elements, because they seem to be internal and not directly addressable by normal address lines. Someone with more memory than I have (1 K bytes of user memory) could monitor the control lines on the sound generator (see figure 3) and perhaps determine the phonetic makeup of individual sounds.

If you don't mind listening to your computer spell everything, give it a voice and let it speak.■



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Penny Pincher's Joystick Interface

Steven Wexler
1634 Buck Hill Dr
Huntingdon Valley PA 19006

One of the more entertaining input devices that can be operated by a human hand is the joystick. Physically, the device consists of a lever that moves in two dimensions. The lever operates two potentiometers, which translate the position of the lever into two analog resistance values. A joystick hardware interface, in conjunction with the appropriate software, can convert the resistance values into corresponding binary integer values. These integers can be used to move a cursor, alter music, or control a robot, along with a myriad of other applications.

There are several ways to interface a joystick to your computer. Each scheme has its advantages and disadvantages. The particular method I have chosen has the advantages of being inexpensive, easy to build, easy to understand, and of requiring a minimum of input/output (I/O) programming.

The disadvantages? This method is slower than some other interfaces I have seen, uses more software than do the expensive hardware-intensive schemes, and is less precise than some of the more elaborate circuit concoctions.

Operating Theory

The key to my "penny pincher's" joystick interface is the 556 dual timer configured as two monostable multivibrators or one-shots, as shown in figure 1. In English, this means that if you trigger the one-shot, its output will go high for a predetermined interval, after which the output will return to its normal low state.

By using a joystick potentiometer as a timing resistor, the duration of one output pulse will be proportional to the position, in one dimension, of the joystick lever. Software is used to convert the pulse duration into a binary value. Duplicating the circuit for the second timer, the other joystick potentiometer will yield a different output-pulse duration and binary value for the other dimension. Remember, joysticks operate in two or more dimensions.

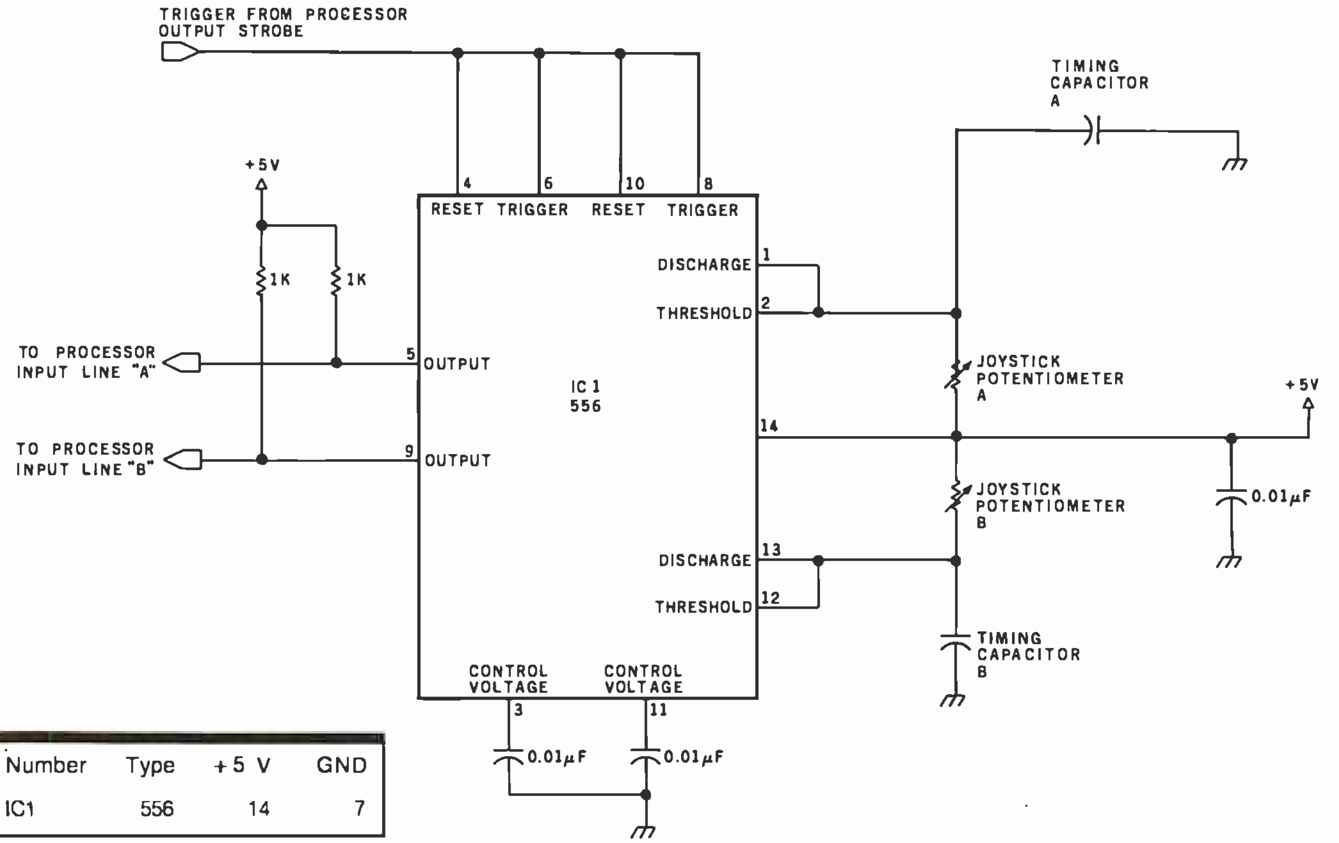
Joystick Interface Circuit

Careful study of figure 1 will reveal a most curious aspect of the interface. The *trigger* and *reset* lines for each circuit are all tied to a common processor output line. This certainly saves output lines, but how can you trigger and reset simultaneously? An explanation of the trigger requirements for the timer circuits should help to clear up this anomaly.

Normally, the timer will start to output a pulse on the high-to-low transition (ie: negative-going edge) of the input trigger signal. For the device to work properly, it is necessary to return the trigger input to its normal high state before the timed-output pulse returns low. In other words, before the device times out, the trigger input must go high.

If the timer receives a trigger signal in the middle of an output pulse, the signal is ignored. The obvious conclusion is that we must either trigger each of the 556 timers independently, or we must reset the second timer before it is triggered. Otherwise, how are we to avoid attempting to trigger the second timer before it has timed out from the initial signal? Tying the resets and triggers to a common computer-output line avoids the timing pitfall, while simplifying both hardware and software.

When the computer-output line goes low, the timing function is reset and the device returns to its initial state. As the processor-output line returns high (ie: positive-going edge), the circuit is reset before it is triggered; this allows the timing pulse to begin normally. The I/O line used to reset and trigger the 556 can also be used to reset and trigger additional joysticks. How's that for efficiency! I have not included the values of the timing capacitors and potentiometers



Number	Type	+5 V	GND
IC1	556	14	7

Figure 1: *The key to the penny pincher's joystick interface is the 556 dual timer, configured as two monostable multivibrators. The interval of each output pulse is determined by the joystick resistance, in conjunction with a user-selected timing capacitor.*

in figure 1; these values depend on software, processor speed, and personal preference.

Software

The software needed for the penny pincher's interface is very straightforward. The 556 timers are triggered by setting the proper computer-output line first low, then high. After this, the processor should enter a tight, time-efficient counting loop until one circuit times out. The software should immediately store the count and then start the process over for the next timer. It is recommended that you disable interrupts during the counting process; otherwise an inaccurate count may occur.

Listing 1 presents the joystick-driving software for my KIM-1 computer (6502 processor). The program assumes that the reset/trigger line is tied to the KIM-1 I/O line B1. The timer's outputs are tied to B2 and B3; a second joystick may be tied to lines B4 and B5.

Utilizing consecutive I/O lines in this manner allows for efficient I/O line polling by merely shifting an I/O mask. Figure 2 is a flowchart of the

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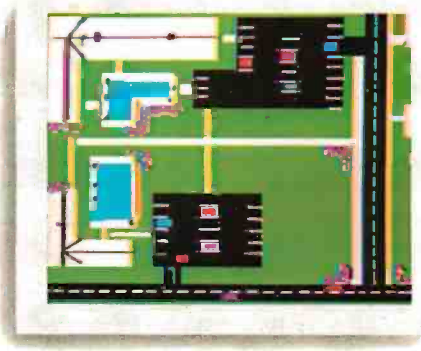

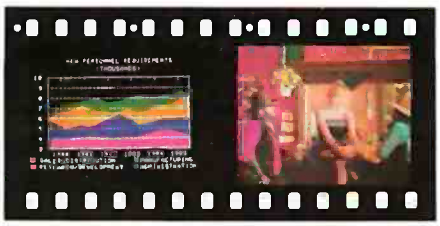

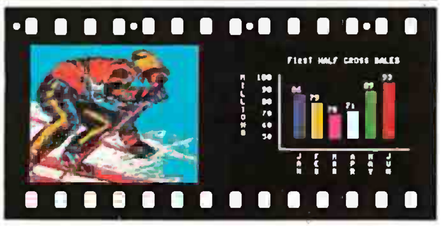

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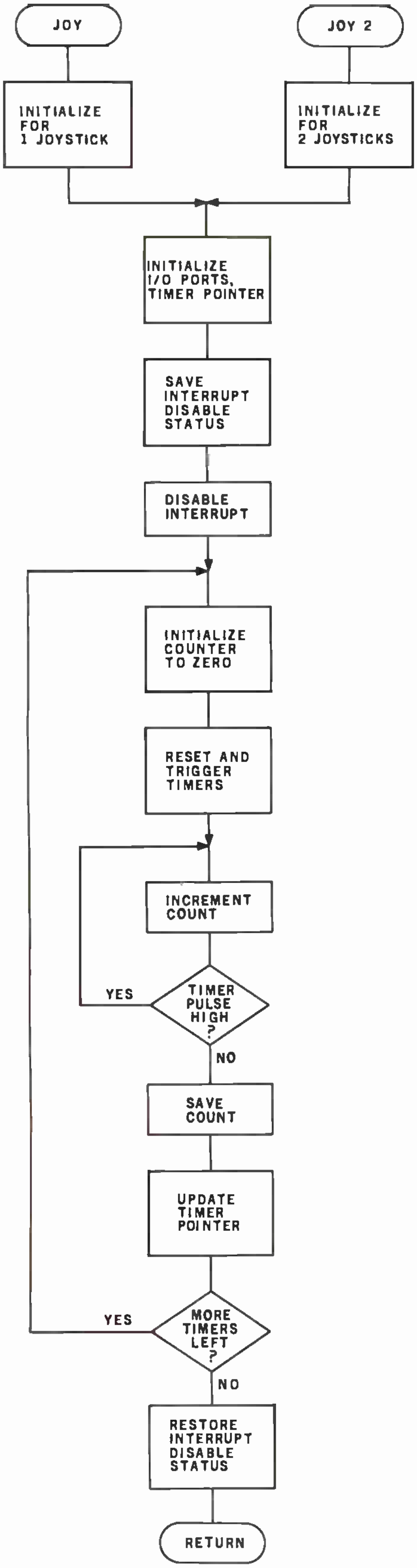

Figure 2: *The joystick-driving software consists mainly of a counting loop; this determines the stick position by timing the output pulse interval. High resolution can be attained by using a fast counting loop.*

Listing 1: *The software used on the author's KIM-1 system resets the interface timers with a low logic state on I/O line B1. When the same line goes high, the timers are retriggered. This technique, using only one output line, contributes to the simplicity of the hardware.*

```
                    POT     =$17E3      POT 1, Y AXIS
                    POT+1   =$17E4      POT 1, X AXIS
                    POT+2   =$17E5      POT 2, Y AXIS
                    POT+3   =$17E6      POT 2, X AXIS
                    PBD2    =$1702      PORT B DATA REGISTER
                    PBDD2   =$1703      PORT B DIRECTION REGISTER

8510  A2 01         JOY    LDX #1       ENTRY FOR ONE JOYSTICK.
8512  D0 01                BNE HOP      FORCED JUMP.
8514  A2 03         JOY2   LDX #3       ENTRY FOR TWO JOYSTICKS.
8516  A9 02         HOP    LDA #2       INITIALIZE TIMER POINTER.
8518  8D 03 17             STA PBDD2    SET LINE B1 FOR OUTPUT, REST INPUT.
851B  08                   PHP          SAVE INTERRUPT STATUS.
851C  78                   SEI          DISABLE INTERRUPT.
851D  0A            LP     ASL          UPDATE TIMER POINTER.
851E  A0 00                LDY #0       TRIGGER TIMER VIA
8520  8C 02 17             STY PBD2     LOW TO
8523  A0 02                LDY #2       HIGH TRANSITION
8525  8C 02 17             STY PBD2     OF LINE B1.
8528  A0 FF                LDY #FF      INITIALIZE COUNTER.
852A  CA            LP1    INY          UPDATE COUNT.
852B  2C 02 17             BIT PBD2     TEST TIMING PULSE.
852E  D0 FA                BNE LP1      IF HIGH, CONTINUE COUNT.
8530  48                   PHA
8531  98                   TYA
8532  9D E3 17             STA POT,X    SAVE COUNT.
8535  68                   PLA
8536  CA                   DEX
8537  10 E4                BPL LP       MORE TIMERS?
8539  28                   PLP          NO, RESTORE INTERRUPT STATUS.
853A  60                   RTS
```

program. Remember to keep the counting loop as efficient as possible.

Calibration

The count we obtain from the interface is equivalent to the duration of the timing pulse divided by the processing time required by the computer to execute one counting loop. My 6502 system, running at a clock frequency of 1 MHz, will execute the counting loop in listing 1 (hexadecimal 852A thru 852E) in 9 μs. It stands to reason that if you want a joystick to read from 0 to 100 on this machine, you would choose a potentiometer and capacitor that would set the maximum duration of the timing pulse to 909 μs (101 $\times$ 9 μs).

The following formula is used to derive the value of the timing capacitor:

$$C = \frac{\text{pulse duration}}{1.1 \times R}$$

where C is in farads, duration is in seconds, and R is in ohms. Assuming a joystick with 100 k-ohm potentiometers, a 0.0083 μF capacitor is needed to produce a 909 μs timing pulse. Since the actual value of most capacitors is not precisely known, it may be desirable to trim the maximum timer intervals. This can be done by placing extremely small-value capacitors in parallel with the main timing capacitor of the circuit that has the *smaller* maximum pulse of the two. Silver mica capacitors should work well here.

Construction

The circuit is quite simple and compact. With point-to-point wiring, several joystick interfaces can be constructed on a small circuit card. Placement of components is not critical. Each interface should draw less than 40 mA from a +5 V supply. Surplus joysticks can be purchased for about \$4, while the 556 timer costs less than \$1; so, for about \$6 and one night's work, you can add this joystick interface to your system. ■

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Retrieve by Last Name	NO	YES	Relative record cannot file alphabetically
Erase a record	NO	YES	Relative record cannot erase records
Dynamic record allocation	NO	YES	KRAM files grow as needed
Dynamic compression	NO	YES	KRAM recaptures space when records are deleted
Mutliple files open	NO	YES	KRAM can keep 5 files open simultaneously
BEST WAY	NO	YES	It's obvious

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Pascal and the Great Race

David A Mundie, 104 Oakhurst Cir, Charlottesville VA 22903

I have some comments on the record maintenance techniques described in "The Great Race and Micro Disk Files," by J J Roehrig (April 1980 BYTE, page 142).

Mr Roehrig's initial method took almost a minute just to write 120 real variables, so it is little wonder that he began looking for a better way. His decision to minimize disk transfers by not sorting the records on the disk seems eminently sensible. However, his other decision, to read and write individual elements of the array instead of using a FOR...NEXT loop is lamentable. Surely there is something wrong with a language so inefficient that loops are prohibitively slow. One wonders what he would have done had there been 1000 elements in the array rather than twelve.

Mr Roehrig might consider changing programming languages as a solution to his problem. The root of his difficulty is that BASIC does not allow for files of arrays (or any other structured data type, for that matter). In Pascal, it would be possible to define SCRATCH as a file of arrays of reals, with twelve reals in each array. Writing an array is then accomplished by the simple statement PUT(SCRATCH), while reading is done by GET(SCRATCH)—no loops, and especially no referencing of each element of the array.

Listing 1

```
PROGRAM RACETEST;
CONST DUMMYVALUE = 1.23456;
TYPE REALARRAY = ARRAY[1..12] OF REAL;
VAR I,J: INTEGER;
  DUMMY: REALARRAY;
  SCRATCH: FILE OF REALARRAY;
PROCEDURE CLOCK;
BEGIN
  WRITELN ('CLOCK: ');
  READLN
END;
BEGIN (*RACETEST—MAIN PROGRAM*)
  FOR I := 1 TO 12 DO
    DUMMY[I] := DUMMYVALUE;
  CLOCK;
  REWRITE (SCRATCH, 'SCRATCH');
  FOR I := 1 TO 10 DO
    BEGIN
      SCRATCH↑ := DUMMY;
      PUT (SCRATCH)
    END;
  CLOCK;
  FOR J : = 1 TO 5 DO
    BEGIN
      RESET (SCRATCH);
      FOR I := 1 TO 10 DO
        BEGIN
          DUMMY := SCRATCH↑;
          GET (SCRATCH)
        END;
    END;
  CLOCK;
  CLOSE (SCRATCH)
END.
```

A Pascal program equivalent to his program is given in listing 1. Because ten arrays of twelve reals do not fill up the minimum UCSD Pascal buffer of 512 bytes, for benchmarking purposes I actually used an array size of 120 real variables, then divided the execution times by 10. This yields a time of about 0.4 seconds to write ten records, compared to Mr Roehrig's minimum of 3 seconds, or the estimated 20 seconds using loops. Reading ten records five times took about 1 second, compared to his minimum of 6 seconds. Part of the difference may be attributable to hardware (I used a Pascal Microengine with double-density 8-inch disks), but I am convinced that the difference is largely due to Pascal's more rational handling of files. In this case, at least, higher-level constructs seem to be not only easier to use, but also more efficient than those at a low level. ■

The article "A Power-Line Protection Circuit" by Neil Schneider and Bror Erickson (March 1980 BYTE, page 126) generated a great deal of correspondence. This included the following criticism by Mr Newswanger and the circuit offered by Mr Schafer.

Protection Circuits

Donald W Newswanger, Dept of Building and Safety, City Hall, Rm 485, Los Angeles CA 90012

I was disappointed to see the article "A Power-Line Protection Circuit" (March 1980 BYTE, page 126). No direct internal connection should ever be made to a *hot-chassis* transformerless television set. The antenna terminals may be safely used with a suitable RF (radio-frequency) modulator, but no attempt should be made to connect directly into the video circuit. Transformer-isolated television sets and monitors are readily available for this purpose.

The circuits in both figure 1 and figure 2 of that article introduce problems into the building wiring system. The use of either circuit will trip a ground-fault circuit breaker. Circuit 2 is particularly bad since it directly interconnects the ground wire and the neutral during normal operation. The neutral conductor of a two-wire circuit carries the same current as the *hot* wire of the circuit. The interconnection of the neutral and ground wire will cause part of the normal neutral current from all applicances connected to the circuit to flow through the ground wire. The ground wire is intended to provide a ground path for appliances and should never be used as a current-carrying conductor. These circuits violate the provisions of the National Electrical Code and the UL/ANSI Standards.

I have a low-cost personal computer and feel that my 120 VAC/12 VDC portable television set was a good investment. BYTE should encourage the use of line-isolated television sets and monitors and discourage the use of makeshift substitutes.■

Steven A Schafer, 202 West Dr, Princeton NJ 08540

The purpose of the ground wire in the standard power delivery system is to provide a stable reference and to bleed away any small charges caused by leakage currents or static. It should *never* be used to supply power to any device. A current of more than a few milliamperes in the ground line is enough to trigger a ground-fault interrupter, if such a device is installed.

For the same reason, the neutral wire should never be connected to the ground wire; even though they are supposedly at the same potential, the neutral wire is not guaranteed to be at earth-ground, and connecting it to the ground wire will often cause a small current to flow. For obvious safety reasons, neither the hot nor the neutral side of the power line should be connected to any exposed conductor.

The circuit shown in figure 1 is a nearly foolproof way to protect against wiring errors. If a polarity error exists between the protected equipment and any other devices connected to it, relay 2 and the neon indicator will turn on, disabling relay 1 and preventing power from being applied to the protected equipment. If there is no error, relay 2 remains off, and depressing the push-button switch

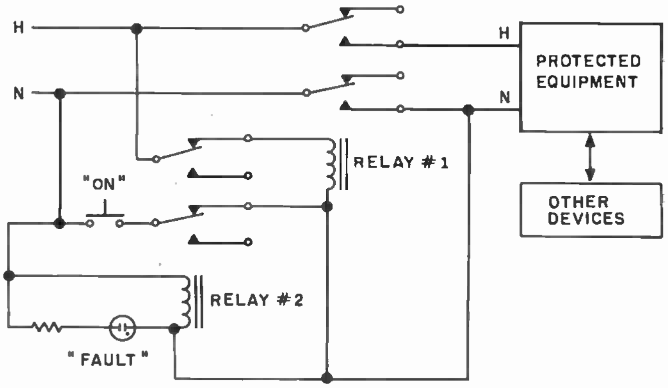

Figure 1: *Steven Schafer's power-line protection circuit. The line marked H is the hot side of the power line; the line marked N is the neutral side of the power line. The resistor in series with the neon lamp should have a value of 100 k ohms.*

will latch relay 1 *on* and apply power to the load. The only way to defeat the circuit is to hold the push-button switch closed while inserting the power plug in the wall socket. ■

Making 6502 Indirect Subroutine Calls Efficient

Philip K Hooper, 5 Elm St, Northfield VT 05663

I enjoyed the article "Indirect Addressing for the 6502," by Kenneth Skier (January 1980 BYTE, page 118), and I would like to suggest some alternative techniques. These are based on the observation that once the subroutine of interest has finished executing, control may return directly to the original calling program rather than to the interim location holding the volatile address of the subroutine. Implementing this permits savings in both time and storage, as will be shown.

Approach A involves initially writing hexadecimal 4C (the JMP op code) into the first of three read/write memory locations, the second and third of which will be set dynamically to the actual address of the desired subroutine, as in Mr Skier's article. The subroutine will then be summoned correctly by a simple JSR to the read/write memory location containing the 4C. Return will be to the main program.

Approach B requires no initialization of read/write memory, although two consecutive bytes of read/write memory must be reserved for use as a pointer. The main program does require three additional bytes containing hexadecimal 6C (op code for JMP indirect) followed by the address, low byte first, of the read/write memory location reserved for the pointer. In use, the pointer will be loaded (as before) with the actual subroutine address, and a JSR to the byte containing the 6C will result in the correct location, execution, and return from the desired subroutine.

Table 1.

	Approach used in article	Approach A	Approach B
Time overhead in μs	24 (JSR JSR RTS RTS)	15 (JSR JMP RTS)	17 (JSR JMPI RTS)
Bytes needed to do initialization	8 or 10	4 or 5	0
Additional bytes of program memory	0	0	3
Bytes of read/write memory required	4	3	2
Bytes required by stack	4	2	2

Table 1 summarizes the storage and time overhead requirements of these three JSR(I) techniques. For sheer speed, approach A performs best, while approach B can save two or three bytes, at a cost of two cycles per invocation. ■

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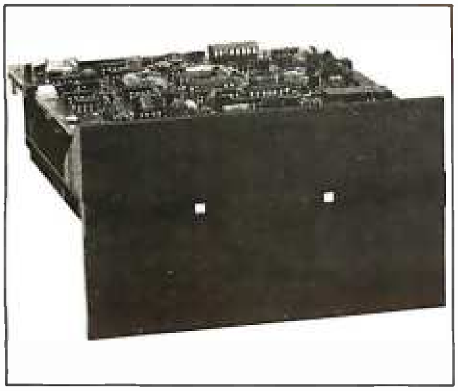

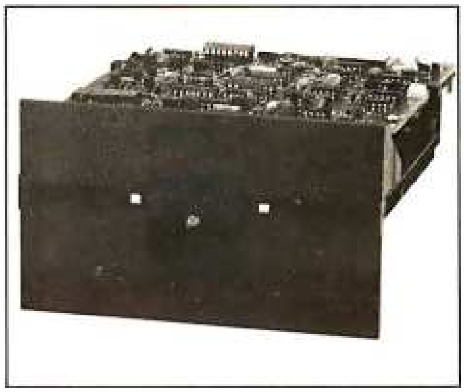

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Michael Fallgatter, 514 Bethesda Ct, Waukesha WI 53186

The article "Indirect Addressing for the 6502," by Kenneth Skier (referenced above), was most interesting, but I would like to point out that, in the case of indirect transfers to subroutines, a much faster-running linkage is possible. Rather than using the linkage routine:

```
JSR    variable address
RTS
```

the linkage using the 6502 indirect-jump command

```
JMP    variable pointer
```

produces the same result, takes less memory, and cuts the time required for the transfer of control by over 50%, from thirty-eight to eighteen machine cycles. Using this technique and assuming a table of subroutine addresses residing in a single page of memory, the listings in Mr Skier's article become those shown here.

Listing 1: *Initiate zero-page bytes*

```
LDA  #$6C                   Write JMP indirect
STA  zero-page byte #1      via pointer to subroutine
                            address table
LDA  #$table page
STA  zero-page byte #3
```

Listing 2: *Transfer from main program*

```
LDX  subroutine #-pointer to address in table
STX  zero-page byte #2
JSR  zero-page byte #1
```

Listing 3: *Zero-page linkage routine to create subroutine call*

```
STX  zero-page byte #2
JMP  indirect, via subroutine address table
```

Listing 4: *Simulate indirect subroutine jump*

```
LDX  subroutine #
JSR  CALL SUBROUTINE(X)
```

Finally, since no indexed instructions are involved, the A register could be used instead of X. Also, there is a very minimal memory and execution-time penalty paid for using a nonzero page for the transfer routine. ■

Technical Forum is a feature intended as an interactive dialog on the technology of personal computing. The subject matter is open-ended, and the intent is to foster discussion and communication among readers of BYTE. We ask that all correspondents supply their full names and addresses to be printed with their commentaries. We also ask that correspondents supply their telephone numbers, which will not be printed.

Machine Problem Solving, Part 1:

Trial-and-Error Search, A Mechanical Plan to Save the Missionaries

Professor Peter W Frey
Northwestern University
Cresap Neuroscience Laboratory
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Modern computers are famous for their number-crunching ability. Their facility at inverting a 60 by 60 matrix or at solving a set of linear differential equations is truly impressive. In fact, machines are so good at solving numerical problems that most of us take these skills for granted.

Computers are also useful as general-purpose control devices. Many personal-computing enthusiasts enjoy impressing their neighbors with their machine's ability to control lights, water sprinklers, and burglar alarms, and to take telephone calls and regulate the furnace. Homes of the future will be completely computerized.

The computer also makes an excellent bookkeeper: faithfully recording financial transactions, maintaining mailing lists, and generating timely reminders for important meetings. Personal computers also provide many hours of entertainment for their owners with games of manual dexterity, games of chance, and simulated battles among the stars or in dark dungeons. These many uses provide a clear rationale for the rapidly developing popularity of the personal computer.

The most exciting application of the computer lies in still another direction. It is as a *thinking machine* that the modern computer truly sparks our imagination. When faced with a problem that has no easy numerical solution, men have typically discarded their mechanical calculators and put on their proverbial thinking caps. For this type of problem, the human brain has always been superior to mechanical devices. An immense amount of respect for the human brain can be gained by trying to program a computer to select the best move in a game like chess. Even a multimillion-dollar mainframe computer turns out to be a woodpusher when asked to compete against a skilled human player.

Solutions by Searching

When machines confront nonnumerical problems, their primary weapon in finding a solution is to examine a vast labyrinth of potential outcomes in search of one which satisfies the desired conditions. Although this approach is not very elegant, it is, in fact, highly similar to that used by humans. The noted psychologist Donald Campbell (see reference 1) observed that trial-and-error search plays a key role in human problem solving: "a blind-variation-and-selective-survival process is fundamental to all inductive achievements, to all genuine increases in knowledge, to all increases in fit of system to environment."

It is as a *thinking machine* that the modern computer truly sparks our imagination.

Campbell also concluded that specialized problem-solving skills such as those observed in an experienced surgeon or airline pilot are "inductive achievements achieved originally by a blind-variation-and-selective-survival process." Thus, trial-and-error search provides the cornerstone for human efforts in acquiring new knowledge.

Search is even more important in solving problems by computer. With most problems, humans have background information which can be successfully employed to direct the solution process. Machines generally lack this. Problem solving by computer usually requires that all relevant facts be discovered during the solution process. This important difference between human and machine problem solvers has been addressed by recent efforts in artificial intelligence. By developing specialized information libraries, the computer scientist has created search programs which are reasonably competent at tasks such as diagnosing medical problems or developing three-dimensional models for complex chemical structures. For

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most problem-solving efforts, however, it is much easier to emphasize search rather than sophisticated pattern matching.

Games as Problems

Games and puzzles provide excellent sample problems. Marvin Minsky states that "it is not that the games and mathematical problems are chosen because they are clear and simple; rather it is that they give us, for the simplest initial structures, the greatest complexity, so that one can engage some really formidable situations after a relatively minimal diversion into programming." (See reference 2.) Man's fascination with intellectual games is not a new phenomenon. The Dutch scholar Huizinga suggested many years ago that the human race should have been named *homo ludens* (the game player) rather than *homo sapiens*.

There are two important aspects of playing a game or solving a puzzle. The first consists of representing the problem in a way that permits efficient analysis. The second involves devising a search technique which is capable of finding a solution. The first task, finding a good way to represent the problem, is usually the key to an elegant solution. Unfortunately, few guidelines exist that provide a mechanical rule for developing a good representation. For this reason, problem representation generally must be devised individually for each game or puzzle by the human programmer.

The situation is quite different in respect to the search process. In this case, there are well-developed principles that have proven useful in many different problem areas. My purpose in this article will be to focus on the search process and to consider general techniques that have broad applicability.

The most basic type of search is called the trial-and-error search.

Trial-and-Error Search

The most basic type of search process is called *trial-and-error search*. In this case, the problem solver examines various operations until a sequence is found that leads to a solution. In primitive implementations, the different options are considered haphazardly rather than being ordered according to a specific plan. To demonstrate this approach, we will develop a solution for the missionaries-and-cannibals problem.

In its traditional form, this problem involves three missionaries and three cannibals who are located on one bank of a river and wish to cross. A boat is available which will hold two people and which can be navigated by one or two people. The special restriction that makes the problem interesting is that the sequence of river crossings must never result in an arrangement where the cannibals outnumber the missionaries on either bank. If the missionaries are outnumbered, their life expectancy will be immediately and permanently shortened.

In determining the number of individuals on each bank, the persons in the boat when it reaches shore are considered to be residents of that bank. The object for the problem solver is to develop a schedule of river crossings which transports the entire party across without losing any missionaries.

Representing the Problem

The first step in addressing this problem is to find a representation that is compatible with a machine problem-solving approach. For our effort, we would like to write a program in Level II BASIC for the Radio Shack TRS-80 computer. This machine is widely available and has more than enough power to solve this puzzle. We will consider the problem in terms of discrete *states* and discrete *operations*. We will not concern ourselves with the details of paddling a boat across a river, but rather with the executive decisions, ie: who is to be in the boat on each journey across.

The *state space* will consist of a description of the number and types of occupants on each bank before the boat makes a crossing or after a crossing is completed. We will employ a shorthand notation which represents a missionary by the letter M, a cannibal by the letter C, the boat by the symbol <=>, and the river by two vertical lines. Therefore, the character sequence CCMM | <=> |CM indicates that there are two cannibals and two missionaries on the left bank of the river and one cannibal, one missionary, and the boat on the right bank. This notation is adequate to describe all possible states of the problem.

The *operations* (ie: legal moves) we can perform to transpose one state into another are quite limited in number. In fact, there are a maximum of five operations that can be used, and often only a subset of these will be feasible. The five operations consist of transporting (1) one

cannibal, (2) two cannibals, (3) one missionary, (4) two missionaries, or (5) one cannibal and one missionary.

To execute one of these operations in a particular direction, the boat must be located on the departure bank. In addition, an operator cannot be applied if the appropriate individuals are not present on the departure bank. For example, we cannot move two missionaries from the left bank to the right bank if there are fewer than two missionaries on the left bank at that point in time.

Programming the Problem

Our program will start with a few "housekeeping" functions that are necessary even though they have little to do with the logic of our solution. It is necessary to set aside 300 bytes of memory for string variables, to inform the machine that all variables that are not specifically defined as string variables are to be treated as integer variables (this saves memory and speeds execution), to define two special variables (X$ and Y$) for clearing sections of the video display, and to blank out the entire screen.

In addition, for our graphic presentations we need a representation for the boat on the left side of the river (BL$) and one for the boat on the right side of the river (BR$). All of this is accomplished in our first two lines (given here and as part of listing 1; the function STRING$ (*n*, *"X"*) returns a string consisting of *n* symbols using the first character of *"X"*):

```
100 CLEAR 300: DEFINT A-Z:
      Y$=STRING$(40," "): CLS
110 X$=STRING$(9," "):
      BL$="< = >"+X$:BR$=X$+"< = >"
```

It is also helpful to set up a few arrays to store essential information. We need to know the position of the boat, the number of cannibals on the left bank, and the number of missionaries on the left bank after each river crossing. This information will be retained in arrays B, C, and M. We also need to remember which of the crossing options (1 cannibal, 2 cannibals, 1 missionary, etc) we have considered at each choice point in our crossing sequence. This information is stored numerically by array D and for graphic purposes in string array MV$. Finally, we need to specify the crossing options with respect to the cannibals, array CT, and the missionaries, array MT. The TRS-80 is instructed to establish these arrays in line 120:

```
120 DIM B(30), C(30), CT(5), D(30),
      M(30), MT(5), MV$(30)
```

To make the program more interesting, we will generalize the problem so that the number of travelers can vary from four to sixteen. The number of travelers will be represented by the variable N which can be specified by the user:

```
130 PRINT@526, "NUMBER OF TRAVELERS
      (4 TO 16)";: INPUT N
140 CLS: IF N<4 OR N>16 THEN 130
```

Line 140 makes sure that the value entered for N is in the proper range. This is important with the TRS-80 because keyboard bounce is apt to provide a value like 122 when we intended 12. The program would experience difficulties if it attempted execution with N set at a value of 122.

Next, we set the stage properly. First we need a title (line 150) and then we need a river for our travelers to cross (line 160):

```
150 PRINT@24, "MISSIONARIES AND
      CANNIBALS";
160 FOR K=4 TO 43: SET (58,K): SET (85,K):
      NEXT K
```

Program Operation

Now it is time to get on with the main act. The initial number of cannibals on the left bank (CI) is computed as

Listing 1: *Trial-and-error solution to the cannibals-and-missionaries problem, written for the TRS-80 in Level II BASIC.*

```
100 CLEAR 300: DEFINT A-Z: Y$=STRING$(40," "): CLS
110 X$=STRING$(9," "): BL$="< = >"+X$:BR$=X$+"< = >"
120 DIM B(30), C(30), CT(5), D(30), M(30), MT(5), MV$(30)
130 PRINT@526, "NUMBER OF TRAVELERS (4 TO 16)";:
    INPUT N
140 CLS: IF N<4 OR N>16 THEN 130
150 PRINT@24, "MISSIONARIES AND CANNIBALS";
160 FOR K=4 TO 43: SET(58,K): SET(85,K): NEXT K
200 CI=INT(N/2): MI=N-CI: BP=1: I=0
210 CL=CI: CR=0: ML=MI: MR=0
220 CT(1)=2: CT(2)=1: CT(3)=0: CT(4)=0: CT(5)=1
230 MT(1)=0: MT(2)=0: MT(3)=2: MT(4)=1: MT(5)=1
300 GOSUB 2000: GOSUB 1000
310 C(I)=CL: M(I)=ML: B(I)=BP
320 IF ML=0 AND CL=0 THEN 700
330 FOR K = 1 TO 800: NEXT K
340 I=I+1: D(I)=0
350 D(I)=D(I)+1: IF D(I)>9 THEN 600
360 IF BP= -1 THEN 380
370 IF CL<CT(D(I)) OR ML<MT(D(I)) THEN 350 ELSE 390
380 IF CR<CT(D(I)) OR MR<MT(D(I)) THEN 350
390 CL=CL-BP*CT(D(I)): CR=CI-CL
400 ML=ML-BP*MT(D(I)): MR=MI-ML: BP= -BP
410 IF ML>0 AND CL>ML THEN 500
420 IF MR>0 AND CR>MR THEN 500 ELSE K=0
430 IF CL=C(K) AND ML=M(K) AND BP=B(K) THEN 500
440 K=K+1: IF K<I THEN 430
450 A$=STRING$(CT(D(I)),"C"): B$=STRING$ (MT(D(I)),"M")
460 IF BP= -1 THEN MV$(I)=A$+B$+"- >"
    ELSE MV$(I)="< -"+A$+B$
470 GOTO 300
500 BP= -BP: CL=CL+BP*CT(D(I)): CR=CI-CL
510 ML=ML+BP*MT(D(I)): MR=MI-ML: GOTO 350
600 PRINT@960, "BACK UP AND TRY SOMETHING ELSE";
610 I=I-1: IF I<1 THEN PRINT@ 960, Y$;: GOTO 800
620 CL=C(I-1): CR=CI-CL: ML=M(I-1): MR=MI-ML
630 BP=B(I-1): GOSUB 2000: GOSUB 1000
640 FOR K=1 TO 800: NEXT K
650 PRINT@ 960, Y$;: GOTO 350
700 PRINT@ 960, "SUCCESS";: GOTO 700
800 PRINT@ 64, X$;: PRINT@ 960, "FAILURE";: GOTO 800
1000 IF I=0 THEN RETURN
1010 FOR K=1 TO 14: PRINT@ K*64, X$;: NEXT K
1020 S=I-13: IF S<1 THEN S=1
1030 FOR K=S TO I: J=K-S+1
2000 Z$=STRING$(8-CR," "): CR$=STRING$(CR,"C")+Z$
2010 Z$=STRING$(8-CL," "): CL$=Z$+STRING$(CL,"C")
2020 Z$=STRING$(8-MR," "): MR$=STRING$(MR,"M")+Z$
2030 Z$=STRING$(8-ML," "): ML$=Z$+STRING$(ML,"M")
2040 IF BP=1 THEN B$=BL$ ELSE B$=BR$
2050 PRINT@ 468, CL$;: PRINT@ 492, CR$;: PRINT@ 478, B$;
2060 PRINT@ 532, ML$;: PRINT@ 556, MR$;: RETURN
```

is the initial number of missionaries on the left bank (MI). We will assume an equal number of missionaries and cannibals when N is even and an extra missionary when N is odd. (If there were an extra cannibal at the beginning, our problem would end before we had a chance to try our first crossing.)

The position of the boat will be indicated by the variable BP. When the boat is on the left bank, BP will have a value of 1. A value of −1 will indicate that the boat is on the right bank. The index reflecting the number of crossings (I) is set to zero and the values for the variables indicating the number of cannibals on the left bank (CL), the number of cannibals on the right bank (CR), the number of missionaries on the left bank (ML), and the number of missionaries on the right bank (MR) are also initialized:

```
200 CI=INT(N/2): MI=N-CI: BP=1: I=0
210 CL=CI: CR=0: ML=MI: MR=0
```

We also wish to specify each crossing option by specifying the number of cannibals (CT) and the number of missionaries (MT) who are transported:

```
220 CT(1)=2: CT(2)=1: CT(3)=0: CT(4)=0:
    CT(5)=1
230 MT(1)=0: MT(2)=0: MT(3)=2: MT(4)=1:
    MT(5)=1
```

The main loop of our program begins with calls to two subroutines which handle the graphic display. One subroutine (which appears later in this article at line 1000) displays an up-to-date list of the crossings attempted so far. The other subroutine (line 2000) provides a pictorial representation of the current position of the missionaries, cannibals, and boat. These routines are not essential for solving the problem, but they add a nice touch to the program and allow the user to watch the machine's "thought processes." These subroutines are invoked at line 300:

```
300 GOSUB 2000: GOSUB 1000
```

Each time through the loop, it is necessary to make a permanent record of the current status of our principal characters:

```
310 C(I)=CL: M(I)=ML: B(I)=BP
```

and then to check to see if the problem has been solved:

```
320 IF ML=0 AND CL=0 THEN 700
```

If not, we create a brief delay so that the human observer will not miss any of the action:

```
330 FOR K=1 TO 800: NEXT K
```

and then get about our main business, examining the feasibility of making a particular crossing by incrementing I by one and initializing D(I), which keeps track of the particular crossing option we are trying at each step I in the crossing sequence. The variable D(I) is then incremented and a test is made to see if we have exhausted the available options:

```
340 I=I+1: D(I)=0
350 D(I)=D(I)+1: IF D(I)>5 THEN 600
```

Testing Options

If all options have been tried without success, the machine is directed to line 600 and asked to execute a back-up procedure that tries another option at an earlier position in the sequence. If we still have a viable option at this previous value of I, we continue by examining the particular crossing option which is indicated. First, we determine the location of the boat (line 360), then make sure we have a sufficient number of missionaries and cannibals on the departure bank to carry out the indicated crossing (lines 370 and 380), and finally we make the crossing (lines 390 and 400):

```
360 IF BP=-1 THEN 380
370 IF CL<CT(D(I)) OR ML<MT(D(I))
       THEN 350 ELSE 390
380 IF CR<CT(D(I)) OR MR<MT(D(I)) THEN 350
390 CL=CL--BP*CT(D(I)): CR=CI-CL
400 ML=ML-BP*MT(D(I)): MR=MI-ML:
       BP=-BP
```

Next, we check to make sure that the cannibals do not outnumber the missionaries on either bank. If they do, we go to line 500 to reverse the crossing, and then to line 350 to select another crossing option:

```
410 IF ML>0 AND CL>ML THEN 500
420 IF MR>0 AND CR>MR THEN 500 ELSE K=0
```


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In addition to an insufficient number of the appropriate persons or the threat of cannibalism, there is another reason for discarding the current crossing plan and going to line 350 to try another. This third reason has to do with repetition of a previous state of the system. We have no desire to create loops which transport the same individuals back and forth forever. In lines 430 and 440, we check to make sure that the current state has not occurred previously:

```
430 IF CL=C(K) AND ML=M(K) AND BP=B(K)
    THEN 500
440 K=K+1: IF K<I THEN 430
```

If our current crossing option passes these three tests, then we are ready to proceed. The crossing is recorded for posterity's sake; then we jump to line 300 to start the process once again:

```
450 A$=STRING$(CT(D(I)),"C"):
    B$=STRING$(MT(D(I)),"M")
460 IF BP=-1 THEN MV$(I)=A$+B$+"->"
    ELSE MV$(I)="<-"+A$+B$
470 GOTO 300
```

Backing Up

This completes the main loop of the program. We have a few loose ends which need to be taken care of before the job can be considered finished. When we found that a crossing option was not feasible either because of cannibalism (lines 410 and 420), or because of repetition of a previous position (lines 430 and 440), the machine was instructed to go to line 500 and reverse its previous move. Line 500 must therefore exist as follows:

```
500 BP=-BP: CL=CL+BP*CT(D(I)):
    CR=CI-CL
510 ML=ML+BP*MT(D(I)):
    MR=MI-ML: GOTO 350
```

After returning to line 350 to try another crossing, we may find that all five options have been exhausted. If so, it is time to back up our search and try something different at an earlier point in the crossing sequence. The back-up instructions start at line 600:

```
600 PRINT@960, "BACK UP AND TRY
    SOMETHING ELSE";
610 I=I-1: IF I<1 THEN PRINT@ 960,
    Y$;: GOTO 800
620 CL=C(I-1): CR=CI-CL: ML=M(I-1):
    MR=MI-ML
630 BP=B(I-1): GOSUB 2000: GOSUB 1000
640 FOR K=1 TO 800: NEXT K
650 PRINT@ 960, Y$;: GOTO 350
```

The back-up procedure is a little tricky. First, we decrement I by 1, then we set the current status of our main characters to the way it was *before* we made the last crossing. Our objective is to examine another crossing option at the new value of I. To do this, the position we transform must be the situation as it existed before the

A search program such as this one can be quite effective if the number of possible move combinations is not too large.

last move. The back-up procedure also calls our graphic routines (line 630), delays a bit for dramatic effect (line 640), and then erases the back-up message (line 650) before exiting for line 350.

There are two terminal conditions for the search process. If we move all the cannibals and missionaries across the river, our mission is successfully completed. This condition is detected by line 320 which directs the machine to line 700:

```
700 PRINT@ 960, "SUCCESS";: GOTO 700
```

If we back up to the point where I=0, then we have exhausted all possibilities and our search has failed. This state of affairs is tested in line 610 and if it holds, the machine is sent to line 800:

```
800 PRINT@ 64, X$;: PRINT@ 960, "FAILURE";:
    GOTO 800
```

This finishes our program except for specifying the two subroutines which maintain our video display. The first of these occurs at line 1000 and keeps an up-to-date listing of the crossing sequence:

```
1000 IF I=0 THEN RETURN
1010 FOR K=1 TO 14: PRINT@ K*64, X$;:
     NEXT K
1020 S=I-13: IF S<1 THEN S=1
1030 FOR K=S TO I: J=K-S+1
1040 PRINT@ J*64, K; " "; MV$(K);:
     NEXT K: RETURN
```

The second subroutine provides a graphic display of the current position of the boat and of all missionaries and cannibals:

```
2000 Z$=STRING$(8-CR," "):
     CR$=STRING$(CR,"C")+Z$
2010 Z$=STRING$(8-CL," "):
     CL$=Z$+STRING$(CL,"C")
2020 Z$=STRING$(8-MR," "):
     MR$=STRING$(MR,"M")+Z$
2030 Z$=STRING$(8-ML," "):
     ML$=Z$+STRING$(ML,"M")
2040 IF BP=1 THEN B$=BL$ ELSE B$=BR$
2050 PRINT@ 468, CL$;: PRINT@ 492, CR$;:
     PRINT@ 478, B$;
2060 PRINT@ 532, ML$;: PRINT@ 556, MR$;:
     RETURN
```

Limitations and Features

A search program such as this one can be quite effective if the number of possible move combinations is not too large. The missionaries-and-cannibals problem is an ideal example for this type of search because there is a limited number of options at each choice point. If there were many options at each choice point, a simple trial-and-error search might take a very long time to find a solution sequence. If there were a solution, however, it would find it.

The key features of this program are the I index and the D(I) array. If we use game terminology, the I variable indexes the move number (ie: first move, second move, third move, etc) and the D(I) array keeps track of which move option is currently being considered at each level I of the search. In the missionaries-and-cannibals problem, our program exhaustively considers the various move options. It accepts the first legal move option it can find at each level I of the search.

A move is legal unless it fails one of the three tests (insufficient passengers, lines 370 and 380; cannibalism, lines 410 and 420; or repetition, lines 430 and 440). The search continues forward until it reaches a level where none of the five possible move options are feasible. It then backs up until it can find a new move option at a lower level and then starts forward again. This is a simple yet powerful strategy.

Improving the Process

Our implementation of this strategy could be made considerably more "intelligent" if we gave some thought to the order in which crossings are considered. In lines 220 and 230, we define the five crossing options. We could reduce the number of back-ups by establishing one order of move consideration for trips across to the right bank and another order for trips back to the left bank.

The interested reader might enjoy looking at academic studies which have examined this issue in detail (see, for example, reference 3). Some minor modifications can increase the efficiency of the present program by a large factor. One strategy for implementing this idea consists of defining one set of crossing options for left-to-right movement (say lines 220 and 225) and another set of crossing options for right-to-left movement (say lines 230 and 235) and then selecting between the two depending on the value of BP.

Many problems require more direction to the search process if a solution is to be found in a reasonable amount of time. Next month, in the second part of this three-part article, we will consider a much more challenging endeavor, cryptarithmetic. Allen Newell, one of the pioneers in analyzing human thinking in terms of information-processing models, made extensive use of cryptarithmetic as a valuable research paradigm. We will develop a search program in TRS-80 Level II BASIC that is capable of solving all cryptarithmetic problems.■

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BYTE's Bits

A Better Way to Indirectly Address the 6502

In the article "Indirect Addressing for the 6502," by Ken Skier in the January 1980 BYTE (page 118), there was an error in listings 2 and 3. Because absolute addresses occupy 2 bytes, the address of the *X*th subroutine will be in position 2*X* in the address table, not the *X*th. This problem can be corrected by storing the high address bytes in one table and the low-order bytes in another. With this structure the *X*th entry will correspond to the *X*th subroutine.

I would like to suggest two other methods of implementing indexed indirect jumps which are more efficient in terms of code length and execution time. The first method is that of vectoring: 3 bytes are reserved as the "vector." The first byte always contains a hexadecimal 4C (JMP). The target address is placed in the next 2 bytes and a JMP or JSR is then done to the vector, so that control passes to the selected module.

The second method, however, is the more effective and concinnate. Suppose that we wish to call routine *X*, and that the address table is structured as 2 rows: TBL.LO and TBL.HI. Consider the routine CALL.X, shown here as listing 1.

By doing a JMP or JSR to CALL.X an indexed indirect JMP or JSR will be effected to the *X*th routine. One point to be observed here is that the execution of a RTS instruction pops the stack into the program counter, and then increments it. Thus the addresses in the table must be one less than their actual value.

Thomas Gettys, Co-editor
SYM-Physis
SYM-1 Users' Group
POB 315
Chico CA 95927

Listing 1

```
CALL.X   LDA TBL.HI,X    ;GET ADDRESS X, HIGH BYTE
         PHA             ;AND PUSH IT TO THE STACK
         LDA TBL.LO,X    ;GET ADDRESS X, LOW BYTE
         PHA             ;AND PUSH IT TO THE STACK
         RTS             ;GO TO ROUTINE X
```

Notes on Attending a USUS Meeting

The first meeting of the USUS (UCSD System Users Society) was held in San Diego, California, on June 20 and 21, 1980. The meeting was called by SofTech Microsystems, then turned over to the approximately one hundred participants at the meeting. Speakers at the meeting included Carl Helmers and Ken Bowles. Organization, choosing a name, and the election of officers were the main formal goals. Jim Bandy was elected president, A Winsor Brown was elected vice-president, Chip Chapin was elected secretary, and Jon Bondy was elected treasurer. Informal accomplishments included the usual exchange of information which occurs between users of similar software. The next meeting of the USUS group will coincide with the Minicomputer and Microcomputer Conference and Exposition to be held on October 14, 15, and 16, 1980, in San Francisco, California. For further information, contact the secretary, Chip Chapin, at the following temporary address: UCSD System Users Society, attn: Chip Chapin, Secretary, 9494 Black Mountain Rd, San Diego CA 92126....CH■

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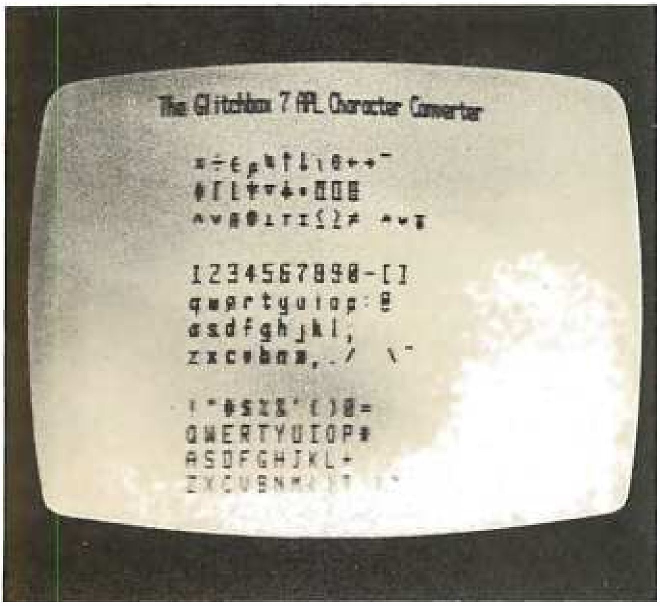

Photo 1: *Video screen display of the character set produced by the APL character-generator circuit described in this article.*

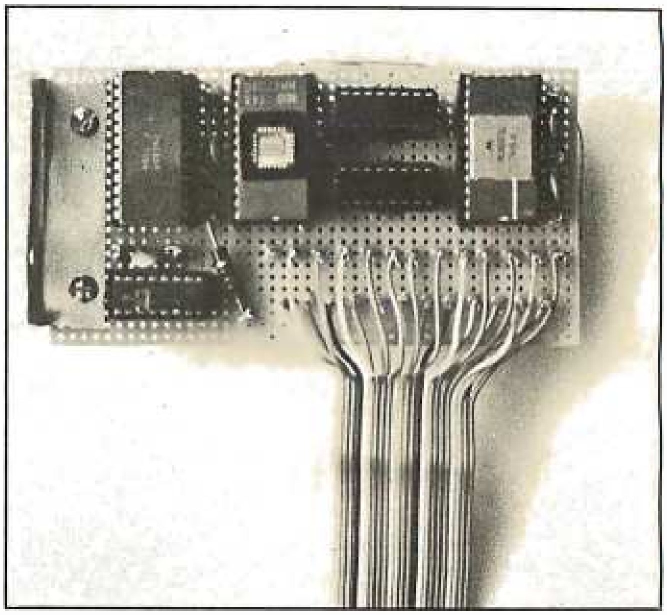

Photo 2: *The circuit of figure 1 as constructed on a small perforated circuit board.*

Many computer enthusiasts are beginning to use APL and are discovering the benefits of this powerful high-level language. Unfortunately, most personal computers are not equipped to generate the special APL characters.

Various solutions to this problem have been proposed, ranging from using inverse-video characters to using a programmable display that allows you to define any characters you want under program control.

Here is another solution. With the addition of only a few integrated circuits, and with only a single change in your present video interface, you can have the essential APL characters, including overstrikes. The circuit presented here should work with any video display using the popular MCM6571 character generator and can easily be adapted for others.

The first thirty-two positions in the MCM6571 are occupied by Greek letters and other seldom-used characters. The idea is to replace these with APL characters. After I listed the useful APL characters and

Author's Note:

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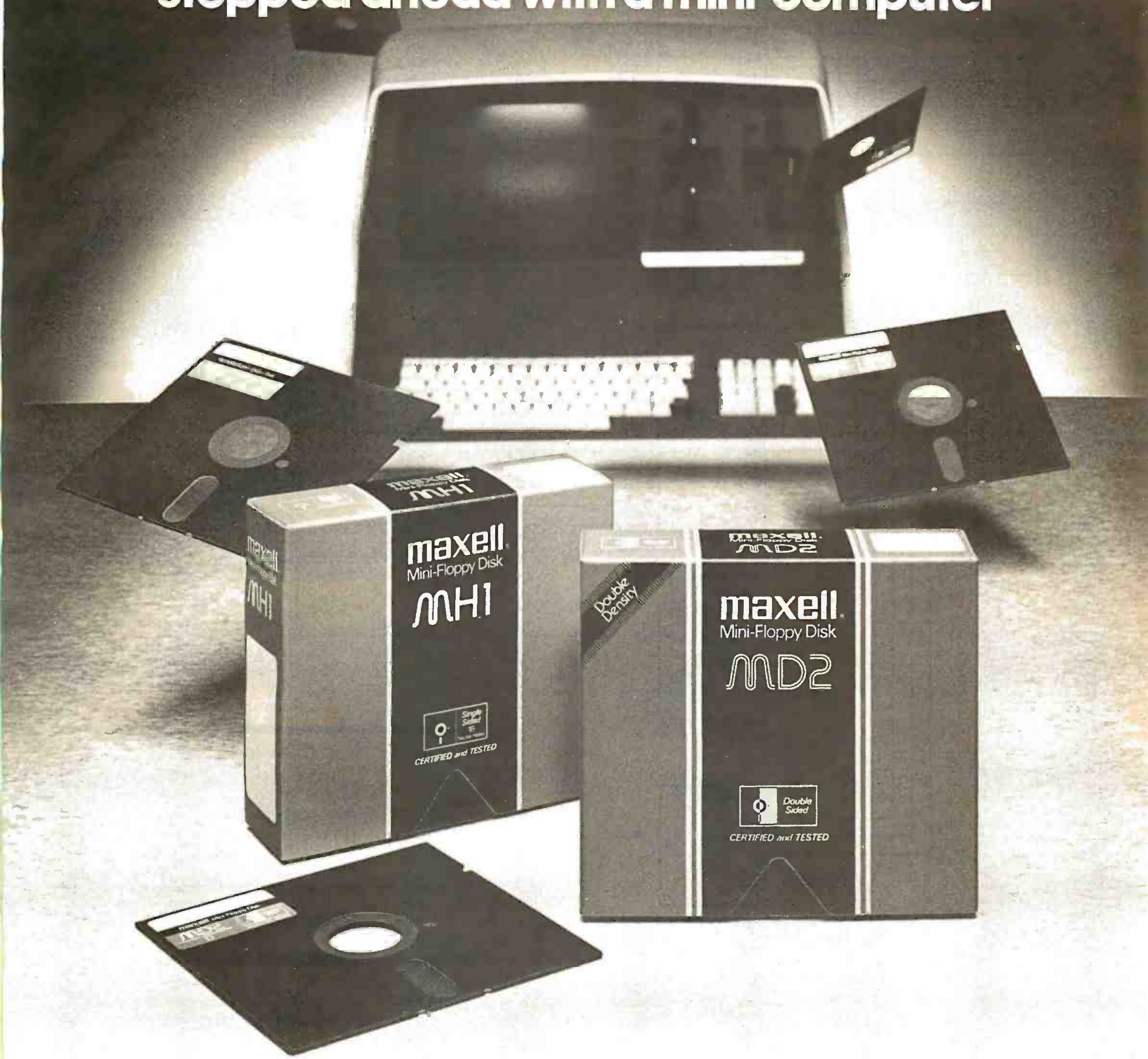

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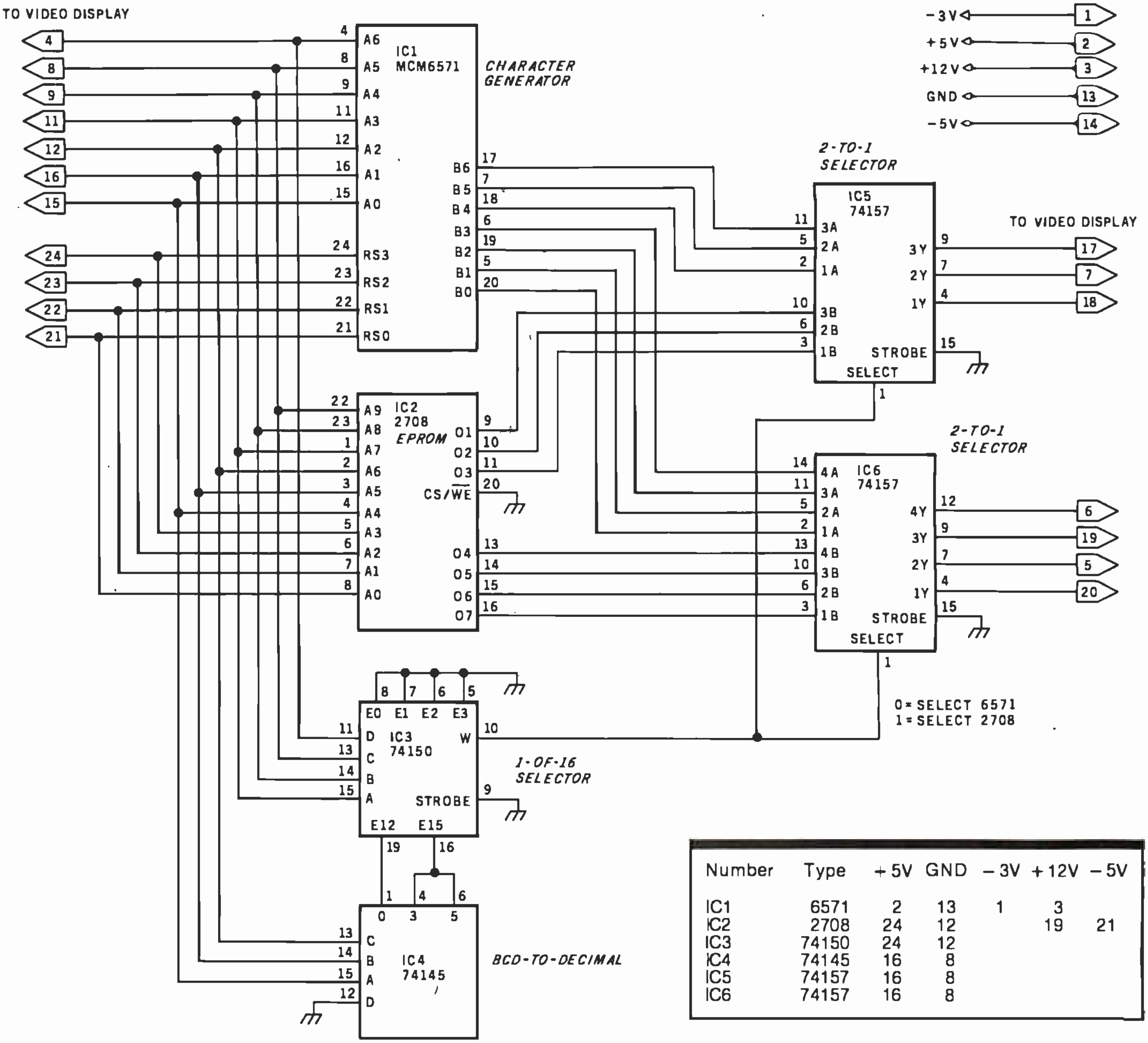

Number	Type	+5V	GND	−3V	+12V	−5V
IC1	6571	2	13	1	3	
IC2	2708	24	12		19	21
IC3	74150	24	12			
IC4	74145	16	8			
IC5	74157	16	8			
IC6	74157	16	8			

Figure 1: *Schematic diagram of the character-generator circuit which is to be constructed on a small circuit board for connection to the main video display board by a multiconductor cable. All connections are made through a 24-pin dual-in-line plug that plugs into the socket vacated by the removal of the MCM6571 from the video display board. The MCM6571 socket must have −5 V potential applied to its pin 14; this is the only modification needed on the video display board itself. Adding this −5 V connection does not affect normal operation since pin 14 on the MCM6571 package is not connected inside. To get the { and } characters instead of the ⍲ and ⍱ characters, disconnect pin 16 of the 74150 device.*

eliminated those already found in the ASCII (American Standard Code for Information Interchange) character set, thirty-five remained to be implemented.

Most people can probably do without the braces and accent grave ({ } `) from the ASCII character set, so I replaced them. If you need to have the braces, you can substitute them for the ⍲ (NAND) and ⍱ (NOR) symbols.

The circuit to produce the APL characters is presented in figure 1. It contains the original MCM6571 character generator from the video interface and a 2708 erasable programmable read-only memory (EPROM) programmed as an APL character generator. The 74145 BCD-to-decimal decoder and 74150 1-of-16 data selector decide which character generator to select, and the 74157 noninverting 2-to-1-line data selectors act accordingly.

The circuit can be built on a small board and plugged into your video display with a short ribbon cable and a 24-pin dual-in-line plug. The only modification to your video interface is to connect −5 V to pin 14 of the character-generator socket. This will *not* affect normal operation because pin 14 is not connected inside the MCM6571.

The data that must be programmed into the 2708 is listed in table 1. The character codes that invoke the APL characters are shown in table 2. ■

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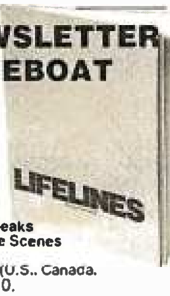

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Digital Microsystems	A1*
Discus	See Morrow Discus
Durango F-85	RL
Dynabyte DB8/2	R1
Dynabyte DB8/4	A1*
Exidy Sorcerer + Lifeboat CP/M	O2
Exidy Sorcerer + Exidy CP/M	O4
Heath H8 + H17/H27	P4
Heath H89 + Lifeboat CP/M	P4
Heath H89 + Magnolia CP/M	P7
Helios II	See Processor Technology
Horizon	See North Star
iCOM 2411 Micro Floppy	R3
iCOM 3712	A1
iCOM 3812	A1*
iCOM 4511 5440 Cartridge CP/M 1.4	D1#
iCOM 4511 5440 Cartridge CP/M 2.2	D2#
IMS 5000	RA
IMS 8000	A1*
IMSAI VDP-40	R4**
IMSAI VDP-42	R4**
IMSAI VDP-44	R5**
IMSAI VDP-80	A1**
Intecolor	See ISC Intecolor
Intel MDS Single Density	A1
Intertec SuperBrain DOS 0.1	R7
Intertec SuperBrain DOS 0.5-2.X	RJ
Intertec SuperBrain DOS 3.X	RK
ISC Intecolor 8063/8360/8963	A1
Kontron PSI-80	RF
Meca 5¼"	P6
Micromation (Except TRS-80 below)	A1*
Micropolis Mod I	O1
Micropolis Mod II	O2
MITS 3200/3202	B1
Morrow Discus	A1*
Mostek	A1
MSD 5¼"	RC
North Star Single Density	P1
North Star Double/Quad	P2
Nylac Single Density	O3
Nylac Micropolis Mod. II	O2
Ohio Scientific C3	A3
Onyx C8001	T2#
Pertec PCC 2000	A1*
Processor Technology Helios II	B2
Quay 500	RO
Quay 520	RP
RAIR Single Density	R9
RAIR Double Density	RE
Research Machines 8"	A1
Research Machines 5¼"	RH
REX	O3
Sanco 7000 5¼"	RO
SD Systems 8"	A1*
SD Systems 5¼"	R3
Sorcerer	See Exidy Sorcerer
Spacebyte	A1
SuperBrain	See Intertec
Tarbell	A1*
TEI 5¼"	R3
TEI 8"	A1*
Thinkertoys	See Morrow Discus
TRS-80 Model I 5¼"	R2
TRS-80 Model I + FEC Freedom	RN
TRS-80 Model I + Micromation	A4*
TRS-80 Model I + Omikron 5¼"	RM
TRS-80 Model I + Omikron 8"	A1
TRS-80 Model I + Shuffleboard 8"	A1
TRS-80 Model II	A1*
VDP-40/42/44/80	See IMSAI
Vector MZ	O2
Versatile	See CDS Versatile
Vista V80 5¼" Single Density	P5
Vista V200 5¼" Double Density	P6
Zenith Z89 + Lifeboat CP/M	P4
Zenith Z89 + Magnolia CP/M	P7

Prices F.O.B. New York. Shipping, handling and C.O.D. charges extra.

Manual cost applicable against price of subsequent software purchase.

The sale of each proprietary software package conveys a license for use on one system only.

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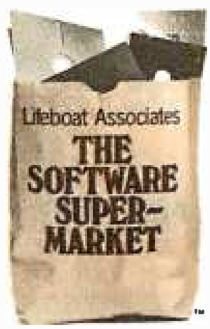
** IMSAI formats are single density with directory offset of zero.

A media surcharge of $25 for orders on tape formats T1 and T2 and of $100 for orders on disk formats D1 and D2 will be added.

The list of available formats is subject to change without notice. In case of uncertainty, call to confirm the format code for any particular equipment.



™ *The Software Supermarket is a trademark of Lifeboat Associates*

Address	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	
000	00	00	00	00	00	00	00	00	04	02	7F	02	04	00	00	00	→
010	00	00	00	00	00	00	08	08	1C	2A	2A	2A	1C	08	08	00	⌽
020	00	00	00	00	00	00	00	3E	08	08	08	08	00	00	00	00	⊥
030	00	00	00	00	00	00	22	22	22	3E	22	22	1C	00	00	00	A
040	00	00	00	00	00	00	1C	10	10	10	10	10	10	10	10	00	L
050	00	00	00	00	00	00	0C	10	20	3C	20	10	0C	00	00	00	∊
060	00	00	00	00	00	00	08	08	08	1C	2A	49	7F	08	08	00	⍋
070	00	00	00	00	00	00	00	00	08	14	22	41	7F	00	00	00	∇
080	00	00	00	00	00	00	08	08	7F	49	2A	1C	08	08	08	00	⍒
090	00	00	00	00	00	00	04	08	08	08	08	10	00	00	00	00	ι
0A0	00	00	00	00	00	00	00	00	18	24	24	18	00	00	00	00	∘
0B0	00	00	00	00	00	00	7F	41	41	41	41	49	49	49	7F	00	⍞
0C0	00	00	00	00	00	00	7F	41	41	41	41	41	41	41	7F	00	⎕
0D0	00	00	00	00	00	00	00	3E	08	08	08	3E	00	00	00	00	⌶
0E0	00	00	00	00	00	00	00	08	08	08	08	3E	00	00	00	00	⊤
0F0	00	00	00	00	00	00	00	1C	22	41	49	41	22	1C	00	00	⊙
100	00	00	00	00	00	00	00	00	10	20	7F	20	10	00	00	00	←
110	00	00	00	00	00	00	00	00	22	14	08	14	22	00	00	00	×
120	00	00	00	40	20	10	1E	11	11	0E	00	00	00	00	00	00	⍴
130	00	00	00	00	00	00	10	10	10	10	10	10	10	10	1C	00	⌈
140	00	00	00	00	00	00	00	01	1E	26	2A	32	3C	40	00	00	⍉
150	00	00	00	00	00	00	08	1C	2A	08	08	08	08	08	08	00	↓
160	00	00	00	00	00	00	00	1C	22	35	49	6B	2A	1C	00	00	⍟
170	00	00	00	00	00	00	00	08	00	00	7F	00	00	08	00	00	÷
180	00	00	00	00	00	00	00	00	08	14	22	41	00	00	00	00	∨
190	00	00	00	00	00	00	08	08	08	08	08	08	2A	1C	08	00	↑
1A0	00	00	00	00	00	00	00	00	00	41	22	14	08	00	00	00	∧
1B0	00	00	00	00	00	00	7F	41	49	41	7F	41	49	41	7F	00	⌹
1C0	00	00	00	00	00	00	3E	00	04	08	10	20	10	08	04	00	≤
1D0	00	00	00	00	00	00	00	00	00	00	00	00	00	00	7F	00	-
1E0	00	00	00	00	00	00	3E	00	10	08	04	02	04	08	10	00	≥
1F0	00	00	00	00	00	00	00	40	20	7F	08	7F	02	01	00	00	≠

Table 1: *Data that must be programmed into the 2708 erasable programmable read-only memory (EPROM) device. This data tells the video display how to form the APL characters from a dot matrix. To the left is the address of the data, in the center*

200	00	00	00	00	00	00	08	1C	2A	2A	1C	08	7F	00	00	00	Φ
210	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
220	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
230	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
240	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
250	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
260	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
270	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
280	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
290	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
2A0	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
2B0	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
2C0	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
2D0	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
2E0	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
2F0	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	

300	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
310	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
320	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
330	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	
340	00	00	00	00	00	00	4A	2E	20	57	2E	20	00	00	00	00	
350	00	00	00	00	00	00	4C	61	6E	67	6E	65	72	20	00	00	
360	00	00	00	00	00	00	57	42	32	4F	53	5A	2F	36	20	00	
370	00	00	00	00	00	00	33	2F	34	2F	37	38	00	00	00	00	
380	00	00	00	00	00	00	42	24	18	18	24	42	00	00	00	00	x
390	00	00	00	3C	02	02	3E	42	42	42	42	42	00	00	00	00	y
3A0	00	00	00	00	00	00	7E	20	10	08	04	7E	00	00	00	00	z
3B0	00	00	00	00	00	00	00	00	00	41	6A	15	08	00	00	00	
3C0	00	00	00	00	00	00	08	08	08	08	00	08	08	08	08	00	¦
3D0	00	00	00	00	00	00	00	00	08	54	2B	41	00	00	00	00	
3E0	00	00	00	00	00	00	00	00	44	2A	11	00	00	00	00	00	~
3F0	00	00	00	00	00	00	7F	7F	7F	7F	7F	7F	7F	7F	7F	00	■

is the data in hexadecimal form, and to the right is the character formed by the data in that row.

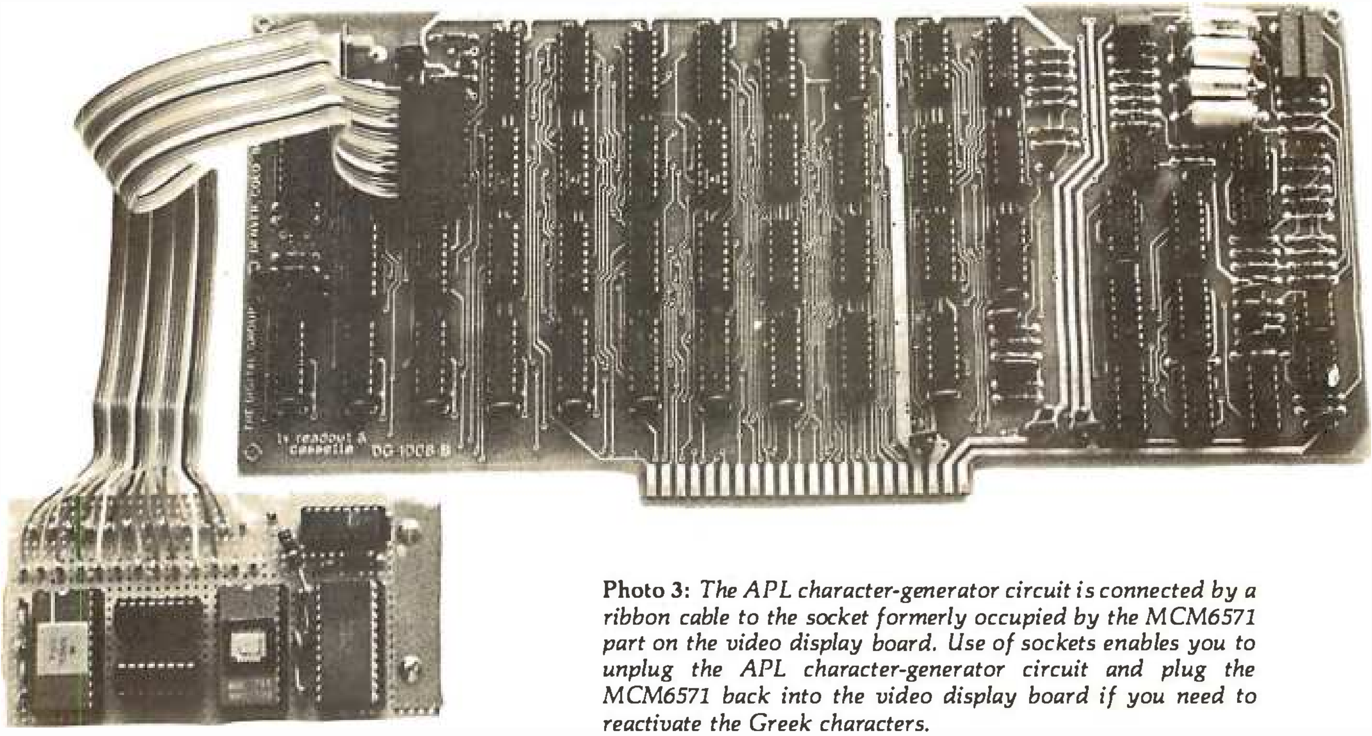


Photo 3: *The APL character-generator circuit is connected by a ribbon cable to the socket formerly occupied by the MCM6571 part on the video display board. Use of sockets enables you to unplug the APL character-generator circuit and plug the MCM6571 back into the video display board if you need to reactivate the Greek characters.*

Hexadecimal Code	Old Character	New Character	Hexadecimal Code	Old Character	New Character
00	α	→	10	ρ	←
01	β	⌽	11	σ	×
02	γ	⊥	12	τ	ρ
03	δ	⍝	13	υ	⌈
04	ε	⌊	14	φ	⍉
05	ζ	∊	15	χ	↓
06	η	⍒	16	ψ	⊗
07	θ	∇	17	ω	÷
08	ι	⍋	18	Ω	∨
09	κ	\	19	√	↑
0A	λ	∘	1A	→	∧
0B	μ	⍞	1B	←	⌹
0C	ν	⎕	1C	↑	≤
0D	ξ	⌶	1D	÷	¯
0E	ο	⊤	1E	Σ	≥
0F	π	⊙	1F	≈	≠
			60	\`	⍕
			7B	{	⍲
			7D	}	⍱

Table 2: *Table of character substitution to swap the APL characters for the Greek alphabet and other seldom-used characters in the MCM6571 character-generator chip.*

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This General Ledger system performs the essential functions of dual entry bookkeeping and matches revenues and expenses:
MICROLEDGER includes the following programs.:
LEDGER 1 - builds and maintains the CHART OF ACCOUNTS file. This file contains both current and accumulated totals for each account.
LEDGER 2 - builds and updates the JOURNAL TRANSACTION file.
LEDGER 3 - lists both the the JOURNAL file and the CHART OF ACCOUNTS.
LEDGER 4 - computes the TRIAL BALANCE and executes POSTING of journal transactions into the CHART OF ACCOUNTS. An AUDIT TRIAL of all transaction is output.
LEDGER 5 - produces the PROFIT AND LOSS STATEMENT.
LEDGER 6- produces the BALANCE SHEET. Assets, liabilities and owners' equities are shown by account and by totals. **$140.00**

MICROPAY

An Accounts Payable system, MICROPAY includes the following program & functions:
PAY 1 - initializes both Transaction and Master files, then begins the Accounts Payable process by inputting and adding records in the Transaction file.
PAY 2 - allows for changes and deletions of Transaction and Master records.
PAY 3 - reports outstanding Accounts Payables in four categories; under 30 days, 31-60 days, 61-90 days, and over 90 days.
PAY 4 - reports all outstanding Accounts Payables for a single customer or for all customers, and computes Cash Requirements.
PAY 5 - reports all outstanding Accounts Payables for a single date or for a range of dates and computes the Cash Requirements.
PAY 6 - lists both the Transactions and Master files.
PAY 7 - prints checks and accumulates and journalizes Accounts Payables. This program simultaneously creates entries for the MICROLEDGER file. **$140.00**

MICROREC

An Accounts Receivable system. MICROREC includes the following programs and functions:
REC 1 - initializes Accounts Receivable files, adds A/R record and prints invoices.
REC 2 - accepts receipt of customer payments and changes or deletions of A/R Transaction or Master file records.
REC 3 - reports outstanding Accounts Receivables in four categories; under 30 days, 31-60 days, 61-90days, and over 90 days.
REC 4 - reports all outstanding Accounts Receivables for a single customer, or for all customers and computes Cash Projections.
REC 5 - produces reports for all outstanding Accounts Receivables for a single date or for a range of dates and computes Cash projections.
REC 6 - lists Transaction and Master files and accumulates and journalizes Accounts Receivables, creating JOURNAL entries which communicate with the MICROLEDGER JOURNAL file. **$140.00**

MICROINV

This Inventory Control system presents a general method of Inventory Control and produces several important reports. Its program includes:
INV 1 - initializes Transaction and Master files and adds and updates Transaction and Master records.
INV 2 - handles inventory issued or received, creating inventory records. This program also accumulates and journalizes transactions, producing JOURNAL entries which communicate with the MICROLEDGER file.
INV 3 - lists both Transaction and Master files.
INV 4 - produces the STOCK STATUS REPORT, showing the standard inventory stock data and stock valuation, and the ABC ANALYSIS breaking down the inventory into groups by frequency of usage.
INV 5 - gives a JOB COST REPORT/MATERIALS, showing allocation of materials used year-to-date by each job or work code. (This is complemented by the Job Cost Report/Personnel in the MICROPERS program.)
INV 6 - computes and provides the E.O.Q. (Economic Order Quantities) **$140.00**

MICROPERS

This is a Payroll/Personnel program whose functions include:
PERS 1 - initializes the Master file and allows for entry and updates of Master records.
PERS 2 - initializes the Payroll file and allows for entry and updates of payroll records.
PERS 3 - lists an Employee Master Record or the entire Employee Master file; lists a single Payroll Record or the entire Payroll file.
PERS 4 - computes Payroll and prints the PAYROLL REGISTER. Prints PAYCHECKS and creates JOURNAL entries to be fed into the MICROLEDGER JOURNAL file.
PERS 5- produces the JOB COST REPORT/PERSONNEL, computes the quarterly 941 bank deposit, and the Annual W-2 run. **$140.00**

All COMPUMAX programs available in machine readable format (diskette form) for the following machines:

TRS-80™ Model I	Micropolis 1053/11
APPLE II	Microsoft under CP/M
PET	CBASIC under CP/M
	Cromemco

FROM ADVENTURE INTERNATIONAL (By Scott Adams)

† 1. **ADVENTURELAND** - You wander through an enchanted world trying to recover the 13 lost treasures. You'll encounter wild animals, magical beings, and many other perils and puzzles. Can you rescue the Blue Ox from the quicksand? Or find your way out of the maze of pits? Happy Adventuring .....

† 2. **PIRATE'S ADVENTURE** - "Yo ho ho and a bottle of rum" You'll meet up with the pirate and his daffy bird along with many strange sights as you attempt to go from your London flat to Treasure Island. Can you recover Long John Silver's lost treasures? Happy Sailing, matey .....

3. **MISSION IMPOSSIBLE ADVENTURE** - Good morning, your mission is to... and so it starts. Will you be able to complete your mission in time? Or is the world's first automated nuclear reactor doomed? This one's well named. It's hard, there is no magic, but plenty of suspense. Good luck .....

4. **VOODOO CASTLE** - Count Cristo has had a fiendish curse put on him by his enemies. There he lies, with you his only hope. Will you be able to rescue him or is he forever doomed? Beware the Voodoo Man .....

5. **THE COUNT** - You wake up in a large brass bed in a castle somewhere in Transylvani. Who are you, what are you doing here, and WHY did the postman deliver a bottle of blood? You'll love this Adventure, in fact, you might say it's Love at First Byte .....

6. **STRANGE ODYSSEY** - Marooned at the edge of the galaxy, you've stumbled on the ruins of an ancient alien civilization complete with fabulous treasures and unearthly technologies. Can you collect the treasures and return or will you end up marooned forever? .....

7. **MYSTERY FUN HOUSE** - Can you find your way completely through the strangest Fun House in existence, or will you always be kicked out when the park closes? ...

8. **PYRAMID OF DOOM** - An Egyptian Treasure Hunt leads you into the dark recesses of a recently uncovered Pyramid. Will you recover all the treasures or more likely will you join its denizens for that long eternal sleep? .....

9. **GHOST TOWN** - Explore a deserted western mining town in search of 13 treasures From rattlesnakes to runaway horses, this Adventure's got them all! Just remember, Pardner, they don't call them Ghost Towns for nothin'. (Also includes new bonus scoring system!) .... **$14.95 Per Adventure**

* **Note:** Apple requires 24K and has no lower case.
† Recommended for the novice adventurer, with many built-in HELPS!

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• Records are easily located, using the SCAN feature. SCAN for records with a field over, below, or between a range of values.
• Records are easily added and updated. DMS "prompts" you with questions.
• Multi-diskette capabilities for larger files - up to 85,000 characters per file!
• Sort the records into almost any order, using up to 10 fields as "keys". So you can sort for customer numbers; within zip code, for instance.
• Delete records, "compact" files, and backup files on data diskettes easily.

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• Print reports with records in any order.
• Select fields to be printed.
• Print mailing labels.
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Construction of a Fourth-Generation Video Terminal: Part 2

Theron Wierenga
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Last month in Part 1, I presented the first part of a complete plan for building a versatile, microprocessor-controlled video terminal. Now we'll look at the rest of the construction details.

We stopped at the point of troubleshooting the 8085 microprocessor and related circuitry. If your tests with oscilloscope and frequency counter show that everything built so far checks out properly, you can proceed with the remainder of the construction.

Getting the Debug Monitor Operating

The next step is to install the four 2114 memory circuits, IC19 (the 74LS138 that decodes the 2114s), IC13 (the 7401 that is used with the 74LS138 decoder), and IC4 and IC5 (the two 8212s that are connected back-to-back to buffer the 2114s). The 2716 must be programmed again, this time with the entire software package that is given in listing 2.

The numbering sequence of figures, listings, and photos is continued from Part 1 of this article.

Before continuing, let me define some terms that are frequently used in the next section. Figure 4 on page 128 is a block diagram relating a number of these terms.

- Host computer: the computer to which your completed video terminal will be connected. It will operate completely independently of the terminal circuitry. Communications between the host computer and the video terminal will be via a serial interface driven by UARTs.
- 8085 microprocessor: the computer that will control the internal operation of the video terminal.
- Checkout terminal: any standard computer terminal with a current-loop interface that will be used to debug your video terminal's hardware and software.
- Temporary interface: a simple circuit that must be built to temporarily connect your video terminal to the checkout terminal.
- Terminal control software: the software that directs the 8085 in the procedure of controlling the terminal. It operates the display and takes care of incoming characters and scrolling. This software resides in the 2716 programmable read-only memory.
- System monitor: a separate operating system that resides within the terminal control software. When this monitor is used, the 8085 microprocessor "abandons" the video terminal circuitry, and then behaves as a separate computer for the checkout terminal. The monitor allows the user to load and display memory locations, run simple programs, and fill and move blocks of data in the memory. The data transfer lines to the host computer are not connected when using the monitor.

Activating the Monitor

In normal operation the 8085 operates as a dedicated microprocessor. This means that the microprocessor's total job is to operate the display and process incoming characters. The 2716 programmable read-only memory can hold 2048 bytes of program code. Only about 1500 bytes are needed for the terminal control software, so a portion of the

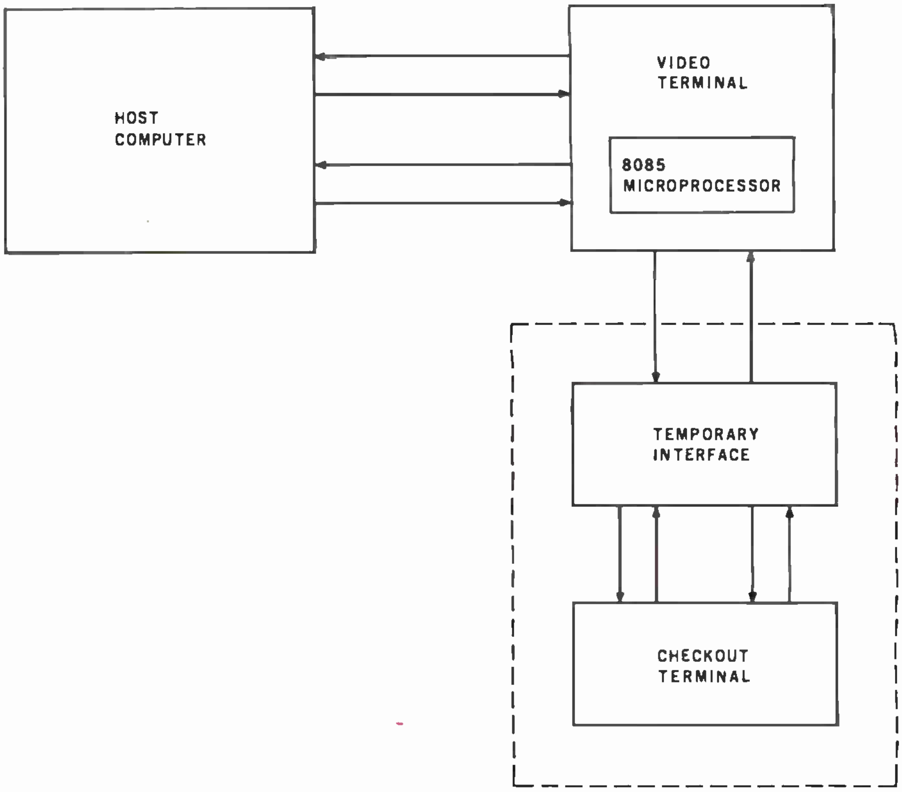


Figure 4: *Block diagram of the connection of the video terminal to the host computer. Also shown are the temporary connections to the checkout terminal, used for debugging the project.*

additional memory has been filled with a completely separate operating system which is termed the *system monitor*. By causing the 8085 microprocessor to execute a TRAP interrupt, a jump is made to the section of memory wherein the system monitor resides. In this mode the 8085 microprocessor and its associated circuitry cease to control the video terminal circuitry. The 8085 now behaves as a simple computer with a system monitor. Another terminal, the checkout terminal, is necessary to communicate with the system monitor; the temporary interface is also necessary to connect to the checkout terminal.

Construct this interface for temporary use by breadboarding. A schematic diagram was shown in figure 3, part 1. Any general-purpose computer terminal with a 20 mA current-loop interface can now be connected to your video-terminal board. The 8085 microprocessor will be acting as a computer for the checkout terminal. Be sure that the data rate is the same for both devices. If your checkout terminal runs at 110 bps, you will have to temporarily connect a 7040 Hz square wave into pins 9 and 25 of the 8251 (IC7), since this frequency is not available on the video-terminal board.

When all connections to the temporary interface are made, open the TRAP switch for a moment. The 8085 microprocessor should send a carriage return, line feed, and question mark to your checkout terminal. Next, type a letter D, and the terminal should perform a carriage return and line feed. Now type in four 0s, and it should again perform the carriage return and line feed. Lastly, type in "003F" and the checkout terminal should print out four lines of memory contents. If you get to this point, congratulate yourself, take a break, have a glass of wine, and show the family you're not as crazy as they thought you were to start this project.

If you were able to get the first test program to send out "U" characters,

Text continued on page 152:


Universal Data Systems
DATA
TALK

Listing 2: *The main video-terminal-control routine. Appended at the end is the system monitor used in the checkout procedure. This code is stored in the 2716 read-only memory. The program was modified by the author from the original routine provided by Intel Corporation.*

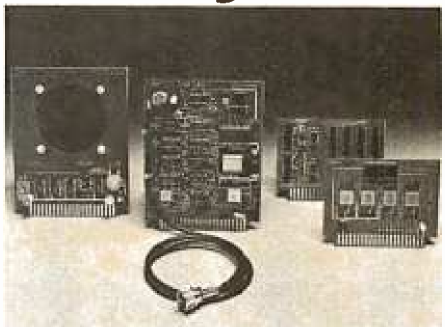
```
 C CRTLF
1
 8080 MACRO ASSEMBLER, VER 2.0  ERRORS = 0 PAGE 1


                     ;****************************************
                     ;****          CRT DRIVER           ****
                     ;****************************************
                     ;**** AS PER 'INTEL PERIPHERAL      ****
                     ;**** DESIGN HANDBOOK', PAGE 2-164. ****
                     ;**** COPYRIGHT INTEL CORP. - 1978  ****
                     ;****************************************
                     ;**** MODIFIED BY THERON WIERENGA   ****
                     ;**** JANUARY 10, 1979              ****
                     ;****************************************
 0001                CNCTL  EQU  0001H
 0000                CNIN   EQU  0000H
 0000                CNOUT  EQU  0000H      ;8251 OUPUT DATA ADD
 0061                KCOM   EQU  061H       ;8279 COMMAND ADD
 0060                KDAT   EQU  060H       ;8279 DATA ADDRESS
 0051                CRCOM  EQU  051H       ;8275 COMMAND ADD
 0050                CRDAT  EQU  050H       ;8275 DATA ADDRESS
 0044                PC2SA  EQU  044H       ;8257 CH 2 START ADD
 0045                PC2TC  EQU  045H       ;8257 CH 2 TERM COUNT
 0046                PC3SA  EQU  046H       ;8257 CH 3 START ADD
 0047                PC3TC  EQU  047H       ;8257 CH 3 TERM COUNT
 0000                MDC57  EQU  0          ;8257 MODE CLEAR
 0084                MDS57  EQU  084H       ;8257 MODE SET
 0048                PMD57  EQU  048H       ;8257 MODE SET
                     ;***************************************************
                     ; COLD START
                     ;
 0000  C34000               JMP  CRTGO      ;JUMP TO START OF PROGRAM
 0024                       ORG  0024H
 0024  C3E905               JMP  SSS2       ;TRAP TO MONITOR
 0040                       ORG  0040H
 0040  31FF87        CRTGO: LXI  SP,87FFH   ;LOAD STACK POINTER
                     ;
                     ; CLEAR MEMORY
                     ;
 0043  21FF7F               LXI  H,7FFFH    ;LOAD SCREEN START-1
 0046  23            ALPHA: INX  H          ;INCREMENT ADDRESS
 0047  3620                 MVI  M,020H     ;LOAD A SPACE
 0049  7D                   MOV  A,L        ;CHECK IF L=CF
 004A  FECF                 CPI  0CFH
 004C  C24600               JNZ  ALPHA      ;IF NOT LOOP
 004F  7C                   MOV  A,H        ;CHECK IF H=87
 0050  FE87                 CPI  087H
 0052  C24600               JNZ  ALPHA      ;IF NOT LOOP,ELSE DONE
                     ;
                     ; POINTER/BUFFER CLEAR
                     ;
 0055  210000        NXT2:  LXI  H,0
 0058  22D387               SHLD RCTAD      ;ZERO ROW COUNT
 005B  22E287               SHLD LOCBUF     ;ZERO BUFFER
 005E  22D887               SHLD LOCAD      ;ZERO CHAR. LOCATION
1
 8080 MACRO ASSEMBLER, VER 2.0  ERRORS = 0 PAGE 2
 0061  22DA87               SHLD LOC01      ;ZERO 1ST CHAR IN ROW
 0064  22DC87               SHLD LOC80      ;ZERO 80TH CHAR IN ROW
 0067  22DE87               SHLD LOCXX      ;ZERO LOC OF 1ST CHAR
 006A  22E087               SHLD LOCPR      ;ZERO LOC OF 1ST CHAR
 006D  210080               LXI  H,8000H    ;POINT TO TOP OF SCREEN
 0070  22D687               SHLD TOPAD      ;SET TOP=8000H
 0073  218087               LXI  H,8780H    ;POINT TO BOT OF SCREEN
 0076  22E687               SHLD BOTAD      ;SET BOT=8780H
 0079  3E00                 MVI  A,0
 007B  32D287               STA  CCTAD      ;ZERO COLUMN COUNT
 007E  32D587               STA  CURSY      ;SET CURSOR Y POINTER
 0081  32E487               STA  XFLG       ;ZERO ESC SEQ FLAG
 0084  32E587               STA  USCHR      ;ZERO 8251 CHAR BUFF
                     ;
                     ; INITIALIZE 8251
                     ;
 0087  3E7B                 MVI  A,07BH
 0089  D301                 OUT  CNCTL
 008B  3E27                 MVI  A,027H
 008D  D301                 OUT  CNCTL
                     ;
                     ; INITIALIZE 8279
                     ;
 008F  3E3F                 MVI  A,03FH     ;DIVIDE BY 31
 0091  D361                 OUT  KCOM
                     ;
                     ; INITIALIZE 8275
                     ;
 0093  3E00                 MVI  A,0        ;RESET & STOP DISPLAY
 0095  D351                 OUT  CRCOM
 0097  3E4F                 MVI  A,04FH     ;SCREEN PARAM BYTE 1
 0099  D350                 OUT  CRDAT
 009B  3E58                 MVI  A,058H     ;SCREEN PARAM BYTE 2
 009D  D350                 OUT  CRDAT
 009F  3E89                 MVI  A,089H     ;SCREEN PARAM BYTE 3
 00A1  D350                 OUT  CRDAT
 00A3  3E59                 MVI  A,059H     ;SCREEN PARAM BYTE 4
 00A5  D350                 OUT  CRDAT
 00A7  3E80                 MVI  A,080H     ;CURSOR POSITION
 00A9  D351                 OUT  CRCOM
 00AB  3E00                 MVI  A,0        ;X CURSOR POSITION
 00AD  D350                 OUT  CRDAT
 00AF  3E00                 MVI  A,0        ;Y CURSOR POSITION
 00B1  D350                 OUT  CRDAT
 00B3  3EE0                 MVI  A,0E0H     ;PRESET COUNTERS
 00B5  D351                 OUT  CRCOM
 00B7  3E23                 MVI  A,023H     ;START DISPLAY
 00B9  D351                 OUT  CRCOM
 00BB  CD6704               CALL RT75       ;SET UP 8257
 00BE  DB01          LOOP:  IN   CNCTL      ;CHECK FOR CHAR REC.
 00C0  E602                 ANI  002H
1
 8080 MACRO ASSEMBLER, VER 2.0  ERRORS = 0 PAGE 3


 00C2  C4D200               CNZ  AGGIE      ;READ CHAR IN 8251
 00C5  DB51                 IN   CRCOM      ;READ 8275 STATUS
```

Listing 2 continued on page 132

The VP-111 hobby computer: Start programming for only $99.



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Circle 88 on inquiry card.

Listing 2 continued from page 130:

```
00C7    E620             ANI  020H       ;MASK INTERUPT BIT
00C9    C46704           CNZ  RT75       ;SERVICE 8257 IF INT
00CC    CDA004           CALL KPOLL      ;CHECK FOR KEYPRESS
00CF    C3BE00           JMP  LOOP
                 ;
                 ; SERVICE 8251 AND ENTER CHAR INTO DISPLAY
                 ;
00D2    CDD900   AGGIE:  CALL RDF51      ;READ 8251
00D5    CDE100           CALL CHREC      ;CHAR HANDLING ROUTINE
00D8    C9               RET
                 ;
                 ; 8251 READ CHAR SUBROUTINE
                 ;
00D9    DB00     RDF51:  IN   CNIN       ;IN CHAR FROM 8251
00DB    E67F             ANI  07FH       ;MASK OFF BIT 8
00DD    32E587           STA  USCHR      ;STORE THE CHAR
00E0    C9               RET
                 ;
                 ; CHARACTER HANDLING ROUTINE
                 ;
00E1    3AE487   CHREC:  LDA  XFLG       ;LOAD ESC FLAG
00E4    E6FF             ANI  0FFH       ;SET/RESET ZERO FLAG
00E6    CAED00           JZ   NXTX       ;1=2ND CHAR ESC SEQ
00E9    CD0B01           CALL ESREC      ;ESC SEQ ROUTINE
00EC    C9               RET
00ED    3AE587   NXTX:   LDA  USCHR      ;LOAD UART CHAR
00F0    E660             ANI  060H       ;MASK ALL BUT BIT 6&7
00F2    CAF900           JZ   NXTY       ;0=CTRL,1=DISPLAY CHAR
00F5    CD4103           CALL DISPL      ;DISPLAY CHAR ROUTINE
00F8    C9               RET
00F9    3AE587   NXTY:   LDA  USCHR      ;LOAD UART CHAR
00FC    E610             ANI  010H       ;MASK ALL BUT BIT 5
00FE    C20501           JNZ  NXTZ       ;0=CTRL,1=ESC SEQ
0101    CD2301           CALL CNTRL      ;CTRL CODE ROUTINE
0104    C9               RET
0105    21E487   NXTZ:   LXI  H,XFLG     ;POINT TO ESC FLAG
0108    3601             MVI  M,1        ;SET ESC SEQ FLAG
010A    C9               RET
                 ;
                 ; ESCAPE SEQUENCE ROUTINE
                 ;
010B    3E00     ESREC:  MVI  A,0        ;ZERO A
010D    32E487           STA  XFLG       ;RESET ESC FLAG
0110    3AE587           LDA  USCHR      ;LOAD UART CHAR
0113    E60F             ANI  00FH       ;MASK OFF HIGH 4 BITS
0115    07               RLC             ;SHIFT L FOR OFFSET
0116    21C104           LXI  H,BSET1    ;BASE ADD TABLE 1
0119    110000           LXI  D,0
011C    5F               MOV  E,A        ;MOVE OFFSET TO DE
1
 8080 MACRO ASSEMBLER, VER 2.0   ERRORS = 0 PAGE 4


011D    19               DAD  D          ;ADD OFFSET TO BASE
011E    5E               MOV  E,M        ;LOAD VECTOR IN DE
011F    23               INX  H
0120    56               MOV  D,M
0121    EB               XCHG            ;VECTOR TO HL
0122    E9               PCHL            ;VECTOR TO PC
                 ; CONTROL CODE ROUTINE
                 ;
0123    3AE587   CNTRL:  LDA  USCHR      ;LOAD UART CHAR
0126    E606             ANI  006H       ;SAVE BITS 2+3
0128    21E104           LXI  H,BSET2    ;BASE ADD TABLE 2
012B    110000           LXI  D,0
012E    5F               MOV  E,A        ;MOVE OFFSET TO DE
012F    19               DAD  D          ;ADD OFFSET TO BASE
0130    5E               MOV  E,M        ;LOAD VECTOR IN DE
0131    23               INX  H
0132    56               MOV  D,M
0133    EB               XCHG            ;VECTOR TO HL
0134    E9               PCHL            ;VECTOR TO PC
                 ;
                 ; CURSOR UP ROUTINE
                 ;
0135    2AD387   ESCA:   LHLD RCTAD      ;LOAD ROWCOUNT IN HL
0138    7D               MOV  A,L        ;LOW BYTE TO A
0139    FE00             CPI  0          ;IS IT ZERO?
013B    CA4201           JZ   ALPH       ;IF ZERO CONTINUE
013E    CDFE02           CALL ROWUP
0141    C9               RET
0142    7C       ALPH:   MOV  A,H        ;HIGH BYTE IN A
0143    FE00             CPI  0          ;IS IT ZERO?
0145    CA4C01           JZ   BETA       ;IF 0,ROW=1ST ROW
0148    CDFE02           CALL ROWUP
014B    C9               RET
014C    218007   BETA:   LXI  H,0780H    ;ROWCOUNT=LAST ROW
                                         ;(1920 DECIMAL)
014F    22D387           SHLD RCTAD      ;STORE IN ROWCNT BUFF
0152    3E18             MVI  A,018H     ;18H TO CURS Y BUFF
0154    32D587           STA  CURSY      ;CURSOR Y-POS=LAST ROW
0157    CD3203           CALL WP75       ;LOAD CURSOR POS SUB
015A    C9               RET
                 ;
                 ; CURSOR DOWN ROUTINE
                 ;
015B    2AD387   ESCB:   LHLD RCTAD      ;ROWCOUNT TO HL
015E    7D               MOV  A,L        ;LOW BYTE TO A
015F    FE80             CPI  080H       ;IS IT 80H ?
0161    CA6801           JZ   GAMMA      ;IF BYTE=80H THEN CONTINUE
0164    CD1003           CALL ROWDN      ;ROWDOWN SUB.
0167    C9               RET
0168    7C       GAMMA:  MOV  A,H        ;HIGH BYTE TO A
1
 8080 MACRO ASSEMBLER, VER 2.0   ERRORS = 0 PAGE 5


0169    FE07             CPI  007H       ;IS IT 7 ?
016B    CA7201           JZ   DELTA      ;IF=7,ROWCNT.=LAST ROW
016E    CD1003           CALL ROWDN      ;ROWDOWN SUB.
0171    C9               RET
0172    CD3203   DELTA:  CALL WP75       ;CURSOR POS ROUTINE
0175    CDFF03           CALL SCROL      ;SCROLL SUBROUTINE
0178    C9               RET
                 ;
                 ;CURSOR RIGHT ROUTINE
                 ;
0179    3AD287   ESCC:   LDA  CCTAD      ;COL.CNT. TO A
017C    FE4F             CPI  04FH       ;IS IT 4FH ?
017E    CA8501           JZ   ZETA       ;IF=4FH COL. CNT =
```

Listing 2 continued on page 134

Circle 87 on inquiry card.

Listing 2 continued from page 132:

```
                                        ;LAST CHAR IN ROW
0181   CD2A03          CALL  COLRT      ;COL. RIGHT SUB.
0184   C9              RET
0185   2AD387  ZETA:   LHLD  RCTAD      ;ROWCOUNT TO HL
0188   7D              MOV   A,L        ;LOW BYTE TO A
0189   FE80            CPI   080H       ;IS IT 80H ?
018B   C29401          JNZ   CCTOA      ;IF=80H CONTINUE
018E   7C              MOV   A,H        ;HIGH BYTE TO A
018F   FE07            CPI   007H       ;IS IT 7 ?
0191   CA9D01          JZ    CCTOB      ;IF 7,ROWCNT.=LAST ROW
0194   3E00    CCTOA:  MVI   A,0
0196   32D287          STA   CCTAD      ;ZERO COL. CNT. BUF
0199   CD1003          CALL  ROWDN      ;ROWDOWN SUBROUTINE
019C   C9              RET
019D   3E00    CCTOB:  MVI   A,0
019F   32D287          STA   CCTAD      ;ZERO COL. CNT. BUF
01A2   CD3203          CALL  WP75       ;CURSOR POS. ROUTINE
01A5   CDFF03          CALL  SCROL      ;SCROLL ROUTINE
01A8   C9              RET
               ;
               ; CURSOR LEFT ROUTINE
               ;
01A9   3AD287  ESCD:   LDA   CCTAD      ;COL. CNT. TO A
01AC   FE00            CPI   0          ;IS IT ZERO ?
01AE   CAB501          JZ    NXTA       ;IF=0 COL. CNT.=
                                        ;1ST CHAR IN ROW
01B1   CD2203          CALL  COLLT      ;COLUMN LEFT SUB.
01B4   C9              RET
01B5   2AD387  NXTA:   LHLD  RCTAD      ;ROWCOUNT TO HL
01B8   7D              MOV   A,L        ;LOW BYTE TO A
01B9   FE00            CPI   0          ;IS IT ZERO ?
01BB   C2C401          JNZ   CCTMA      ;IF BYTE=0 CONTINUE
01BE   7C              MOV   A,H        ;HIGH ROWCNT. TO A
01BF   FE00            CPI   0          ;IS IT ZERO ?
01C1   CACD01          JZ    CCTMB      ;IF 0,HOME POS EXISTS
01C4   3E4F    CCTMA:  MVI   A,04FH     ;SET COLUMN COUNT
01C6   32D287          STA   CCTAD      ;TO 4FH
01C9   CDFE02          CALL  ROWUP      ;CALL ROWUP ROUTINE
1
8080 MACRO ASSEMBLER, VER 2.0   ERRORS = 0 PAGE 6

01CC   C9              RET
01CD   218007  CCTMB:  LXI   H,0780H    ;ROWCNT. = 780H
01D0   22D387          SHLD  RCTAD      ;(1920D)
01D3   3E4F            MVI   A,04FH     ;SET COLUMN COUNT
01D5   32D287          STA   CCTAD      ;TO 4FH
01D8   3E18            MVI   A,018H     ;LOAD CURSOR WITH
01DA   32D587          STA   CURSY      ;18H=24D,LAST LINE
01DD   CD3203          CALL  WP75       ;LOAD CURSOR ROUTINE
01E0   C9              RET
               ;
               ; HOME ROUTINE
               ;
01E1   210000  ESCH:   LXI   H,0        ;ZERO HL
01E4   22D387          SHLD  RCTAD      ;SET ROWCOUNT=0
01E7   3E00            MVI   A,0        ;ZERO A
01E9   32D287          STA   CCTAD      ;COLUMN CNT.=0
01EC   32D587          STA   CURSY      ;CURSOR Y PNTR=0
01EF   CD3203          CALL  WP75       ;LOAD CURSOR ROUTINE
01F2   C9              RET
               ;
               ; ERASE LINE ROUTINE
               ;
01F3   2AD687  ESCK:   LHLD  TOPAD      ;LOAD TOP IN HL
01F6   EB              XCHG             ;MOVE TO DE
01F7   2AD387          LHLD  RCTAD      ;ROWCOUNT IN HL
01FA   19              DAD   D          ;TOP+ROWCOUNT
01FB   22DE87          SHLD  LOCXX      ;STORE RESULT
01FE   3E87            MVI   A,087H     ;87H TO A
0200   BC              CMP   H          ;COMPARE TO 87H
0201   D20A02          JNC   FRODO      ;NO CARRY=CONT.
0204   CD2002          CALL  COMRX      ;COMPENSATION ROUT.
0207   C31602          JMP   BILBO
020A   C21602  FRODO:  JNZ   BILBO      ;IF NO 0 END COMPARE
020D   3ECF            MVI   A,0CFH     ;CFH TO A
020F   BD              CMP   L          ;COMPARE TO CFH
0210   D21602          JNC   BILBO      ;IF NC,LOCXX<=87CFH
0213   CD2002          CALL  COMRX      ;IF C,COMPENSATE
0216   2ADE87  BILBO:  LHLD  LOCXX      ;LOCXX TO HL
0219   22E287          SHLD  LOCBUF     ;STORE IN BUFFER
021C   CD2604          CALL  FILL       ;FILL ROW WITH SPACES
021F   C9              RET
               ;
               ; COMPENSATION ROUTINE
               ;
0220   2ADE87  COMRX:  LHLD  LOCXX      ;LOCXX TO HL
0223   1130F8          LXI   D,0F830H   ;COMP VALUE TO DE
0226   19              DAD   D          ;SUM THE TWO
0227   22DE87          SHLD  LOCXX      ;STORE SUM
022A   C9              RET
               ;
               ; CLEAR SCREEN ROUTINE
1
8080 MACRO ASSEMBLER, VER 2.0   ERRORS = 0 PAGE 7
               ;
022B   3EF0    ESCE:   MVI   A,0F0H     ;EOR CHAR. TO A
022D   0619            MVI   B,019H     ;25 LINES TO B
022F   115000          LXI   D,050H     ;80 CHAR LINE TO DE
0232   210080          LXI   H,8000H    ;STARTING ADDRESS
0235   77      LOADX:  MOV   M,A        ;EOR CHAR. TO MEM.
0236   19              DAD   D          ;ADD 80 TO HL
0237   05              DCR   B          ;DEC LINE COUNT
0238   C23502          JNZ   LOADX      ;LOOP
023B   210000          LXI   H,0        ;ZERO HL
023E   22D387          SHLD  RCTAD      ;ZERO ROWCOUNT
0241   210080          LXI   H,8000H    ;BEGIN ADDRESS
0244   22D687          SHLD  TOPAD
0247   218087          LXI   H,8780H    ;END ADDRESS
024A   22E687          SHLD  BOTAD
024D   3E00            MVI   A,0        ;ZERO A
024F   32D287          STA   CCTAD      ;ZERO COLUMN COUNT
0252   32D587          STA   CURSY      ;ZERO CURSOR Y POS
0255   32E487          STA   XFLG       ;ZERO ESC SEQ FLAG
0258   CD3203          CALL  WP75       ;LOAD CURSOR POS
025B   C9              RET
               ;
               ; ERASE TO END OF SCREEN ROUTINE
               ;
025C   2AD687  ESCJ:   LHLD  TOPAD      ;TOP TO HL
025F   EB              XCHG             ;MOVE TO DE
0260   2AD387          LHLD  RCTAD      ;ROW COUNT TO HL
```

Listing 2 continued on page 136

Listing 2 continued from page 134:

```
0263    19                  DAD  D           ;SUM=POS OF 1ST CHAR
                                             ;IN PRESENT ROW
0264    22E087              SHLD LOCPR       ;STORE IN MEM
0267    3E87                MVI  A,087H      ;87H TO A
0269    BC                  CMP  H           ;COMPARE TO 87H
026A    D27302              JNC  VAR         ;NC=CONT COMPARE
026D    CDE402              CALL COMRY       ;COMPENSATE ROUTINE
0270    C37F02              JMP  FIN
0273    C27F02      VAR:    JNZ  FIN         ;IF NE END COMPARE
0276    3ECF                MVI  A,0CFH      ;CFH TO A
0278    BD                  CMP  L           ;COMPARE TO LOW BYTE
0279    D27F02              JNC  FIN         ;NC MEANS <= 87CFH
027C    CDE402              CALL COMRY       ;COMPENSATION ROUT.
027F    2AD687      FIN:    LHLD TOPAD       ;TOP TO HL
0282    7D                  MOV  A,L         ;LOW BYTE TO A
0283    FE00                CPI  0           ;IS IT ZERO?
0285    C29702              JNZ  TROLL       ;IF NOT TO TROLL
0288    7C                  MOV  A,H         ;HIGH BYTE TO A
0289    FE80                CPI  080H        ;IS IT 80H ?
028B    C29702              JNZ  TROLL       ;IF NOT TO TROLL
028E    218087              LXI  H,8780H     ;BOTTOM=8780H
0291    22E687              SHLD BOTAD       ;STORE IN MEM
0294    C3A102              JMP  GNOME       ;JUMP TO GNOME
0297    11B0FF      TROLL:  LXI  D,0FFB0H    ;-80D TO DE
1
 8080 MACRO ASSEMBLER, VER 2.0  ERRORS = 0 PAGE 8


029A    2AD687              LHLD TOPAD       ;STORE IN MEM
029D    19                  DAD  D           ;ADD -80D TO TOP
029E    22E687              SHLD BOTAD       ;STORE IN MEM
02A1    3EF0        GNOME:  MVI  A,0F0H      ;EOR CHAR TO A
02A3    2AE087              LHLD LOCPR       ;LOCPR TO HL
02A6    77                  MOV  M,A         ;EOR CHAR TO MEM
02A7    7D                  MOV  A,L         ;LOW BYTE TO A
02A8    FE80                CPI  080H        ;IS IT 80H ?
02AA    C2CB02              JNZ  WIZAR       ;IF NOT TO WIZAR
02AD    7C                  MOV  A,H         ;HIGH BYTE TO A
02AE    FE87                CPI  087H        ;IS IT 87H ?
02B0    C2CB02              JNZ  WIZAR       ;IF NOT TO WIZAR
02B3    EB          GZONK:  XCHG             ;PRESENT LOC TO DE
02B4    2AE687              LHLD BOTAD       ;BOTTOM TO HL
02B7    7D                  MOV  A,L         ;LOW BYTE TO A
02B8    BB                  CMP  E           ;DOES E=A
02B9    C2C202              JNZ  FUN         ;IF NOT TO FUN
02BC    7C                  MOV  A,H         ;HIGH BYTE TO A
02BD    BA                  CMP  D           ;DOES D=A
02BE    C2C202              JNZ  FUN         ;IF NOT TO FUN
02C1    C9                  RET
02C2    210080      FUN:    LXI  H,8000H     ;8000H TO HL
02C5    22E087              SHLD LOCPR       ;SET POCPR TO 8000H
02C8    C3A102              JMP  GNOME       ;LOOP
02CB    EB          WIZAR:  XCHG             ;LOCPR TO DE
02CC    2AE687              LHLD BOTAD       ;BOTTOM TO HL
02CF    7D                  MOV  A,L         ;LOW BYTE TO A
02D0    BB                  CMP  E           ;DOES E=A
02D1    C2DA02              JNZ  NUF         ;IF NOT TO NUF
02D4    7C                  MOV  A,H         ;HIGH BYTE TO A
02D5    BA                  CMP  D           ;DOES D=A
02D6    C2DA02              JNZ  NUF         ;IF NOT TO NUF
02D9    C9                  RET
02DA    215000      NUF:    LXI  H,050H      ;LOAD 80D IN HL
02DD    19                  DAD  D           ;ADD 80D TO LOCPR
02DE    22E087              SHLD LOCPR       ;STORE SUM IN MEM
02E1    C3A102              JMP  GNOME       ;LOOP
                    ;
                    ; COMPENSATION ROUTINE
                    ;
02E4    2AE087      COMRY:  LHLD LOCPR       ;LOCPR TO HL
02E7    1130F8              LXI  D,0F830H    ;COMP VALUE TO DE
02EA    19                  DAD  D           ;ADD COMP TO LOCPR
02EB    22E087              SHLD LOCPR       ;STORE IN MEM
02EE    C9                  RET
                    ;
                    ; LINE FEED ROUTINE
                    ;
02EF    C35B01      CTRLJ:  JMP  ESCB        ;CURSOR DOWN 1 LINE
                    ;
                    ; CARRIAGE RETURN ROUTINE
1
 8080 MACRO ASSEMBLER, VER 2.0  ERRORS = 0 PAGE 9


                    ;
02F2    3E00        CTRLM:  MVI  A,0         ;ZERO A
02F4    32D287              STA  CCTAD       ;COLUMN CNT. = 0
02F7    CD3203              CALL WP75        ;LOAD CURSOR POS.
02FA    C9                  RET
                    ;
                    ; BACK SPACE ROUTINE
                    ;
02FB    C3A901      CTRLH:  JMP  ESCD        ;MOVE CURSOR LEFT 1
                    ;
                    ; ROWUP ROUTINE
                    ;
02FE    2AD387      ROWUP:  LHLD RCTAD       ;ROWCOUNT TO HL
0301    11B0FF              LXI  D,0FFB0H    ;-80D TO DE
0304    19                  DAD  D           ;ADD -80D TO ROWCOUNT
0305    22D387              SHLD RCTAD       ;STORE IN MEM
0308    21D587              LXI  H,CURSY     ;CURSOR Y TO HL
030B    35                  DCR  M           ;DECREMENT CURS Y
030C    CD3203              CALL WP75        ;LOAD CURSOR POS
030F    C9                  RET
                    ;
                    ; ROWDOWN ROUTINE
                    ;
0310    2AD387      ROWDN:  LHLD RCTAD       ;ROWCOUNT TO HL
0313    115000              LXI  D,050H      ;+80D TO DE
0316    19                  DAD  D           ;ADD +80D TO ROWCOUNT
0317    22D387              SHLD RCTAD       ;STORE IN MEM
031A    21D587              LXI  H,CURSY     ;CURSOR Y TO HL
031D    34                  INR  M           ;INCREMENT CURS Y
031E    CD3203              CALL WP75        ;LOAD CURSOR POS
0321    C9                  RET
                    ;
                    ; COLUMN LEFT ROUTINE
                    ;
0322    21D287      COLLT:  LXI  H,CCTAD     ;COL CNT TO HL
0325    35                  DCR  M           ;DCR COL COUNT
0326    CD3203              CALL WP75        ;LOAD CURSOR POS
0329    C9                  RET
```

Listing 2 continued on page 138

Listing 2 continued from page 136:

```
                        ; COLUMN RIGHT ROUTINE
                        ;
032A    21D287          COLRT: LXI  H,CCTAD     ;COL CNT TO HL
032D    34                     INR  M           ;INR COL COUNT
032E    CD3203                 CALL WP75        ;LOAD CURSOR POS
0331    C9                     RET
                        ;
                        ; LOAD CURSOR POSITION ROUTINE
                        ;
0332    3E80            WP75:  MVI  A,080H      ;LOAD CUR POS COMMAND
0334    D351                   OUT  CRCOM
0336    3AD287                 LDA  CCTAD       ;A=CURSOR X POSITION
1
8080 MACRO ASSEMBLER, VER 2.0   ERRORS = 0 PAGE 10


0339    D350                   OUT  CRDAT
033B    3AD587                 LDA  CURSY       ;A=CURSOR Y POSITION
033E    D350                   OUT  CRDAT
0340    C9                     RET
                        ;
                        ; DISPLAY CHAR HANDLING ROUTINE
                        ;
0341    3AD287          DISPL: LDA  CCTAD       ;COLUMN CNT TO A
0344    FE4F                   CPI  04FH        ;DOES IT = 79D
0346    CA5003                 JZ   CTA         ;IF 79D, LAST CHAR
                                                ;IN THE ROW
0349    CD7403                 CALL DIS1
034C    CDB103                 CALL DISA
034F    C9                     RET
0350    2AD387          CTA:   LHLD RCTAD       ;ROWCOUNT TO HL
0353    7D                     MOV  A,L         ;LOW BYTE TO A
0354    FE80                   CPI  080H        ;IS IT 80H ?
0356    CA6003                 JZ   CTB         ;IF=80H CONT COMPARE
0359    CD7403                 CALL DIS1
035C    CDB903                 CALL DISB
035F    C9                     RET
0360    7C              CTB:   MOV  A,H         ;HIGH BYTE TO A
0361    FE07                   CPI  007H        ;IS IT 7 ?
0363    CA6D03                 JZ   CTC         ;IF=7,END OF DISPLAY
0366    CD7403                 CALL DIS1
0369    CDB903                 CALL DISB
036C    C9                     RET
036D    CD7403          CTC:   CALL DIS1
0370    CDD003                 CALL DISC
0373    C9                     RET
                        ;
                        ; SUBROUTINE DIS1
                        ;
0374    2AD687          DIS1:  LHLD TOPAD       ;TOPAD TO HL
0377    EB                     XCHG             ;MOVE IT TO DE
0378    2AD387                 LHLD RCTAD       ;ROWCOUNT TO HL
037B    19                     DAD  D           ;ADD TOP AND ROWCNT
037C    22DA87                 SHLD LOC01       ;STORE LOC OF 1ST
                                                ;CHAR IN ROW
037F    EB                     XCHG             ;MOVE TO DE
0380    210000                 LXI  H,0         ;ZERO HL
0383    3AD287                 LDA  CCTAD       ;COLUMN CNT TO A
0386    6F                     MOV  L,A         ;MOVE TO L
0387    19                     DAD  D           ;LOC=TOP+ROWCNT+COLCNT
0388    22D887                 SHLD LOCAD       ;STORE IN MEM
038B    3E87                   MVI  A,087H      ;87H TO A
038D    BC                     CMP  H           ;IS H 87H ?
038E    D29703                 JNC  NXTCM       ;NC=CONTINUE COMPARE
0391    CDDC03                 CALL COMRT       ;COMPENSATE ROUTINE
0394    C3A303                 JMP  XSTAD       ;JUMP OVER
0397    C2A303          NXTCM: JNZ  XSTAD       ;NE,END COMPARE
1
8080 MACRO ASSEMBLER, VER 2.0   ERRORS = 0 PAGE 11


039A    3ECF                   MVI  A,0CFH      ;CFH TO A
039C    BD                     CMP  L           ;IS L=CFH
039D    D2A303                 JNC  XSTAD       ;NC=LOC<=87CFH
03A0    CDDC03                 CALL COMRT       ;IF CARRY COMPENSATE
03A3    CDF103          XSTAD: CALL EORT        ;END OF ROW CHAR TEST
03A6    21E587                 LXI  H,USCHR     ;UART CHAR ADD TO HL
03A9    7E                     MOV  A,M         ;UART CHAR TO A
03AA    E63F                   ANI  03FH        ;MASK UPPER 2 BITS
03AC    2AD887                 LHLD LOCAD       ;LOCATION TO HL
03AF    77                     MOV  M,A         ;MOV TO LOC IN DISP
03B0    C9                     RET
                        ;
                        ; SUBROUTINE DISA
                        ;
03B1    21D287          DISA:  LXI  H,CCTAD     ;COL CNT ADD TO HL
03B4    34                     INR  M           ;INC COL COUNT
03B5    CD3203                 CALL WP75        ;LOAD CURSOR POS
03B8    C9                     RET
                        ;
                        ; SUBROUTINE DISB
                        ;
03B9    3E00            DISB:  MVI  A,0         ;ZERO A
03BB    32D287                 STA  CCTAD       ;ZERO COLUMN CNT
03BE    2AD387                 LHLD RCTAD       ;ROWCOUNT TO HL
03C1    115000                 LXI  D,050H      ;80D TO DE
03C4    19                     DAD  D           ;ADD 80D TO ROWCOUNT
03C5    22D387                 SHLD RCTAD       ;STORE IN MEM
03C8    21D587                 LXI  H,CURSY     ;CURSOR Y ADD TO HL
03CB    34                     INR  M           ;INC CURSOR Y
03CC    CD3203                 CALL WP75        ;LOAD CURSOR POS
03CF    C9                     RET
                        ;
                        ; SUBROUTINE DISC
                        ;
03D0    3E00            DISC:  MVI  A,0         ;ZERO A
03D2    32D287                 STA  CCTAD       ;ZERO COLUMN CNT
03D5    CD3203                 CALL WP75        ;LOAD CURSOR POS
03D8    CDFF03                 CALL SCROL
03DB    C9                     RET
                        ;
                        ; ADDRESS COMPENSATION ROUTINE
                        ;
03DC    2AD887          COMRT: LHLD LOCAD       ;CHAR LOCATION
03DF    1130F8                 LXI  D,0F830H    ;COMP VALUE TO DE
03E2    19                     DAD  D           ;ADD TO LOCATION
03E3    22D887                 SHLD LOCAD       ;STORE IN MEM
03E6    2ADA87                 LHLD LOC01       ;LOC OF 1ST CHAR
03E9    1130F8                 LXI  D,0F830H    ;COMP VALUE TO DE
03EC    19                     DAD  D           ;ADD TO LOCATION
03ED    22DA87                 SHLD LOC01       ;STORE IN MEM
03F0    C9                     RET
```

```
1
8080 MACRO ASSEMBLER, VER 2.0   ERRORS = 0 PAGE 12
                        ;
                        ; END OF ROW TEST ROUTNE
                        ;
03F1   2ADA87   EORT:   LHLD LOC01       ;LOC OF 1ST CHAR
03F4   7E               MOV  A,M         ;1ST CHAR TO A
03F5   FEF0             CPI  0F0H        ;END OF ROW CHAR ?
03F7   C0               RNZ              ;IF NOT EXIT
03F8   22E287           SHLD LOCBUF      ;STORE 1ST CHAR ADD
03FB   CD2604           CALL FILL        ;FILL ROW WITH SPACES
03FE   C9               RET
                        ;
                        ; SCROLL SUBROUTINE
                        ;
03FF   2AD687   SCROL:  LHLD TOPAD       ;TOP TO HL
0402   22E287           SHLD LOCBUF      ;STORE 1ST CHAR ADD
0405   CD2604           CALL FILL        ;FILL ROW WITH SPACES
0408   2AD687           LHLD TOPAD       ;TOP TO HL
040B   7D               MOV  A,L         ;LOW BYTE TO A
040C   FE80             CPI  080H        ;IS IT 80H ?
040E   C21E04           JNZ  DUCK        ;IF NOT CONTINUE
0411   7C               MOV  A,H         ;HIGH BYTE TO A
0412   FE87             CPI  087H        ;IS IT 87H ?
0414   C21E04           JNZ  DUCK        ;IF NOT CONTINUE
0417   210080           LXI  H,8000H     ;IF 8087 TOP=8000H
041A   22D687           SHLD TOPAD       ;STORE IN MEM
041D   C9               RET
041E   115000   DUCK:   LXI  D,050H      ;80D TO DE
0421   19               DAD  D           ;ADD 80D TO TOP
0422   22D687           SHLD TOPAD       ;STORE IN MEM
0425   C9               RET
                        ;
                        ; FILL SUBROUTINE
                        ;
0426   2AE287   FILL:   LHLD LOCBUF      ;1ST CHAR IN ROW
0429   115000           LXI  D,050H      ;LOAD 80D IN'DE
042C   19               DAD  D           ;ADD 80D TO 1ST CHAR
042D   22DC87           SHLD LOC80       ;STORE IN MEM
0430   012020           LXI  B,2020H     ;SPACES IN BC
0433   210000           LXI  H,0         ;ZERO HL
0436   39               DAD  SP          ;SP TO HL
0437   EB               XCHG             ;SP TO DE
0438   2ADC87           LHLD LOC80       ;LOC OF LAST CHAR IN
                                         ;ROW TO HL
043B   F9               SPHL             ;LAST CHAR LOC IN SP
043C   C5               PUSH B           ;FILL LINE WITH SPACES
043D   C5               PUSH B
043E   C5               PUSH B
043F   C5               PUSH B
0440   C5               PUSH B
0441   C5               PUSH B
0442   C5               PUSH B
1
8080 MACRO ASSEMBLER, VER 2.0   ERRORS = 0 PAGE 13

0443   C5               PUSH B
0444   C5               PUSH B
0445   C5               PUSH B
0446   C5               PUSH B
0447   C5               PUSH B
0448   C5               PUSH B
0449   C5               PUSH B
044A   C5               PUSH B
044B   C5               PUSH B
044C   C5               PUSH B
044D   C5               PUSH B
044E   C5               PUSH B
044F   C5               PUSH B
0450   C5               PUSH B
0451   C5               PUSH B
0452   C5               PUSH B
0453   C5               PUSH B
0454   C5               PUSH B
0455   C5               PUSH B
0456   C5               PUSH B
0457   C5               PUSH B
0458   C5               PUSH B
0459   C5               PUSH B
045A   C5               PUSH B
045B   C5               PUSH B
045C   C5               PUSH B
045D   C5               PUSH B
045E   C5               PUSH B
045F   C5               PUSH B
0460   C5               PUSH B
0461   C5               PUSH B
0462   C5               PUSH B
0463   C5               PUSH B
0464   EB               XCHG             ;SP TO HL
0465   F9               SPHL             ;RESTORE STACK
0466   C9               RET
                        ;
                        ; 8275 INTERRUPT SERVICE
                        ; 8257 REINITIALIZATION
                        ;
0467   3E00     RT75:   MVI  A,MDC57     ;MODE CLEAR COMMAND
0469   D348             OUT  PMD57       ;OUT TO 8257
046B   2AD687           LHLD TOPAD       ;TOP TO HL
046E   7D               MOV  A,L         ;LOW BYTE TO A
046F   D344             OUT  PC2SA       ;CHAN 2 START ADDRESS
0471   7C               MOV  A,H         ;HIGH BYTE TO A
0472   D344             OUT  PC2SA       ;CHAN 2 START ADDRESS
0474   7D               MOV  A,L         ;LOW BYTE TO A
0475   2F               CMA              ;COMPLEMENT A
0476   6F               MOV  L,A         ;MOVE TO L
0477   7C               MOV  A,H         ;HIGH BYTE TO A
1
8080 MACRO ASSEMBLER, VER 2.0   ERRORS = 0 PAGE 14

0478   2F               CMA              ;COMPLEMENT A
0479   67               MOV  H,A         ;MOVE TO H
047A   23               INX  H           ;2'S COMP IN HL OF TOP
047B   11CF87           LXI  D,87CFH     ;87CFH TO DE
047E   19               DAD  D           ;ADD=87CFH-TOP
047F   110080           LXI  D,8000H     ;8000H TO DE
0482   19               DAD  D           ;ADD 8000H+87CFH-TOP
0483   7D               MOV  A,L         ;LOW BYTE TO A
0484   D345             OUT  PC2TC       ;OUT CHAN 2 TC TO 8257
0486   7C               MOV  A,H         ;HIGH BYTE TO A
0487   D345             OUT  PC2TC       ;OUT CHAN 2 TC TO 8257
0489   210080           LXI  H,8000H     ;8000H TO HL
048C   7D               MOV  A,L         ;LOW BYTE TO A
```

Listing 2 continued on page 142

9K RAM (8K user available),
14K BASIC interpreter
operating system ROM.
Built-in RF
modulator.
Built-in sound
synthesizer.
Two built-in
game controllers,
with joysticks and
numeric keypads.
User-programmable, in
both BASIC and MC6800
machine language.
APF MP1000
The Imagination Machine APF
Built-in cass
deck, with both dig
and audio tra
Load in excess
1500 baud ra
Saves and loa
programs
45 second
or less
Keyword shift plate.
Full, standard, 53-key
typewriter keyboard.
Built-in speaker.
Microphone jack
enables you to
add audio to
program tapes.
High resolution picture
on your TV screen, in
8 colors.
256 x 192 graphics mode.

All that computer for $599.

The Imagination Machine, the personal computer from APF Electronics.

The Imagination Machine is more personal computer than you'd expect at $599.

The Imagination Machine is a superbly designed, expandable, user-programmable computer system... at $599.

No other personal computer on the market can touch it, at that price.

Read what it brings you:

First of all, The Imagination Machine has 9K RAM and 14K BASIC-IN-ROM. A full 53-key professional, typewriter keyboard. A high-resolution picture on your TV set, in eight colors. Fast loading (1500+ baud rate), built-in dual-track cassette deck, for APF's digitally recorded tape programs. Built-in sound synthesizer. And, even a built-in RF modulator, which is a $40 option on other computer systems.

All that, plus user-programmability.

We know sophisticated users aren't going to be satisfied forever using preprogrammed software. (Even though we offer a large library of educational, entertainment, home and business management programs.) So, we made The Imagination Machine user programmable, in both BASIC and MC6800 machine language. To simplify matters, we've just developed the first and only BASIC TUTOR course on cassette. With it, you can learn to program The Imagination Machine in BASIC, with hands-on training, right at the computer.

Some exceptional features.

The Imagination Machine has several unique features that can help you use your time at the computer more effectively.

For example, it stores programs and data on the same cassette tape. (With other computers, you have to read programs from one tape into the computer, remove the tape, put in another tape and store your data on the new tape.)

Another special feature is The Imagination Machine's unique keyword system, which simplifies BASIC programming. The machine has 24 different programs statements and commands printed at the top of the keyboard. You can enter these 24 into your program without retyping them every time you use them. Instead of typing out "PRINT," for example, you just press two keys and the word appears on the screen. The system helps prevent typing errors and can speed up entering programs.

A third feature is Timed Response Monitoring, which automatically adjusts the computer's pace and level to your own. It makes "tutoring programs," for instance, easier and more interesting to follow.

And then there are The Imagination Machine's three graphic display modes: 1. Alpha numerics, mixed with low-resolution graphics in as many as eight colors. 2. High resolution — up to eight colors — 128 x 192 display. 3. High resolution graphics — up to four colors — with 256 x 192 display.

And expandability.

A personal computer that can't grow along with your growing requirements soon becomes obsolete. So, we designed The Imagination Machine to be expandable. By adding APF's optional "Expansion Box" and interface cartridges, you can hook up any compatible floppy disk or printer, or an additional 8K RAM memory cartridge.

Full mini-floppy system $995.

For small business and professional use, you may require a full mini-floppy system. In that case, order APF's System II. It includes The Imagination Machine, the "Expansion Box," floppy disk interface and 72K-byte, mini-floppy disk drive. All for just $995! No one can come close to that price.

You can't beat our prices or our guarantee.

If you can find a better personal computer system for the money, let us know. In the meantime, we stand by our statement: There is no other personal computer on the market that offers so much for so little. And if you order now, we'll even include our $19.95 APF Technical Reference Manual, with complete schematics, absolutely free.

Order The Imagination Machine directly from APF Electronics, with the assurance that if you are not completely satisfied, you can return it within 30 days of purchase for a complete refund. To order, or to learn the name of the dealer nearest you, call TOLL FREE 1-800-223-1264. New York residents call 212-869-1960. MasterCard and VISA accepted.

Price list:

System I, The Imagination Machine.	$599.
System II, Mini-floppy System (Includes The Imagination Machine, BB-2, and Mini-floppy Disk Drive).	$995.
BB-1. Expansion Box with RS232 cartridge.	$199.95
BB-2. Expansion Box with floppy disk interface cartridge.	$199.95
8K RAM memory cartridge.	$ 99.95
RS232 cartridge.	$ 99.95
Floppy-disk interface cartridge.	$149.95
Mini-floppy Disk Drive.	$399.95

$599. Manufacturer's suggested retail price.

APF electronics inc.
1501 Broadway New York, NY 10036

Circle 90 on inquiry card.

Listing 2 continued from page 139:

```
04BD    D346            OUT  PC3SA       ;CHAN 3 START ADD TO 8257
048F    7C              MOV  A,H         ;HIGH BYTE TO A
0490    D346            OUT  PC3SA       ;CHAN 3 START ADD TO 8257
0492    21CF87          LXI  H,87CFH     ;87CFH TO HL
0495    7D              MOV  A,L         ;LOW BYTE TO A
0496    D347            OUT  PC3TC       ;CHAN 3 START ADDRESS
0498    7C              MOV  A,H         ;HIGH BYTE TO A
0499    D347            OUT  PC3TC       ;CHAN 3 START ADDRESS
049B    3E84            MVI  A,MDS57     ;MODE SET VAL TO A
049D    D348            OUT  PMD57       ;OUT MODE SET TO 8257
049F    C9              RET
                ;
                ; 8279 KEYBOARD POLLING ROUTINE
                ;
04A0    DB61    KPOLL:  IN   KCOM        ;INPUT FIFO STATUS
04A2    E607            ANI  007H        ;SAVE BITS 0-2
04A4    C8              RZ               ;RETURN IF EMPTY
04A5    CDA904          CALL XMIT        ;TRANSMIT CHARACTER
04A8    C9              RET
                ;
                ; CHARACTER TRANSMIT ROUTINE FOR 8251
                ;
04A9    DB60    XMIT:   IN   KDAT        ;INPUT FIFO CHAR
04AB    EEC0            XRI  0C0H        ;INVERT TOP 2 BITS
04AD    21E904          LXI  H,BSET3     ;LOAD BASE ADD TABLE 3
04B0    110000          LXI  D,0         ;ZERO DE
04B3    5F              MOV  E,A         ;MOVE CHAR TO DE
04B4    19              DAD  D           ;ADD BASE TO CHAR
04B5    DB01    USZ:    IN   CNCTL       ;INPUT UART STATUS
04B7    E601            ANI  001H        ;MASK TREADY BIT
04B9    CAB504          JZ   USZ         ;LOOP IF NOT READY
04BC    7E              MOV  A,M         ;LOAD CHAR FROM TABLE
04BD    D300            OUT  CNOUT       ;OUT CHAR TO UART
04BF    C9              RET
                ;
                ; DUMMY ROUTINE
                ;
04C0    C9      DUMY:   RET
1
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                ;
                ; LOOKUP TABLES
                ;
04C1    C004    BSET1:  DW   DUMY
04C3    3501            DW   ESCA
04C5    5B01            DW   ESCB
04C7    7901            DW   ESCC
04C9    A901            DW   ESCD
04CB    2B02            DW   ESCE
04CD    C004            DW   DUMY
04CF    C004            DW   DUMY
04D1    E101            DW   ESCH
04D3    C004            DW   DUMY
04D5    5C02            DW   ESCJ
04D7    F301            DW   ESCK
04D9    C004            DW   DUMY
04DB    C004            DW   DUMY
04DD    C004            DW   DUMY
04DF    C004            DW   DUMY
04E1    FB02    BSET2:  DW   CTRLH
04E3    EF02            DW   CTRLJ
04E5    F202            DW   CTRLM
04E7    C004            DW   DUMY
                ;*********************************************
04E9    1B      BSET3:  DB   01BH        ;ESC
04EA    31              DB   031H        ;1
04EB    32              DB   032H        ;2
04EC    33              DB   033H        ;3
04ED    34              DB   034H        ;4
04EE    35              DB   035H        ;5
04EF    36              DB   036H        ;6
04F0    00              DB   0           ;NC
04F1    09              DB   009H        ;TAB
04F2    51              DB   051H        ;Q
04F3    57              DB   057H        ;W
04F4    45              DB   045H        ;E
04F5    52              DB   052H        ;R
04F6    54              DB   054H        ;T
04F7    59              DB   059H        ;Y
04F8    00              DB   0           ;NC
04F9    00              DB   0           ;NC
04FA    41              DB   041H        ;A
04FB    53              DB   053H        ;S
04FC    44              DB   044H        ;D
04FD    46              DB   046H        ;F
04FE    47              DB   047H        ;G
04FF    48              DB   048H        ;H
0500    00              DB   0           ;NC
0501    00              DB   0           ;L BLANK
0502    5A              DB   05AH        ;Z
0503    58              DB   058H        ;X
1
 8080 MACRO ASSEMBLER, VER 2.0   ERRORS = 0 PAGE 16

0504    43              DB   043H        ;C
0505    56              DB   056H        ;V
0506    42              DB   042H        ;B
0507    4E              DB   04EH        ;N
0508    20              DB   020H        ;SPACE
                ;*********************************************
0509    00              DB   0           ;R BLANK
050A    00              DB   0           ;NC
050B    00              DB   0           ;NC
050C    2F              DB   02FH        ;/
050D    2E              DB   02EH        ;.
050E    2C              DB   02CH        ;,
050F    4D              DB   04DH        ;M
0510    00              DB   0           ;NC
0511    0D              DB   00DH        ;CR
0512    7B              DB   07BH        ;L BRACE
0513    27              DB   027H        ;'
0514    3B              DB   03BH        ;;
0515    4C              DB   04CH        ;L
0516    4B              DB   04BH        ;K
0517    4A              DB   04AH        ;J
0518    00              DB   0           ;NC
0519    0A              DB   00AH        ;LF
051A    5C              DB   05CH        ;
051B    5B              DB   05BH        ;L BRACKET
051C    50              DB   050H        ;P
```

Listing 2 continued on page 144

COMPUTERS—TERMINALS—MODEMS!

NEW!
TI-99/4 Home Computer

Optional color monitor
$449

Main console unit
$889
(Includes RF modulator for use with any TV)

Write for a list of extensive program modules available—everything in games, education, and home computer applications.

NEW!
From Perkin-Elmer 1250 Super Owl

$1799

Intelligent CRT

Incredibly powerful and flexible

- 24 **fully programmable** function keys
- Full screen editing capabilities
- RAM memory for down line loading by host computer
- Built-in printer port
- Full polling capabilities
- Detachable keyboard
- Optional light pen

Much more!

Penril 300/1200 Modem

Connect any computer or terminal to the phone lines.

- 1200 Baud—Bell 212A **$799**
- 300 Baud
- Originate/Auto answer
- Full duplex
- RS232
- 1 year warranty

Direct connection to the phone lines via RJ11C standard extension phone jack

USR-330 Modem

- 0-300 Baud—Bell 103/113
- Originate/Auto answer
- Half/Full duplex
- RS232
- 1 year warranty

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Direct connection to the phone lines via RJ11C standard extension phone jack

USR-1600P Computer

NEW!

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PASCAL

With **power** and **speed** for business, educational, and scientific applications.

W.D. Microengine™-based single board computer with 64K RAM

- 1 megabyte of floppy disc
- 2 parallel ports
- 2 serial ports
- Floppy disc controller with DMA
- File manager
- Screen oriented editor
- Single cabinet design
- Includes power supply

Perkin-Elmer Bantam 550 CRT

$749

- Transparent mode
- Addressable cursor
- Editing functions
- Upper/lower case
- Compact

The Phone-Link Acoustic Modem NEW!

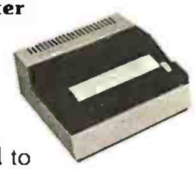
- Sleek, low profile
- 0-300 Baud
- Originate/Answer modes
- Half/Full duplex
- Self-test
- RS232—Will work with any RS232 computer or terminal
- LED displays of all functions
- 1 year warranty

At your computer store now!

$179

Perkin-Elmer 650/655
CRT Page Printer

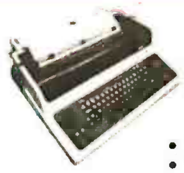
- 100 CPS
- Quiet
- Compact
- RS232
- Can be added to any CRT with our interface option.



$999

The printer designed to give you rapid, reliable, hard copy of your CRT screen display.

DEC LA34



$995

- Teletype 43 plug compatible
- Variable character sizes
- Full width paper
- Many more features

Write for print sample

Teletype Model 43KSR $1049
Microterm Mime IIA CRT $819
Microterm ACT VA $779

We offer full service, on-site maintenance plans on all equipment. Any product may be returned within 10 days for a full refund.

U.S. ROBOTICS INC.
203 N. WABASH SUITE 1718 CHICAGO, ILL 60601

SALES	(312) 346-5650
GENERAL OFFICES	(312) 346-5651
SERVICE	(312) 733-0497

Listing 2 continued from page 142:

```
051D    4F              DB    04FH          ;O
051E    49              DB    049H          ;I
051F    55              DB    055H          ;U
0520    7F              DB    07FH          ;DEL
0521    5C              DB    05CH          ;
0522    3D              DB    03DH          ;=
0523    2D              DB    02DH          ;-
0524    30              DB    030H          ;0
0525    39              DB    039H          ;9
0526    38              DB    038H          ;8
0527    37              DB    037H          ;7
0528    08              DB    008H          ;BACKSPACE
                ;**************************************************
0529    1B              DB    01BH          ;ESC
052A    21              DB    021H          ;!
052B    40              DB    040H          ;AT SIGN
052C    23              DB    023H          ;#
052D    24              DB    024H          ;$
052E    25              DB    025H          ;%
052F    5E              DB    05EH          ;
0530    00              DB    0             ;NC
0531    09              DB    009H          ;TAB
0532    51              DB    051H          ;Q
0533    57              DB    057H          ;W
0534    45              DB    045H          ;E
1
8080 MACRO ASSEMBLER, VER 2.0   ERRORS = 0 PAGE 17


0535    52              DB    052H          ;R
0536    54              DB    054H          ;T
0537    59              DB    059H          ;Y
0538    00              DB    0             ;NC
0539    00              DB    0             ;NC
053A    41              DB    041H          ;A
053B    53              DB    053H          ;S
053C    44              DB    044H          ;D
053D    46              DB    046H          ;F
053E    47              DB    047H          ;G
053F    48              DB    048H          ;H
0540    00              DB    0             ;NC
0541    00              DB    0             ;L BLANK
0542    5A              DB    05AH          ;Z
0543    58              DB    058H          ;X
0544    43              DB    043H          ;C
0545    56              DB    056H          ;V
0546    42              DB    042H          ;B
0547    4E              DB    04EH          ;N
0548    20              DB    020H          ;SPACE
                ;**************************************************
0549    00              DB    0             ;R BLANK
054A    00              DB    0             ;NC
054B    00              DB    0             ;NC
054C    3F              DB    03FH          ;?
054D    3E              DB    03EH          ;>
054E    3C              DB    03CH          ;<
054F    4D              DB    04DH          ;M
0550    00              DB    0             ;NC
0551    0D              DB    00DH          ;CR
0552    7D              DB    07DH          ;R BRACE
0553    22              DB    022H          ;"
0554    3A              DB    03AH          ;:
0555    4C              DB    04CH          ;L
0556    4B              DB    04BH          ;K
0557    4A              DB    04AH          ;J
0558    00              DB    0             ;NC
0559    0A              DB    00AH          ;LF
055A    7C              DB    07CH          ;VERT. BROKEN BAR
055B    5D              DB    05DH          ;R BRACKET
055C    50              DB    050H          ;P
055D    4F              DB    04FH          ;O
055E    49              DB    049H          ;I
055F    55              DB    055H          ;U
0560    7F              DB    07FH          ;DEL
0561    7E              DB    07EH          ;TILDE
0562    2B              DB    02BH          ;+
0563    5C              DB    05CH          ;
0564    29              DB    029H          ;)
0565    28              DB    028H          ;(
0566    2A              DB    02AH          ;*
1
8080 MACRO ASSEMBLER, VER 2.0   ERRORS = 0 PAGE 18


0567    26              DB    026H          ;&
0568    08              DB    008H          ;BACKSPACE
                ;**************************************************
0569    1B              DB    01BH          ;ESC
056A    00              DB    0             ;NC
056B    00              DB    0
056C    00              DB    0
056D    00              DB    0
056E    00              DB    0
056F    00              DB    0
0570    00              DB    0             ;NC
0571    09              DB    009H          ;TAB
0572    11              DB    011H          ;CTRL Q
0573    17              DB    017H          ;CTRL W
0574    05              DB    005H          ;CTRL E
0575    12              DB    012H          ;CTRL R
0576    14              DB    014H          ;CTRL T
0577    19              DB    019H          ;CTRL Y
0578    00              DB    0             ;NC
0579    00              DB    0             ;NC
057A    01              DB    001H          ;CTRL A
057B    13              DB    013H          ;CTRL S
057C    04              DB    004H          ;CTRL D
057D    06              DB    006H          ;CTRL F
057E    07              DB    007H          ;CTRL G
057F    08              DB    008H          ;CTRL H
0580    00              DB    0             ;NC
0581    00              DB    0             ;L BLANK
0582    1A              DB    01AH          ;CTRL Z
0583    18              DB    018H          ;CTRL X
0584    03              DB    003H          ;CTRL C
0585    06              DB    006H          ;CTRL V
0586    02              DB    002H          ;CTRL B
0587    0E              DB    00EH          ;CTRL N
0588    20              DB    020H          ;SPACE
                ;**************************************************
0589    00              DB    0             ;R BLANK
058A    00              DB    0             ;NC
```

Listing 2 continued on page 146

Listing 2 continued from page 144:

```
058B   00                DB   0          ;NC
058C   00                DB   0          ;/
058D   00                DB   0          ;.
058E   00                DB   0          ;,
058F   0D                DB   00DH       ;CTRL M (CR)
0590   00                DB   0          ;NC
0591   0D                DB   00DH       ;CR
0592   00                DB   0          ;L BRACE
0593   00                DB   0          ;'
0594   00                DB   0          ;;
0595   0C                DB   00CH       ;CTRL L
0596   0B                DB   00BH       ;CTRL K
0597   0A                DB   00AH       ;CTRL J (LF)
1
 8080 MACRO ASSEMBLER, VER 2.0  ERRORS = 0 PAGE 19

0598   00                DB   0          ;NC
0599   0A                DB   00AH       ;LF
059A   1C                DB   01CH       ;CTRL
059B   1B                DB   01BH       ;CTRL L BRACKET
059C   10                DB   010H       ;CTRL P
059D   0F                DB   00FH       ;CTRL O
059E   09                DB   009H       ;CTRL I (TAB)
059F   15                DB   015H       ;CTRL U
05A0   7F                DB   07FH       ;DEL
05A1   1C                DB   01CH       ;CTRl
05A2   00                DB   0          ;=
05A3   00                DB   0          ;-
05A4   00                DB   0          ;0
05A5   00                DB   0          ;9
05A6   00                DB   0          ;8
05A7   00                DB   0          ;7
05A8   08                DB   008H       ;BACKSPACE
                  ;**************************************************
05A9   0000              DW   0
05AB   0000              DW   0
05AD   0000              DW   0
05AF   0000              DW   0
05B1   0000              DW   0
05B3   0000              DW   0
05B5   0000              DW   0
05B7   0000              DW   0
05B9   0000              DW   0
05BB   0000              DW   0
05BD   0000              DW   0
05BF   0000              DW   0
05C1   0000              DW   0
05C3   0000              DW   0
05C5   0000              DW   0
05C7   0000              DW   0
05C9   0000              DW   0
05CB   0000              DW   0
05CD   0000              DW   0
05CF   0000              DW   0
05D1   0000              DW   0
05D3   0000              DW   0
05D5   0000              DW   0
05D7   0000              DW   0
05D9   0000              DW   0
05DB   0000              DW   0
05DD   0000              DW   0
05DF   0000              DW   0
05E1   0000              DW   0
05E3   0000              DW   0
05E5   0000              DW   0
05E7   0000              DW   0
                  ;**************************************************
1
 8080 MACRO ASSEMBLER, VER 2.0  ERRORS = 0 PAGE 20


                         ; MINIMAL MONITOR
                         ;
05E9   3E40      SSS2:   MVI  A,040H
05EB   D301              OUT  1
05ED   3EFB              MVI  A,0FBH
05EF   D301              OUT  1
05F1   3E27              MVI  A,027H
05F3   D301              OUT  1
05F5   F3                DI
05F6   31FF87    START:  LXI  SP,87FFH
05F9   CDA306            CALL CR
05FC   3E3F              MVI  A,'?'
05FE   CD8906            CALL SOUT
0601   CD7706            CALL SIN
0604   E67F              ANI  07FH
0606   FE4C              CPI  'L'
0608   CA2306            JZ   LOAD
060B   FE44              CPI  'D'
060D   CC3606            CZ   DUMP
0610   FE46              CPI  'F'
0612   CCF306            CZ   FIL
0615   FE4D              CPI  'M'
0617   CC1007            CZ   MOVE
061A   FE47              CPI  'G'
061C   C2F605            JNZ  START
                         ; 'GO' ROUTINE
                         ;
061F   CD6B06            CALL INAD
0622   E9                PCHL
                         ; 'LOAD' ROUTINE
                         ;
0623   CD6B06    LOAD:   CALL INAD
0626   CD5F06    T1:     CALL OUTAD
0629   3E2D              MVI  A,'-'
062B   CD8906            CALL SOUT
062E   CDD506            CALL ZIN
0631   77                MOV  M,A
0632   23                INX  H
0633   C32606            JMP  T1
                         ; 'DUMP' ROUTINE
                         ;
0636   CD6B06    DUMP:   CALL INAD
0639   EB                XCHG
063A   CD6B06            CALL INAD
063D   EB                XCHG
063E   7D        B2:     MOV  A,L
063F   E60F              ANI  00FH
0641   C24706            JNZ  B1
0644   CD5F06            CALL OUTAD
0647   3E20      B1:     MVI  A,' '
0649   CD8906            CALL SOUT
```

Listing 2 continued on page 148

Listing 2 continued from page 146:

```
1
 8080 MACRO ASSEMBLER, VER 2.0   ERRORS = 0 PAGE 21

 064C   7E               MOV   A,M
 064D   CDE606           CALL  ZOUT
 0650   7C               MOV   A,H
 0651   BA               CMP   D
 0652   CA5906           JZ    X7
 0655   23        X8:    INX   H
 0656   C33E06           JMP   B2
 0659   7D        X7:    MOV   A,L
 065A   BB               CMP   E
 065B   C25506           JNZ   X8
 065E   C9               RET
                         ; OUTPUT HEX ADDRESS
                         ;
 065F   CDA306    OUTAD: CALL  CR
 0662   7C               MOV   A,H
 0663   CDE606           CALL  ZOUT
 0666   7D               MOV   A,L
 0667   CDE606           CALL  ZOUT
 066A   C9               RET
                         ; INPUT HEX ADDRESS
                         ;
 066B   CDA306    INAD:  CALL  CR
 066E   CDD506           CALL  ZIN
 0671   67               MOV   H,A
 0672   CDD506           CALL  ZIN
 0675   6F               MOV L,A
 0676   C9               RET
                         ; INPUT CHAR FROM TTY
                         ;
 0677   DB01      SIN:   IN    1
 0679   E602             ANI   002H
 067B   CA7706           JZ    SIN
 067E   DB00             IN    0
 0680   FE1B             CPI   01BH
 0682   CAF605           JZ    START
 0685   CD8906           CALL  SOUT
 0688   C9               RET
                         ; OUTPUT CHAR TO TTY
                         ;
 0689   F5        SOUT:  PUSH  PSW
 068A   DB01             IN    1
 068C   E602             ANI   002H
 068E   CA9806           JZ    XY
 0691   DB00             IN    0
 0693   FE1B             CPI   01BH
 0695   CAF605           JZ    START
 0698   DB01      XY:    IN    1
 069A   E601             ANI   001H
 069C   CA9806           JZ    XY
 069F   F1               POP   PSW
 06A0   D300             OUT   0
1
 8080 MACRO ASSEMBLER, VER 2.0   ERRORS = 0 PAGE 22

 06A2   C9               RET
                         ; SENDS OUT CR/LF
                         ;
 06A3   3E0D      CR:    MVI   A,00DH
 06A5   CD8906           CALL  SOUT
 06A8   3E0A             MVI   A,00AH
 06AA   CD8906           CALL  SOUT
 06AD   C9               RET
                         ; INPUT CHAR, ADD ASCII BIAS
                         ; CHECKS FOR A HEX CHAR
 06AE   CD7706    XIN:   CALL  SIN
 06B1   FE30             CPI   030H
 06B3   DAF605           JC    START
 06B6   FE3A             CPI   03AH
 06B8   D8               RC
 06B9   FE41             CPI   041H
 06BB   DAF605           JC    START
 06BE   FE47             CPI   047H
 06C0   D2F605           JNC   START
 06C3   C609             ADI   009H
 06C5   C9               RET
                         ; OUTPUT CHAR, ADD ASCII BIAS
                         ;
 06C6   E60F      XOUT:  ANI   00FH
 06C8   C630             ADI   030H
 06CA   FE3A             CPI   03AH
 06CC   DAD106           JC    Z1
 06CF   C607             ADI   007H
 06D1   CD8906    Z1:    CALL  SOUT
 06D4   C9               RET
                         ; INPUT 2 ASCII CHAR
                         ; PACK IN REG A
 06D5   CDAE06    ZIN:   CALL  XIN
 06D8   0F               RRC
 06D9   0F               RRC
 06DA   0F               RRC
 06DB   0F               RRC
 06DC   E6F0             ANI   0F0H
 06DE   47               MOV   B,A
 06DF   CDAE06           CALL  XIN
 06E2   E60F             ANI   00FH
 06E4   80               ADD   B
 06E5   C9               RET
                         ; OUTPUT 2 ASCII CHAR
                         ; PACKED IN REG A
 06E6   F5        ZOUT:  PUSH  PSW
 06E7   0F               RRC
 06E8   0F               RRC
 06E9   0F               RRC
 06EA   0F               RRC
 06EB   CDC606           CALL  XOUT
1
 8080 MACRO ASSEMBLER, VER 2.0   ERRORS = 0 PAGE 23

 06EE   F1               POP   PSW
 06EF   CDC606           CALL  XOUT
 06F2   C9               RET
                         ; FILL MEMORY
                         ;
 06F3   CD6B06    FIL:   CALL  INAD
 06F6   EB               XCHG
 06F7   CD6B06           CALL  INAD
 06FA   EB               XCHG
 06FB   13               INX   D
 06FC   CDA306           CALL  CR
```

Listing 2 continued on page 150

Listing 2 continued from page 148:

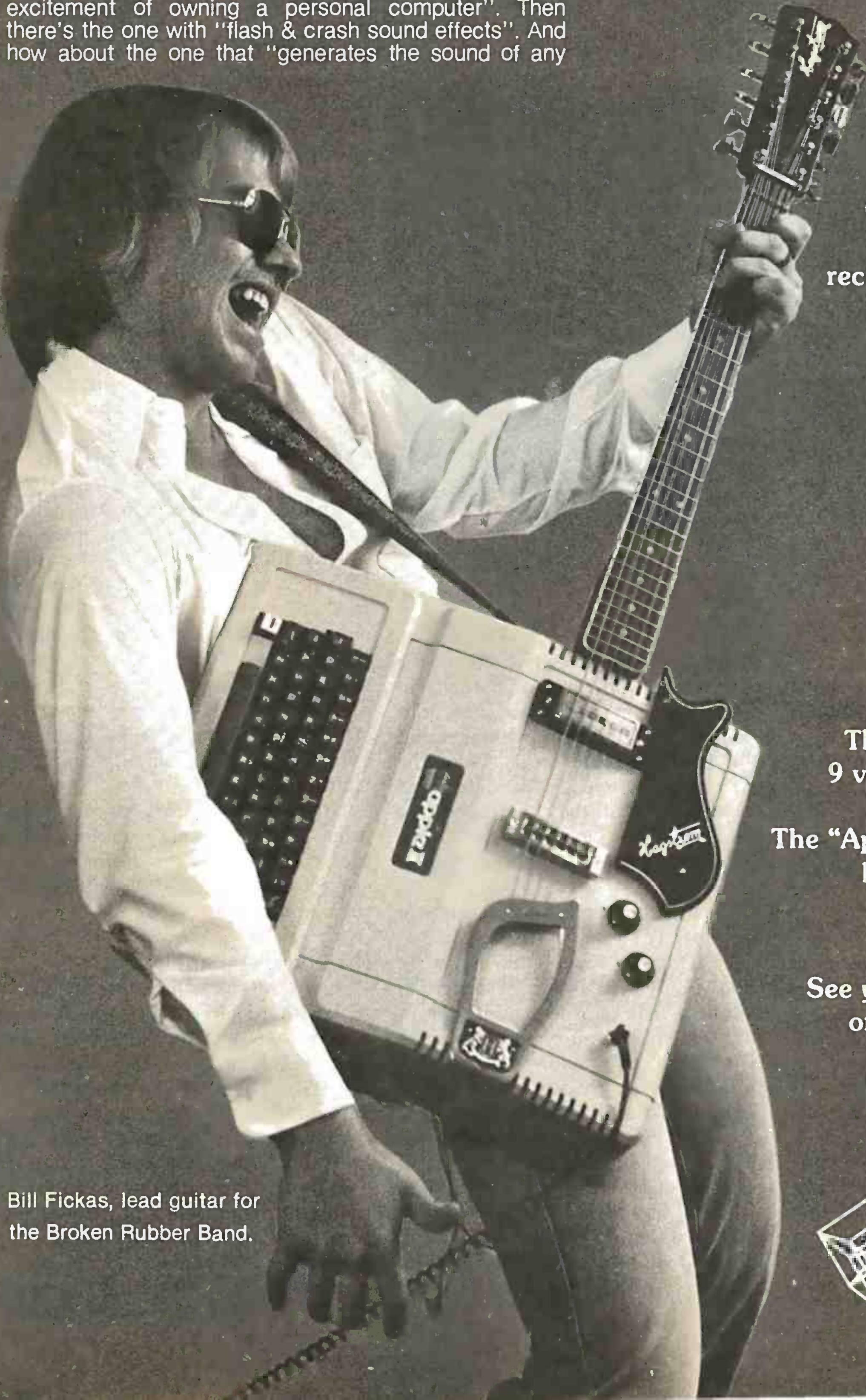
```
06FF    CDD506              CALL  ZIN
0702    47                  MOV   B,A
0703    70          XX:     MOV   M,B
0704    23                  INX   H
0705    7C                  MOV   A,H
0706    BA                  CMP   D
0707    C20307              JNZ   XX
070A    7D                  MOV   A,L
070B    BB                  CMP   E
070C    C20307              JNZ   XX
070F    C9                  RET
                            ; BLOCK MOVE IN MEM
                            ;
0710    1603        MOVE:   MVI   D,3
0712    CD6B06      BKM:    CALL  INAD
0715    E5                  PUSH  H
0716    15                  DCR   D
0717    C21207              JNZ   BKM
071A    E1                  POP   H
071B    C1                  POP   B
071C    03                  INX   B
071D    D1                  POP   D
071E    1A          BKZ:    LDAX  D
071F    77                  MOV   M,A
0720    13                  INX   D
0721    23                  INX   H
0722    7A                  MOV   A,D
0723    B8                  CMP   B
0724    C21E07              JNZ   BKZ
0727    7B                  MOV   A,E
0728    B9                  CMP   C
0729    C21E07              JNZ   BKZ
072C    C9                  RET
                    ;
                    ; VARIABLE STORAGE
                    ;
87D2                        ORG   87D2H
0001                CCTAD:  DS    1
0002                RCTAD:  DS    2
0001                CURSY:  DS    1
1
 8080 MACRO ASSEMBLER, VER 2.0  ERRORS = 0 PAGE 24


0002                TOPAD:  DS    2
0002                LOCAD:  DS    2
0002                LOC01:  DS    2
0002                LOCBO:  DS    2
0002                LOCXX:  DS    2
0002                LOCPR:  DS    2
0002                LOCBUF:DS     2
0001                XFLG:   DS    1
0001                USCHR:  DS    1
0002                BOTAD:  DS    2
                    END
 NO PROGRAM ERRORS
1
 8080 MACRO ASSEMBLER, VER 2.0  ERRORS = 0 PAGE 25


                        SYMBOL TABLE

  * 01

  A       0007      AGGIE   00D2      ALPH    0142      ALPHA   0046
  B       0000      B1      0647      B2      063E      BETA    014C
  BILBO   0216      BKM     0712      BKZ     071E      BOTAD   87E6
  BSET1   04C1      BSET2   04E1      BSET3   04E9      C       0001
  CCTAD   87D2      CCTMA   01C4      CCTMB   01CD      CCTOA   0194
  CCTOB   019D      CHREC   00E1      CNCTL   0001      CNIN    0000
  CNOUT   0000      CNTRL   0123      COLLT   0322      COLRT   032A
  COMRT   03DC      COMRX   0220      COMRY   02E4      CR      06A3
  CRCOM   0051      CRDAT   0050      CRTGO   0040      CTA     0350
  CTB     0360      CTC     036D      CTRLH   02FB      CTRLJ   02EF
  CTRLM   02F2      CURSY   87D5      D       0002      DELTA   0172
  DIS1    0374      DISA    03B1      DISB    03B9      DISC    03D0
  DISPL   0341      DUCK    041E      DUMP    0636      DUMY    04C0
  E       0003      EORT    03F1      ESCA    0135      ESCB    015B
  ESCC    0179      ESCD    01A9      ESCE    022B      ESCH    01E1
  ESCJ    025C      ESCK    01F3      ESREC   010B      FIL     06F3
  FILL    0426      FIN     027F      FRODO   020A      FUN     02C2
  GAMMA   0168      GNOME   02A1      GZONK   02B3 *    H       0004
  INAD    066B      KCOM    0061      KDAT    0060      KPOLL   04A0
```

Listing 2 continued on page 152

Announcing the music card that turns you into a Rock Star.

Girls will climb over each other to kiss your feet.

Some companies will say anything to sell you a music card. One is "designed by leading experts". One's called the "Super Sound Generator". Another is "part of the excitement of owning a personal computer". Then there's the one with "flash & crash sound effects". And how about the one that "generates the sound of any musical instrument — real or imagined". Sure. Before you listen to their claims, listen to their music. That's where the real differences show up.



Bill Fickas, lead guitar for the Broken Rubber Band.

You can hear our music card at your local Apple dealer.

Or, just send us $1 and we'll send you a demo record of our 9 voice card.

When you listen to a music card, ask if the song you're hearing was programmed by a customer, or by experts at the company that made the card. Was it done with the software you'll get, or with special programming? Over half the songs on our demo record were entered by customers using the software supplied with the card – you can do it the same way. Our manual shows you how step by step.

The "Apple Music][" has 9 voices and is just $195*.

The "Apple Music Synthesizer" has 3 top-quality voices for just $265*.

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Listing 2 continued from page 150:

```
L       0005    LOAD    0623    LOADX   0235    LOC01   87DA
LOC80   87DC    LOCAD   87D8    LOCBU   87E2    LOCPR   87E0
LOCXX   87DE    LOOP    00BE    M       0006    MDC57   0000
MDS57   0084    MOVE    0710    NUF     02DA    NXT2    0055 *
NXTA    01B5    NXTCM   0397    NXTX    00ED    NXTY    00F9
NXTZ    0105    OUTAD   065F    PC2SA   0044    PC2TC   0045
PC3SA   0046    PC3TC   0047    PMD57   0048    PSW     0006
RCTAD   87D3    RDF51   00D9    ROWDN   0310    ROWUP   02FE
RT75    0467    SCROL   03FF    SIN     0677    SOUT    0689
SP      0006    SSS2    05E9    START   05F6    T1      0626
TOPAD   87D6    TROLL   0297    USCHR   87E5    USZ     04B5
VAR     0273    WIZAR   02CB    WP75    0332    X7      0659
X8      0655    XFLG    87E4    XIN     06AE    XMIT    04A9
XOUT    06C6    XSTAD   03A3    XX      0703    XY      0698
Z1      06D1    ZETA    0185    ZIN     06D5    ZOUT    06E6
```

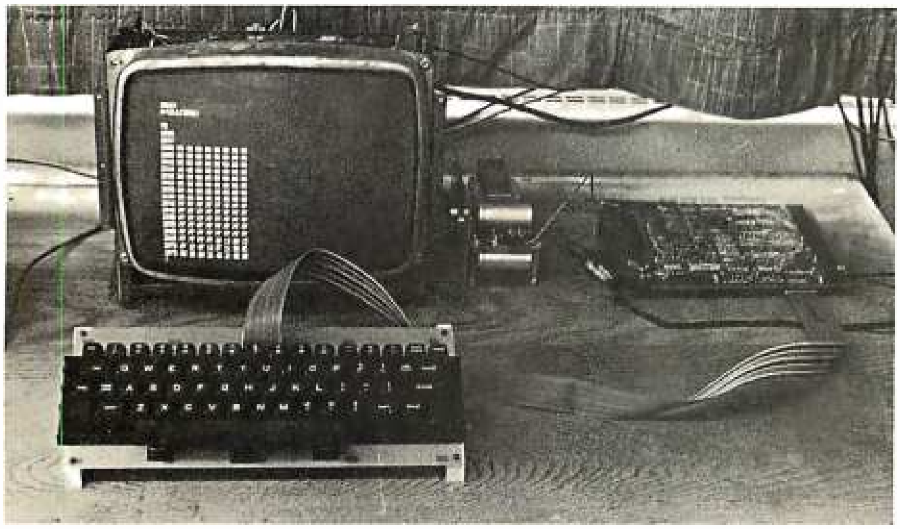

Photo 6: *The complete terminal system with keyboard, monitor, power supply, and main circuitry.*

Text continued from page 128:
but you cannot get the monitor operating with the checkout terminal, then most likely your problem is in the 2114 programmable memories, the decoder circuitry for the 2114s, or the 8212 buffers for the 2114s. Other problems could be caused by the temporary interface or data rates that differ.

Using the Monitor

After your built-in monitor is working, you can jump to it for use in debugging the remainder of the circuit. Opening the TRAP switch will cause the 8085 microprocessor to transfer control to the monitor. To return to the terminal-control software, the 8085 microprocessor is reset. To facilitate this, I have connected the BREAK switch on my keyboard to the 8085 $\overline{\text{RESET IN}}$ line (pin 36). This connection is also useful for resetting the video terminal just after it is turned on, or for easy clearing of the screen. One of the most useful functions of the system monitor is its ability to load into memory and run short programs that will read the status registers of the peripheral circuits to determine whether or not they are operating properly. This includes the 8251, 8257, 8275, and the 8279 integrated circuits.

The system monitor commands are as follows:

D (Dump): Type the letter D followed by two 4-digit hexadecimal numbers that represent addresses in the system. Memory contents between the two addresses will be printed on the checkout terminal in hexadecimal with 16 bytes on a line. The line will begin with the address of the first byte in that line. A dump can be aborted by pressing the ESC key.

F (Fill): To fill a block of memory with a specified value, type an F followed by two 4-digit hexadecimal addresses which are the inclusive locations in memory to be filled. Lastly, type the 2-digit hexadecimal number that the block of memory is to be filled with.

G (Go): Typing a G followed by a 4-digit hexadecimal address *will* transfer that address to the program counter, and program execution will continue from that location. After a short program has been loaded into memory, the Go command can transfer execution to this program.

L (Load): To load sequential memory locations with arbitrary values, type an L, followed by a 4-digit hexadecimal address. The system will prompt the user with sequential addresses, after which the user can type in the desired contents in the form of 2-digit hexadecimal numbers. You can exit from the load routine by typing any nonhexadecimal character.

M (Move): The Move command can write blocks of data from one memory location to another. After the M is typed, three 4-digit hexadecimal addresses must be typed in. The first two addresses enclose the block of data in memory to be moved, and the third address is the beginning location of the area where the block of data is to be written.

Any time a character other than D,F,G,L, or M is typed in response to the "?" prompt, the monitor will simply reissue the prompt character. When the appropriate response should be a hexadecimal character and another character is typed instead, the monitor will cancel the command and reissue the prompt character.

No carriage returns are necessary after typing in data to the system monitor. When the monitor has the correct amount of data it will execute the command.

Keyboard Assembly

I used the sixty-three-key unencoded keyboard offered by Jameco Electronics, 1021 Howard Ave, San Carlos CA 94070. The cost was $29.95. This is a good-quality keyboard for the price. Each pair of switch contacts protrudes from the bottom of the keyboard by about an eighth of an inch, making it necessary to mount the unit on a printed-circuit board. Because of the complexity of the switch matrix, a complete printed-circuit layout would have to

Text continued on page 156

Listing 3: *A hexadecimal object dump of the video-terminal-control routine.*

```
C CRTBO
:03000000C34000FA
:03002400C3E90528
:1000400031FF8721FF7F2336207DFECFC246007C13
:10005000FE87C246002100002 2D38722E28722D8F1
:10006000 8722DA8722DC8722DE8722E08721008050
:1000700022D68721808722E6873E0032D28732D57A
:1000800008732E48732E5873E7BD3013E27D3013EAA
:100090003FD3613E00D3513E4FD3503E58D3503EE4
:1000A00089D3503E59D3503E80D3513E00D3503E69
:1000B00000D3503EE0D3513E23D351CD6704DB0142
:1000C000E602C4D200DB51E620C46704CDA004C31D
:1000D000BE00CDD900CDE100C9DB00E67F32E58767
:1000E000C93AE487E6FFCAED00CD0B01C93AE587BE
:1000F000E660CAF900CD4103C93AE587E610C205BA
:1001000001CD2301C921E4873601C93E0032E487CD
:100110003AE587E60F0721C1041100005F195E234D
:1001200056EBE93AE587E60621E1041100005F1984
:100130005E2356EBE92AD3877DFE00CA4201CDFE3D
:100140002C97CFE00CA4C01CDFE02C921800722F3
:10015000D3873E1832D587CD3203C92AD3877DFE97
:1001600080CA6801CD1003C97CFE07CA7201CD1098
:100170003C9CD3203CDFF03C93AD287FE4FCA85EA
:1001800001CD2A03C92AD3877DFE80C294017CFE5B
:100190007CA9D013E0032D287CD1003C93E00320E
:1001A000D287CD3203CDFF03C93AD287FE00CAB54C
:1001B00001CD2203C92AD3877DFE00C2C4017CFE83
:1001C00000CACD013E4F32D287CDFE02C921800741
:1001D00022D3873E4F32D2873E1832D587CD3203A5
:1001E000C921000022D3873E0032D28732D587CD85
:1001F0003203C92AD687EB2AD3871922DE873E87A6
:10020000BCD20A02CD2002C31602C216023ECFBDE6
:10021000D21602CD20022ADE8722E287CD2604C92B
:100220002ADE871130F81922DE87C93EF00619113F
:1002300050002100807719 05C2350221000022D329
:10024000872100 8022D68721808722E6873E0032E0
:10025000D28732D58732E487CD3203C92AD687EBDD
:100260002AD3871922E0873E87BCD27302CDE402ED
:10027000C37F02C27F023ECFBDD27F02CDE4022AFD
:10028000D6877DFE00C297027CFE80C297022180 45
:100290008722E687C3A10211B0FF2AD6871922E67A
:1002A000873EF02AE087777DFE80C2CB027CFE8706
:1002B000C2CB02EB2AE6877DBBC2C2027CBAC2C2B5
:1002C0002C921008022E087C3A102EB2AE6877DD4
:1002D000BBC2DA027CBAC2DA02C92150001922E09C
:1002E00087C3A1022AE0871130F81922E087C9C329
:1002F0005B013E0032D287CD3203C9C3A9012AD3A4
:100300008711B0FF1922D38721D5873 5CD3203C994
:100310002AD387115000 1922D38721D58734CD32B3
:100320003C921D28735CD3203C921D28734CD32DA
:100330003C93E80D3513AD287D3503AD587D350A0
:10034000C93AD287FE4FCA5003CD7403CDB103C959
:100350002AD3877DFE80CA6003CD7403CDB903C95B
:100360007CFE07CA6D03CD7403CDB903C9CD7403F8
:10037000CDD003C92AD687EB2AD3871922DA87EB97
:100380002100003AD2876F1922D8873E87BCD297C6
:1003900003CDDC03C3A303C2A3033ECFBDD2A3039B
:1003A000CDDC03CDF10321E5877EE63F2AD88777B0
:1003B000C921D28734CD3203C93E0032D2872AD335
:1003C00087115000 1922D38721D58734CD3203C934
:1003D0003E0032D287CD3203CDFF03C92AD8871120
:1003E00030F81922D8872ADA871130F81922DA87EB
:1003F000C92ADA877EFEF0C022E287CD2604C92A08
:10040000D68722E287CD26042AD6877DFE80C21EAB
:1004100047CFE87C21E0421008022D687C91150A9
:1004200001922D687C92AE2871150001922DC87D9
:100430001202021000039EB2ADC87F9C5C5C5C59C
:10044000C5C5C5C5C5C5C5C5C5C5C5C5C5C5C5C55C
:10045000C5C5C5C5C5C5C5C5C5C5C5C5C5C5C5C54C
:10046000C5C5C5C5EBF9C93E00D3482AD6877DD39B
:1004700447CD3447D2F6F7C2F672311CF87191 1C4
:10048000080197DD3457CD345210 0807DD3467CF7
:10049000D34621CF877DD3477CD3473E84D348C9F9
:1004A000DB61E607C8CDA904C9DB60EEC021E9042I
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:1004C000C9C00435015B017901A9012B02C004C038
:1004D00004E101C0045C02F301C004C004C004C014
:1004E00004FB02EF02F202C0041B31323334353612
:1004F0000009515745525459000041534446474 85A
:100500000005A584356424E200000002F2E2C4D1A
:100510000000D7B273B4C4B4A000A5C5B504F495512
:100520007F5C3D2D3039383708 1B21402324255E60
:1005300000009515745525459000041534446474819
:1005400000005A584356424E200000003F3E3C4DAA
:10055000000D7D223A4C4B4A000A7C5D504F4955B4
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:100570000009111705121419000001130406070 8D9
:10058000001A180306020E20000000000000000DF3
:1005900000D0000000C0B0A000A1C1B100F0915AF
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:1005C000000000000000000000000000000000002B
:1005D000000000000000000000000000000000001B
:1005E0000000000000000000003E40D3013EFBD3AD
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:10066000A3067CCDE6067DCDE606C9CDA306CDD595
:10067000 0667CDD5066FC9DB01E602CA7706DB0047
:10068000FE1BCAF605CD8906C9F5DB01E602CA984C
:10069000 6DB00FE1BCAF605DB01E601CA9806F17F
:1006A000D300C93E0DCD89063E0ACD8906C9CD7756
:1006B00006FE30DAF605FE3AD8FE41DAF605FE47C8
:1006C000D2F605C609C9E60FC630FE3ADAD106C62B
:1006D0007CD8906C9CDAE060F0F0F0FE6F047CD47
:1006E000AE06E60F80C9F50F0F0F0FCDC606F1CD90
:1006F000C606C9CD6B06EBCD6B06EB13CDA306CDBD
:10070000D5064770237CBAC203077DBBC20307C965
:100710001603CD6B06E515C21207E1C103D11A77A6
:0D07200013237ABBC21E077BB9C21E07C999
:0000000000
$
```

Text continued from page 152:
be double sided and include plated-through holes. Since producing this type of printed-circuit board is beyond the capabilities of most amateur builders (including myself), I opted for a single-sided board with additional wire-wrap pins and connections to complete the wiring. The wiring diagram of the switch matrix is shown in figure 5, and an illustration of the printed-circuit layout is given in figure 6. A 24-pin wire-wrap socket was mounted at the top of the printed-circuit board and serves as a plug for the interconnecting cable. The cable is a 36-inch long DIP jumper with a 24-pin plug on each end. The Vector board also has a 24-pin wire-wrap socket to mate with the cable.

Install and Check Out the Video Circuitry

The remaining half of the components can be installed at this point. Check the video-dot-timing circuitry thoroughly to be sure that the correct frequencies are being generated at particular points in the circuit. After resetting the 8085 microprocessor, make sure that the 8224 is oscillating at 22.68 MHz. Pin 5 of IC15 (the 7474) should show the dot rate of 11.34 MHz as well as pin 2 of IC21 (the 74163) and pin 7 of IC22 (the 74166). You should measure a frequency of 1.620 MHz, which is the

Text continued on page 160

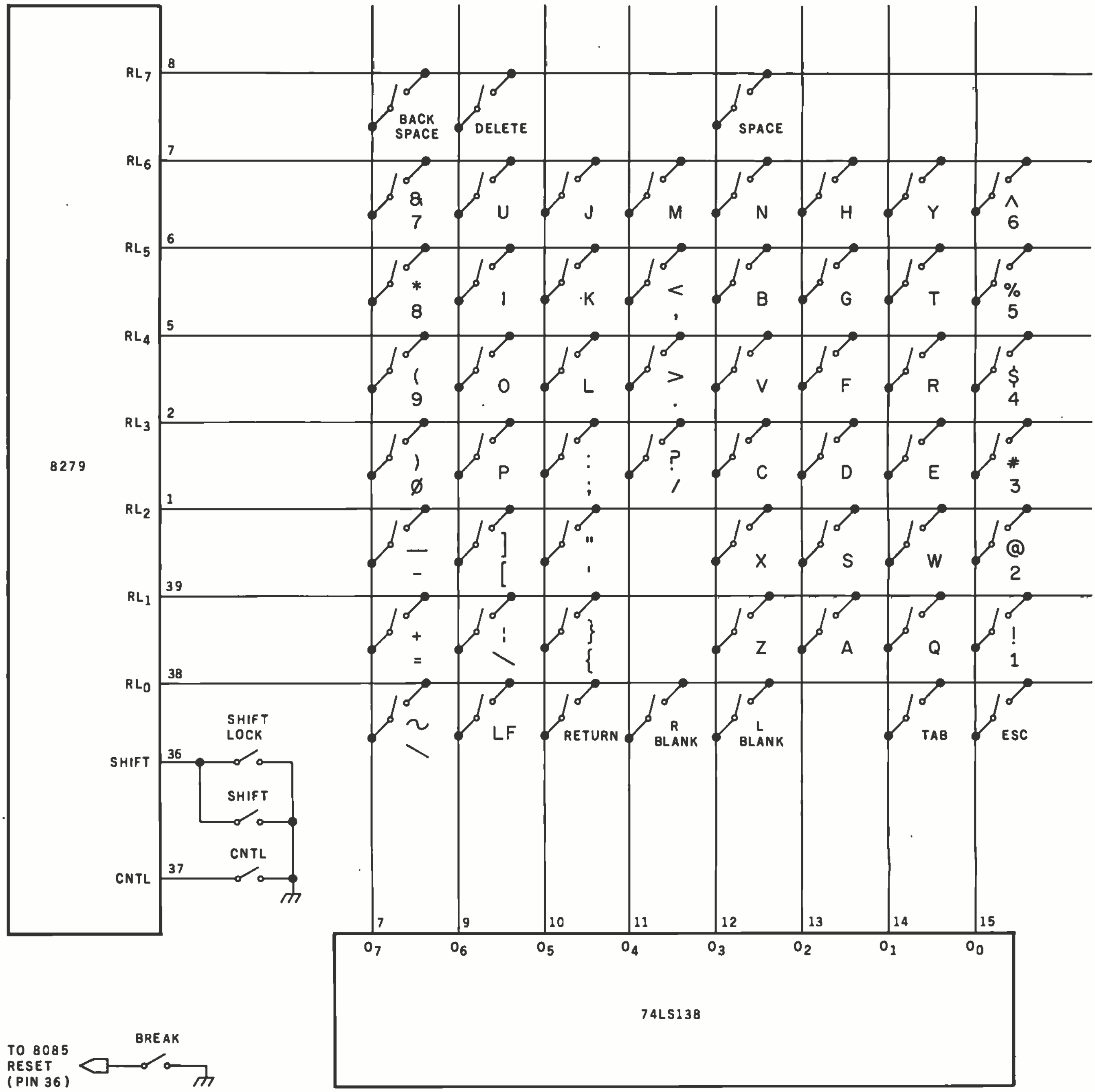
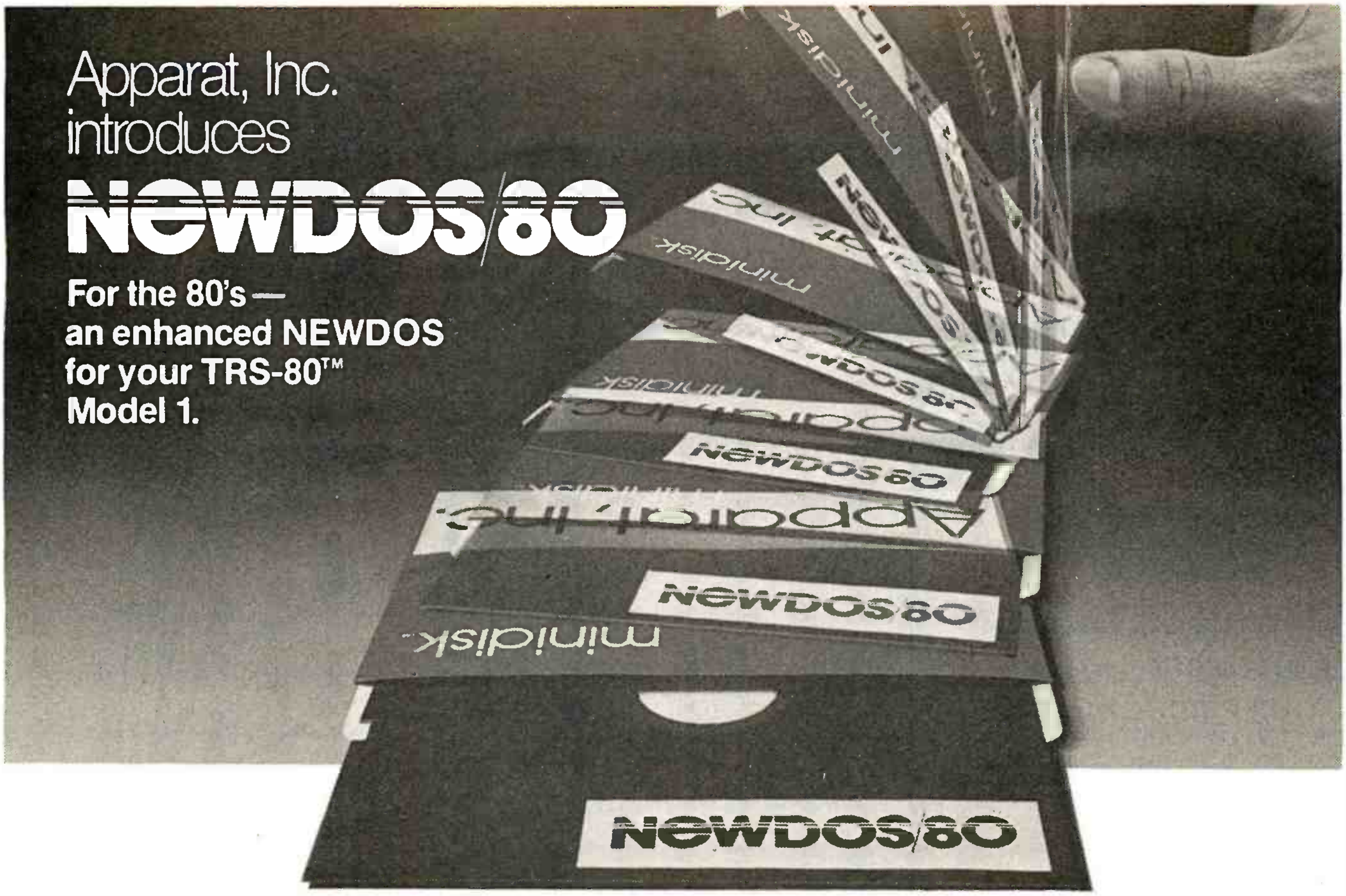


Figure 5: *Schematic diagram showing detail of the keyboard matrix. A sixty-three-key unencoded keyboard from Jameco Electronics was used. The BREAK key is connected to the* $\overline{\text{RESET IN}}$ *line of the 8085 processor.*



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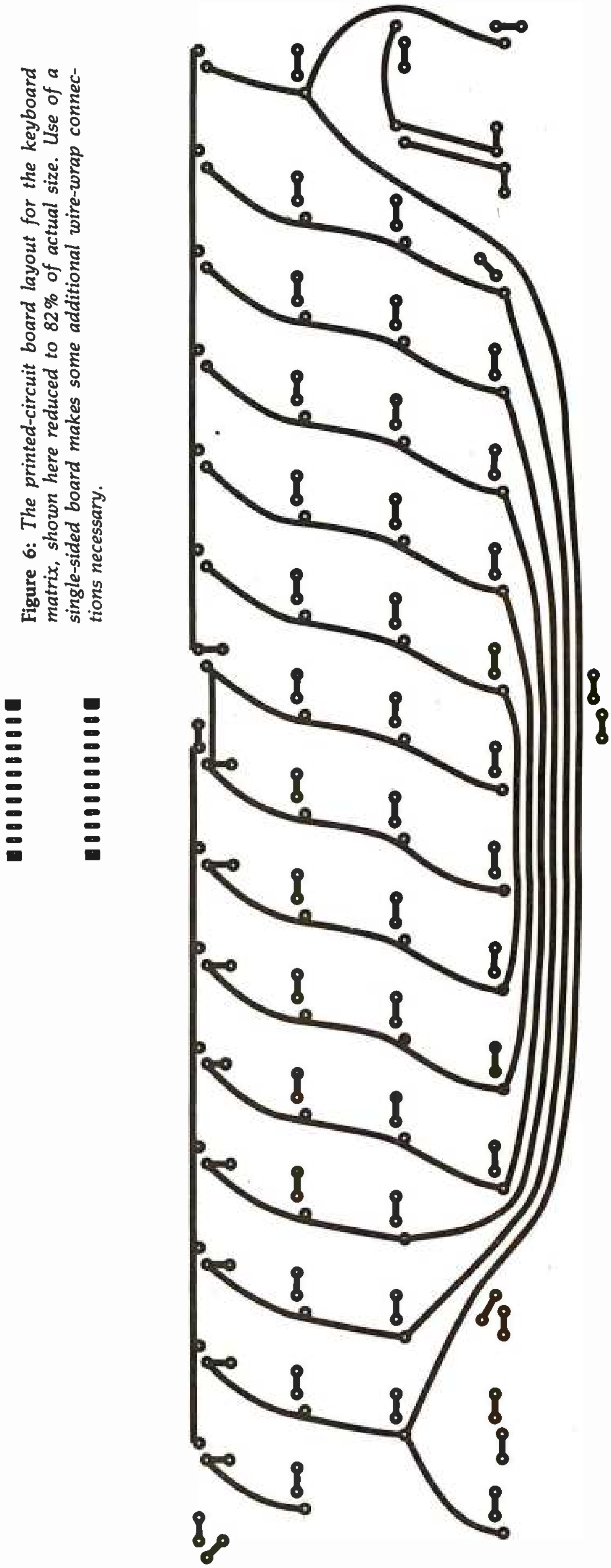

Figure 6: The printed-circuit board layout for the keyboard matrix, shown here reduced to 82% of actual size. Use of a single-sided board makes some additional wire-wrap connections necessary.

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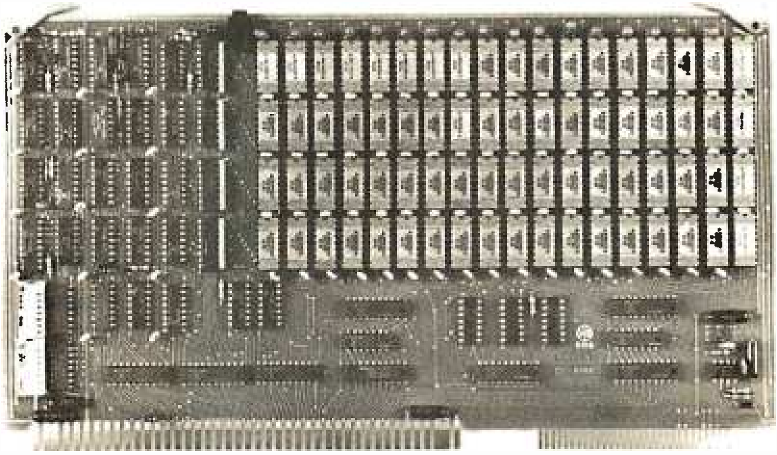

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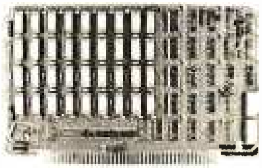

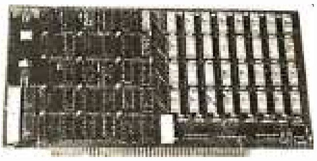

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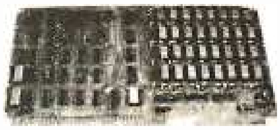

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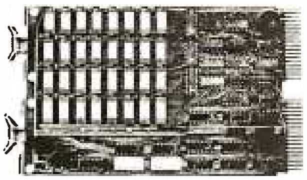

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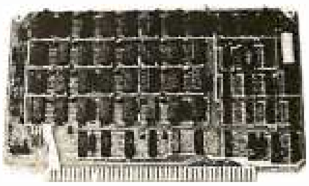

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Circle 101 on inquiry card.

Text continued from page 156:
character clock rate, on pins 6 and 8 of IC14 (the 7410), pin 12 of IC21 (the 74163), on pin 9 of IC23 thru IC27 (all five 74175s), pin 1 of IC21 (the 74163), pin 15 of IC22 (the 74166), and pin 30 of IC9 (the 8275). Pin 7 of the 8275 should measure 16,200 Hz, the horizontal line frequency, and pin 8 should be at 60 Hz, the frame frequency. Do not proceed until you can measure all of these frequencies correctly. If your display shows something quite distorted, torn, or scrambled, it is probably a problem in the video timing. An incorrect horizontal or vertical sync frequency can greatly disrupt a display.

Final Checkout

At this point, your terminal should be working. If it is not, double-check the following:

- On opening the TRAP switch, does the 8085 microprocessor branch to the monitor program and issue a carriage return, line feed, and question mark from the 8251?
- Are all of the frequencies listed above for the video timing correct in your circuit?
- Check the output of pin 35 of the 8275. This is the video-suppression (VSP) output which is active high during horizontal and vertical retrace at the top and bottom rows of every character, and in certain other cases involving end-of-row or end-of-series codes. Video suppression is also turned on if a direct-memory-access underrun occurs. If video-suppression is producing a logical 1 and has no activity on it, a direct-memory-access underrun is most likely your problem. This means that the software is not reinitializing the 8257 at the end of each video frame. The video-suppression line should show a frequency of 12 kHz on it. Pin 37 of the 8275 (the light-enable output) will have a frequency varying from 28 to 32 Hz.
- After the 8085 microprocessor has been reset and before data is sent to the video terminal, IC18 (the 74LS138 peripheral decoder) should be putting out pulses at constant rates. Pins 9, 10, and 15 should show a frequency of about 23 kHz, and pin 11 should show 600 Hz.
- The address-enable line on the 8257 (pin 9) should show a frequency of 1.5 kHz, and the address strobe (pin 8) should be 135 kHz. Again, these frequencies should be measured by a counter using a full 1-second gate time, since the duty cycles of pulses of these lines are not constant. This is especially true of the address-strobe output of the 8257.

Using a frequency counter and an oscilloscope to check for the correct activity on the various pins of integrated circuits is an effective method of troubleshooting your circuit. It is possible that a single wiring mistake is your only problem. Using an ohmmeter as a continuity tester and checking every connection is often worth the effort. I turn the circuit board over and put the ohmmeter probes on the pins of the integrated circuits themselves. This also serves to check for a bad socket connection. Draw over the connecting lines on your progress-checking schematic with a different colored pen as you make each check.

Possible Additions

Some readers may wish to make further modifications to my design. Here are some possibilities:

- Lowercase letters could be added fairly easily if the 7 by 10 format for each character is retained. The +5 V 2513 character generator is also available with a lowercase set of letters. The second character generator could be added by using the full 7-bit ASCII code in memory. Only six bits are stored in memory in this design. The most significant bit could be used to select which character generator would be enabled. The character-handling routine in the terminal control software would also have to be modified. If a larger format for characters was desired (eg: that used by the Motorola 6571 character generator), the entire dot timing would have to be changed, as well as the initialization of the 8275 in the software.
- The 8275 Video Display Controller has provisions for light-pen detection. Very little hardware would be needed to add this feature; only a small switch and a small light-sensor circuit using a phototransistor. When the raster sweep reaches the light sensor, it presents a signal to the light pen (LPEN) input, and the row and character positions are stored in a pair of registers in the 8275. These registers can be read on command. Modification of the control software would be necessary to read the registers and act upon their contents.
- Character- and field-attribute codes can also be handled by the 8275. Character-attribute codes are used to generate graphics symbols without the use of the character generator. These symbols can also be programmed to blink or be individually highlighted. Field attributes are codes that affect the characteristics of a field of characters. These characteristics are blink, highlight, reverse video, underline, and two general-purpose outputs that can be user defined. The Intel *Peripheral Design Handbook* gives details on implementing these features in both hardware and software.

Conclusion

This terminal is not a suitable project for a beginner or for those who are inexperienced in microprocessor hardware. Time and patience will be indispensable in completing this project. I spent about three months assembling the parts and building the circuit. A month of this time involved debugging both hardware and software, due to the many changes I made in the original Intel design.

I would appreciate hearing from those readers who complete this project. Descriptions of any modifications made would also be welcome. ■

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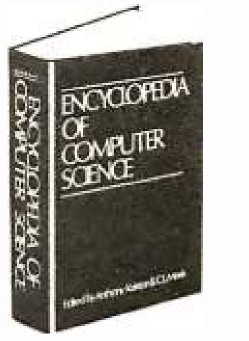

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In 1978 Ohio Scientific introduced a revolutionary new low cost computer — the Superboard II. This computer provides all important personal computer features on a single board at a cost of under $300. The Superboard II received rave reviews by microcomputer experts such as:

"We can heartily recommend the Superboard II computer system for the beginner who wants to get into microcomputers with a minimum of cost. Moreover, this is a 'real' computer with full expandability."
POPULAR ELECTRONICS MARCH, 1979

"The Superboard II weighs in at $279 and provides a remarkable amount of computing for this incredible price."
KILOBAUD MICROCOMPUTING FEBRUARY, 1979

"The Superboard II and its fully dressed companion the Challenger 1P series incorporate all the fundamental necessities of a personal computer at a very attractive price. With the expansion capabilities provided, this series becomes a very formidable competitor in the home computer area."
INTERFACE AGE APRIL, 1979

"The graphics available permit some really dramatic effects and are relatively simple to program . . . The fact that the system can be easily expanded to include a floppy means that while you are starting out with a low-cost minimal system, you don't have to throw it away when you are ready to go on to more complex computer functions. At $279, Superboard II is a tough act to follow."
RADIO ELECTRONICS JUNE, 1979

"The Superboard is an excellent choice for the personal computer enthusiast on a budget."
BYTE MAY, 1979

Since the introduction of Superboard II, the cost of personal computers has actually gone up with new models by major manufacturers ranging from $1000 to well over $4000 due to the general cost of inflation and the increasing functionality included in these computers. Today Cleveland Consumer Computers is offering you the original Superboard II at its original price of just $279. In today's economy this is by far the best buy in personal computing ever!

The Superboard II can entertain your whole family with spectacular video games and cartoons, made possible by its ultra high resolution graphics and super fast BASIC. It can help you with your personal finances and budget planning, made possible by its decimal arithmetic ability and cassette data storage capabilities. It can assist you in school or industry as an ultra powerful scientific calculator, made possible by its advanced scientific math functions and built-in "immediate" mode which allows complex problem solving without programming! This computer can actually entertain your children while it educates them in topics ranging from naming the Presidents of the United States to tutoring trigonometry — all possible by its fast extended BASIC, graphics and data storage ability.

The machine can be economically expanded to assist in your business, remotely control your home, communicate with other computers and perform many other tasks via the broadest line of expansion accessories in the microcomputer industry.

This machine is super easy to use because it communicates naturally in BASIC, an English-like programming language. So you can easily instruct it or program it to do whatever you want, but you don't have to. You don't because it comes with a complete software library on cassette including programs for each application stated above. Ohio Scientific also offers you hundreds of inexpensive programs on ready-to-run cassettes. Program it yourself or just enjoy it; the choice is yours.

The Superboard II comes fully assembled and tested. It requires +5V at 3 Amps and a video monitor or TV with RF converter to be up and running. $279.00

Standard Features:

- Uses the ultra powerful 6502 Microprocessor.
- 8K Microsoft BASIC-in-ROM. Full feature BASIC runs faster than currently available personal computers and all 8080 based business computers.
- 4K static RAM on board expandable to 8K.
- Full 53-key keyboard with upper/lower case and user programmability.
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Optional Extras:

- Available 610 expander board features up to 24K static RAM (additional), dual mini-floppy interface, and an OSI 48 line expansion interface.
- Assembler/Editor and Extended Machine Code monitor available.
- 630 I/O Expander. RGB color and NTSC composite color outputs with up to 16 colors, Dual 8-axis joystick interface, AC remote control interface which mates with AC-12P, home security interface which mates with the AC-17P, 16-line parallel I/O interface, 16-pin I/O bus interface which allows the connection of parallel I/O lines or high speed analog I/O module, or a PROM blaster or solderless interface prototyping board, programmable sound generator and program selectable modem and high speed printer ports, and more.

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Software:

Ohio Scientific and independent suppliers offer hundreds of programs for the Superboard II, in cassette and mini-floppy form. Here is a sampling of popular Ohio Scientific programs for the Superboard II.

EDUCATIONAL PROGRAMS	SBII&C1P	Price
BASIC Tutor Series	SCE-336	$35.00
Clock Tutor	SCE-353	6.50
Continents Quiz	SCE-332	6.50
Definite Integral	SCE-326	6.50
French Drill & Tutor	SCE-339	6.50
German Tutor & Drill	SCE-342	6.50
Hangman (8K)	SCE-324	9.00
Log Tutors 1-3	SCE-344	6.50
Math Blitz	SCE-329	6.50
Math Intro	SCE-319	6.50
Mathink	SCE-337	9.00
Matrix Tutors 1-3	SCE-345	6.50
Metric Tutor & Quiz	SCE-335	6.50
Spanish Drill & Tutor	SCE-352	6.50
Spelling Quiz	SCE-333	6.50
Trig Tutor (8K) I & II	SCE-318	6.50
BUSINESS PROGRAMS		
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Advertisement Demo	SCB-520	6.50
Inventory Demo	SCB-518	6.50
Mailing List (8K)	SCB-524	6.50
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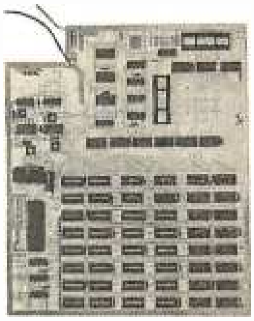
Tiger Tank	SCG-950	14.00



610 Board

CS-600

Hardware:

Superboard II	as specified in the advertisement.	$279
610 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. Requires +12V@ 1.5 amps and +5V@ 0.7 amps.	299
630 Board	As specified in the advertisement.	229
AC-3P	12" combination black and white TV/video monitor.	159
4KP	4K RAM chip set.	79
PS-005	5V 4.5 amp power supply for Superboard II.	35
PS-003	Mini-floppy power supply.	29
C1P Sams	C1P/Superboard II Manual.	8
OS-65D	V3.2 Disk Operating System with 9-digit extended BASIC, random access and sequential files.	49
CS-600	Metal case for Superboard II, 610 and 630 board and two power supplies.	49
CS-610	Metal case for single floppy disk drive and power supply.	49
AC-12P	Wireless AC remote control system. Includes control console, two lamp modules and two appliance modules for use with 630 board.	175
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BYTELINES

NEWS AND SPECULATION ABOUT PERSONAL COMPUTING

Conducted by Sol Libes

Radio Shack's New Products: This fall, Radio Shack will offer a $399 terminal/modem combination called the Videotex. This product will be billed as "the world's first low-cost home/office two-way information-retrieval system," and will allow a user to access CompuServe's MicroNet information utility and similar services.

The Videotex will connect directly to a telephone line and to the antenna terminals of a standard television set (not supplied).

A $30 software package will be required for a TRS-80 Model I to use the MicroNet system. In a radical departure from its past marketing policy, Radio Shack will also sell versions of the access software for non-TRS-80 computer systems such as the Apple II computer.

The MicroNet service will be accessible from 235 sites in the United States, providing news, syndicated columns, and sports, as well as access to credit-card verification and limited banking services.

Observers of the microcomputer industry have been expecting an announcement of three new Radio Shack computer products at any time now. A replacement for the TRS-80 Model I is due, and anticipation of more advanced systems is mounting.

Sharp To Introduce Under-$125 Computer: Sharp Corporation, of Japan, plans to introduce in 1981 an under-$125 hand-held computer, which is programmable in BASIC. It will store up to 400 program steps and have twenty-six memory locations for data storage. It will have an alphanumeric keyboard and a one-line LCD (liquid-crystal display). Optional printer and cassette interfaces will also be offered. Sharp is presently marketing a similar, but more powerful, machine in Japan, for $175.

Japanese Show Personal Computers in US: Several Japanese companies showed personal-computer systems at the recent National Computer Conference (NCC) in Anaheim, California. Nippon Electric Company (NEC) displayed a Z80-based system that currently sells for $730 in Japan. It includes a 12-inch color monitor, up to 64 K bytes of programmable and read-only memory and uses Microsoft BASIC.

Casio presented a system with 4½-inch video display and 4 K bytes of main memory, expandable to 32 K. SDC International Corporation said it is preparing to market an S-100-based system.

68000, Where Art Thou? Two computer-system manufacturers have reported to me that they are in a "holding" position on 68000-based 16-bit microcomputer-system development. They claim that Motorola has still not clearly defined some of the operation codes and will not commit to delivery on anything other than sample quantities. These manufacturers contend that similar problems occurred with the 6809 microprocessor. At this point, it does not appear likely that any 68000 products will become available this year.

Wanted: One And A Half Million Programmers: "There could be a demand for over one million computer programmers by 1990," said Andrew S Grove, Intel's president, in a recent interview. *Datamation* magazine has gone even further. In a recent article it reported that new software breakthroughs will cause the number of software programmers to increase 10% per year from 563,000 in 1980 to 1.5 million in 1990.

Japanese Memories Superior? According to a report made by Richard W Anderson, manager of Hewlett-Packard's Data Systems Division, Japanese 16 K memory devices are superior to US-made devices. According to Anderson, Japanese 16 K components showed a zero failure rate on incoming inspection compared to a 0.11 to 0.19% rate on US-made devices (ie: 100 failures out of 50,000). Further, field failures for 1000 hours of operation were 0.010 to 0.019% for Japanese parts versus 0.059 to 0.267% for US-made parts.

World Computer Chess Championship: The third world computer chess championship is scheduled to take place this month in Linz, Austria, from September 25 thru 29.

The former world champion program, Kaissa (from the Moscow Institute of System Studies), will provide strong competition for the best programs from the West. The current World and North American champion, Chess 4.9 (written by David Slate and Larry Atkin) will defend its title alongside other entries from the United States such as Belle, Chaos, and Duchess. The current European champion, the program Master, is also expected to compete.

As in previous tournaments, David Levy will be the Tournament Director. Mr Levy is an International Master of chess and has been noted for his own play versus computer programs.

Where Can I Store Ten Gigabits? Optical disks are expected to be the next major advance in high-density mass storage. Capacities of 10,000,000,000 bits (10 gigabits) are expected by 1982, 10^{12} bits (1 terabit) by 1985, and 10^{14} (100 terabits) by 1989. Video-disk technology is also advancing rapidly, but one shortcoming is that video disks are not erasable, limiting them to archival storage. Some systems now being designed are said to offer 10 billion bytes of storage on a 12-inch disk with 250 ms access time.

Bubble Memory Update: The first bubble-memory components were introduced in 1977 by Texas Instruments and Rockwell International. The number of bubble-memory suppliers has now increased substantially and includes Intel, Fujitsu, National Semiconductor, and Hitachi. Furthermore, Motorola and Siemens are second-sourcing the Rockwell device. It is likely that several other semiconductor makers will also enter the market.

Intel was the first to introduce a 1-megabit bubble-memory device, last year. Texas Instruments followed a few months later with its 1-megabit unit, and Rockwell is expected to announce its unit shortly.

Further, several manufacturers are also supplying support integrated circuits for simpler construction of the bubble-memory controller.

At this time, the major problem to acceptance of these devices is the lack of standardization. The available devices and support circuits from different manufacturers are not compatible. A Joint Electron Device Engineering Council (JEDEC) committee is currently holding discussions toward establishing standards on device design, reliability, testing, interfacing, and terminology. There still is no agreement as to whether the standard should apply to the device or to the controller level. Hence, it seems that a bubble-memory standard is still some time off, and we are unlikely to see bubble memory in wide use for some time to come.

Kentucky Farmers Get Viewdata: One hundred Kentucky farmers are trying out a Viewdata-type service to get information on markets, local crop conditions, and weather. The service is called the "Green Thumb Agricultural Weather Marketing Project." Using a box attached to a television set and phone line, a farmer can request information from the State's HP-3000 time-sharing computer, by means of a menu-oriented prompting system augmented by local county Z80-based computer systems. Up to eight items may be requested per telephone call. Currently one hundred farmers are testing the units made by Motorola in cooperation with Radio Shack.

Xerox, DEC, And Intel Join Forces For Office Network: Xerox, Digital Equipment Corporation, and Intel have joined forces in an effort to create a new internal data-communications network for business offices. Called Ethernet, it is intended for large or complex business offices. It will link together different types and makes of automated office machines (eg: terminals, intelligent copiers, word processors, etc) into a single system. Xerox holds the basic patents and will license others to manufacture compatible Ethernet products. A prototype system with several hundred machines is reported to have been operating for five years.

Large-Size Flat Display Technique Announced: RCA Laboratories, one of the leaders in display technology, has disclosed a new technical concept for building a wall-mounted 50-inch (diagonal-measure), color, flat-panel television display. A paper presented at the recent annual Society of Information Display conference estimated that the display could be in production by 1990. The display would consist of forty 1-inch-wide by 30-inch-high modules fastened together, side by side, to form a display 40 inches wide by 30 inches high. Each module would contain an electron gun and beam-guide system.

Othello Tournament Results: The best human player of the game Othello can still beat the best Othello-playing computer programs. This we conclude from the results of the First International Man-Machine Othello Tournament, held on June 19, 1980, on the campus of Northwestern University in Evanston, Illinois. Six of the best computer programs and the top two human players participated in a seven-round round-robin tournament. Mr Hiroshi Inoue, the current world champion from Tokyo, Japan, defeated five of the programs and the other human entry, Mr Jonathan Cerf of New York, New York, to win the tournament. Mr Cerf is the United States' Othello champion and is considered to be second-best in the world, although he placed third in this tournament.

The second-place finish was obtained by the computer program written by Dan and Kathe Spracklen of San Diego, California, who are well known for their chess-playing program, Sargon. The Spracklens' program defeated Cerf in the fourth round of the tournament; this defeat was somewhat ironic because Mr Cerf had given the Spracklens help in refining their game-playing algorithms.

Mr Inoue was narrowly defeated by only one opponent, a program called "The Moor" written by David Levy, Michael Stean, and Michael Reeve, all of London, England. This defeat, like the defeat of Cerf by the Spracklens' program, took place in the fourth round. Since the fourth round took place immediately after lunch, many observers have speculated that digestive factors may have impaired the performance of the human players. Oddly enough, The Moor was soundly beaten by programs which were themselves soundly beaten by Mr Inoue.

Fourth place in the final standings went to the program Odin, written by Peter Frey of Northwestern University. Fifth place was occupied by the program Iago, written by Paul Rosenbloom of Carnegie-Mellon University, followed by The Moor in sixth place. Peter Nachtwey, a US naval officer stationed in Newfoundland, Canada, entered his program Reversi Master which ended up in seventh place. Last place was occupied by a program written by Tom Truscott and Dennis Rockwell of Duke University.

Look for a full report on this tournament in a future issue of BYTE. (The name Othello is a trademark of Gabriel Industries, a subsidiary of CBS, Inc.)

AMSAT-OSCAR Phase III Satellite Crashes: When the first stage of the French Arriane rocket exploded during launch on Friday, May 23, 1980, the OSCAR Phase III satellite was lost. The spacecraft had an equivalent value of $250,000 and had required thirty man-years of effort for design and construction. The launch was not insured, so the Radio Amateur Satellite Corporation (AMSAT) has had to absorb a major loss.

The Phase III spacecraft appeared on the cover of the November 1978 BYTE and was discussed in Joe Kasser's article "The Sky's the Limit: Use Ham Radio Bands for Intercomputer Communication" (November 1978 BYTE, page 48). Part of the planned use of the satellite was to have been relaying of computer data by amateur radio operators in personal computer networks.

AMSAT is determined to build a second spacecraft (Phase III-B) to replace the lost unit, but the new satellite may take two years to complete. Fortunately, some material was left over from the original construction and may be used now.

AMSAT is continuing to develop software to be used by ground stations in the satellite networks and is seeking support from personal computer users in this software-development effort and in other areas of the rebuilding program. Information on AMSAT and its programs may be found in *Orbit*, which is published every two months and received by all members of the AMSAT group. A year's membership may be obtained for $10 from AMSAT, POB 27, Washington DC 20044.

The AMSAT space program is not a complete loss, however. The Phase II OSCAR-8 satellite continues in orbit, and a group of radio amateurs from the University of Surrey in England will launch the scientific-research satellite UOSAT in late 1981. Carrying a coherent high-frequency beacon, a magnetometer, and a slow-scan television camera, the "bird" will provide opportunity for ham radio and personal-computer users to gain experience in tracking satellites and monitoring telemetry.

Random Bits: It is interesting to note that IBM, via its Science Research Associates subsidiary, is marketing the Atari personal computer to educational users. In fact, IBM is offering a special sale. If you buy one Atari Model 800 system, they will give you an Atari Model 400 system free....Avalon-Hill, well known in the war gaming field for its historical simulation board games, has introduced a line of microcomputer-assisted games for the TRS-80, Apple II, and Commodore PET....The sales of the Texas Instruments (TI) Model 99/4 personal computer have been so disappointing that in the Los Angeles area TI has started offering $100 worth of free software plus a $100 cash rebate....Apple Computer Company has shifted its Apple II production from Silicon Valley to Carrolton, Texas, a mere 30 miles away from the new 100,000-square-foot plant Tandy has built to make TRS-80s....A record 82,000 people attended the National Computer Conference (NCC), in Anaheim, California, this past May. The NCC is the largest computer show in the world. When it was held in Anaheim two years ago, 55,000 attended, which set the record just smashed....Data General has begun selling its business-oriented microcomputer systems through independent computer stores nationwide....Fujitsu America Inc, Lake Bluff, Illinois, has announced a plug-in "Bubble Memory Cassette." It provides a portable, detachable, read/write block of 64 K bits. Fujitsu has also introduced a new fully-formed-character printer with speeds up to 80 cps (characters per second), nearly twice the speed of conventional daisy-wheel machines. The printer is currently offered as a $4500 option to a word-processor system....Texas Instruments is now making the voice-synthesizer components used in the Speak & Spell and talking Language Translator available separately at $13 in OEM (original equipment manufacturer) quantity....Shugart Technology, BASF, Control Data, and Erwin International, Ann Arbor, Michigan, are all expected to have 5-inch Winchester hard-disk drives available by the year's end....Commodore will be the first US manufacturer to use the new low-cost Shugart/Matsushita 5-inch floppy-disk drive....Zilog and Mostek have both announced that 6 MHz versions of the Z80 microprocessor will be available in production quantities next year.

Random Rumors: It is rumored that Commodore will soon introduce two low-end personal-computer systems. One will be a black-and-white unit for under $500 and the other a color unit for under $800....Apple may be working on a low-end consumer computer that will compete with Mattel's Intellivision....Personal Software, Sunnyvale, California, the folks who brought out Microchess and VisiCalc (probably the two largest-selling personal-computer software packages to date) are rumored about to release VisiText, a superpowerful text editor with features never before seen....NEC (Nippon Electric Corporation) is rumored to be investigating selling its Model PC-8000 microcomputer here in the US, after selling it in Japan for some time.

IBM Demonstrates Continuous Voice Recognition: IBM research scientists, at the Thomas J Watson Research Center in Yorktown Heights, New York, have demonstrated that continuous speech can be recognized by a computer with an accuracy of 91%. In continuous speech there are no pauses between words. In the IBM experiment, the computer transcribed normal-speed speech into printed form. The program took 100 minutes to display or type a transcript of a 30-second sentence. In other words, it has a 200:1 response-time ratio. The experiment proves that continuous speech recognition by computers is possible.

UCSD Pascal Controversy Continues: Several former University of California, San Diego (UCSD) Pascal licensees are threatening to file suit against UCSD and its new exclusive licensee, SofTech Microsystems. The licensees charge that UCSD violated the "fair use doctrine" in arbitrarily cancelling their licenses only a short time before the software would have entered the public domain.

About thirty organizations, mostly computer hobbyist clubs, paid $200 to $300 for a UCSD Pascal license that permitted distribution of the software to their members and, after two years, would have placed no restrictions on copying the software.

These licensees are also upset over what they charge to be software developed with public funds now being sold by a private organization. SofTech counters this charge by asserting that it is merely an agent of the university and that it intends to spend as much money on developing UCSD Pascal as did the university.

One UCSD Pascal purchaser had an uncancellable license: Apple Computer Company. Its license, however, is restricted exclusively to use of the software on Apple Computer systems.

Terminal Gets Voice Input: Heuristics Inc of Sunnyvale, California, has introduced a speech-recognition system which works with a Lear Seigler ADM-3A video terminal. The unit, called VOCON 5000, recognizes 64 words or phrases that can control a program being run on the computer. A 99% recognition rate is claimed for the unit, which sells for $2000.

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

LECTURE PROGRAM

A schedule of free lectures is available to all visitors. Lectures run about 50 minutes each, including, in most cases, some time for questions from the floor. Some topics are given twice, and, in some cases, topics of related interest are given on the same day for the visitor's convenience. (Program is subject to change without notice, but lectures will be posted daily in the show lobby.)

THURSDAY, OCTOBER 30

Noon	Introduction to Small Systems for Business, Stan Veit, Associated Computer Industries
Noon	Mailing Lists: Several Directions, Dr. Norman I. Agin, Mathtech, Inc.
1 p.m.	Selecting a Small Computer for Business, David Benevy, Computer Mart of New Jersey
1 p.m.	Evaluating and Improving Your Computer's Performance, Philip Grossman, Raytheon Co.
2 p.m.	Law Office Systems Aspects of Word Processing, Bernard Sternin
2 p.m.	Future Smart Machines: 2000 A.D. and Beyond, Dr. Earl Joseph, Sperry Univac
3 p.m.	Computer Contracts—Facing the Issues, Alan C. Verbit, Verbit and Company
3 p.m.	Accounts Receivable/Accounts Payable/ General Ledger
4 p.m.	Using FORTRAN on a Microcomputer, Richard A. Zeitlin
4 p.m.	Investment Analysis of Stocks and Commodities on a Microcomputer, Fred Cohen, Shearson Loeb Rhoades, Inc.

FRIDAY, OCTOBER 31

Noon	Introduction to Small Systems for Business, Stan Veit, Associated Computer Industries
Noon	BASIC Programming, Michael Mulcahey, Worcester Stage College
1 p.m.	Selecting a Small Computer for Business, David Benevy, Computer Mart of New Jersey
1 p.m.	Videoprints: Full-Color, Low-Cost, Hard-Copy Computer Graphics, Warren Sullivan, Image Resource Corp.
2 p.m.	Mailing Lists: Several Directions, Dr. Norman I. Agin, Mathtech, Inc.
2 p.m.	Business Applications Software Development via Data Base Management, Dr. Andrew Whinston, Micro Data Base Systems
3 p.m.	Application of PASCAL to Small Systems for Business, Panel, Stan Veit, Moderator, Associated Computer Systems

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3 p.m. Investment Analysis of Stocks and Commodities on a Microcomputer, Fred Cohen, Shearson Loeb Rhoades, Inc.
4 p.m. Advantages of Distributed Processing and Multi-Processing, John Steefel, Q1 Corp.
4 p.m. To be assigned.

SATURDAY, NOVEMBER 1

Noon Educational Software: The Good, the Bad, the Ugly. Jo Ann Comito, S.U.N.Y. at Stony Brook
Noon Introduction to Personal Computing, RCA—Solid State
1 p.m. Computer-Assisted Mathematics Courses, Dr. Frank Scalzo, Queensborough Community College
1 p.m. Artificial Intelligence Update, Prof. Peter Kugel, Boston College
2 p.m. Compiling and Retrieving Personal Medical Data, Dr. Derek Enlander, St. Luke's Hospital
2 p.m. The Present State of CP/M Compatible Software, Tony Gold, Lifeboat Associates
3 p.m. High Volume Date Handling: An Introduction to File Processing, Prof. Peter Kugel, Boston College
3 p.m. Connecting the Computer to the Outside World, Prof. James Gips, Boston College
4 p.m. Educational Applications in the Home, David Ahl, "Creative Computing Magazine"
4 p.m. Household Applications—Some New, Dr. Dennis J. McGuire

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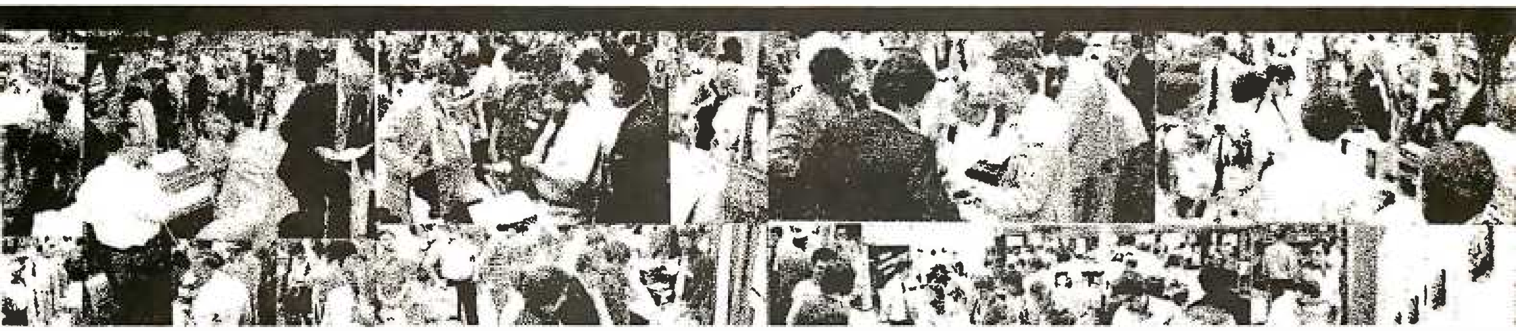

Computer Show

Circle 106 on inquiry card.

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Ask BYTE

Conducted by Steve Ciarcia

Levels to Bits

Dear Steve,

I have been shopping around for the analog-to-digital (A/D) converter integrated circuit that you used in your wood-stove interface (see "A Computer-Controlled Wood Stove," February 1980 BYTE, page 32), but it does not seem to be readily available.
C W Vuaun

I try to avoid specifying components that are not commonly available. While I obtain parts through industrial distributors rather than surplus outlets, I check the latter often to see what is available. In the case of the ADC0808, the time-lag is greater than I expected. However, in the meantime there is a sixteen-channel version, the ADC0816CCN, which is the same in every respect (except that it has twice as many channels). It is available from Digi-Key Corporation, POB 677, Thief River Falls MN 56701. Their toll-free phone is (800) 346-5144. Call or write them for the current price. **Steve**

More Power

Dear Steve,

I noticed your comment on UPSs (uninterruptible power supplies) in the June 1980 BYTE (see "Ask BYTE," page 86), and thought I would mention that they are commercially available in sizes small enough to be useful to personal-computer users (see the Hardside catalog, page 34). I do not know who the actual manufacturer is, but I would like to know more about these items. The devices I am concerned with have specifications that accommodate 60 and 120 Hz power, with and without surge protection, and supply 150 or 200 W. The trade name is "Mayday."
R M Sanford

Thank you for pointing out the Mayday UPS. It is manufactured by Sun-Technology Inc, which is located in New Durham, New Hampshire. The Mayday UPS is available from Hardside, 6 South St, Milford NH 03055, (800) 258-1790. According to the Hardside catalog, prices begin at $168.... **Steve**

A Hot Tip

Dear Steve,

The solid-state sensor you described for your wood stove (see "A Computer-Controlled Wood Stove," February 1980 BTYE, page 50) is very interesting. I have constructed the circuit, but I am having trouble calibrating the device for a range of −18 to +100°C.
Ron Goodmaster

The circuit you refer to can be calibrated in a number of ways. There is an offset and gain adjustment included for this purpose.

In normal practice, say for a range of 0° C to 100° C, we would adjust for offset so that the output was 0 V with the temperature probe in an ice bath and adjust the gain so that the output is 1.00 V when it is placed in boiling water. To have it actually read −18° as −0.18 V you will have to modify the circuit slightly. Presently the 50 k offset-adjustment potentiometer is connected between +12 V and ground. By connecting it instead between +12 V and −12 V you can impress a negative current flow into IC2 such that it has a negative offset. The gain of the circuit will now have to be adjusted for a 118-degree span instead of 100 degrees. The trick is that to accurately calibrate the unit you should have a −18° C standard when you set the low end. Substituting a voltage source for the LM334 will only give you a relative calibration, but it may be all you need.... **Steve**

Remote Control at Home

Dear Steve,

The other day I was thumbing through a BYTE magazine and I came across the article you wrote about using the TRS-80 and the BSR X-10 home-control system. (See "Computerize a Home," January 1980 BYTE, page 28.) I had been working on the same project in my spare time, and I had been using opto-isolators for interfacing; however, your method is well above the idea that I was attempting. Your article was very informative and the accompanying software was excellent. I have since looked up your articles in other BYTEs, and I must say that you never fail to come up with interesting and practical pieces.

I have decided to use your method, and I will shortly be purchasing a "Busy Box" from MicroMint in Woodmere, New York.

Whenever I have my TRS-80 up and running, the Sears home-control-unit operation is either marginal or nonexistent. The minute I turn the TRS-80 off, the home-control unit works fine. I assume that the prob-

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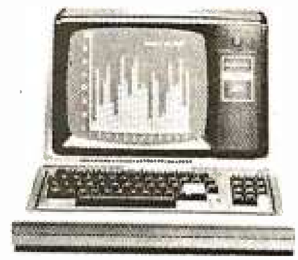

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Circle 108 on inquiry card.

lem is RFI (radio-frequency interference), but I am not quite sure how to cope with the problem. I know the TRS-80 is a great noise generator, but I know little of how to deal with the problem. If you can give me any help along these lines, I would appreciate it very much. Thanks.

Robert G Romppel

Radio-frequency interference (RFI) is so pervasive among personal computers and consumer electronic gadgets that the Federal Communications Commission (FCC) has extended the long arm of the law. See Terry Mahn's article "FCC Regulation of Personal Computers and Home Computing Devices" on page 180 in this issue.

As for now, there are various alternatives open to you. First, try plugging the BSR unit into a different wall socket than the TRS-80. The range of the Busy Box is 30 feet, so it doesn't have to be right next to the computer anyway. (Avoid extra long extension cords and use a plug strip for the computer and peripherals.) The noise from the computer is being radiated into the power line; therefore you want to put as much electrical distance between the TRS-80 and the X-10 as possible. While there may be five wall outlets in an average room, they are rarely all on the same circuit breaker. For the noise to reach an appliance plugged into another circuit loop, it must first travel back to the breaker box. This is a lot of wire and the resulting inductance will diminish some of the interference.

If that doesn't work, next try to kill the noise at the source (the computer) by placing capacitors at the outlet. I suggest using three 0.1 μF 600 V disc ceramic capacitors, one from each side of the AC line connected to a good earth ground and another across the line. Ordinarily, you would also connect the computer chassis to ground but this is not advisable on the TRS-80.

To really eliminate line noise, you need a combination of inductance and capacitance. Rather than trying to wind your own coils, it is better for you to buy a commercial noise suppressor. You want one that covers at least a range of 100 kHz to about 200 MHz. They are about $20 and up. One company that lists a few in its catalog is: Hardside, 6 South St, Milford NH 03055, (800) 258-1790.

*If none of this works, then encase the entire thing in copper screening and run it on a battery! ...***Steve**

Remote Control on the Farm

Dear Steve,

I am a graduate business student at Colorado State University working with David R Miller, Sun Up Angus Farms, Smithville, Missouri, in establishing an in-house computer system for his ranch. This will also be the topic of my thesis.

Presently the main areas that we see a need for a computer are:

1) *cattle inventory* —pedigree, calving dates, breeding dates, calf weights;
2) *customer service*—date, identification, and price of animals purchased, commercial or registered breeder, size of herd, etc;
3) *accounting system* —basically following the Internal Revenue's 1040 form with some variations;
4) various other programs for feed-ration analysis, investment analysis, profitability, etc.

I am interested in any existing computer programs or any information on the hardware available. Also, if you have any information about the cost, complexity,

satisfaction, or problems encountered in such a system, I am sure I would find it very useful.

My main problem in trying to choose a computer system is in deciding between two very diverse opinions. One opinion is that for a system as I have specified, I need a computer with 64 K bytes of memory and two 8-inch double-density floppy-disk drives for about one million bytes of storage. This would run in the neighborhood of $8000 in hardware (computer, printer, and terminal). The other major opinion is that I could get by with 50 K bytes of memory and 50 K bytes of storage; ie: a system that would sell for $1500 (such as the Intecolor 3600 Series from Intelligent Systems Corporation).

If you could give me any answers these questions, I would greatly appreciate it. Thank you for your time.

Laurie A Miller

It looks to me as though you already have a good idea what kind of computer you need. At least 48 K, preferably 64 K, bytes of memory are required plus dual disks. If your data base is exceedingly large, or a large portion of it must be on-line at one time, make sure you choose a system that is expandable. This could include two more floppy-disk drives or a 10-megabyte or larger Winchester hard disk. If because of finances you choose to start small, select a system that does not require a masters degree in electrical engineering to expand. Time of execution is generally the only real difference between large and small computers. The more disks you have to sort through to find the data you want, the longer it takes to get an answer. The software you want sounds like specific applications of generally available accounting and data-base management programs.

Hardware is only one part of the consideration however. Be aware that you are configuring a classic small-business system and the inventory and data-base management programs would be similar to, say, a dairy cooperative. While the choice of the hardware is important, adequate software and system maintenance are more signficant in the long run. Once the computer is installed it is very easy to become dependent upon it working.

There are many computers on the market that will satisfy your requirements: Cromemco, Hewlett-Packard, and Data General to name a few. The larger computer stores not only sell equipment like this, but offer custom programming and on-call field service as well. Take the time to evaluate the post-sale support for your computer, and check to see if your software will be compatible with other systems.

I do not know much about cattle, but the complaints I've herd—oops!—heard from small-business computer users have been registered.

..Steve ■

In "Ask BYTE," Steve Ciarcia answers questions on any area of microcomputing. The most representative questions received each month will be answered and published. Do you have a nagging problem? Send your inquiry to:

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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.

FCC Regulation of Personal- and Home-Computing Devices

New Rules After a 3-Year Study

Terry G Mahn
Wewer & Mahn PC
1762 Church St NW
Washington DC 20036

If you have been reading BYTE within the last half year, you are probably aware that the FCC (Federal Communications Commission) has handed down a set of regulations prohibiting the sale of personal computers that emit unacceptable levels of RFI (radio-frequency interference). But the FCC has changed its regulations several times, and in any case, information on and interpretation of these rulings have been scarce. I hope to clarify these most recent FCC regulations and to describe how (and when) they will affect you as a personal-computer user or vendor and the industry in general.

It is current FCC policy for computer manufacturers to bear the associated costs of their technology.

It is a common misconception by many in the computer industry that the FCC is empowered by the 1934 Communication Act only to regulate communications providers and users—that is, common carriers, broadcasters, and Citizens Band radio users. This misconception emanates from the nearly decade-old controversy surrounding the Commission's so-called "Computer Rules." First adopted in 1971, these regulations attempted to define the technological boundary line between common-carrier communications and data processing, to identify the FCC's jurisdictional perimeter under Title II (common-carrier services) of the Act. Recently, the computer rules have undergone a major revision in an effort to halt FCC encroachment into the traditionally nonregulated computer and data-processing industries.

The FCC's regulatory reach into the computer industry, however, is not as limited as the Computer Rules might seem to indicate. Title III of the Act (radio services) specifically empowers the FCC to *protect* communications systems from RFI, from whatever source derived. Insofar as virtually all computing devices emit spurious radio frequencies that can potentially interfere with radio or television services, manufacturers and vendors of such equipment come directly within the FCC's Title III jurisdiction.

It is not axiomatic that where federal authority exists, industry regulation and increase of the cost of doing business is sure to follow. (Under Chairman Ferris, for example, the FCC has been particularly notorious in reducing regulation of American industry.) Nevertheless, the FCC has chosen to regulate in this area for purely economic reasons. Because the radio spectrum is a valuable, but limited resource that can be used in various but incompatible ways, simple economic efficiency suggests that such resources be employed in their

About the Author

Terry G Mahn is a principal in the law firm Wewer and Mahn PC in Washington DC, where he specializes in intellectual property protection and licensing, and the legal, regulatory, and policy issues affecting the data processing and telecommunications industries. He has previously served as general counsel to the Computer and Communications Industry Association and as a computer specialist for the US House of Representatives Committee on House Administration. Currently, he is regulatory counsel to MITA (Microcomputer Industry Trade Association).

most valuable way—namely, in the way that yields the greatest public benefits. Just as raising a crop of corn and grazing cattle are incompatible uses of the same plot of land, so too may the operation of a computing device and the transmission of television signals present incompatible uses of the electromagnetic spectrum. The FCC, therefore, is forced to balance the demands placed on electromagnetic spectrum usage by American businesses and consumers: the difficulty arises in determining which use will yield the greatest public benefits.

Consider, for example, the following possible public-cost/benefit scenarios involving computing devices and communications services:

- A suspected criminal is being pursued by police through winding city streets. Several patrol cars begin converging on the suspect from different directions as information on the suspect's location and movement is relayed over the police radio band. Suddenly, the suspect makes an abrupt turn through the parking lot of a cocktail lounge. Before the pursuing car can communicate the suspect's sudden movement, however, interference crackles over the police band, drowning out all communications for several seconds. When the band finally clears, the police learn that they have lost track of the fleeing suspect. Later, the police investigate the cause of the interference on their restricted band and learn that one of the coin-operated video games in the cocktail lounge was the source of the interfering radio frequencies.
- An airplane pilot finds himself caught in bad weather and is forced to make an "instrument" landing. As the pilot approaches the airfield, he asks his copilot to render a quick computation to better gauge their position. The control tower, which has the plane on radar, warns the pilot of an approaching larger aircraft. Suddenly, before the tower's automatic collision-avoidance instructions are received, interference drowns out the radio channel. While waiting for the channel to clear, the pilot nearly collides with a commercial airliner but manages to land safely. The FAA (Federal Aviation Administration) later conducts an investigation and learns that the electronic calculator used by the copilot emitted the RFI that caused the interference on the restricted aeronautical-frequency band.
- A young mathematics student receives a personal computer for his fifteenth birthday. Shortly thereafter his entire family begins to use the computer for various applications: the father does tax and financial planning for his insurance clients; the mother stores cooking recipes and addresses and telephone numbers of friends and relatives; and the younger brother plays electronic video games. Soon, even the family's home-security and energy-control systems are being run by the computer. Meanwhile a neighbor complains to an FCC field office that he has been experiencing interference each evening over one of his local television channels. The field office investigates and learns that the personal computer is the source of the RFI. The family is told to correct their computer or discontinue its use. Since the

> manufacturer's warranty does not cover RFI defects, the family is forced to undertake expensive corrective measures of their own.

While these examples may seem a little contrived, in fact, each concerns a theoretical situation with which the FCC is concerned.

Moreover, in every case brought to the FCC's attention involving RFI from computers, the FCC has routinely decided that radiation from such devices is a less valuable use of the spectrum than the radio-communication services which might be interfered with. Stated another way, it is current FCC policy for computer equipment manufacturers to bear the associated costs of their new and beneficial technology.

Computing Device Interference

Computers and other similar devices emit potentially harmful radio-frequency signals. Inside a computer, very rapid electrical signals and pulses are generated and used to regulate sequences of events and to carry out the control and logic functions of the computer. These rapid electrical pulses produce high-frequency emissions that "float" around inside the cabinet of the computer. Unless this energy is somehow contained or filtered, it is radiated into space to be picked up by radio or television receivers.

Computers have been reported to cause harmful interference to almost all radio services, particularly those services below 200 MHz, including police, aeronautical, and broadcast services. Several factors that have contributed to the recent increase in computer-interference complaints include:

- the proliferation of digital electronic equipment in both businesses and homes;
- the development of higher-speed computers, which require designers to contend with problems of radio-frequency emission never before experienced;
- the increased replacement of steel cabinets with plastic cabinets, which provide little or no RFI shielding.

To the extent that computing devices are harmful in terms of their potential for generating RFI, and because private mediation between interfering uses is considered highly unlikely, the FCC becomes the final arbiter of spectrum interference.

Part 15 of the Commission's Rules specifically addresses these concerns by setting forth various technical and administrative specifications for all devices that generate or use radio-frequency energy. Computer and other digital devices not intended to radiate RFI are defined as *restricted-radiation devices.* Until very recently, however, restricted-radiation devices were subject to technical performance standards first drafted by the FCC in 1938. In further complication of matters, under these 40-year-old rules, personal computers are subject to vastly different technical standards depending on whether they contain their own video displays or connect to an external television set.

Three years ago the FCC initiated a rule-making procedure to modernize its Part 15 rules and to render them more workable and nondiscriminatory in our evolving electronic society. The proceeding was recently concluded with the adoption of new regulations that will affect *all* computer manufacturers. Hardest hit, however, will be the personal-computer industry.

FCC Classification of Computing Devices

In order to establish RFI standards that are appropriate for a given computer's actual harm-causing potential, the Commission has classified all computing devices under a binary scheme: Class A devices are defined as computing devices used in commercial environments, and Class B devices are defined as those used in a residential environment or widely marketed to the public.

The basis for this dual classification scheme is rooted in the theory that Class B (consumer) devices are located in closer proximity to radio, television, and (in many cases) land-mobile radio services and thus have a higher potential for causing interference than do Class A (commercial) devices. Additionally, the Commission has reasoned that consumer products usually do not contain the technical sophistication found in commercial equipment, nor do they receive the same level of preventive maintenance.

In recognition of these important differences, between consumer and commercial products, the FCC has imposed technical standards on consumer equipment that are *ten times* more stringent than those standards imposed on commercial equipment. More importantly perhaps, the Commission is requiring manufacturers of consumer devices to *register* their products with the FCC *by January 1, 1981* or cease all marketing; no similar rule applies to manufacturers of commercial computing equipment.

(In addition, the FCC rules further distinguish between Class B "personal computing" devices that contain their own video displays and those that connect to a standard home television receiver (so-called Class I TV devices), with the latter being subject to somewhat stricter rules. Such distinctions between personal-computing devices should soon disappear, pending the successful completion of an on-going rulemaking in this area.)

The Regulatory Scheme for Computing Equipment

The FCC's regulatory scheme for computing devices consists of both technical standards and administrative procedures. The technical standards are designed to minimize the likelihood that computing devices will cause interference with any FCC-authorized communications services. Therefore, standards for radiation as well as conduction (ie: through a building's wiring) limit the amount of radio frequency that computing devices will be permitted to emanate during their normal operation.

The administrative procedures adopted by the FCC are intended to ensure that manufacturers comply with the appropriate technical standards; these procedures also apprise the users of each class of equipment of its interference potential and what to do in case of technical failure. Most important, however, are the compliance deadlines that manufacturers must meet in order to continue (or begin) advertising and marketing their computing equipment. As explained more fully below, the rules differ substantially between commercial and consumer equipment, with the latter being subject to more stringent requirements.

Class Definition Distinctions

The FCC defines a "computing device" to be any electronic system that generates timing signals or pulses in excess of 10,000 cycles per second (10 kHz) *and* uses digital techniques. This definition includes, among other things, digital telephone equipment or any device that generates radio frequencies for the purpose of performing data-processing functions such as "electronic computations, operations, transformations, recording, filing, sorting, storage, retrieval, or transfer." The Commission notes that computer terminals and peripherals also fall within this definition but that other components and subassemblies do not.

Class A devices are further defined as any computing devices that are marketed for use in a commercial, industrial, or business environment. Class B devices are defined to be computing devices *marketed for use* in a residential environment in spite of their potential use in commercial environments. Examples of Class B devices are electronic games, personal computers, calculators, and similar electronic devices marketed to the general public. Temporarily exempt-

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ed (pending further rulemaking by the FCC) from the specific Class B technical and administrative requirements are microprocessors utilized in transportation vehicles, home appliances, test equipment, and electronic power or control systems utilized in industrial plants.

Compliance Verification Procedures

Class A device manufacturers are required, prior to marketing, to *verify* that their devices meet the technical provisions set forth in the FCC's rules. In contrast, manufacturers of most Class B devices on the market (eg: electronic video games and personal computers) must *certify* to the Commission that their devices comply. Herein lies the heavy burden to be shouldered by the personal computing industry under the FCC regulations. (For, if any lesson is to be learned from the FCC's "Part 68 Program" for certification of telephone devices, it is that federal regulations of this type are both costly and time consuming for manufacturers.)

(1a) RADIATION · Maximum field-strength limits

	Frequency (MHz)	Distance (meters)	Field Strength (μV/m)
Class A	30 to 88	30	30
	88 to 216	30	50
	216 to 1000	30	70
Class B	30 to 88	3	100
	88 to 216	3	150
	216 to 1000	3	200

(1b) CONDUCTION · Maximum voltage levels

	Frequency (MHz)	Maximum RF Line Voltage (μV)
Class A	0.45 to 1.6	1000
	1.6 to 30	3000
Class B	0.45 to 30	250

Table 1: *Radiation and conduction standards for computing devices. Table 1a sets the maximum permissible level of radiated radio-frequency emissions for both Class A (commercial) and Class B (consumer) devices. Table 1b does the same for conducted emissions impressed on the electrical-power network.*

Verification (for commercial devices) is basically an approval procedure based on the honor system, whereby a manufacturer tests his equipment to verify to the public that it complies with the appropriate technical standards. Although no FCC notification is imposed, manufacturers are still required to maintain records of their testing procedures and results.

By comparison, certification (for consumer devices) is an arduous equipment-authorization procedure which requires manufacturers to test their product for compliance and submit the test information to the FCC along with a completed application (FCC Form 731), photographs, and fees. After the FCC reviews the submissions, a certification number is issued for the tested equipment; the manufacturer must affix this number to every model thereafter imported, advertised, or marketed. Any subsequent change in the circuitry or operation requires that the equipment be recertified to the FCC.

Due to their high potential for causing RFI, the Commission has determined that only the following devices must be certified: electronic games, including coin-operated video games (but excluding handheld games that do not use a television receiver for display); personal computers (excluding digital clocks, desktop calculators, and handheld calculators); and peripherals and terminals capable of being attached to a personal computer. All other Class B devices need merely be verified by manufacturers prior to their marketing.

Technical Standards

The technical standards imposed by the new rules are designed to provide a "reasonable degree" of protection for radio and television receivers. Since unwanted interference from computing devices can result from radiated as well as conducted RFI, the standards regulate both types of emission. (See table 1.) Radiation testing requires manufacturers to measure the radio-frequency emanations at specified frequencies and distances from their equipment to ensure that certain maximum energy levels are not exceeded. Conduction testing is designed to ensure that equipment will not impart more than a maximum level of energy over a specified frequency range into the electrical-power network. [*For example, this restriction will apply to devices that use house wiring to remotely control appliances....*GW] (The actual equipment-test procedures to be used by manufacturers are the subject of a current rulemaking before the FCC. Until final rules are issued, the Commission has approved certain conventional industry test procedures.)

Together, both tests protect against interference frequencies as low as 450 kHz (just below AM radio) to frequencies as high as 1000 MHz (above UHF television signals). As stated previously, the standards for Class B equipment are ten times more stringent than those for Class A.

Labeling and User Information

Complex rules notifying users of their computing devices' potential (or lack thereof) for interference with radio communications and spelling out corrective action to be taken are key aspects of the FCC's administrative regulations. In essence, *all* computing devices will require some type of labeling or warning after January 1, 1981; however, these regulations will vary depending on the classification of the device as well as the device's mandatory-compliance date. All Class A equipment (unless certified under the Class B standards) must warn users that its operation in a residential environment may cause interference for which the user will be held accountable.

Mandatory-Compliance Dates

With regard to the new rules' effective dates, here too, the Commission's regulations are complicated and confusing. Originally, the Commission proposed a single deadline, July 1, 1980, after which all manufacturers of computing devices would have to comply with the appropriate rules or cease marketing their equipment. However, it soon became obvious to the Commission that several factors made a unified effective date impractical; these factors include the apparent lack of trained personnel to perform the necessary tests, the large number of devices in production that would have to be tested, and the shortage of emission-suppression components.

Upon reconsideration, therefore, the FCC adopted the following schedule of mandatory effective dates for compliance with its Part 15 rules (see table 2):

- Personal computers and other devices requiring certification (eg: video games, peripherals, and terminals) must meet the Class B standards by January 1, 1981.
- All other computing devices (Classes A and B) must comply with the appropriate device standards if *first manufactured* after October 1, 1981.
- If such (noncertificated) devices, however, are placed into production before October 1, 1981, compliance will not be required (for subsequently produced devices) until October 1, 1983.

Any device failing to meet these mandatory-compliance dates cannot lawfully be marketed, imported, or advertised for sale in the United States.

Special Rules for Subassemblies and Peripherals

Components and subassemblies of computing devices are not required to comply independently with the Commission's technical standards. In addition, peripherals supplied as part of a computing device do not need to be considered separately. Nevertheless, because all *end products* must comply, systems vendors and integrators can be expected to pressure their components suppliers into indirect compliance with these new rules.

On the other hand, peripherals marketed independently from their associated computing devices must comply directly with all technical and administrative standards. Peripherals marketed as part of any personal computing systems (which are in the Class B certified category) therefore must be certificated; all other peripherals (in the Class B noncertified and Class A categories) need merely be verified. In addition, peripherals sold separately from their computing systems also must be individually labeled.

Enforcement of Computing Device Rules

Lest there be any question as to the Commission's experience or commitment in enforcing its interference regulations as they pertain to the mass distribution of consumer devices, you need only recall the regula-

Compliance Date	Equipment Class
January 1, 1981	All Class B devices requiring certification (personal computers, electronic video games, and peripherals and terminals capable of being attached to personal computers) *manufactured* after this date.
October 1, 1981	All Class A devices and Class B devices not requiring certification which are *first placed into production* after this date.
October 1, 1983	All Class A devices and Class B devices not requiring certification which are *manufactured* after this date, regardless of when first placed into production.

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Table 2: *Dates of mandatory compliance for computing devices.*

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tory crackdown that accompanied the Citizens Band radio craze of a few years ago. There, the Commission revealed that it had adequate power over both manufacturers and retailers to prevent users from gaining access to equipment that was improperly engineered or tested.

The FCC can enforce its rules through either civil or criminal proceedings. For simple violations of any rules, the FCC has the power to issue cease-and-desist orders (ie: administrative injunctions) commanding the violator to comply with the rules or possibly face severe consequences. The severe consequences may be in the form of court-ordered injunctions or, in the case of willful violations, felony prosecutions with possible fines and prison terms of up to 2 years. Needless to say, criminal sanctions are rarely imposed by the Commission.

The FCC is hoping, rather, for manufacturers and vendors to comply willingly with its rules to avoid developing a reputation for selling customer equipment that results in widespread interference. Should large-scale noncompliance result, however, more vigorous standards and more troublesome equipment-authorization procedures could very likely be adopted by the Commission and imposed on the entire industry.

Conclusion

As with any FCC rulemaking that involves evolutionary consumer products, the Commission's activities to date may reveal only the tip of the iceberg. The protracted FCC proceedings involving telephone-equipment registration bear strong witness to this observation. New microprocessor-based devices may create unforeseen RFI problems not addressed in the new rules, changing work patterns will slowly blur the environmental distinctions between the home and office, and evolving communication services will continue to place additional demands on spectrum usage. Indeed, the Commission's fundamental assumption for its classification of computing devices (ie: proximity to RF receivers) is already starting to erode as radio receivers become increasingly utilized in commercial environments for the provision of Teletext and direct (rooftop) broadcast satellite services.

With new rules come new costs—whether they be costs of equipment redesign, costs of RFI-suppression components, or costs of testing, labeling, and FCC-certification delays.

The FCC is currently in the midst of a rulemaking proceeding to develop the Part 15 equipment-testing procedures. Slated for possible future rule amendments are handheld calculators, home appliances, microprocessor-based transportation systems, and other similar devices. Manufacturers of these types of equipment, therefore, should adapt to the idea that the FCC represents a cost of doing business that cannot be avoided—from now on.

Incidentally, the FCC's rules seek only to prevent interference between computing devices and (FCC-approved) communications *services*. Interference between incompatible *devices* utilized in the home (eg: wireless intercoms, burglar- and fire-detection systems, wireless switches, etc) is probably beyond the FCC's jurisdiction. Thus, it will be up to the industry itself to resolve among its own members—possibly through the newly-formed Home Bus Standards Association—these emerging interference issues. ■

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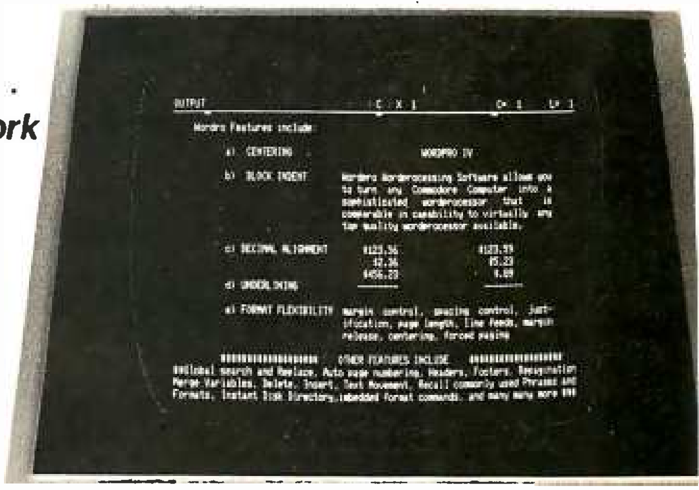

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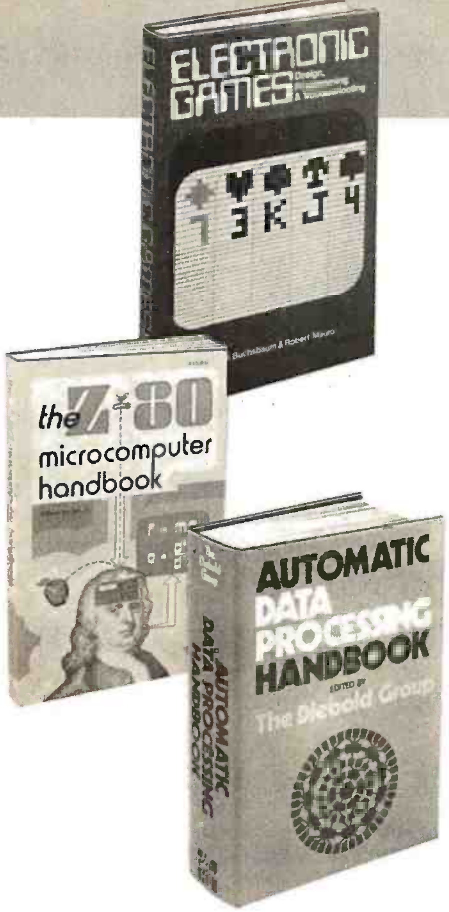

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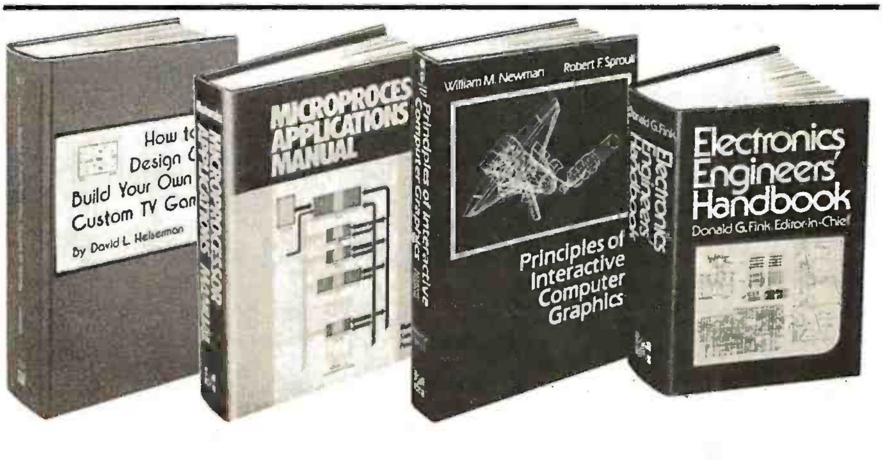

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Relocating Assemblers and Linking Loaders

Ottmar E Bochardt, 4560 Decarie #301, Montreal PQ H3X 2H6, Canada

Relocating assemblers and linking loaders are two pieces of assembly-language-oriented software that are probably unfamiliar to the average computer enthusiast. As a matter of fact, the very words *relocating* and *linking* (especially the latter) sometimes conjure up ideas of some vague, unspecified process. In reality, though, relocating assemblers and linking loaders are companion pieces of software that are easy to understand. The purposes of this Technical Forum are to:

- explain the relocating and linking processes;
- compare the two major linking methods;
- demonstrate how the assembly process is made slightly more complicated by relocating and linking;
- comment on the microprocessor-software standard proposed by Formaniak and Leitch.

My machine-language examples are all based on the MOS Technology 6502 processor. The Technical Forum "A Proposed Microprocessor Software Standard" by Peter Formaniak and David Leitch appeared on page 34 of the July 1977 BYTE.

Relocating and Linking Process

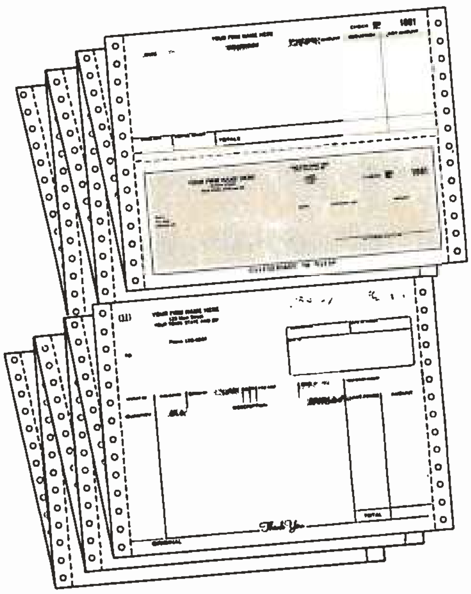
A *relocating* assembler is one which assumes that your program will be stored beginning at location zero in memory. In addition to object-module records that give the assembled machine-language code, the relocating assembler also generates extra information in *relocation records* to indicate which parts of the object module must be changed if the code is loaded beginning at some location other than zero.

A relocating loader, then, need only be slightly more intelligent than an ordinary (or absolute) loader. It must be able to:

- separate the input stream into individual object modules;
- assign a relocation address to each module;

Listing 1: *Example output from a relocating assembler. The code followed by the symbol R indicates a relative address, one that will be changed if this code is relocated to any starting location other than hexadecimal 0000. The code followed by the symbol G or G' indicates an external address, one that will have a known value only when this module is linked with other modules of code.*

Hexadecimal Address	Hexadecimal Code	Label	Instruction Mnemonic	Operand	Commentary
0000R			.ENTRY	SUB1	declare SUB1 to be an internal symbol
0000R			.EXTRN	SUB2	
0000R			.EXTRN	COMMON1	
0000R			.EXTRN	VAL001	
0000R	C3 70 00R	SUB1	LDA	COUNT	
0000R	A2 00		LDX	#0	
.					
.					
0040R	CA	LOOP	DEX		
0041R	D4 00 01		STA	DATA	
.					
.					
004DR	A0 00G'		LDY	#VAL001	
004FR	BD 0C 00G		LDA	COMMON1 + 12,X	
0052R	20 00 00G		JSR	SUB2	
0055R	4C 40 00R		JMP	LOOP	
.					
.					
0070R	1E	COUNT	.BYTE	$1E	
.					
.					
009CR	60		RTS		
0000			.ASECT		deposit some absolute code
0100			* = $100		
0100	00 03 07	DATA	.BYTE	0,3,7	
0000R			.END	SUB1	



- load each object module in correct relation to the new beginning address;
- read the relocation records to determine which memory locations must be changed to point to correct locations within the relocated code.

The example given in listing 1, which is source code to be processed by a hypothetical relocating assembler, will help illustrate these functions.

Suppose that the object module is to be loaded at hexadecimal location 0500. The effect of changing the load point of each object module by adding the relocation address shows that all relative addresses (those marked by an R in column 5 of the address) are offset by the amount hexadecimal 500; ie: hexadecimal 500 is added to each of these addresses.

Certain addresses within a portion of code are referred to in the code itself. If the code is moved (or *relocated*) to a different location, all references to these addresses (which are called *relative addresses*) must be changed so as to point to the correct location within the newly relocated code. Specifically, if the relocatable machine code is written to begin at memory location 0000, all references to a relative address must be replaced by the sum of the original address plus the relocation offset (which is equal to the beginning address of the code in its new location).

An example of this is the JMP LOOP instruction at hexadecimal location 0055 in listing 1. When the code is written to begin at hexadecimal location 0000, the label LOOP refers to memory location 0040. However, when this code is relocated to location 0500, LOOP becomes location 0540, and the JMP LOOP instruction now at 0555 is 4C 40 05 (4C is the JMP op code, and 40 05 is the address 0540, as stored in the computer, low byte first). In the example of listing 1, all data flagged with an R will be incremented by 0500.

(Note, however, that a relative address is not to be confused with assembly-language relative addressing. The latter refers to a mode of addressing available in the instruction sets of most microprocessors, where the byte being addressed is specified by how far away that byte is from the beginning of the next instruction. A relative addressing displacement byte is usually limited to a signed, one-byte quantity. A relative address, as part of a relocatable object module, is a two-byte address (for all 8-bit microcomputers) that must be changed when the module is relocated to another beginning address.)

An *absolute address* is an address that is not modified during the relocation process because it refers to a portion of memory outside the area being relocated. In our example of listing 1, the three bytes at 0100 are designated as being absolute (because they follow the .ASECT or *absolute* section pseudo-operation). When this section of code is relocated to hexadecimal 0500, the data bytes will still be at 0100. Thus, the reference to DATA (in the STA DATA line) still points to location 0100. This is because the data at 0100 has not been relocated.

Often assembly-language modules are written separately and are meant to be combined at a later time. In many cases, these modules reference each other. A label used in one program but defined in another is called

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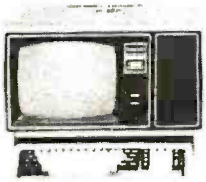

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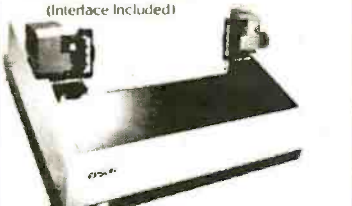

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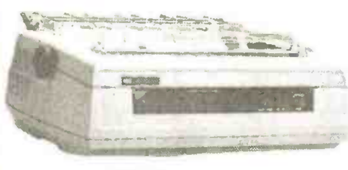

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an *external symbol*. When the modules are combined into one program, not only must they be relocated to separate memory areas, but they must also be *linked;* ie: the relocated values of each of the external symbols must be known by all of the modules. This means that the external symbols must be declared as such within the assembly-language source file.

In the sample program of listing 1, the purpose of the .ENTRY pseudo-operation is to declare that the value of the label SUB1 (ie: the address of the routine's entry point) is to be made available to other assembly modules. The character string "SUB1" and its value will be included in the object module, as part of an *internal symbol* record.

The next three statements indicate that the symbols SUB2, COMMON1, and VAL001 are referenced but not defined by this module (they will be defined later, when the modules are linked). These external symbols must be defined as internal symbols by exactly one of the assembly modules present at linking time. All listing lines flagged with a G or G' have an associated entry in an *external symbol record*, which includes the label name and a pointer to the label's use within the module. For example, the load module used with the module in listing 1 will have an external symbol record that associates the symbol "SUB2" with the address 0053R.

Implementing the Link Process

As an example, let us look at the format of *object modules* (ie: the machine-language module created by assembling a source module) resulting from the Mostek SDB-80 assembler. (A description of this standard is given by Formaniak and Leitch. See references.)

For each external symbol found, only one object record is produced. All references to a given symbol are linked together with the external-symbol record containing the address of the head of the list and the last entry in the list containing the hexadecimal value FFFF. (See figure 1.) In other words, when the SDB-80 assembler encounters an external reference, it uses that two-byte memory location to indicate to the loader where to find the *previous* reference to that symbol.

In terms of object-file size, this is probably the most efficient way to store linkage information, because it guarantees that only one external-symbol record per symbol will be used, regardless of how many times the symbol is referenced. It follows that, since the number of records being processed is smaller because of the link process, the time taken to link a series of object files will be minimized.

In the case of assembler source code (especially when written for a 6502 or similar processor), this linkage technique has several drawbacks. First of all, there is no provision for handling single-byte values, because two bytes of memory are required within the object code for the pointers. This is a serious deficiency for machines like the MOS Technology 6502 and the Motorola 6800, because these processors allow heavy use of page-zero addressing; in this manner the user can specify an address with one byte. Also, it is convenient to define small-valued parameters externally (such as VAL001 in listing 1) for use in two-byte instructions; the Mostek and other assemblers do not allow this.

Another point: it is impossible to specify an external symbol as having an absolute address. This is due to the fact that the *internal symbols* (symbols that have an address equated with them, such as SUB1 and LOOP in listing 1) do not contain a flag to indicate whether the

Hexadecimal Address	Hexadecimal Code	Instruction Mnemonic	Operand	Commentary
*		*	*	
0000R		.ENTRY	SUB2	
0000R		.EXTRN	XTR1	this is external symbol
.		.		
.		.		
.		.		
0021R	20 FFFF	JSR	XTR1	first reference (end of chain)
.		.		
.		.		
003AR	20 00 22	JSR	XTR1	backwards pointer to 0022
.		.		
.		.		
004ER	20 00 3B	JSR	XTR1	backwards pointer to 003B
.		.		
.		.		
006FR		.END	SUB2	

Figure 1: *Keeping track of external symbol use with a linked list. When the source file of an assembly-language module (consisting of the columns marked with an asterisk) is assembled into an object module of machine-language bytes, an external symbol record is created which points to the last place that the symbol is used (ie: the last memory location that must be filled with the address of the symbol, once that address is known—after linking). Within the data records that contain the object code for the routine, each reference of the external symbol points to the address of the previous reference, with a value of hexadecimal FFFF terminating the chain; this is shown by the arrows in the second column.*

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Listing 2: *Use of a separate page-zero assembly module. Use of a module like this on computers that have a set of special page-zero addresses allows page-zero addresses (such as XNOW) and system parameters (such as XMAX) to be defined in a central location.*

Hexadecimal Address	Hexadecimal Code	Label	Instruction Mnemonic	Operand	Commentary
0000R			.NLIST		turn off the listing
0000			.ASECT		enter absolute mode
000F			• = 15		
		;			
		;	common variables		
		;			
0010		XNOW	• = •+1		current horizontal position
0011		YNOW	• = •+1		current vertical position
0012		XVEL	• = •+1		horizontal velocity
.					
.					
		;			
		;	simulator parameters		
		;			
	00 A0	XMAX	EQU	160	maximum horizontal location
	00 0C	XVMAX	EQU	12	maximum horizontal velocity
.					
.					
0000R			.CSECT		re-enter relative mode
0000R			.LIST		turn the listing back on

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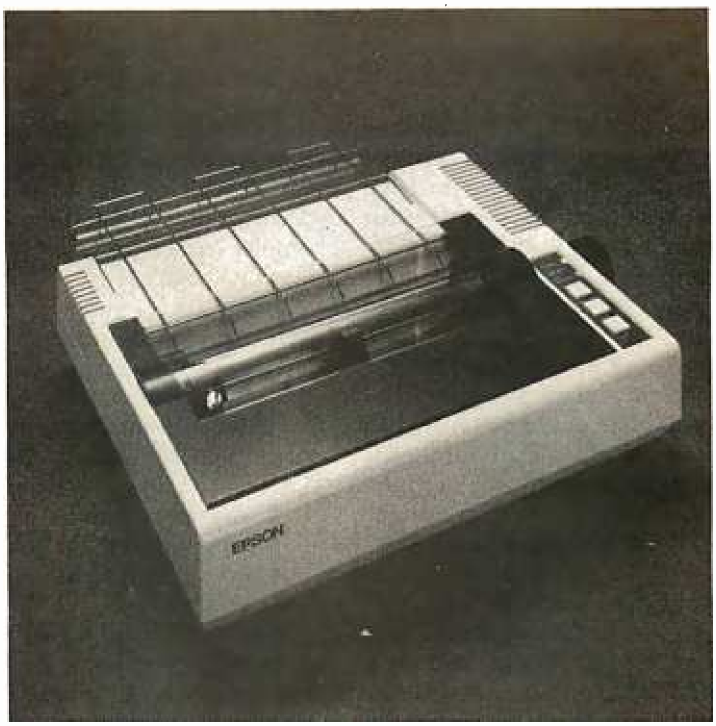

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23844 Hawthorne Boulevard, Torrance, California 90505, Telephone (213) 378-2220 defined symbol is relative or absolute. This could be changed by adding a flag byte to the internal-symbol record or by splitting the external-symbol record into two types: one for relocatable external symbols, the other for absolute-valued external symbols.

Also notice that code cannot be placed in absolute locations, because there is only one kind of data record and it is subject to relocation.

In all fairness, I would like to point out that there is a way around most of the problems mentioned above. A separate page-zero assembly module could be created to define both the addresses of all page-zero locations, which would probably have to be done anyway, and the values of all parameters that the system designer might want to change. This idea is demonstrated by the example given in listing 2.

Any good assembler should have some sort of copy command that instructs it to accept in-line source text from a separate file; this could be used to easily include a zero-page module like listing 2 wherever it is needed. A less convenient alternative would be to always prefix the page-zero module to the assembler input stream. This method of information binding (ie: giving a symbol its final value; see references, Elson) has the advantage of forcing the designer to define all assembly variables centrally, rather than having them scattered throughout the source code. Unfortunately, a major redefinition of the page-zero module would require reassembly of all associated programs. Also, the additional I/O (input/output) for the page-zero module could prove to be time- and resource-consuming on limited systems.

I have one more criticism about the proposed standard: it does not allow external variables to be referenced in an operand-arithmetic expression. This can be a strong drawback when referring to many fixed-data structures. Consider the following external declaration, written in FORTRAN:

```
COMMON / STATUS / XNOW, YNOW, XVEL ... /
```

An external declaration in any compiled language will take this form. Quite obviously, it should be possible to directly address any one of the variables in the common block. However, only the value of STATUS (the beginning address of the common block) is available using the proposed Mostek standard; the instruction would be .EXTRN STATUS. This means that a reference to XVEL, for example, could be done only through an address computation (ie: its address is equal to that of STATUS plus a certain number of bytes). Needless to say, the result is a waste of machine time, memory, and perhaps microprocessor facilities (eg: an index register). This problem directly affects the assembler programmer, since his coding style is interfered with.

The most practical alternative would be to allow offsets in external references. The offset could then be stored in the target location, to be adjusted at link time (the method shown in the program of listing 2). This will necessitate one entry in an external symbol record for each reference to that symbol in a source program. The result is, of course, increased object-module size and increased time taken to link or load a given set of modules.

It is possible to decrease both program size and execution time by separating the linking loader into a *linker* program (which links together a set of object modules, creating one file of fully defined machine code) and a simpler *loader* program (which loads the already linked machine code).

Relocating Assemblers

To an absolute assembler, all variable names are alike; ie: each represents a known value. On the other hand, a relocating assembler must be able to distinguish between three types of entries in its symbol table:

- absolute symbols
- relative symbols
- external symbols

When a relocating assembler encounters an arithmetic expression containing more than one symbol, it must determine several things: whether the expression is valid or not; and if it is valid, what its value is and whether an external or a relocation record (if any) need be written. Also, the use of arithmetic operators is limited by the combination of symbols being worked upon. For example, REL + EXT is valid if an external record is generated for the resulting sum; REL - REL is always valid; but REL - EXT is always invalid. (REL and EXT refer to a relative and an external symbol, respectively.) The actual rules for combination of symbols are more complicated and must be taken into account when designing a linking assembler.

An additional difference is that a relocating assembler must be able to recognize specialized directives. The ones that I have used in this article are:

.ASECT	enter absolute mode
.CSECT	enter relative mode
.ENTRY	define a list of internal symbols
.EXTRN	define a list of external symbols

In addition to these, there should be a directive to explicitly declare a one-byte external symbol, so that the assembler will know whether or not to generate a short (page-zero) form of an ambiguous instruction. As previously noted, this is most relevant to 6502- and 6800-type processors.

As shown in the previous section, a relocating assembler need be only slightly more complex than an absolute assembler, and allows the use of modular software-generation techniques. Unless the system being developed is extremely small (eg: 512 bytes or less), its advantages easily outweigh its drawbacks.■

References

Elson, M, *Concepts of Programming Languages*. Science Research Associates, Chicago IL, 1973.

Formaniak, P G, and Leitch, D, "A Proposed Microprocessor Software Standard," July 1977 BYTE, page 34.

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Varieties of Threaded Code for Language Implementation

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Between a high-level language (HLL) and its underlying machine architecture lurk many language implementation techniques. These include the older techniques of interpretation and compilation, as well as newer ones like intermediate languages and threaded code. In this article, we will present four types of threaded code techniques for implementing intermediate languages. We will examine how these four logically equivalent techniques offer various trade-offs of execution speed, program storage, and use of processor resources.

Implemention of a Language

The implementation of a high-level language on various logical or physical machine architectures involves such characteristic trade-offs as size of the language implementation, size of generated code, and speed of program execution. We will bypass other issues of high-level language use (eg: interaction, debugging, testing, etc) and concentrate on language implementation considerations.

Language implementation techniques can be logically divided into two categories: translation and interpretation.

Translation: Translation techniques replace elements of higher-level syntax with lower-level instructions that perform an equivalent operation. The resulting translation is then executed in order to run the program. A compiler is a computer program that translates high-level language programs into instructions of another language. Traditionally, assemblers and compilers translate their input into machine-level code.

Interpretation: Interpretation techniques directly execute the high-level language program. The interpreter is a program that sees the high-level language source program as a series of operation (op) codes used to guide its execution. The interpretive system appears to the user as a "virtual machine" that has the architecture of the high-level language.

Any form of interpretation offers significant opportunities for implementing debugging tools. Tests performed as each command is interpreted can result in a programmer-controlled display of debugging information. This is the basis for trace or breakpoint facilities that can be included in the interpreter.

Combinations: Combination techniques may translate the sequence of characters representing a high-level-language keyword into a form that is easier to interpret. Most BASIC interpreters translate the BASIC keywords into one-byte tokens that are easier to identify. This technique avoids the continual string searches of a traditional interpreter, but executes a language that is syntactically unchanged from the high-level-language source program. (For our purposes here, the term *syntax* will specifically refer to the structural relationship between language elements.)

Intermediate language: Intermediate-language (IL) techniques translate the high-level-language programs into a language that is simultaneously easier to deal with and syntactically different from the original. Many compilers translate a high-level-language program into an intermediate language, which is then translated into

About the Authors

Terry Ritter and Gregory Walker are software engineers at the Motorola Microprocessor Design Group, where their exploration into the structure of computer languages led them to examine FORTH and other threaded languages for use as a possible software tool. Terry Ritter is one of the co-architects of the MC6809 microprocessor and has been involved with personal computing since 1974. Gregory Walker is on the IEEE floating-point standards committee and has been involved with microcomputers since 1975.

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Intermediate-language techniques offer the advantage of machine independence of the source language.

machine code. When used in this manner, the intermediate language can allow global code-optimization techniques to be more easily applied.

Since the translation into the intermediate language is independent of the target machine, different compilers for the same target machine need only produce the simpler code of the intermediate language. Similarly, different code generators (which translate the intermediate language into machine language) can allow the same compiler to produce code for different computers. Intermediate-language techniques offer the advantage of machine independence of the source language and allow *program portability*, the ability to execute the same source program on widely different computers.

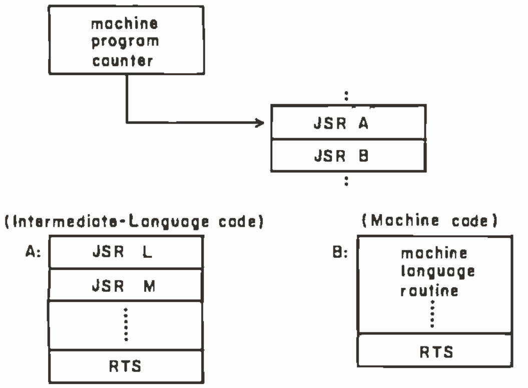
The intermediate-language representation of a program might also be interpreted instead of translated to machine code. To minimize interpretation overhead, we need complex and powerful machine-language routines. But machine independence is best accomplished by having simple, easy-to-write machine-language routines. This same trade-off of machine independence versus execution speed must be made in the design of any intermediate language. An example of this use of intermediate language is the pseudocode (p-code) used to implement most versions of Pascal.

This article is principally concerned with a class of intermediate-language representations particularly suited to interpretation; these are known as *threaded codes*. Naturally, the intermediate-language code will be generated by a compiler or by some other translation program. We will not discuss the translation process, which is a function of the syntax of the high-level language and other programming considerations; rather, we will discuss the resulting intermediate language and its interpreter.

Aspects of Intermediate-Language Architecture

An intermediate language is composed of a set of primitive operations (which, in combination, can express any algorithm) and storage capabilities for both internal and program data. In particular, it must be possible to pass data values between routines that make up the intermediate language. The intermediate-language program can use a fixed number of memory locations to simulate general-purpose registers, but then routines are needed that load (and store) each register from memory, as well as routines that simply move values between registers. If the intermediate language approaches the complexity of the original machine language, its use is of dubious value.

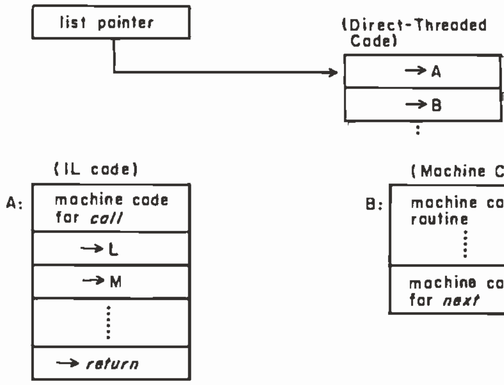
One approach that simplifies an instruction set is a "zero-address" or *stack* architecture. In this architecture, all operations will obtain values by pulling them from the stack and results will be returned by pushing them onto the stack. Only two operations with memory are now required: the "pull (from stack) and store (to memory)" operation and the "load (from memory) and push (on the stack)" operation. By designing a zero-address architec-



next *call* *routine*

next	JSR/RTS pair
call	JSR instruction
return	RTS instruction

Figure 1: *Diagram of subroutine-threaded code (STC). In this and figures 2 thru 4, the pointer points to the main program being executed. Both A and B are subprograms called by the main program; A is an intermediate-language subprogram of the same type as the main program, and B is an in-line machine-language program that directly executes the machine language of the host computer. The words* next, call, *and* return *refer to operations that must be performed for any threaded-code language. The information to the right of these words tells how each operation is performed in the current type of threaded code.*



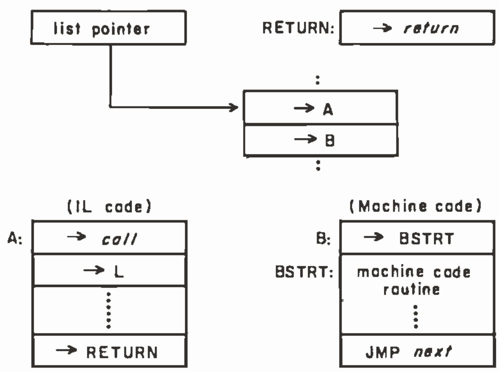
next *call* *return*

next
1. copy current list item to temporary storage
2. point list pointer to next list item
3. jump to machine code at address in temporary storage

call
1. push current list pointer onto stack
2. load list pointer with address of the intermediate-language subroutine list
3. do "next"

return
1. load list pointer with top of stack
2. do "next"

Figure 2: *Diagram of direct-threaded code (DTC). Here, "temporary storage" refers to a memory location that is used to hold the address of the machine-code routine associated with the current unit of code.*



next *call* *return*

next
1. copy current list item to indirect temporary storage
2. point list pointer to next list item
3. load code temporary storage with item at address in indirect temporary storage
4. jump to machine code at address in code temporary storage

call
1. push current list pointer onto stack
2. point indirect temporary storage to next list item
3. load current list pointer from indirect temporary storage
4. do "next"

return
1. load current list pointer from top of stack
2. do "next"

Figure 3: *Diagram of indirect-threaded code (ITC). Here, "indirect temporary storage" and "code temporary storage" store the indirect and direct pointers to the machine code routine associated with the current unit of code.*

ture into the intermediate language, the parameter transfer location is implied and need not be part of the intermediate language representation. (A stack architecture is certainly *simpler* than other architectures, but that does not mean it is *better*; many complex trade-offs that are beyond the scope of this article are involved.)

Threaded Code

Threaded code is an intermediate-language implementation technique that organizes the control of program flow into a sequence of subroutine invocations. *No other aspects of the language are represented in threaded code.* Threaded code is especially applicable to interpretation; the interpretation process consists of transferring control to the routines selected by the threaded-code op codes. The functions available in the intermediate language are provided by the subroutines that are invoked and are not an inherent part of the threaded code itself.

[*The characteristics of the language FORTH are independent of its current implementation via threaded code. FORTH enthusiasts often blur the distinction, attributing the language's speed and compactness to the language instead of to its threaded-code implementation. I think this is an important point to remember when talking about the advantages of FORTH....*GW]

Threaded-code intermediate languages are especially applicable to the implementation of virtual machines embodying zero-address architectures. As such, the technique of using threaded code to implement a language can be applied to, for example, Pascal (using the p-code intermediate language), LISP interpreters, or, of course, FORTH. We classify four varieties of threaded code: subroutine, direct, indirect, and token.

All varieties of threaded code consist of a data structure that is a sequence of unique subroutine identifiers. Traditionally, threaded code has been kept close to the machine level and has included actual pointers to the subroutines (which themselves may be either intermediate language or machine code). Also traditionally, a portion of the processor resources—in particular, processor registers—has been dedicated to the use of the threaded-code interpreter. As we shall see, neither absolute pointers nor register resources need be used to implement threaded code.

Implementing Threaded Structures

We will now describe the structures associated with the various types of threaded code. Figures 1 through 4 present diagrams of subroutine-, direct-, indirect-, and token-threaded code structures, respectively, along with a description of the three operations, *next*, *call*, and *return*, which make up the complete threaded-code interpreter. In the diagrams, the notation "→A" means a pointer to the memory location labeled "A".

Subroutine-threaded code: A sequence of subroutine calls *with no other embedded instructions* implements an intermediate language. Each subroutine call may be considered a single intermediate-language operation, which need not be related to the underlying machine architecture. Subroutine-threaded code (STC) is a control mechanism that is widely supported at the machine-hardware level.

The peculiar program organization consisting only of subroutine calls is rarely used by programmers (who have no reason to resist obvious opportunities for optimization), but it is sometimes used by compilers. It is the most general intermediate language possible, and it retains the advantages of machine independence by not generating in-line machine language. (The difference in the form of subroutine call and return instructions on various computers is usually trivial.)

Subroutine-threaded code will incur less execution overhead than most intermediate languages because its interpretation is handled by hardware rather than by a sequence of instructions. Furthermore, subroutine-threaded code can be optimized by using in-line machine code for operations where subroutine overhead is excessive, an advantage unobtainable with other types of threaded code. Of course, the resulting optimized code is no longer machine-independent; the additional translation step converts the intermediate language into object code for a particular machine.

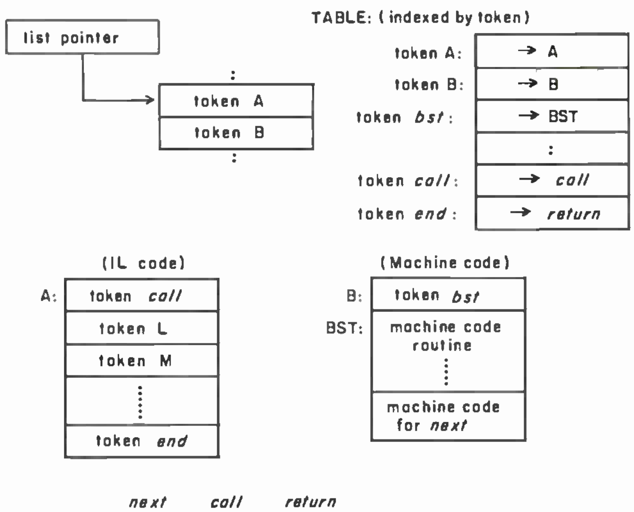
Direct-threaded code: Direct-threaded code (DTC) may be considered a sequence of machine-language subroutine calls with the "call" op code removed. This results in a list of addresses, each of which points to a machine-language subroutine. Since the direct-threaded program includes no op codes, a short machine-language program must be written to read the next address in the list and transfer control to that address. Traditional direct-threaded code implementations do not allow the use of true subroutines at the machine level but instead require that each routine terminate by executing the *next* operation.

In order to call direct-threaded routines (see the instructions for "call" in figure 2), machine-language code (executing the instructions for "call") must be included at the beginning of each direct-threaded routine to put the current value of the list pointer on an address stack, load the list-pointer register with the start address of the list of routine addresses for this just-begun, direct-threaded routine, and execute the *next* operation.

The *next* operation (coded here as in-line machine code) causes the computer to execute the routine pointed to by the list pointer, regardless of whether the routine pointed to is another intermediate-language routine or a machine-language routine.

In order to return to a higher level of nesting, the last list item in an intermediate-language routine points to the code for the *return* operation. When executed by the *next* operation, this operation recovers the previous value of the list pointer from the stack, then executes the *next* operation, which in turn executes the first routine past the routine the computer just returned from.

Thus direct-threaded code is implemented in three operations: *next*, *call*, and *return*.



next
1. get current token from list
2. point list pointer to next list item
3. look up address corresponding to token
4. get indirect token at address
5. look up address corresponding to indirect token
6. jump to machine code at that address

call
1. push current list pointer onto stack
2. load list pointer with start of new list
3. do "next"

return
1. load current list pointer from top of stack
2. do "next"

Figure 4: *Diagram of token-threaded code (TTC). Since tokens can be made shorter than addresses, this makes the threaded code more compact, but the table lookup makes the resulting code slower. Here, the "indirect token" is the contents of the table entry that matches the current token of code.*

Indirect-threaded code: Indirect-threaded code (ITC) consists of a list of addresses, but each address points to another address which then points to the machine-code routine. (See figure 3.) As compared to direct-threaded code, in indirect-threaded code, the interpreter must go through an extra level of indirection. Indirect-threaded intermediate-language subroutines do not contain machine-language code for the *call* operation, and one advantage of indirect-threaded code is that a compiler using it need only produce pointers. By manipulating only pointers, the compiler generates intermediate-language code that does not include machine-language code itself; thus it is independent of the target machine. However, a disadvantage of indirect-threaded code is that the interpreter has the overhead of an extra level of indirect addressing.

Token-threaded code: The varieties of threaded code previously mentioned contained pointers that were actual addresses of the subroutines in memory. Using memory addresses to select routines wastes storage because the number of subroutines in the system is far smaller than the number of memory locations. A savings in intermediate-language program size can be obtained by using short tokens to identify the subroutines to be invoked. Typically, token-threaded code (TTC) can be implemented by using the current token to index into a table of subroutine addresses. (See figure 4.)

High-Level Descriptions of Threaded-Code Interpreters

Listings 1 thru 3 illustrate the logical implementation of direct-, indirect-, and token-threaded code, respectively. The program descriptions are written in a high-level language that is similar in appearance to Pascal. It differs from Pascal in that the variables are not declared as standard Pascal data types. Also, the *next*, *call*, and *return* operations are not written as Pascal procedures; this was done to remain faithful to actual implementations where

these three code segments are reached by jump instructions rather than by subroutine calls.

Several other notational conventions used in these listings may also need explanation. The data type *pointer* means an actual machine address. If *ip* is a pointer variable, then → *ip* means the value at the location which is pointed to by the address in variable *ip*. Therefore, the statement

goto → ip;

means jump to a new location using the contents of variable *ip* as the address at which to proceed with execution.

Implementation Concerns

The traditional implementations of threaded-code interpreters have had one or more machine registers dedicated to the exclusive use of the interpreter; implementations on microcomputers have tended to use *all* microprocessor resources. One problem with these implementations is that all machine-language routines (where all real computation is done) must save processor registers before modifying them and must restore them before returning to the interpreter.

Additionally, this use of machine resources, simply for the transfer of control, obstructs the use of standard machine-language subroutines that pass parameters through the registers. In the context of microcomputer

Listing 1: *Description of a direct-threaded code interpreter in a Pascal-like language. See figure 2.*

```
const pointer_length = (length of an address pointer);
      call_code_length = (length of "call" code segment);
var   list_pointer: pointer; { interpreted program counter  }
      list_item:  pointer; {  contains threaded-code item   }
label next,call,return;

next: list_item := ^list_pointer;
      list_pointer := list_pointer + pointer_length;
      goto ^list_item;

call: push_on_stack(list_pointer);
    {  The value of list_item was set by the preceding       }
    {       "next" operation.                                }
      list_pointer := list_item + call_code_length;
    {  The following code duplicates the "next" operation.   }
      list_item := ^list_pointer;
      list_pointer := list_pointer + pointer_length;
      goto ^list_item;

return:  list_pointer := pop_from_stack();
     {     The following code duplicates the "next" operation. }
         list_item := ^list_pointer;
         list_pointer := list-pointer + pointer_length;
         goto ^list_item;
```

Listing 2: *Description of an indirect-threaded code interpreter in a Pascal-like language. See figure 3.*

```
const pointer_length = (length of an address pointer) ;
var   list_pointer: pointer;  { interpreted program counter  }
      list_item: pointer;     { contains threaded-code item   }
      code_pointer: pointer; { points to actual machine code  }
label next,call,return;

next: list_item := ^list_pointer;
      list_pointer := list_pointer + pointer_length;
      code_pointer := ^list_item;  { here is the extra       }
                                   {  level of indirection  }
      goto ^code_pointer;

call: push_on_stack(list_pointer);
   {   The value of list_item was set by the                 }
   {      preceding "next operation.                         }
      list_pointer := list_item + pointer_length;
   {   The following code duplicates the "next" operation.   }
      list_item := ^list_pointer;
      list_pointer := list_pointer + pointer_length;
      code_pointer := ^list_item;
      goto ^code_pointer;

return:  list_pointer := pop_from_stack();
    {    The following code duplicates the "next" operation.    }
         list_item := ^list_pointer;
         list_pointer := list_pointer + pointer_length;
         code_pointer := ^list_item;
         goto ^code_pointer;
```

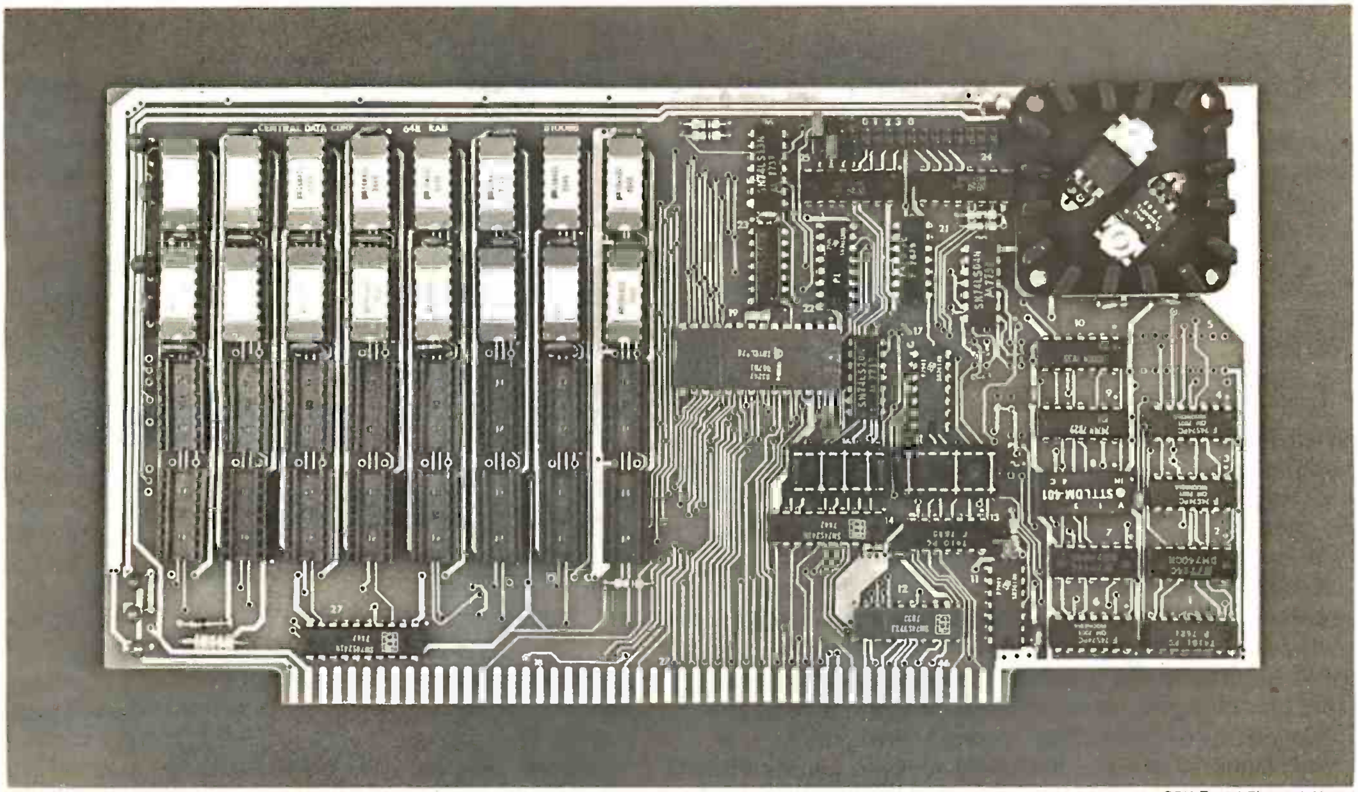
Listing 3: *Description of a token-threaded code interpreter in a Pascal-like language. See figure 4.*

```
const token_length = (length of token) ;
      call_code_length  = (length of "call" code segment);
      toknumber = (number of tokens possible); { is 256 for an }
                                               { 8-bit token    }
var   list_pointer: pointer;  { interpreted program counter  }
      code_pointer: pointer;  { pointer to machine code       }
      table: array[1..toknumber] of pointer; {subroutine table }
      token_item: short token;
label next,call,return;

next: token_item := ^list_pointer;
      list_pointer := list_pointer + token_length;
      code_pointer := table[token_item];
      token_item := ^code_pointer;
      code_pointer := table[token_item];
      goto ^code_pointer;

call: push_on_stack(list_pointer);
   {    The value of the code_pointer was set by the preceding }
   {       "next" operation.                                   }
      list_pointer := code_pointer + call_code_length;
   {    The following code duplicates the "next" operation.    }
      token_item := ^list_pointer;
      list_pointer := list_pointer + token_length;
      code_pointer := table[token_item];
      goto ^code_pointer;

return:  list_pointer := pop_from_stack();
    {    The following code duplicates the "next" operation.    }
         token_item := ^list_pointer;
         list_pointer := list_pointer + token_length;
         code_pointer := table[token_item];
         goto ^code_pointer;
```



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Listing 4: *A simple direct-threaded code interpreter for the MC6809 microprocessor.*

```
RETURN: PULS  Y           GET NEW THREAD PTR
        JMP   [,Y++]      DO "NEXT"


Machl Routine       IL Routine

          CALL: PSHS  Y
   ____         LEAY  *+7,PCR      STACK OLD THREAD POINTER
   ____         JMP   [,Y++]       ADDR OF FOLLOWING IL CODE
   ____
JMP  [,Y++]     ____
                ____
                FDB   RETURN       ADDR OF "RETURN"
```

systems (which may want to use read-only memory modules), this limitation requires that special "header" and "trailer" code be written to move data values used by the intermediate language to and from the registers used by previously written machine-language code.

It is also possible to eliminate the use of processor resources in an intermediate language by storing the interpreter's "registers" in memory; this leaves the processor free for use by machine-language code at the expense of additional overhead during interpretation. [*This overhead consists of having to move these registers between memory and the hardware registers of the host processor when you want to manipulate the contents of the interpreter registers....*GW] The use of absolute locations in memory would itself be a problem, because these locations can then conflict with locations used by other software packages. By saving the intermediate-language registers on the *stack*, the language may be made inde-

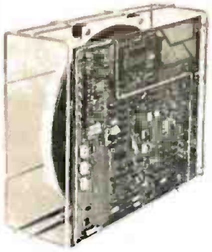
Listing 5: *A simple indirect-threaded code interpreter for the MC6809 microprocessor. In this and listings 6 thru 8, each block of information in lowercase is a "stack picture"—ie: a diagram of what is on the stack at that particular place in the code.*

```
         s ->thread ptr 1
             thread ptr 2

NEXT:    LEAS  -2,S                 MAKE SPACE
         PSHS  X                    SAVE X

         s ->x
             space
             thread ptr 1
             thread ptr 2

         LDX   [,Y++]               GET ADDRESS OF ROUTINE
         STX   2,S                  SAVE AS UPCOMING PC

         s ->x
             routine addr
             thread ptr 1
             thread ptr 2

         PULS  X,PC                 RECOVER X AND GO!

         s ->thread ptr 1
             thread ptr 2


CALL:    PSHS  Y                    SAVE CURRENT THREAD PTR
         LDY   ,--Y                 GET PREVIOUS INDIRECT PTR
         LEAY  2,Y                  NEW THREAD PTR
         BRA   NEXT

RETURN:  PULS  Y                    RECOVER OLD THREAD PTR
         BRA   NEXT
```

Listing 6: *A more complex direct-threaded code interpreter for the MC6809 microprocessor. Execution of the intermediate-language subroutine starts at the label ENTRY.*

```
          s ->next
              thread ptr 1
              thread ptr 2

RETURN:   LEAS  2,S          DISCARD "NEXT"
          PULS  Y            GET SAVED THREAD PTR

N1:       BSR   N2           PUSH ADDR OF NEXT
          s ->thread ptr 2
NEXT:     BRA   N1           SET UP RETURN TO NEXT
N2:       JMP   [,Y++]       GO TO ROUTINE

          s -> next
               thread ptr 2


    I-Code Routine  (start at ENTRY)

         PSHS  X             SAVE X
          s -> x
               thread ptr 0
               space
               next
               thread ptr 1
               thread ptr 2
         LDX   6,S           GET ADDR OF "NEXT"
         STX   4,S           MOVE IT
         STY   6,S           SAVE OLD THREAD PTR
          s ->x
              thread ptr 0
              next
              y (old thread ptr)
              thread ptr 1
              thread ptr 2
         PULS  X,Y           RECOVER X, NEW THREAD PTR
         JMP   [,Y++]        DO SIMPLE "NEXT"
ENTRY:   LEAS  -2,S          MAKE SPACE
         BSR   *-14       PUSH NEW THREAD PTR, GOTO PSHS X
   0:    ____                START OF THE IL CODE
         ____
         ____
         FDB   RETURN        ADDR OF "RETURN"
```

PRIAM Hard Disks Now Available from SIRIUS SYSTEMS!



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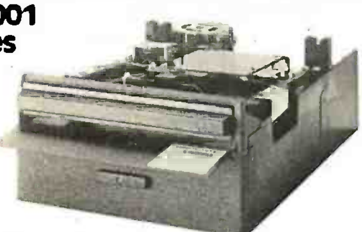

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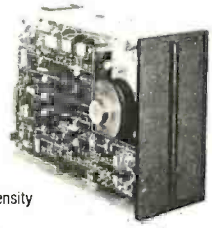

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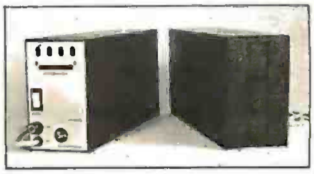

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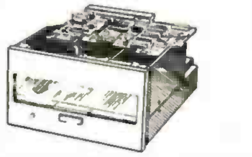

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> Software can be written to function properly on widely varying computers that use the same microprocessor.

pendent of particular programmable memory locations.

Another way to eliminate the use of processor resources, as well as maximize throughput, is to use subroutine-threaded code (STC). Subroutine-threaded code makes use of only the program counter and the subroutine return stack, resources already dedicated to the control of program flow. Thus, the processor resources traditionally available to the programmer remain free for use by machine-language code.

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To maximize sales, it is necessary that everyone who has a computer and who wants to use the program be able to do so. Given machine-language distribution, the market is already limited to those users with a particular processor; it should not also be limited to those users with a particular computer system.

Software can be written such that it functions properly on systems that use different locations for programmable memory, read-only memory, and input/output (I/O) devices, as well as systems that use completely different I/O devices. The system-independent read-only memory must be written in code that is position independent, and it must also include features for linking to other similar modules. These criteria can be satisfied with machine-language code (on certain processors) or with a correctly designed intermediate language. Widest distribution requires such properly written code.

Machine-Language Examples of Threaded-Code Interpreters

Here we present assembly-language code for the Motorola MC6809 microprocessor which implements complete interpreters for direct-threaded code, indirect-threaded code, and token-threaded code. Most of these listings are punctuated by "stack pictures" (typed in lowercase) that represent the current state of the stack at various points in the listing; visualization of the stack is often crucial to understanding the interpretive process.

An illustration of subroutine-threaded code (using subroutine jump and return instructions) would be trivial, and thus is not included. However, it should be noted that a position-independent form of subroutine-threaded code is available on computers with long rela-

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tive branch instructions (eg: the LBSR, long branch-to-subroutine, and RTS, return-from-subroutine, instructions on the MC6809).

Listing 4 illustrates a very simple implementation of a direct-threaded code interpreter. This particular implementation is very fast, but it has the following undesirable properties:

- it requires a special machine-language return instruction (ie: JMP [,Y++]);
- it reserves the Y register for use by the interpreter;
- it requires that the interpreter location (the address of RETURN) be known to the compiler, making the resulting intermediate-language code definitely position-dependent.

In operation, the Y register points to the next address in a direct-threaded code list; that address, of course, points directly to machine code. Executing the operation JMP [,Y++] (indirect, autoincrement by 2) causes the machine to start execution at the address contained in the list element; simultaneously, the Y register is updated to point at the next item in the list of addresses.

The single instruction JMP [,Y++] ends each machine-language subroutine. By reserving a processor register for use as the current thread pointer, a speed advantage is obtained; transfer of control using JMP [,Y++] requires nine machine cycles (on the MC6809), while a JSR-RTS pair requires thirteen.

The situation becomes more complex when control is transferred to a subroutine composed of intermediate-language statements. Machine-language instructions are included at the beginning of the intermediate-language subroutine to perform the *call* operation. The Y register may be thought of as the topmost location of the stack of intermediate-language return addresses; its contents are pushed onto the stack, and Y is loaded with the address of the start of the intermediate-language subroutine list.

The last item in an intermediate language list is the address of the *return* routine. This recovers an old intermediate-language pointer from the stack and continues interpretation where it left off when it did a subroutine call.

In listing 5, we show a very simple indirect-threaded code interpreter. As in the previous example, the interpretation process is fast, but again it has the following limitations:

- it must use a position-dependent, machine-language return instruction (eg: JMP NEXT);
- it uses the Y register to hold the list pointer;
- it still requires that the compiler generate position-dependent pointers to the CALL and RETURN routines.

Listing 6 is an example of a moderately complex direct-threaded code interpreter. It is somewhat slower than the simple interpreter in listing 4, but it uses a standard RTS instruction to return from machine-language routines. Thus, the machine-language routines need not contain pointers to the *next* operation. Still, this advantage is bought at the expense of additional machine-language code in each intermediate-language subroutine. The intermediate-language subroutines themselves do have

Listing 7: *An improved direct-threaded code interpreter for the MC6809 microprocessor. This interpreter does not use any of the microprocessor registers.*

```
          s ->ptr to new thread
              addr of "next"
              old thread ptr

 CALL:    PSHS D              SAVE D
          LDD 2,S             GET NEW PTR
          STD 4,S             THREAD PTR

          s ->d
              space
              new thread ptr
              old thread ptr

          PULS D              RECOVER D
          LEAS 2,S            DELETE SPACE
 NEXT:    LEAS -4,S           MORE SPACE

          s ->space
              space
              thread ptr

RETURN:   PSHS X,D            SAVE X, D

          s ->d
              x
              space
              space
              thread ptr

          LDX 8,S             GET THREAD PTR
          LDD ,X++            GET NEXT MACHL ADDR
          STX 8,S             STACK THREAD PTR
          STD 4,S             STACK ROUTINE ADDR
          LEAX NEXT,PCR       GET ADDR OF "NEXT"
          STX 6,S             SAVE AS MACHL RETURN

          s ->d
              x
              machl routine
              addr of "next"
              thread ptr

          PULS D,X,PC         GO TO MACHL ROUTINE

          s ->addr of "next"
              thread ptr


 I-CODE:   JSR CALL <instl> ...  <RETURN>
```

Listing 8: *Token-indirect token-threaded interpreter for the MC6809 microprocessor. Because of the use of two levels of lookup, this interpreter is completely position independent.*

```
        s -> table addr
             old indirect
             thread ptr

NEXT:   LEAS   -4,S        MAKE FREE STACK SPACE
        PSHS   U,X,D       SAVE REGISTERS

        s -> d
             x
             u
             space
             space
             table addr
             indirect
             thread ptr
```

Listing 8 continued on page 222

Listing 8 continued:

```
LDU  10,S           GET TABLE ADDR
LDX  14,S           GET THREAD PTR

LDB  ,X+            GET INDIRECT TOKEN
STX  14,S           SAVE THREAD PTR
CLRA                :
ASLB                : TWO BYTES PER TOKEN
ROLA                :
LDX  D,U            TABLE-RELATIVE INDIRECT PTR
ADDD 4,S            NOW ABSOLUTE
TFR  D,X

LDB  ,X+            GET TOKEN
STX  12,S           SAVE INDIRECT PTR
CLRA
ASLB
ROLA
LDD  D,U            TABLE-RELATIVE MACHL ADDR
ADD  4,S            NOW ABSOLUTE
TFR  D,X

STX  6,S            SAVE AS UPCOMING PC
LEAX NEXT, PCR      ADDR OF NEXT
STX  8,S            SAVE FOR MACHL RTS
PULS D,X,U, PC      RECOVER REGS + GO!


s -> addr of "next"
     table addr
     indirect
     thread ptr

 CALL:  PSHS  D            SAVE D

        s -> d
             addr of "next"
             table addr
             indirect
             thread ptr

        LDD  4,S           GET TABLE ADDR
        STD  2,S           MOVE IT
        PULS D             RECOVER D
        BRA  NEXT

RETURN: PSHS  D            SAVE D

        s -> d
             addr of "next"
             table addr
             old indirect
             thread ptr 1
             thread ptr 2

        LDD  4,S           GET TABLE ADDR
        STD  6,S           MOVE IT
        LDD  0,S           RECOVER D
        LEAS 6,S           DISCARD JUNK
        BRA  NEXT
```

pointers to the *return* operation, of course (making the code position-dependent), and the interpreter reserves the Y register for its own use.

Listing 7 illustrates a direct-threaded code interpreter that does not reserve any processor registers; this interpreter also allows the return from machine-language routines by means of a standard RTS instruction. The absolute locations of the interpreter *call* and *return* routines must be included in each direct-threaded code subroutine; this usually precludes the distribution of such subroutines in read-only memory.

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Type of Threaded Code	MC6809 Machine Cycles Used	Ratio of Cycles Used	Relative Size of Resulting Intermediate-Language Code	Can this Code Be Marketed to All Users of a Given Microprocessor?
Subroutine-threaded code	91	1.0	3	no
Relative subroutine-threaded code	98	1.1	3	yes
Simple direct-threaded code (listing 4)	93	1.1	2	no
Simple indirect-threaded code (as in listing 5)	371	4.1	2	no
Moderately complex direct-threaded code (as in listing 6)	228	2.5	2	no
Improved direct-threaded code (as in listing 7)	552	6.1	2	no
Token-threaded code (as in listing 8)	1083	11.9	1	yes

Table 1: *Comparison of threaded-code techniques. Notice that only two forms of threaded code, the relative subroutine-threaded code and the token-indirect token-threaded code are sufficiently system-independent to be used for mass distribution to (potentially) all users of a given microprocessor.*

A possible alternative would be to modify the direct-threaded code interpreter in listing 7 to use strictly self-relative pointers. Then by including code for *call* and *return* in each read-only memory device, a form of distributable direct-threaded code might be obtained. However, because the read-only memory still contains machine-dependent code, the use of direct-threaded code in a read-only memory environment offers little advantage.

The improved direct-threaded code interpreter allows the use of most previously coded machine-language modules and allows these routines to pass parameters through the processor registers. Routines cannot pass parameters on the hardware stack (which is used to maintain the state of the interpreter), but could easily use the user stack of the MC6809 microprocessor for parameter transfer.

A similarly improved interpreter could be built for indirect-threaded code, but the position-independence problem is inherent in this intermediate language as well. Each indirect-threaded subroutine must include a pointer to the *call* routine, thus making the resulting intermediate-language code unsuitable for distribution in read-only memory.

However, it *is* possible to build a token-thread interpreter that has a completely position-independent intermediate-language representation. Listing 8 shows one implementation that achieves these goals. Notice the increased complexity and overhead when compared to our original direct-threaded code interpreter.

This token-thread interpreter produces intermediate-language code that is more compact than that produced by previously mentioned interpreters. The advantage of a compact representation need not affect execution speed severely; remember that the overall efficiency of any interpretation scheme (including the hardware interpretation of op codes) depends more upon the work actually accomplished than the time spent in the interpretation process itself.

This particular implementation is essentially a token-indirect token-thread interpreter. Two levels of token lookup are involved so that neither machine-language nor absolute addresses need be included as part of the intermediate-language subroutine. Of course, perhaps

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other, more advantageous forms of token-threaded code interpreters are possible. However, we have shown that there is no longer a question whether position-independent threaded code is possible; now the question is: "at what cost?"

The Cost of Implementation

The claims made for threaded-code techniques in an intermediate-language implementation include reduced program storage and high speed of execution. Unfortunately, these claims are justified only in certain limited contexts. The original implementations of threaded code, which occurred on the Digital Equipment Corporation PDP-11, made use of the instruction JMP @(Rn)+ ; this instruction jumps through a memory pointer while retaining the location of *next* in a register. This is equivalent to the MC6809 instruction JMP [,r++] .

The instruction JMP @(Rn)+ does not save a return address on a memory stack and thus is faster than a JSR instruction. In the environment of a single intermediate-language program that calls only machine-language subroutines, stacking and unstacking of the return address need not occur. Of course, when intermediate-language programs call intermediate-language subroutines, such stacking must occur in a process that will take *longer* than a normal JSR. Thus, for maximum speed, the threaded-code intermediate-language program should not call intermediate-language subroutines.

On the other hand, the instruction JMP @(Rn)+ does eliminate the in-line 16-bit JSR op code for a 50% code reduction (on the PDP-11). But the 50% code reduction achieved on the PDP-11 (which uses a 16-bit JSR op code) is only a 33% code reduction on most microcomputers, which have 8-bit JSR op codes. (The LBSR instruction can be used in the case of the MC6809.) And if the motivation for threaded code is reduction of the intermediate-language code size, token-threaded code implementations can improve the storage efficiency by *another* 50%.

The two traditional forms of threaded code (direct and indirect) are optimized for the environment of a particular computer architecture that is represented by the PDP-11 (and also reflected in the MC6809). Consequently, many microcomputer threaded-code implementations have provided neither maximum code efficiency nor maximum speed and have devoured virtually all of the machine-level microprocessor resources. Comparisons of the four types of threaded code demonstrate that it is unlikely that the speed and code-efficiency maxima will ever coincide.

The main factor affecting code compaction is the use of subroutines instead of in-line code; but the use of subroutines inherently increases interpretation overhead. Since all methods of threaded-code implementation allow the use of subroutines, effects due to the use of subroutines can be disregarded and the efficiency of the implementation methods can be compared directly. Table 1 shows this comparison with values from the machine-language routines developed earlier (based on six *next* operations for each *call* and *return* operation).

Conclusions

Languages that have been historically associated with threaded code will probably continue to use these techniques when implemented on microcomputers. New implementations should take advantage of the interpretive nature of threaded code to provide extensive debugging facilities. However, there is no excuse for the threaded-code implementor to prohibit the use of previously coded machine-language modules by eliminating parameter passage through microprocessor registers. Either the interpreter can be designed to keep these registers free, or special routines must be written by the implementor to save and restore these registers when using library routines stored in read-only memory.

Similarly, the motivation for distributing software in an open market (to many different users with many different systems) leads directly to the requirement for position independence. While the MC6809 directly supports position-independent code at the machine-language level, it is also possible to devise threaded-code intermediate languages that are position independent. But any intermediate language or interpreter that requires particular absolute storage locations is so obnoxious as to be unworthy of discussion in polite programming society. Absolute-address storage requirements are simply unacceptable in code written for mass distribution.

Within these constraints, the various forms of threaded code offer different trade-offs of speed and code efficiency. Because these forms are logically equivalent, a single compiler could be used to generate any of them at the user's choice. Thus, without changing the source program, a threaded-code technique could be selected that would give the desired trade-off between speed and code efficiency for a particular situation.

In the end, threaded-code implementation techniques are neither particularly compact nor are they particularly fast. Continued development of direct-threaded code structures could result in a language representation that would look more like Pascal p-code than threaded code. Threaded code does offer a conceptually simple and general control-transfer technique that displays a clear boundary between interpretation and language. However, threaded code is probably not an optimal representation for any particular language, including FORTH. ■

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New Cultures from New Technologies

Seymour Papert, Project LOGO, Massachusetts Institute of Technology, Artificial Intelligence Laboratory, 545 Technology Sq, Cambridge MA 02139

When I was asked to write this Education Forum for BYTE, I was in the process of correcting the proofs of my book, *Mindstorms: Children, Computers and Powerful Ideas*. (See reference 1.) There I struggled to present in two hundred pages a vision of a few ways in which computers might affect how children learn; it is challenging now to find the right 3000 *words* to convey something of the same vision. What images, what metaphors best capture for me the essence of the computer as it might enter the lives of children?

I start with an image, more general than the computer, that has helped me to think about how the world takes up any new technology. The first movies were made by setting the newly invented motion-picture camera in front of a stage where a play was performed just as plays always had been. Only after some time did cinema become more than theatre plus camera. When it did, what emerged was something original and unique, a whole new culture with new modes of thinking and new breeds of people—stars, directors, scriptwriters, cameramen, critics, and audiences whose sensitivities, expectations, and ways of seeing were quite different from those of the theatre-goers of the past.

So too with the computer. The first instinct of educators is to couple the new technology to their old methods of instruction. My vision is of something much grander. So I dream of using this powerful new technology not to "improve" the schools we have always known (and, to be honest, hated) but to replace them with something better. I do not believe that this something will look anything like what is now known as "computer-aided instruction" (CAI). I think it will be more like the growth of a new culture, a "computer culture" in which the presence of computers will have been so integrated into new ways to think about ourselves and about the subject matters we learn that the nature of learning itself will be transformed.

In thinking about the nature of such potential transformation, the LOGO group of the Massachusetts Institute of Technology (MIT) Artificial Intelligence Laboratory has been guided by the idea of creating computer-based environments in which mathematics and other areas of "formal" learning can be learned in a natural fashion, much as a child learns to speak; and applying concepts from artificial intelligence to children's learning, to help children become articulate about, and thus gain control over, the learning process. Before developing these ideas, I would like readers to clear their minds of a misleading but common image. People generally think about computers in schools as a scarce resource to which students have occasional access. It is time we learned to think in terms of a computer for every child, and we should think about children having access to computers from infancy. If we think in these terms, we begin to recognize that there is a clear discontinuity between the current ideas about using computers in schools and the situation of the future. I really believe that almost everything being done today is only relevant to the future in that it sets a bad example so that people become accustomed to primitive models.

A natural place to begin a search for "something new in education" is to look for examples of highly successful learning. For me the most dramatic image of successful learning is the way children learn to talk. This learning contrasts with school learning in many ways, of which I think two are most important. First, it is highly successful: all children learn to speak the colloquial dialect in which they grow up. Second, it has none of the technical paraphernalia of schooling—no curriculum, no set lesson times, no quizzes, no grades, no professional teachers. It is part of living. I call it learning-without-teaching or

Piagetian learning (after the Swiss philosopher-scientist Jean Piaget who has done more than anyone else to show us how very much children learn in this way).

Much of the work done to date in the whole area of computers and education—eg: CAI—has promoted a style of learning that gives the impression of a child being "programmed" by the computer. Our approach has been diametrically opposed to that. By striving to make the computer's processes as transparent as possible and creating activities in which children "teach" (ie: program) computers in a well-structured, procedural language like LOGO, we have aimed toward putting children in control of their own learning. Obviously, I cannot hope to explore these ideas in much depth in a short space. What I shall try to do is to describe a couple of learning environments we have created which I believe challenge the fundamental assumptions our society makes about children and learning.

Mathland

The belief that only a few people are mathematically minded is a truism in our culture and a cornerstone of our educational system. It is therefore sobering to reflect on the flimsiness of our reasons for believing it. In fact, the only evidence is crass empiricism: look around and you will see that most people are very poor at mathematics. But look around and see how poor most Americans are at speaking French. Does anyone draw the conclusion that most Americans are "not French-minded?", that they are not capable of learning French? Of course not! We all know that these same people would have learned to speak French perfectly well had they grown up in France. If there is any question of lack of aptitude, the aptitude they lack is not for French as such but for learning French in schools.

Could the same be true of mathematics? Could there be a place, a "mathland," which is to mathematics as France is to French, where children would learn to speak mathematics as easily and as successfully as they learn to speak their native dialect?

I believe that the answer is *Yes*. In *Mindstorms* I suggest that the world we live in contains pockets of mathland, which explains why all children learn some mathematics spontaneously (eg: one-to-one correspondences, conservation of number, reversibility of logical operations) and some children become very good at it. Here I have space only to talk about some ways in which the world could become much more of a mathland for everyone.

Computers are the Proteus of machines: they take on many different forms. One of their manifestations is as mathematics-speaking beings. If children grew up surrounded by such beings, the learning of mathematics might very well be much like the learning of spoken language. Developing and testing this image has become a central research question for us at MIT: under what conditions will children talk in mathematical languages to mathematics-speaking computers? The results have already convinced us that the idea of mathland is fundamentally sound and that, indeed, what the mathematics schools fail to teach can be learned successfully on the model of picking up living languages.

But computers do not automatically create that result. For example, instructing computers in FORTRAN to

manage inventories is of no interest to the average child. Babies brought up in IBM computer centers will be no better at mathematics than any others. They may even be worse (and their other lapses of culture might be more disturbing). In order for computers to play the role of mathland for a child, two conditions are necessary: the computer must understand a language a child can learn (and love to learn), and the computer must be able to do something for the child.

Euclidean Geometry → Cartesian Geometry → Computational Geometry

Turtle graphics is this kind of mathland. It was first developed in our laboratory as part of the programming language LOGO and then taken over by several other languages including Smalltalk and UCSD-Apple Pascal.

A lot of experience has taught us that computer graphics can be a great turn-on. People of all ages enjoy putting images on the screen, and when these images can be made to move and change color, they acquire a dimension completely lacking in conventional pencil-and-paper drawing. At the heart of the work on turtle graphics is the idea of developing a new kind of geometry—"turtle geometry"—which provides powerful and yet easily accessible means to manipulate shapes and motions. To put this in perspective, recall that you probably encountered at school at least two styles of doing geometry: Euclid's style (primarily logical in structure) and Descartes' style (primarily algebraic). Turtle geometry is a new style matched to the computer: it is a computational style of thinking about geometry. The difference in spirit is illustrated by how one thinks about a familiar geometric object in Cartesian and in turtle geometry. Descartes taught us to think of the circle as an equation such as:

$$x^2 + y^2 = R^2$$

In turtle geometry it is possible to use such equations, but the natural way to think about a circle is as a process. To do this, turtle geometry adopts as its fundamental concept an entity called a *turtle* whose properties include its *position* (as does the point in Euclidean and Cartesian geometry) and also its *heading*. At any particular time, it is at a position and is facing in a particular heading. The position and the heading are changed by commands that are built into a programming language. Among these are FORWARD <*some number*> which causes the turtle to move in the direction of its heading without changing the heading, and RIGHT <*some number*> which causes the turtle to change the heading while keeping the position fixed; ie: to pivot in place. Given these commands, a program in LOGO to draw a square of a certain fixed size takes the simple form:

```
TO SQUARE
FORWARD 100
RIGHT 90
FORWARD 100... etc
```

A slightly more sophisticated program to draw squares of varying size takes the form:

```
TO SQUARE SIZE
REPEAT 4 [FORWARD :SIZE RIGHT 90]
```

Now we can think of a circle as generated by:

```
TO CIRCLE
REPEAT 360 [FORWARD 1 RIGHT 1]
```

More sophisticated programming leads to circles of variable diameter and even to letting the number of steps go to the limit, but the simple example will illustrate the main point I want to make here. Children can solve the problem of drawing a circle by using a very powerful heuristic principle: play turtle, walk out yourself what you want the turtle to do and describe what you did in turtle language. The children are practicing a lot of powerful ideas. They are exposed to the idea of using heuristic knowledge, they are learning to think of formal mathematics as rooted in (not opposed to) intuitive body-mathematics, and they are using mathematics as a language; moreover, they are learning to think about mathematics not as a ritual to be learned by rote but as an instrument to be used for personal ends.

Computer as Pencil

This image refers to the many uses of the pencil: it is used to scribble, to doodle, to draw, to write, to work sums, or to chew on. It is used for illicit notes as well as for official assignments. I see the computer in the life of the child as equally ubiquitous and equally versatile. I also see it as equally personal. Children own pencils, they are not intimidated by them. This should be equally true of the child's personal computer.

The metaphor of the pencil is a good way to summarize some of the ways the image of the computer I am building up here differs from the one that is becoming established in schools.

Suppose that the only access children had to pencils (which I take in a generic sense including pens, crayons, and the like) was at school, and even there "pencil time" had to be scheduled on the one or two pencils available to each classroom. This might (or might not) be better than having no pencils at all, but clearly under those conditions the pencil would not play the important role it now does in the intellectual development of children from infancy onwards. In my vision the computer will become as free a resource as the pencil now is.

Second, there is the question of the power of the computer to be used flexibly for many purposes. The microcomputers in schools today can barely be used flexibly by those few who have the inclination to become virtuoso programmers in BASIC. This is very different from the model of the pencil that can be picked up by everyone—even the one-year-old infant—and also used by the most sophisticated writer or artist. LOGO and Smalltalk are only first steps toward programming languages that will truly satisfy our slogan: "No threshold and no ceiling." A child of five or less should be able to write a program in the first few minutes of contact with the computer and a computer scientist should find the system congenial and rich.

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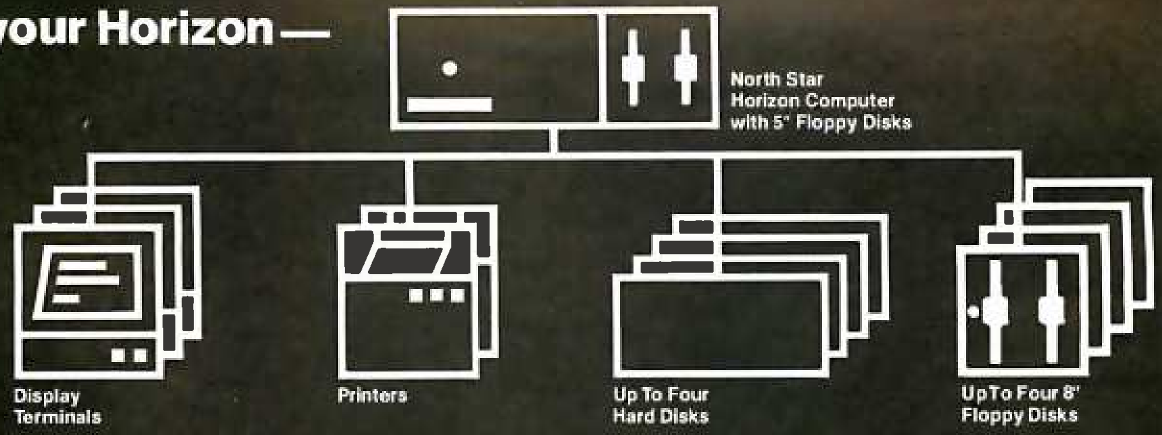

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Third, I mention the use of the pencil and of the computer as writing instruments. The computer is rapidly becoming the standard writing instrument. Most journalists use word processors, as do increasingly many offices. I am using one as I compose this article. But the schools are not offering children this facility, although one could argue that it is children who are in most need of writing aids. The reason is clearly linked to the ratio of computers to students. One or two computers per class simply does not give enough access for the computer to become the primary writing instrument. On the other hand, one computer per child, which is how I think we should be thinking about the future, could lead to massive changes in the way children develop writing skills. A well-designed text editor makes editing—substitution and deletion of words, shifting of sentences or paragraphs, and so on—an easy and aesthetically acceptable process. Compare the situation of a child attempting such a task with paper and pencil: the mess of multiple erasures and labor of rewriting means that the first draft is almost always the final copy. I have seen children who hated writing become avid writers when they have a text editor at their disposal. Wide availability of computers with text-editing capabilities might lead to even more fundamental changes in children's relation to alphabetic representation of language. Consider the implications of the following story:

> *Recently I observed the first group of nursery-school children working with a computer called the Lamplighter Computer (a Texas Instruments 99/4 personal computer with additional memory to support an extended version of LOGO and a real-time text-editing system) developed over the past few years through a collaboration between our research group at MIT and Texas Instruments. A four-year-old girl (I shall call her Robin) was working with some dynamic graphics programs that allowed her to make shapes appear on the screen, move, change color, and stick together by pushing one or another of some fourteen keys on the keyboard. The plan was that when Robin was tired of using a program she would ask the teacher to set up a new program. And this is in fact what she did for the first few times. But then Robin took charge of the whole process and began typing the control characters necessary to interrupt a program she no longer wanted and typing the names of the programs she did want, even though this was at a measured rate of about two characters per minute. In breaking out of the role of dependence on adults, Robin symbolized the fact that computers will enable children to break out of many of the roles into which technological primitivity and social custom have cast them.*

We should not pass too quickly over the significance of the simple fact that Robin could make things happen by typing words. It might well be the first time in her life that alphabetic language actually served a real and personal purpose. The spoken language and its precursors enter from the first year of life into a significant process of interaction with the world. Learning to speak empowers the child. But for most children the act of writing serves at most to gain the approval of adults. Could this be the reason children learn to talk so easily and so young

while they learn to write with so much difficulty so many years later? Watching Robin left me more firmly convinced than ever of a conjecture I have pursued for quite a few years. Children could learn to write as early and as easily as they learn to speak if the environment in which they lived gave as much support to the alphabetic language as ours does to the spoken language. I have no doubt that if Robin had her own computer and could use it whenever she wished, and if this computer gave her access to enough exciting things to do, she would within weeks have mastered the keyboard, the alphabet, and enough of spelling and syntax to put her firmly on the road to the kind of mastery of written language that usually comes, if at all, well into the school years.

Meaning Versus Ritual in Learning

The fundamental question for education is not how to improve schools but how to understand why schools are necessary. Why is some knowledge (like learning to talk) picked up so easily and naturally from the culture, while other kinds of knowledge seem to require deliberate, organized instruction? In *Mindstorms* I explore the many factors that make a difference. Here I have space only for one. Children learn to speak because it is a *meaningful* activity, a meaningful part of their lives. It is not surprising that children do not learn to write when writing serves no real purpose in their lives. I think the computer can change this. For Robin, alphabetic communication was beginning to become purposeful. As computers become increasingly available to children I would expect many children to share Robin's experience of writing as a meaningful activity. This shift—from meaningless ritual imposed from above to purposeful, self-directed activity—is also true of Mathland. No activity in school is experienced as more devoid of meaning than the parody of mathematics known as school math.

The harm done by making children learn ritualistically goes very deep. It develops the worst possible habits of learning. It undermines the individual's self-confidence as an independent intellectual agent: it infantilizes the child. A shift to more meaningful learning of fundamental subjects could have far deeper consequences than improved mastery of these subjects. It could mean that children become more effective learners with greater intellectual self-respect. And if this happens, not only the nature of children's learning but also the role of children in society may have changed.

I have hinted at a vision of profound, even revolutionary, change in how children learn. I think this might happen. We have the technology to make it possible. But there is nothing inevitable about it. Society has a very bad track record in making intelligent use of new technologies, and, in this case, many vested interests are threatened by the changes I envision. The "system" will react by defending its old ways. Already in schools we see computers being used to reinforce instead of displace the most ritualistic teaching methods. I believe that the most profound effects of computers on how children learn could occur outside of schools. In fact, I think that computers would tend to make schools as we know them obsolete. But most of my "official research" is concerned with how to use computers in schools. Research funds are easily available for the reformist goals of improving schools. I believe that the most profound effects of computers could be to develop a new respect for children as independent intellectual agents. But most people in our country like to think of children as intellectually dependent.

How will it all work out? It is futile for me to play prophet, but worthwhile to bear some ideas in mind when thinking about the future. I want to end by mentioning an idea that encouraged me to think positively. I can best introduce it by comparing the education market with markets for other products. Suppose you invent a new kind of kitchen machine. If you can prove that there is a market of a million people, you will easily find the capital to develop the idea and get it out into the world. But if you invent a new approach to learning mathematics, the fact that a million people want it may be of no avail—a million people across the nation may still be a tiny minority with no clout in every school district. But once there are a few million owners of home computers capable of carrying powerful learning methods, you will have access to a market of individuals ready to spend personal dollars for the good of their children. The importance of this fact is not that it will enable good ideas now collecting dust on shelves to get out into the world. It will encourage inventive and ambitious people to enter the field of educational innovation in unprecedented numbers. It will be part of the creation of a new class of professionals and of entrepreneurs and perhaps even of "stars" analogous to what happened in the course of the emergence of cinema as a culture. The history of cinema has been the history of that culture. The future of computers in education will be indissociable from the story of the people who will make the computer culture. ■

References

For more about Turtle Geometry see S Papert, *Mindstorms: Children, Computers and Powerful Ideas.* New York, Basic Books, 1980 (ISBN 0-465-04627-4, $12.95). Also see H Abelson and A diSessa, *Turtle Geometry*, MIT Press, Cambridge MA (to appear 1981). For a bibliography of the LOGO group's internal publications, write to LOGO, c/o MIT Artificial Intelligence Laboratory, 545 Technology Sq, Cambridge MA 02139. (Please include $1 for handling.)

Editor's note: *A note in the introduction to the July 1980 BYTE editorial incorrectly states that Education Forum articles by Seymour Papert and James Garson were to appear in the August and September BYTEs, respectively. However, because of unavoidable scheduling considerations, Seymour Papert's article is appearing this month, and James Garson's article will appear in a future issue. We apologize for any inconvenience this change might have caused....*CM

Education Forum *is an occasional feature in BYTE intended to foster debate about the uses of personal computers in the schools and colleges. We encourage reader participation. Contributors should supply their full names and addresses for publication, along with their telephone numbers, which will not be published.*

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Khachiyan's Algorithm, Part 2:

Problems with the Algorithm

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Numbering of figures, tables, listings, and equations is continued from Part 1.

A paper published by the Soviet mathematician Leonid Khachiyan received widespread publicity in late 1979 as a revolutionary new solution to linear programming problems. In Part 1 last month, we discussed the details of Khachiyan's algorithm and its corresponding geometric interpretation. This month in Part 2, we will look at the practical problems in using the algorithm and will examine a BASIC program that uses the algorithm.

A Linear Programming Example

The Whiz-Golly Computer Board Company makes two kinds of video boards: the Ohwow and the Hohum. Each board is handmade by Jim and then tested by Jack. Each Ohwow board takes Jim two days to complete, while he can make one Hohum board each day. Jack can test an Ohwow board in one day, but he needs two days for each Hohum. Like most basement entrepreneurs, Jim and Jack have many other things to do with their time. Jim will not make boards for more than four days a week; Jack will test them for no more than three days a week. If the profit is two dollars for each Ohwow board and three dollars for each Hohum, how many of each should they make per week to obtain the greatest profit?

This is a linear programming problem. It consists of a quantity to be maximized, the *objective function*, which is subject to a list of linear inequalities called *constraints*. If we let x_1 denote the number of Ohwow boards made per week and x_2 the number of Hohums made per week, the problem then is to maximize $P = 2x_1 + 3x_2$, where P is the profit per week in dollars.

Since Jim cannot make a negative number of Hohums in a week, the first constraints we find are the nonnegativity conditions: $x_1 \geq 0$ and $x_2 \geq 0$. In addition, we have the constraints imposed by the number of days that Jim and Jack work per week: for Jim, we have that $2x_1 + x_2 \leq 4$; while, for Jack, we have that $x_1 + 2x_2 \leq 3$.

This problem may now be written in matrix form as:

$$\text{to maximize } P = [2\ \ 3] \cdot \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} \tag{7}$$

$$\text{subject to } \begin{bmatrix} 2 & 1 \\ 1 & 2 \end{bmatrix} \cdot \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} \leq \begin{bmatrix} 4 \\ 3 \end{bmatrix}$$

$$\text{and } \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} \geq 0$$

Of course, we could have combined the two constraint equation sets into one but, as most practical problems naturally include a nonnegativity condition, we will write it separately for emphasis.

The Dual Problem

By a *standard maximum linear programming problem* we mean any problem of the form:

$$\begin{aligned} &\text{to maximize} && P = \mathbf{c}' \cdot \mathbf{x} \\ &\text{subject to} && \mathbf{A} \cdot \mathbf{x} \leq \mathbf{b} \\ &\text{and} && \mathbf{x} \geq 0 \end{aligned} \tag{8}$$

where $\mathbf{A}$ is an m-by-n matrix, $\mathbf{b}$ is a column vector in R^m, $\mathbf{c}$ is a column vector in R^n, and $\mathbf{x}$ is a column vector in n unknowns.

Since Jim and Jack may wish to minimize their expenses, we will also encounter minimization problems. A standard minimum linear programming problem is any problem of the form:

$$\begin{aligned} &\text{to minimize} && C = \mathbf{b}' \cdot \mathbf{y} \\ &\text{subject to} && \mathbf{A}' \cdot \mathbf{y} \geq \mathbf{c} \\ &\text{and} && \mathbf{y} \geq 0 \end{aligned} \tag{9}$$

where $\mathbf{A}$, $\mathbf{b}$, and $\mathbf{c}$ are as in (8) and $\mathbf{y}$ is a column vector in m unknowns.

The two problems given by (8) and (9) are called *dual problems*, and their solutions are closely connected. Suppose that $\mathbf{x}$ satisfies (8) and $\mathbf{y}$ satisfies (9). Then $\mathbf{c}'\mathbf{x} \leq (\mathbf{A}'\mathbf{y})'\mathbf{x} = \mathbf{y}'\mathbf{A}\mathbf{x} \leq \mathbf{y}'\mathbf{b} = \mathbf{b}'\mathbf{y}$ and we see that $\mathbf{c}'\mathbf{x} \leq \mathbf{b}'\mathbf{y}$ for any $\mathbf{x}$ and $\mathbf{y}$ satisfying the respective constraint equations. Since we wish to maximize $\mathbf{c}'\mathbf{x}$ and to minimize $\mathbf{b}'\mathbf{y}$, it follows that any pair of solutions, say $\bar{\mathbf{x}}$ and $\bar{\mathbf{y}}$, must satisfy $\mathbf{c}'\bar{\mathbf{x}} = \mathbf{b}'\bar{\mathbf{y}}$ and conversely.

To solve the pair of linear programming problems (8) and (9), we need only solve the following system of equations:

$$\begin{aligned} \mathbf{c}'\mathbf{x} &= \mathbf{b}'\mathbf{y} \\ \mathbf{A}\mathbf{x} &\leq \mathbf{b} \\ \mathbf{A}'\mathbf{y} &\geq \mathbf{c} \\ \mathbf{x} \geq 0 &\text{ and } \mathbf{y} \geq 0 \end{aligned} \tag{10}$$

The equality $\mathbf{c}'\mathbf{x} = \mathbf{b}'\mathbf{y}$ is equivalent to the two inequalities $\mathbf{c}'\mathbf{x} - \mathbf{b}'\mathbf{y} \leq 0$ and $-\mathbf{c}'\mathbf{x} + \mathbf{b}'\mathbf{y} \leq 0$. The nonnegativity conditions $\mathbf{x} \geq 0$ and $\mathbf{y} \geq 0$ are equivalent to $-\mathbf{I}_n\mathbf{x} \leq 0$ and $-\mathbf{I}_m\mathbf{y} \leq 0$ where $\mathbf{I}_k$ denotes the k-by-k identity matrix. The condition $\mathbf{A}'\mathbf{y} \geq \mathbf{c}$ is equivalent to $-\mathbf{A}'\mathbf{y} \leq -\mathbf{c}$.

If we let $\mathbf{z}$ be the column vector in $n+m$ unknowns formed by adjoining $\mathbf{y}$ to the end of $\mathbf{x}$ (that is, $\mathbf{z}' = (x_1,\ldots,x_n,y_1,\ldots,y_m)$), we can rewrite our linear programming problems in one giant system of inequalities:

$$\begin{bmatrix} \mathbf{A} \\ -\mathbf{I}_n \\ \mathbf{0}_{(n,\,n)} \\ \mathbf{0}_{(m,\,n)} \\ \mathbf{c}' \\ -\mathbf{c}' \end{bmatrix} \begin{bmatrix} \mathbf{0}_{(m,\,m)} \\ \mathbf{0}_{(n,\,m)} \\ -\mathbf{A}' \\ -\mathbf{I}_m \\ -\mathbf{b}' \\ \mathbf{b}' \end{bmatrix} \mathbf{z} \leq \begin{bmatrix} \mathbf{b} \\ \mathbf{0}_{(n,\,1)} \\ -\mathbf{c} \\ \mathbf{0}_{(m,\,1)} \\ 0 \\ 0 \end{bmatrix} \tag{11}$$

where $\mathbf{0}_{(j,\,k)}$ denotes a j-by-k matrix of zeros. If this system of inequalities is consistent, then the point that satisfies all the inequalities at once gives the solutions to both the maximum and the minimum problems.

For our problem (7) with Jim and Jack, we see that the system (11) becomes:

$$\begin{bmatrix} 2 & 1 & 0 & 0 \\ 1 & 2 & 0 & 0 \\ -1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & -2 & -1 \\ 0 & 0 & -1 & -2 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \\ 2 & 3 & -4 & -3 \\ -2 & -3 & 4 & 3 \end{bmatrix} \mathbf{z} \leq \begin{bmatrix} 4 \\ 3 \\ 0 \\ 0 \\ -2 \\ -3 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

The solution to this problem, as we will see later, is:

$$\mathbf{z} = (\,1\tfrac{2}{3},\ \tfrac{2}{3},\ \tfrac{1}{3},\ 1\tfrac{1}{3}\,)$$

a solution that can be derived from the above matrix by use of Khachiyan's algorithm.

Some General Implementation Problems

As we mentioned in our discussion of Khachiyan's paper his achievement of obtaining a polynomial-time algorithm is attained only by paying the price of requiring an incredible level of precision in all the calculations. Moreover, his initial circle of radius 2^L can be replaced by a far smaller circle, as will be explained shortly. This does not matter to Khachiyan, since, at the initial stage of the algorithm, the precision problems are more important.

The main problem we have created for ourselves is in our transformation of dual linear programming problems into a system of linear inequalities. Our statement that $\mathbf{c'x} = \mathbf{b'y}$ is equivalent to the inequalities $\mathbf{c'x} - \mathbf{b'y} \leq 0$ and $-\mathbf{c'x} + \mathbf{b'y} \leq 0$, while true mathematically, is generally false from a computational viewpoint.

If we think of $\mathbf{c'x} - \mathbf{b'y} \leq 0$ and $-\mathbf{c'x} + \mathbf{b'y} \leq 0$ as "half-planes" in some n-dimensional Euclidean space (shown in figure 4 for $n = 2$), then it is true that they will intersect along a "line," where $\mathbf{c'x} - \mathbf{b'y} = 0$. Unfortunately, our computer calculations of the common points will be rounded off to a finite number of decimal places, and we should not be surprised if we cannot correctly calculate a point that has zero difference between our calculated values of $\mathbf{c'x}$ and $\mathbf{b'y}$.

Our solution to this difficulty is to choose a tolerance within which we will agree that our values for $\mathbf{c'x}$ and $\mathbf{b'y}$ are essentially the same. Let $\epsilon > 0$ be this tolerance. If we require that $\mathbf{c'x} - \mathbf{b'y} \leq \epsilon$ and $-\mathbf{c'x} + \mathbf{b'y} \leq \epsilon$ then we have formed a "tube" around the line $\mathbf{c'x} - \mathbf{b'y} = 0$ (shown for $n = 2$ in figure 5) with width ϵ in the direction perpendicular to $\mathbf{x}$. The actual tolerance thus created will depend on the slope of the relation $\mathbf{c'x} - \mathbf{b'y} = 0$ relative to the $\mathbf{x}$ subspace.

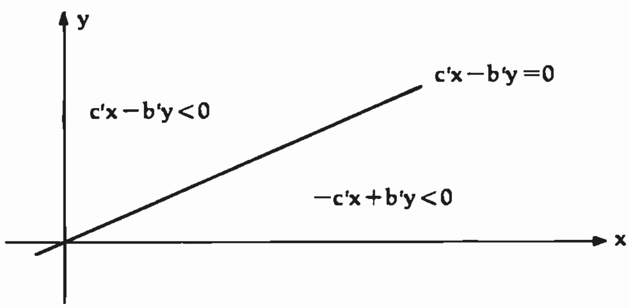

Figure 4: *Dissection of a plane into two half-planes by a line of the form* c'x−b'y=0.

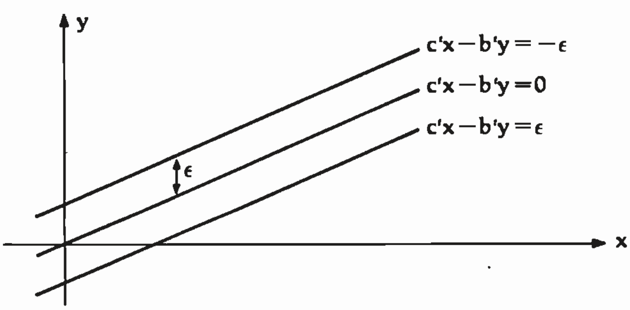

Figure 5: *Dissection of a plane into two half-planes dictated by the limited accuracy of a computer. Because any computer has a limited accuracy, it is unlikely for it to compute the exact location of a point on the line* c'x−b'y=0. *Instead, the line separating the two half-planes (as shown in figure 4) is replaced by a thin "tube" with a diameter less than or equal to 2ϵ. The variable ϵ is chosen so that a given computer can compute the location of a point that is no more than ϵ away from a point on the center line.*

Thus our system of inequalities is no longer (11) but rather:

$$\begin{bmatrix} \mathbf{A} & \mathbf{0}_{(m,\,m)} \\ -\mathbf{I}_n & \mathbf{0}_{(n,\,m)} \\ \mathbf{0}_{(n,\,n)} & -\mathbf{A}' \\ \mathbf{0}_{(m,\,n)} & -\mathbf{I}_m \\ \mathbf{c}' & -\mathbf{b}' \\ -\mathbf{c}' & \mathbf{b}' \end{bmatrix} \mathbf{z} \leq \begin{bmatrix} \mathbf{b} \\ \mathbf{0}_{(n,\,1)} \\ -\mathbf{c} \\ \mathbf{0}_{(m,\,1)} \\ \epsilon \\ \epsilon \end{bmatrix} \qquad (12)$$

Let us now turn to the problem of estimating an initial region that will contain all solutions of the system of linear inequalities (2), from Part 1. The solutions of the systems, if any exist, form a polyhedron determined by the vertices at which the linear inequalities intersect. We can take for our initial region any sphere about the origin containing all these vertices, since such a sphere must then include some solution points of the system.

The problem is then to estimate the distance to the vertex furthest from the origin. The system may be written as $\mathbf{Ax} \leq \mathbf{b}$ where $\mathbf{A}$ is an m-by-n matrix of integers and $\mathbf{b}$ is a column vector with m integer entries. We may suppose that $m \geq n$ since we can otherwise add on $n-m$ trivial inequalities that will not change the solutions of the original system and will add only 0s and 1s to the matrix $\mathbf{A}$.

We can now compute all possible vertices of the region $\mathbf{Ax} \leq \mathbf{b}$ by examining n rows of the equation $\mathbf{Ax} = \mathbf{b}$ at a time and applying Cramer's rule. For each subset of n equations, we will find $x_i = \frac{D_i}{D}$, for $i = 1,\ldots,n$, where D is the determinant of the n-by-n matrix of equation coefficients and D_i is the determinant of the same matrix, but with corresponding n entries of $\mathbf{b}$ replacing the ith column of the matrix.

Since we are dealing with integer coefficients, if $D \neq 0$, then $|x_i| \leq |D_i|$; and, by Hadamard's inequality, $|D_i|$ is no more than the product of the norms of the columns of the matrix in question. This now explains $\mathbf{Q}_0 = 2^L \cdot \mathbf{I}_n$, since 2^L is greater than the product of the absolute values of all the coefficients in the system (2). We now see that an estimate better than 2^L will result if we determine the greatest possible norm for the n-subsets of each column of $\mathbf{A}$ and then combine the $n-1$ greatest such norms with the greatest n-subset norm from $\mathbf{b}$. For example, Khachiyan's estimate for the region of (7) is 2^{44} while the above estimate based on Hadamard's inequality is 2^9.

The problems caused by the precision needed in computing the values required at each step of the algorithm appear to be nearly insurmountable. We shall not pursue this subject further than to observe its central position in the list of difficulties that prevent Khachiyan's algorithm from immediately replacing the Simplex method as the preferred method for solving linear programming problems.

Khachiyan's Algorithm on the TRS-80

The program given in listing 1 represents a translation of the preceding discussion into a computer program. In writing this program, we have attempted to make the translation as literal as possible for two reasons. First, we wished to study how Khachiyan's algorithm actually pro-

ceeds for real examples. Second, once the program is running, it remains a challenge for each user to discover improvements and modifications. We invite you to experiment.

The program will accept two different kinds of problems. If you wish to study the consistency of a system of linear inequalities such as equation set 2 (given in Part 1 of this article, last month), the program will accept the equations in the form $Ax \leq b$. If you wish to study a linear programming problem such as (8) or (9), the program will ask for A, b, c, and ϵ. The program will then create the system given by (12). In either situation, you will have three choices for L: you may have Khachiyan's or Hadamard's values computed or you may specify your own choice.

Because of the limited precision available on the TRS-80 (far less than the 2^{-23nL} required for the algorithm), our program cannot be used to decide the consistency or inconsistency of even the smallest systems of inequalities. Thus it becomes meaningless to terminate the algorithm after $N = 16Ln^2$ steps, so our program does not include a termination statement based on the number of steps executed.

If you enter the system of inequalities (1.1), you can watch the algorithm construct a solution point. It will take about thirty-eight steps to begin to find a reasonable estimate for x. When you try equation set 1.2 (an inconsistent system given in Part 1), you will be able to watch the algorithm attempt to find a solution (a reasonable compromise between the inequalities is (1.5, 1.5)) and then decide that it had better try again.

The actual solution of the linear programming problem given in (7) and its dual is $(x_1,x_2) = (1\frac{1}{3},\frac{2}{3})$ and $(y_1,y_2) = (\frac{1}{3},1\frac{1}{3})$. You should try various values for ϵ and contrast the number of steps required for the algorithm to terminate at a solution.

Klee-Minty Example

As we noted earlier, the importance of Khachiyan's algorithm is that the number of steps required increases as a polynomial based on the size of the system of in-

Text continued on page 255

Listing 1: *A program using Khachiyan's algorithm, written for the Radio Shack TRS-80 Model I running Level II BASIC.*

```
1 '*****************************************************
2 '*                    KHACHIYAN'S ALGORITHM            *
3 '*COPYRIGHT 1979 JC STEVENSON, AM ROCKETT, GC BERRESFORD*
4 '*****************************************************
5 CLEAR100
10 CLS
20 DATA 1,119,1,119,1,119,3,69,118,120,4,69,116,117,121,4,69,115,122,123,8,68,69
,70,95,114,123,124,125,8,67,71,95,112,113,125,126,127,11,64,65,66,72,73,74,94,96
,110,111,123,14,60,61,62,69,73,74,75,76,77,78,93,96,107,124,11,58,60,61,70,79,89
,91
30 DATA 98,99,105,124,10,57,71,72,80,81,87,95,100,101,102,10,56,73,77,81,82,85,9
6,103,104,125,11,56,73,77,78,81,82,85,97,100,103,104,10,56,72,77,81,82,86,97,102
,103,123,11,57,58,80,81,87,88,96,100,101,102,104,13,59,79,80,89,98,99,100,101,10
5,106,107,121,127
40 DATA 8,60,78,79,89,100,106,107,127,1,107
50 FOR I=0 TO 448 STEP 64 : PRINT@I,STRING$(64,191);:NEXT I
60 FOR I=448 TO 511 STEP 2 : PRINT@I,CHR$(131);CHR$(128);:NEXTI
70 PRINT@576,STRING$(4,128);TAB(51)STRING$(13,128);
80 PRINT@512, STRING$(64,128);
90 PRINT@651,"T H E  K H A C H I Y A N  A L G O R I T H M";
100 PRINT@843,"COPYRIGHT 1979";:PRINT@907,"J.C. STEVENSON, A.M. ROCKETT & G.C. B
ERRESFORD";
110 FOR I = 3 TO 20
120 READ JJ
130 FOR J=1 TO JJ : READ J2 : RESET(J2,I) : NEXT J
140 NEXT I
150 FOR I=1 TO 1000 : NEXT I
160 PRINT@834,"DO YOU WISH TO READ THE INTRODUCTION?";
170 PRINT@898,"TYPE 'Y' IF YOU DO, ELSE HIT 'ENTER' TO PRINT THE MENU.";
180 C$=INKEY$ : IF C$="" THEN 180
190 IF C$="Y" THEN 200ELSE 230
200 PRINT@768,"THIS PROGRAM HAS TWO OPTIONS.  YOU MAY USE IT TO SOLVE A LINEAR P
ROGRAMING PROBLEM OR YOU MAY VERIFY THAT A SYSTEM OF INEQUALI- TIES IS CONSISTEN
T.  IF YOU CHOOSE TO SOLVE A PROBLEM, THERE ARE THREE  OPTIONS  FOR CHOOSING THE
 PARAMETER, L.";
210 PRINT"  SEE KHACHIYAN'S PAPER FOR NOTATION.  PRESS 'ENTER' TO CONTINUE.";
220 Z$=INKEY$ : IF Z$="" THEN 220
230 CLS : PRINT@88,"T H E  M E N U " : PRINT @266,"1) SOLVE AN L-P PROBLEM.":PRI
NT@394,"2) CHECK CONSISTENCY OF A SYSTEM.":PRINT:PRINT:INPUT"ENTER THE NUMBER OF
 THE OPTION YOU WISH";C%
```

Listing 1 continued on page 248

Circle 159 on inquiry card.

Listing 1 continued:

```
240 '
250 DEFDBL A,B,F,X,V,W,Q,L
260 CLS
270 '******** HOW TO USE THE PROGRAM ********
280 INPUT"DO YOU WISH TO REVIEW THE FORMAT FOR ENTERING A PROBLEM (Y/N -- 'ENTER
')";Z$
290 IF Z$="N" THEN 400
295 IF C%=1 THEN 300 ELSE CLS:PRINT"TO DECIDE THE CONSISTANCY OF A SYSTEM OF INE
QUALITIES, WRITE THE SYSTEM IN  THE FORM:":PRINTTAB(23)"  A*X <= B":PRINT"WHERE
A IS A N BY N MATRIX AND B AN N-VECTOR.  PRESS 'ENTER' TO BEGIN."
296 Z$=INKEY$:IFZ$=""THEN 296 ELSE 400
300 CLS
310 PRINT"TO SOLVE A STANDARD LINEAR PROGRAMMING PROBLEM OR CHECK         CONSIS
TANCY:":PRINT:PRINT"1) WRITE THE PROBLEM IN THE FORM: MAXIMIZE (C,X)
                    SUBJECT TO THE CONSTRAINTS        A*X <= B"
320 PRINT"                                                AND        X => 0"
330 PRINT"    X AND C ARE COLUMN VECTORS OF DIMENSION N WHILE B              IS
AN M-VECTOR.  A IS AN M BY N MATRIX.  THE NOTA-               TION, (.... , ....)
 IS A STANDARD INNER PRODUCT."
340 PRINT:PRINT:PRINT:PRINT"HIT 'ENTER' TO CONTINUE THE DIRECTIONS"
350 Z$=INKEY$ : IF Z$="" THEN 350
370 CLS:PRINT:PRINT"2) THE COMPUTER SEEKS A SOLUTION OF THE EQUATION
        (C,X) = (B,Y) WHERE Y IS A SOLUTION OF THE DUAL.                IN GENERA
L THE MACHINE CANNOT ACHEIVE THIS, SO A                   TOLERANCE , EPSILON, MUST
 BE GIVEN"
380 PRINT:PRINT"3) PRESS 'ENTER' TO BEGIN THE ALGORITHM.  THE  COMPUTER WILL ASK
   YOU FOR EACH ITEM ABOVE."
390 Z$=INKEY$:IFZ$="" THEN390
400 CLS: INPUT"HOW MANY ROWS HAS THE MATRIX A"; M : INPUT"HOW MANY COLUMNS IN TH
E MATRIX A"; N
```

Listing 1 continued on page 250

Listing 1 continued from page 248:

```
410 IF C%=2 THEN N9=N : M9 =M : GOTO 430
420 N9=M+N : M9=2*(M+N+1)
430 DIM A(N9,M9),B(M9),X1(N9),X0(N9),F(M9),Q1(N9,N9),Q0(N9,N9),V(N9,N9),W(N9,N9)
,B1(M9)
440 CLS: PRINT"PLEASE TYPE IN THE ROWS OF THE MATRIX  A.  PRESS 'ENTER' AFTER  K
EYING EACH NUMBER."
450 FOR J=1 TO M
460 FOR I=1 TO N : INPUT A(I,J) : NEXT I
470 NEXT J
480 CLS:PRINT"HERE IS THE MATRIX A.  IF IT IS NOT CORRECT, NOTE THE INDICES OF T
HE MISKEYED ELEMENTS.  PRESS 'C' TO MAKE CORRECTIONS, ELSE HIT 'ENTER'."
490 FOR J=1TOM : FOR I=1 TO N : PRINT A(I,J);"  ";:NEXTI:PRINT:NEXTJ
500 Z$=INKEY$ : IF Z$ ="" THEN 500
510 IF Z$="C" GOSUB 700ELSE 530
520 GOTO 480
530 CLS: PRINT"PLEASE TYPE IN THE ENTRIES OF THE VECTOR B, YOU NEED ";M;"NUMBERS
."
540 FOR I=1TOM : INPUT B(I) : NEXT I
550 CLS:PRINT"HERE IS THE VECTOR B." :FOR I=1 TO M : PRINT B(I) :NEXT I: INPUT"I
S IT CORRECT (Y/N)";Z$ : IF Z$="N" THEN 530
560 IF C%=2 THEN 730
570 CLS:PRINT"WHAT ARE THE COEFFICIENTS OF THE OBJECTIVE FUNCTION?  YOU MUST   S
UPPLY";N;"NUMBERS."
580 FOR I=M+1 TO N9 : INPUT B(I) : B(I) = -B(I) :NEXT I
590 CLS: PRINT"THE COEFFICIENTS OF THE OBJECTIVE FUNCTION ARE:"
600 FOR I = M+1 TO N9 : PRINT -B(I) : NEXT I
610 IF C%=2 THEN 730
620 INPUT"IS THE OBJECTIVE FUNCTION CORRECT (Y/N)";Z$ : IF Z$="N" THEN 590
630 CLS: INPUT"WHAT POSITIVE NUMBER DO YOU WANT FOR THE 'TOLERANCE', EPSILON
        ";B(M9-1) : B(M9)=B(M9-1)
640 FOR I=1 TO N : FOR J = 1 TO M : A(N+J,M+I)=-A(I,J) : NEXT J : NEXT I
650 FOR I=M+N+1 TO M9-2 : A(I-M-N,I)=-1 : NEXT I
660 FOR J=1 TO N : A(J,M9-1)=-B(J+M) : A(J,M9)=B(J+M) : NEXT J
670 FOR J=N+1 TO N9 : A(J,M9-1)=-B(J-N) : A(J,M9)=B(J-N) : NEXT J
680 GOTO 730
690 STOP
700 CLS: INPUT"TO CORRECT ENTRIES IN A, ENTER THE ROW AND COLUMN INDICES OF THE
ELEMENT TO BE CORRECTED";I,J: INPUT"NOW ENTER THE CORRECT VALUE";A(J,I)
710 INPUT"CORRECTIONS COMPLETE (Y/N)";Z$ : IF Z$="N" THEN 700
720 RETURN
730 CLS
740 PRINT"INDICATE YOUR CHOICE FOR THE DETERMINATION OF L FROM THE LIST   BELOW:
";PRINT:PRINT:PRINT"            1) KHACHIYAN'S FORMULA":PRINT:PRINT"          2) H
ADAMARD'S INEQUALITY":PRINT:PRINT"           3) YOUR OWN CHOICE.":INPUTIC%
750 ON IC% GOTO 770,2040,760
760  INPUT "WHAT IS YOUR VALUE FOR L";LL:GOTO780
770  LL=0 : FOR I=1 TO N9 : FOR J=1TO M9 : LL=LL+LOG(ABS(A(I,J))+1):NEXT J : NEX
T I : FOR I=1 TO M9: LL=LL+ LOG(ABS(B(I)) +1):NEXT I : LL= LL + LOG(N9*M9): LL=
INT(LL/LOG(2))+1
780 PRINT "THE VALUE OF L FOR THIS RUN IS: ";LL
790 INPUT"DO YOU WISH TO CHANGE L (Y/N)";Z$ : IF Z$="Y" THEN 730
800 FOR I=1 TO M9 : B1(I)=-B(I) : NEXT I
810 FOR I=1 TO N9
820 Q0(I,I) = 2 [ LL
830 NEXT I
840 GOSUB 1960: T0=MX
850 '    *****   END OF INITIALIZATION   ******
860 '
870 K7=0
880 '
890 '  ****  BEGINNING OF MAIN ITERATION  ****
900 '
910 K7=K7+1 : CLS : PRINT "COMPUTING STEP #";K7:PRINT"THE CURRENT DISCREPANCY IS
:";MX: FOR I=1 TO N9 : PRINT "X(";I;")=";X0(I) : NEXT I
```

Listing 1 continued on page 252

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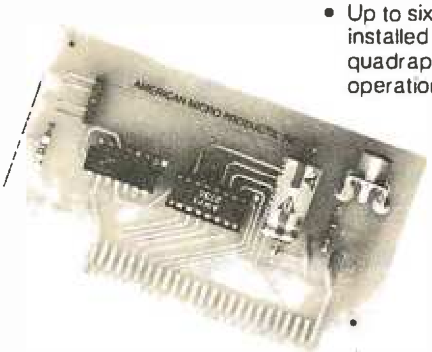

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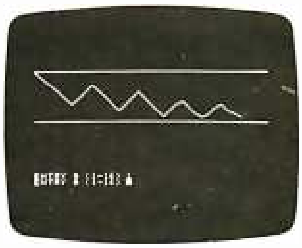

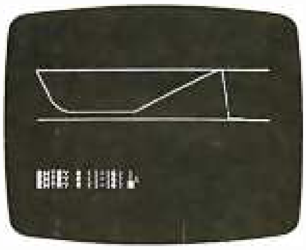

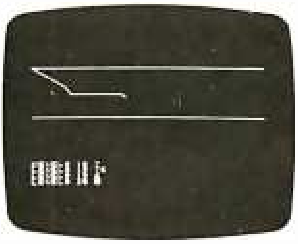

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Listing 1 continued from page 250:

```
920 FOR I = 1 TO N9
930 F(I)=0
940      FOR J = 1 TO N9
950      F(I)=F(I)-Q0(J,I)*A(J,I0)
960      NEXT J
970 NEXT I
980 GOSUB 1010
985 GOTO 1090
990 '  **** FIND THE NORM OF F *****
1000 '
1010 NF=0
1020 FOR I=1 TO N9
1030      NF = NF + F(I)*F(I)
1040 NEXT I
1050 NF = SQR(NF)
1055 IF NF=0 PRINT"WARNING!!!!! THE NORM OF F IS ZERO.  IF YOU WISH TO CONTINUE,
 TYPE 'CONT' FOLLOWED BY 'ENTER'"
1060 RETURN
1070 '  **** STEP TO NEW X-ITERATE ****
1080 '
1090 FOR I=1 TO N9
1100 X1(I)=0
1110      FOR J= 1 TO N9
1120      X1(I)=X1(I)+Q0(I,J)*F(J)
1130      NEXT J
1135 IF NF=0 CLS:PRINT"THE NORM OF F IS TOO SMALL, PRODUCING A MACHINE ZERO.":PR
INT"HERE IS THE VECTOR F:":FOR I = 1 TO N9 : PRINT"F(";I;")=";F(I): NEXT I : PRI
NT"PROGRAM HAS BEEN STOPPED":STOP
1140 X1(I)=X0(I) + X1(I)/NF/(N9+1)
1150 NEXT I
1160 GOSUB 1590
1170 '
1180 '  **** STEP TO THE NEXT Q-ITERATE ****
1190 '
1200 FOR I = 1 TO N9
1210      FOR J = 1 TO N9
1220          Q1(I,J)=0
1230          FOR K= 1 TO N9
1240               Q1(I,J)= Q1(I,J)+ Q0(I,K)*V(K,J)
1250          NEXT K
1260      IF J=1 LET Q1(I,J)=Q1(I,J)*N9/(N9+1)
   ELSE LET Q1(I,J)=Q1(I,J)*N9/SQR(N9*N9-1)
1270      Q1(I,J)=Q1(I,J)*2[(1/(8*N9*N9))
1280      NEXT J
1290 X0(I)=X1(I)
1300 NEXT I
1310 FOR I= 1 TO N9
1320     FOR J = 1 TO N9
1330     Q0(I,J)=Q1(I,J)
1340     NEXT J
1350 NEXT I
1360 '
1370 '  ****  COMPUTE THE NEW DEFECT  ****
1380 '
1390 FOR I= 1 TO M9
1400    B1(I)=0
1410     FOR J = 1 TO N9
1420     B1(I)=B1(I) + A(J,I)*X0(J)
1430     NEXT J
1440 B1(I)= B1(I)-B(I)
1450 NEXT I
1460 GOSUB1960
1470 IF T0>MX THEN T0=MX
1490 IF MX>0 THEN 910
```

Listing 1 continued on page 254

Listing 1 continued from page 252:

```
1500 CLS
1510 PRINT"THE PROCESS TERMINATED AFTER";K7;"STEPS"
1520 PRINT
1530 PRINT"THE SOLUTION IS"
1540 FOR I=1 TO N9
1550      PRINT"X(";I;")=";X0(I)
1560 NEXT I
1570 END
1580 '
1590 ' *****  SUBROUTINE ORT(F)  *****
1600 '
1610 K=1
1620 IF F(K)<>0 THEN 1630ELSE K=K+1 : GOTO1620
1630 FOR I=2 TO N9
1640 FOR J=1 TO N9
1650 W(J,I)=0
1660 IF J<K THEN I1=1 ELSE I1=0
1670 IF J=I-I1 AND J<>K LET W(J,I)=1
1680 NEXT J : NEXT I
1690 WN=0
1700 FOR J = 1 TO N9 : WN=F(J)*F(J)+WN : NEXT
1710 WN=SQR(WN)
1720 FOR I=1 TO N9 :V(I,1)=F(I)/WN : W(I,1)=V(I,1) : NEXT
1730 FOR I=2 TO N9
1740 FOR I1 = 1 TO N9
1750 V(I1,I)=W(I1,I)
1760 NEXT I1
1770 FOR J = 1 TO I-1
1780 L=0
1790 FOR J1=1 TO N9
1800 L=L+V(J1,J)*W(J1,I)
1810 NEXT J1
1820 FOR I1=1 TO N9
1830 V(I1,I)=V(I1,I)-L*V(I1,J)
1840 NEXT I1
1850 NEXT J
1860 WN=0
1870 FOR I2=1 TO N9
1880 WN=WN+V(I2,I)*V(I2,I)
1890 NEXT I2
1900 WN=SQR(WN)
1910 FOR I2=1 TO N9: V(I2,I)=V(I2,I)/WN
1920 NEXTI2
1930 NEXT I
1940 RETURN
1950 '
1960 '  **** FIND THE ELEMENT OF LARGEST ABSOLUTE VALUE  ****
1970 '  **** IN THE ARRAY B1                            ****
1980 '
1990 MX=(B1(1)) : I0=1
2000 FOR I= 2 TO M9
2010 IF B1(I) > MX LET MX=B1(I) : I0=I
2020 NEXT I
2030 RETURN
2040 '    @@@@@@@  THE HADAMARD INEQUALITY  @@@@@@
2050 PN=1 : FOR KZ = 1 TO N9 : FOR J=1 TO M9 : F(J)=A(KZ,J):NEXT J:MT=M9 : GOSUB
 2090  : GOSUB 1010 :B1(KZ)=NF:NEXT KZ
2060 FOR J=1 TO M9 : F(J)=B(J) : NEXT J : GOSUB 2090 : GOSUB 1010 : FOR J=1TO N9
-1 : F(J)=B1(J) : NEXT J :MT = N9 : GOSUB 2090
2070 FOR J= 1 TO N9-1 : PN=PN*F(J) : NEXT J :PN = PN*NF
2080 LL = INT(LOG(PN*SQR(N9))/LOG(2))+1 : GOTO 780
2090 I=1 : T=F(I) : KT=0 : K=I
2100 K=K+1 : IF K>MT LET K=I+KT : I=I+1 : IF I > MT RETURN ELSE T=F(I) : IF K=>M
T RETURN ELSE 2100
2110 IF T=> F(K) THEN 2100 ELSE T=F(K) : FOR J=K TO I+1 STEP -1 : F(J)=F(J-1) :
NEXT J : F(I)=T : KT=KT+1 : GOTO 2100
```

Text continued from page 246:
equalities and not exponentially, as in the Simplex method. An example showing this exponential growth of the number of steps in the Simplex algorithm was constructed in 1972 by Klee and Minty. It is interesting to see how our program reacts to this problem. We are indebted to Dr Philip Wolfe of IBM for showing us the following version of the Klee-Minty problem.

Let n be given. Let $\mathbf{c}' = (10^{n-1}, 10^{n-2}, \ldots, 10^1, 1)$, $\mathbf{b}' = (1, 10^2, 10^4, \ldots, 10^{2(n-1)})$ and:

$$\mathbf{A} = \begin{bmatrix} 1 & 0 & 0 & \ldots & 0 \\ 2\times 10^1 & 1 & 0 & \ldots & 0 \\ 2\times 10^2 & 2\times 10^1 & 1 & \ldots & 0 \\ . & . & & \ldots & . \\ . & . & & \ldots & . \\ . & . & & \ldots & . \\ 2\times 10^{(n-1)} & 2\times 10^{(n-2)} & & \ldots & 1 \end{bmatrix}$$

The Simplex method takes $2^n - 1$ steps to find the solution of the linear programming problem (8). Running our program for Khachiyan's algorithm gave the results shown in table 1.

n	Number of steps for Simplex method	Number of steps for Khachiyan's method
1	1	35 (with ϵ = .01)
2	3	525 (with ϵ = .01)
3	7	2849 (with ϵ = .01)

Table 1: *A short comparison of the Simplex and Khachiyan algorithms. Although this comparison strongly favors the Simplex method, Khachiyan's algorithm would be consistently better, given problems of a sufficiently large size.*

Although this data seems to reflect unfavorably on Khachiyan's method, it must be noted that this is only for small problems. Khachiyan's method would certainly require less steps than the Simplex method in some real-world situations, where a typical industrial problem may involve 10,000 inequalities and 50,000 variables. Far more experience with Khachiyan's method will be required to decide whether its theoretical advantage is of practical value.

We wish to thank the C W Post Research Committee for providing financial support for the preparation of this article. ■

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Meet and exchange ideas with fellow Heath H-8, H-9 and H-89 users. Monthly meetings are held. For more information, contact Ron Lawson, 395 W Main St, Avon CT 06001.

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The Upstate Apple Users Group meets on the third Thursday of the month at 7 PM at Upstate Computer Shop, 629 French Rd, Campus Plz, New Hartford NY 13413. The group is recognized by the International Apple Corps. The group's objectives are: to help newcomers solve hardware and software problems, aid in resources for education and hobbyists, and investigate the use of computers in the area of the handicapped. Contact Tony Violante at the store address above. On The Source, send mail to TCC788 Attn: Tony Violante.

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Both require 48K CP/M, terminal with cursor positioning, home and clear home, one 8" disk or Two 5" disks. CBASIC2 required.

TEXT PROCESSING

TFS—Text Formatting System: An extremely powerful formatter. More than 50 commands. Supports all major features including:
- left & right margin justification
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- underlining and backspace

TFS lets you make multiple copies of any text. For example: Personalized form letters complete with name & address & other insertions from a disk file. Text is not limited to the size of RAM making TFS perfect for reports or any big job.

Text is entered using CP/M standard editor or most any CP/M compatible editor. TFS will link completely with Super-M-List making personalized form letters easy.

Requires: 24K CP/M.

Supplied with extensive user manual: $85.00. Manual alone: $20.00.

Source to TFS in 8080 assembler (can be assembled using standard CP/M assembler) plus user manual: $250.00.

MAILING LIST

SUPER-M-LIST: A complete, easy to use mailing list program package. Allows for two names, two address, city, state, zip and a three digit code field for added flexibility. Super-M-List can sort on any field and produce mailing labels direct to printer or disk file for later printing or use by other programs. Super-M-List is the perfect companion to TFS. Handles 1981 Zip Codes!

Requires: 48K CP/M.

Supplied with complete user manual: $75.00. Manual alone: $10.00

UTILITIES

Utility pack #1: A collection of programs that you will find useful and maybe even necessary in your daily work (we did!). Includes:

- CMP: Compare two files for equality.
- ARCHIVER: Compacts many files into one, useful when you run out of directory entries.
- SORT: In core sort of variable length records.
- XDIR: Extended, alphabetical directory listing with groupings by common extension.
- PRINT: Formatted listings to printer.
- PG: Lists files to CRT a page at a time .. plus more . . .

Requires: 24K CP/M.

Supplied with instructions on discette: $50.00.

PROGRAMMING LANGUAGES

FORTH: a full, extended FORTH interpreter/compiler produces COMPACT, ROMABLE code. As fast as compiled FORTRAN, as easy to use as interactive BASIC.

SELF COMPILING: Includes every line of source code necessary to recompile itself.

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- integer arithmetic
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- FOR (loop)
- sequential disk I/O
- one dimensional arrays
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- WHILE
- 'PEAK' & 'POKE'
- READ & WRITE
- REPEAT . . . UNTIL
- more

'Tiny' Pascal is fast. Programs execute up to ten times faster than similar BASIC programs.

SOURCE TOO! We still distribute source, in 'Tiny' Pascal, on each discette sold. You can even recompile the compiler, add features or just gain insight into compiler construction.

'Tiny' Pascal is perfect for writing text processors, real time control systems, virtually any application which requires high speed. Requires: 36K CP/M. Supplied with complete user manual and source on discette: $85.00.

Manual alone: $10.00.

SOFTWARE SECURITY

ENCODE/DECODE: A complete software security system for CP/M. Encode/Decode is a sophisticated coding program package which transforms data stored on disk into coded text which is completely unrecognizable. Encode/Decode supports multiple security levels and passwords. A user defined combination (One billion possible) is used to code and decode a file. Uses are unlimited. Below are a few examples:
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- correspondence
- accounts pay/rec
- programs
- tax records
- mailing lists

Encode/Decode is available in two versions:

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

Encode/Decode II: $100.00 Manual alone: $15.00

INTERCOMPUTER COMMUNICATIONS

TERM: a complete intercommunications package for linking your computer to other computers. Link either to other CP/M computers or to large timesharing systems. TERM is comparable to other systems but costs less, delivers more and source is provided on discette!

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Requires: 32K CP/M.

Supplied with user manual and 8080 source code: $110.00

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and semiconductor technology, and more. Contact Wescon, 999 N Sepulveda Blvd, El Segundo CA 90245, (213) 772-2965.

September 17-19

ACM Small/Personal Computer Conference, Rickey's Hyatt House, Palo Alto CA. This symposium will blend contributed papers, panel, and informal discussions. Hardware and software topics involving theory, design, construction, marketing, and application will be included. 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) 739-2000.

September 22-25

Software INFO, Hyatt Regency, Chicago IL. This is the first national conference and exhibit on packaged software held in the US. For more information, or to reserve space, call (312) 263-3131 or write Software INFO, Suite 545, 222 W Adams St, Chicago IL 60606.

September 23-25

Compcon '80 Fall, Capital Hilton Hotel, Washington DC. Sponsored by the IEEE (Institute of Electrical and Electronics Engineers), this show is concerned with 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, (617) 879-2960.

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. The show is being produced by National Computer Shows, POB 678, Brookline Village MA 02147, (617) 739-2000.

September 25-29

The Third World Computer Chess Championship, Brucknerhaus, Linz, Austria. This tournament will be a four- or five-round Swiss-style competition with participants restricted to computer chess programs. The current world and North American champion, CHESS 4.9 of Northwestern University, will return to defend its title. Also expected to participate are the former world champion, KAISSA, from the Moscow Institute of System Studies; MASTER, the current European champion; BELLE, CHAOS, DUCHESS, and other programs from Europe, the US, and Canada. For information in the US, contact Professor M M Newborn, School of Computer Science, McGill University, Montreal, Quebec H3A 2K6 Canada. In Europe, contact Frederic Friedel, Hauptstrasse 28B, 2114 Hollenstedt, West Germany (BRD).

September 26-27

Classroom Applications of Computers in Grades K thru 12, Independence High School, San Jose CA. Tutorials, workshops, exhibits, and a trip to "Silicon Valley" 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 30-October 2

Computer Crime: Investigation and Prosecution, San Francisco CA. This workshop is designed for security and law enforcement investigators, prosecutors, attorneys, and computer specialists who have

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had training or experience in investigating financial or computer crimes. The fee is $575. For more information, contact Paul Shaw, *Assets Protection Journal*, 500 Sutter St, Suite 503, San Francisco CA 94102, (415) 392-2955.

October 1980

October 1-2
Choosing and Using Microprocessor Development Systems, London Press Centre, London, England. This seminar will present information and practical experience on which to base the selection and use of microprocessor-development systems. It will provide guidelines to answer questions on the definition of microprocessor-development systems, what features should be looked for, how to analyze particular requirements, and what systems are commercially available. The program is intended for senior engineers and engineering managers who have some knowledge of microprocessors. Contact the Conference and Courses Unit, Sira Institute Ltd, South Hill, Chislehurst, Kent BR7 5EH, England.

October 1-3
The Tenth International Symposium on Fault-Tolerant Computing, Kyoto, Japan. This meeting is devoted to the theory and practice of reliable computing and will cover design of fault-tolerant circuits and systems, analysis of system performance and reliability; applications of coding techniques, software reliability and testing, and more. For information and traveling arrangements, contact Secretary of FTCS-10, Dept of Applied Mathematics and Physics, Faculty of Engineering, Kyoto University, Kyoto 606 Japan.

October 6-8
APL Users Meeting, Toronto, Canada. This conference is aimed at APL users as well as those considering the use of APL in their systems. Speakers will present papers which discuss the practical use of APL. Managing APL resources, teaching APL, and APL programming techniques will also be covered. The registration fee is $180 (in Canadian funds), which 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 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 this symposium. 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 14-16
Minicomputer and Microcomputer Conference and Exposition, Brooks Hall/Civic Auditorium, San Francisco CA. Contact Managing Director, Mini/Micro Conference and Exposition, 32302 Camino Capistrano, Suite 202, San Juan Capistrano CA 92675, (714) 661-3301.

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October 16-19
Midwest Personal and Business Computer Show. For more information on this exposition, contact National Computer Shows, POB 678, Brookline Village MA 02147, (617) 739-2000.

October 26-28
The Eleventh ACM North American Computer Chess Championship, Opryland Hotel, Nashville TN. This is a four-round Swiss-style tournament with participants restricted to computers. All of the best chess programs in North America are expected to participate. A maximum of twelve teams will participate. The deadline for entries is September 8, 1980. Contact Monty Newborn, School of Computer Science, McGill University, 805 Sherbrooke St W, Montreal, PQ, H3A 2K6, Canada,(514) 392-8274.

October 26-29
International Data-Processing Conference and Business Exposition, Philadelphia Sheraton Hotel, Philadelphia PA. This conference is being sponsored by the Data Processing Management Association. Contact the Conference Coordinator, DPMA International Headquarters, 505 Busse Hwy, Park Ridge IL 60068, (312) 825-8124.

October 27-29
ACM Annual Conference—Previewing the Computer Age, Opryland Hotel, Nashville TN. This conference will focus on the computer technology, products, and services that will come into general use during the 1980s. The technical program will be organized around the Association for Computing Machinery's (ACM) Special Interest Groups, with additional sessions for papers of general interest. Contact Dr Gordon Sherman, Technical Program Chairman, ACM '80, University of Tennessee Computer Center, Knoxville TN 37916, (615) 974-6758.

October 27-30
The Fifth International Conference on Computer Communications, Peachtree Plaza Hotel, Atlanta GA. The theme for ICCC/80 is "Computer Communications: Increasing Benefits for Society." More than one hundred speakers will present papers on applications and technical developments of computer communication and assess their worldwide implications for the 1980s. Fees are $175 for preregistration and $200 at the conference. Contact ICCC/80, POB 280, Basking Ridge NJ 07920, (201) 221-8800.

October 28-30
The Fourth Annual Interface West, Los Angeles Convention Center, Los Angeles CA. More than one hundred fifty computer-related companies will exhibit their wares. The conference will offer programs on office automation and small-systems procedures for businessmen, plus data communications, distributed-data processing, and networking for technically oriented managers. Many speakers will be featured. For further information, contact The Interface Group, 160 Speen St, Framingham MA 01701, (617) 879-4502 or call toll free, (800) 225-4620.

October 30-November 1
National Small-Computer Show, New York Coliseum, New York NY. Hourly lectures on data-processing and word-processing applications for small computers, exhibitions of hardware and software, and seminars on various aspects of computer-related news will be featured. A lecture schedule and basic information are available from the National Small Computer Show, 110 Charlotte Pl, Englewood Cliffs NJ 07632, (201) 569-8542.

NOVEMBER 1980

November 8-9
The 1980 Personal Computer Fair, Pacific Science

Center, Seattle WA. The theme of this year's fair is "Hands On." The booths and exhibits will reflect this idea, and the public will have access to as many computers and terminals as possible. Contact the Northwest Computer Society, POB 4193, Seattle WA 98119, (206) 284-6109.

November 10-14

The Fourth Annual Data-Entry Management Conference, Orlando FL. This conference will cover data entry, distributed processing, and word processing with emphasis on data entry, including human-machine interface. Contact Data Entry Management Association, POB 3231, Stamford CT 06905, (203) 322-1166.

November 18-20

The Third Industrial Revolution, McCormick Place, Chicago IL. This exposition and conference is devoted to development by manufacturing companies of systems for information management. Information may be obtained from Banner & Grief Ltd, 110 E 42nd St, New York NY 10017, (212) 687-7730.

November 19-21

Comdex '80, Las Vegas Convention Center, Las Vegas NV. Comdex is a conference and exposition for independent sellers of small-computer and word-processing systems, peripherals, media, and supplies. Address inquiries to the Interface Group, 160 Speen St, Framingham MA 01701, (800) 225-4620, in Massachusetts call (617) 879-4502.

November20-21

Western Educational Computing Conference, San Diego CA. This seminar will feature papers and seminars on the use of computing in higher education for instruction, administration, and research. Contact Ron Langley, Director, Computer Center, California State University, Long Beach, 1250 Bellflower Blvd, Long Beach CA 90840, (213) 498-5459.

November 20-23

Northeast Personal and Business Computer Show, Hynes Auditorium, Boston MA. This is an annual exposition open to the general public. The admission will be $5. Contact National Computer Shows, POB 678, Brookline Village MA 02147, (617) 739-2000.

November 21-23

National Home Entertainment Show, New York Coliseum, New York NY. Exhibits will cover video, photography, audio, games, and home computers. Seminars and demonstrations will be featured in this show. Contact United Business Publications Inc, 475 Park Ave South, NewYork NY 10016, (212) 725-2300. ■

BYTE's Bugs

An Error in Fifteen

I enjoyed seeing my article "Fifteen: A Game of Strategy" appear in the June 1980 BYTE (page 230). Unfortunately a bug crept into the program (listing 1), and it will not run as listed. The problem is in line 720, which should read:

"IF T2>0 THEN 750"

rather than "IF T2>0 THEN 270". With this change it runs as it should.

If the EXIT statements are dropped and the PRINT statements changed, then the program runs very nicely on a TRS-80 under Level II BASIC.

John Rheinstein
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Exploring Ballistics with Your Computer

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Many sports are intricately involved with the properties of objects lofted into the air and thereby committed to the inevitable effects of gravity. Both players and fans relish golf's hole-in-one, the long bomb to the wide receiver in football, and the home run in baseball. In the case of target shooting, the path of the projectile is of particular interest. How the bullet gets to the target is the province of physics, but where it lands resides solely in the skill of the shooter. BALISTIC is a program to calculate just where a bullet will go.

Ballistics

Ballistics is the study of the behavior of projectiles at various ranges. Of interest to shooters are the velocity, time of flight, drop, and drift at evenly incremented ranges of 50 or 100 yards. Also of interest is the maximum height attained by the bullet above a horizontal line from the bore to a bull's-eye, the trajectory above and below a line of sight at various ranges, and the energy of the bullet.

A variety of factors influence the path of a bullet as it leaves the muzzle; most important are muzzle velocity, gravity, and air resistance. Muzzle velocity is determined by internal ballistics and factors such as bullet weight and bore diameter, barrel length, powder weight and burning rates, and maximum pressures. The calculation of these factors is beyond the scope of this article. Muzzle velocity depends upon the direction of the bore relative to the horizontal, since a velocity is formally a vector quantity. As it leaves the muzzle, though, the speed of the bullet can be most easily measured with an instrument called a *chronograph*. Bore elevations at reasonable ranges are typically less than a quarter of a degree, and therefore are of negligible influence. The acceleration of gravity is dependent on latitude and altitude (and thus on the distance to the center of the Earth), and upon local rock density and underlying mass. This, too, tends to minor deviations: only 0.5% from the equator to the poles, only 0.15% from sea level to 15,000 feet. The acceleration of gravity can be regarded as a constant 32.1725 feet per second per second in English system units.

Air resistance is the most complicated factor, and its effect is dependent on the density of the air, temperature (and thus the speed of sound), wind velocity, and the properties of the bullet—specifically, speed, sectional density (proportional to the ratio of mass to frontal area), and shape. Whereas gravity pulls the bullet toward the center of the Earth, air resistance acts as a drag opposite to its direction of motion at any instant. This effect of air resistance, independent of gravity (under usual conditions), determines the time of flight to any range and the remaining velocity. The effect of gravity combined with the influence of air resistance determines bullet drop at any range. Therefore, the calculations of the effects of the air naturally come first.

Air Resistance

The effect of the atmosphere is to push against the moving bullet. Because a force acting on a mass results in an acceleration or deceleration, depending upon the force's direction, a bullet is decelerated at a rate proportional to the ratio of the drag force to the mass. For a *standard* projectile, this retardation R is related to a constant A times a power m of the velocity at any instant: thus $R = AV^m$. It has been deduced that the retardation or drag (call it r) for any other projectile differing from the standard only in scale of size is directly proportional to a ratio of the standard projectile's deceleration to a factor known as the ballistic coefficient: thus $r = R/C$. The ballistic coefficient C for a bullet differing in varying degrees of shape from the standard is, in turn, proportional to the ratio of the sectional density to a quality called the *form factor* (commonly known as i): thus $C = (w/d^2)/i$.

The form factor is usually disagreeably hard to calculate from

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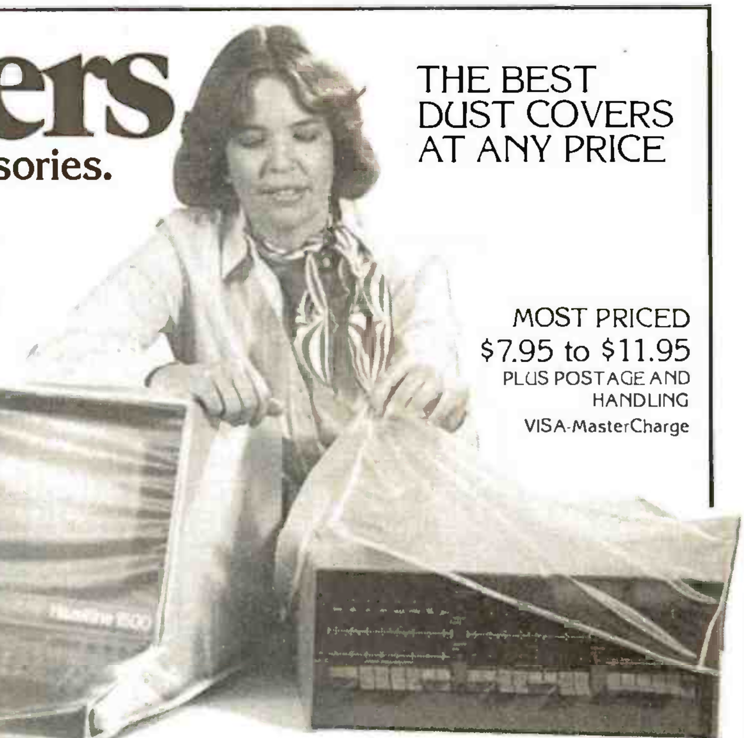

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Circle 184 on inquiry card.

geometric properties alone, and is therefore inferred from the results of ballistic experimentation. But for *ogival* pointed bullets (ie: a bullet with a point shape defined by a circular arc meeting parallel straight sides at a tangent, or *spitzer*) $i=\sqrt{(16n-4)/7n^2}$, $n=L^2+0.25$, n equals the ratio of arc radius to bullet diameter, L equals the ratio of bullet-head length to diameter (see reference 1). Most bullets are ogival in shape, but serious changes in the form factor are caused by even small flats on the nose (such as hollow points or dents in soft-nose jacketed bullets), and no further use of this mathematical relation will be made.

Since the velocity of a bullet at any time is dependent upon the deceleration, which in turn is dependent on the instantaneous velocity, a differential equation is involved. Since a change in velocity is dependent on the integral of acceleration, the use of the calculus is formidably indicated. Whereas given an initial muzzle velocity one might attempt to tabulate range and velocity for suitably small increments of time, it is easier to tabulate changes in range and time for suitably small decrements in velocity, and avoid the calculus entirely. Summations of these increments of time and range give the total time of flight to a given distance. To do this the values of the constants A and m in the equation $R=AV^m$ must be determined.

Values for the constants A and m were determined by Russian Colonel Mayevski based on data compiled by the German firm of Krupp Armorers in 1881. These figures were converted into English units by Colonel James M Ingalls of the United States Army in the form of a famous tabulation known as the Ingalls Ballistics Tables.

The standard projectile used in the Krupp firings was a spitzer-pointed projectile of 2-caliber radius, flat base, and an overall length of 3 caliber. The shape of small-arms bullets today is similar enough to this standard projectile to allow the Ingalls tables to closely predict their performance. It was found that the factors A and m varied with velocity, but could be taken as constants within suitable limits of velocity and still give accurate results. Thus eight ranges of velocity from 5000 feet per second (fps) to 0 fps, each with its own constants A and m, cover the range of small-arms bullets. The factors A and M in listing 1 are these constants. Also available in the program are the constants to reconstruct the British Ballistic Tables of 1909: these seem to more closely agree with hand-loading data such as is in the *Sierra Bullets Reloading Manual* (for the reloading of cartridges by the shooter).

To reconstruct the Ingalls or British tables, a standard projectile is assumed, with a Krupp-shaped nose, weighing 1 pound, 1 inch in diameter, and with an assigned standard ballistic coefficient of 1 and a form factor of 1 (since $w/d^2=1/1^2=1$). For a small change in velocity $v=U-W$ (U=initial velocity, W=final velocity over a small change in velocities), and average velocity $V=(U+W)/2$, the time for the projectile to decelerate from U to W is $t=v/AV^m$, and the distance over which it travels $s=v/AV^{(m-1)}$. The total time to slow from a given muzzle velocity to any velocity W equals the sum of all these increments of time ($T=\Sigma\ t$) and the total distance $S=\Sigma\ s$.

The computer solves these summations for any bullet, given either its ballistic coefficient or form factor

Circle 186 on inquiry card.

Listing 1: *BALISTIC, a North Star BASIC ballistic program. The workings of this program and the peculiarities of North Star BASIC are described in the text.*

```
10   REM  ** 'BALISTIC'   BY R W JENKS  1979  MOD 9/10/79 **
20    GOSUB 1540\REM (OUTPUT TO TERMINAL)
30    LINE 79
40    DIM C$(50),T(10,2)
50    C1=1\ A4=1\ V=5\ R3=500
60 ! CHR$(27),CHR$(42)
70   REM  ** INPUT PARAMETERS **
80 INPUT 'CALCULATE BALLISTIC COEFFICIENT (YES/NO)? ',I$
90    IF I$='YES' THEN F=1 ELSE F=0
100 INPUT 'INGALLS OR BRITISH 1909 TABLES? ',I$
110    IF I$(1,4)='INGA' THEN F1=1 ELSE F1=0
120    T3=59+1*F1
130    P1=29.53+.47*F1
140 INPUT1 'WIND SPEED:',W1\ ! '  Miles Per Hour'
150 INPUT1 'CROSS WIND ANGLE:',A1\ ! '  Degrees From Broadside'
160    W2=W1*COS(2*3.1415927*A1/360)*88/60
170    IF I$='W' THEN 460
180 INPUT 'CARTRIDGE:',C$
190 INPUT1 'WEIGHT:',W\ ! '  Grains'
200    W=W/7000
210 INPUT1 'CALIBER:',D\ ! '  Inch'
220    IF F THEN 290
230 INPUT 'BALLISTIC COEFFICIENT:',C
240    IF C<>0 THEN 260
250 INPUT 'FORM FACTOR:',I
260    IF C=0 THEN C=(W/D^2)/I
270    IF I=0 THEN I=(W/D^2)/C
280    C1=C
290 INPUT 'NON STANDARD CONDITIONS (YES/NO) ?',I$
300    IF I$<>'YES' THEN 460
310   REM  ** NON STANDARD ATMOSPHERIC CONDITIONS **
320 INPUT1 'TEMPERATURE:',T3\ ! '  Degrees Fahrenheit'
330 INPUT1 'PRESSURE:',P1\ ! '  Inches Mercury'
340 INPUT1 'ALTITUDE:',A2\ ! '  Feet'
350    T4=59-(3.566E-3)*A2+1*F1
360    P2=29.53-(8.581E-4)*A2+(8.602E-9)*A2^2+.47*F1
370    A3=1+(3.073E-5)*A2+(6.371E-10)*A2^2
380    A4=A3*(2-P1/P2)*(T3+459.4)/(T4+459.4)
390    C=C1*A4
400    IF F THEN 430
410 !\! 'MODIFIED C:',%5F3,C\!
420    GOTO 440
430    T3=59+1*F1\ P1=29.53+.47*F1\ A2=0
440    I=(W/D^2)/C
450   REM  -- END OF ROUTINE --
460 IF NOT F THEN INPUT 'TO 500 OR 1000 YARDS? ',R3
470    R3=R3/500
480 INPUT1 'MUZZLE VELOCITY:',V1\ ! '  Feet Per Second'
490    V2=V1+V\R2=0
500    IF NOT F THEN 560
510 INPUT1 'RANGE:',R1\ ! '  Yards'
520    R1=R1*3
530 INPUT1 'FINAL VELOCITY:',V4\ ! '  Feet Per Second'
540    I=1\ C=1\ GOTO 700
550   REM  ** PRINT DATA **
560 ! ' ',C$,
570 ! TAB(50),INT(W*7000+.5),' Grains  ',%#5F3,D,' Caliber'
580 ! TAB(25),'BALLISTIC COEFFICIENT:  ',C,'    FORM FACTOR: ',I,%#
590 ! TAB(30),'Based on ',
600 IF F1 THEN ! 'INGALLS',\ IF NOT F1 THEN ! 'BRITISH 1909',
610 ! ' Ballistic Tables'
620 ! ' WIND  ',%#5F1,W1,' MPH   FROM ',A1,' Degrees     CROSSWIND  ',W2,' FPS'
630 ! ' TEMPERATURE ',T3,' Degrees F   PRESSURE ',%5F2,P1,
640 ! ' Inches Hg   ALTITUDE ',%#,INT(A2),' Feet'
650 !
660 ! 'RANGE  VELOCITY  ENERGY  MAX HEIGHT  DROP  DRIFT   TIME'
670 ! 'YARDS   FT/SEC   FT-LBS       IN.       IN.    IN.    SEC.'
680 !
690   REM  ** BEGIN TIME AND DISTANCE CALCULATIONS **
700    K=2*V*C
710    V2=V2-2*V
720    IF F1 THEN GOSUB 1350 ELSE GOSUB 1190
730    S1=S\ S=S+K/(A*V2^(M-1))
740    T1=T\ T=T+K/(A*V2^M)
750    IF F AND V2<V4 THEN 790
760    IF NOT F AND S>=R2 THEN 870
770    GOTO 710
780   REM  ** RESULTS OF BC/FF CALCULATION **
790    S=S1+(S-S1)*(V2+V-V4)/(2*V)
800    C=(R1/S)/A4
810    I=(W/D^2)/C
820 !
830 ! 'BALLISTIC COEFFICIENT:',%#5F3,C
840 ! 'FORM FACTOR:',I,%#
850    C1=C\F=0\ GOTO 1090
860   REM  ** PRINT A ROW OF BALLISTIC DATA **
870    V3=(V2+V)-2*V*(R2-S1)/(S-S1)
880    E=V3^2*W/32.1725/2
890    T2=T1+(T-T1)*(R2-S1)/(S-S1)
900    T(R2/(150*R3),0)=R2/3
910    D1=(110.3+82.7*V3/V1)*T2^2
920    T(R2/(150*R3),1)=D1
930    W3=12*W2*(T2-R2/V1)
```

Listing 1 continued on page 274

Listing 1 continued:

```
940 ! %5I,INT(R2/3+.5),%10I,INT(V3+.5),%8I,INT(E+.5),
950 ! %10F1,48*T2^2,%8F1,D1,%7F1,W3,' ',%6F3,T2
960    R2=R2+150*R3
970    IF NOT(NOT F AND R2>1500*R3) THEN 710
980   REM  ** TRAJECTORY TABLE **
990 INPUT1 'SIGHT ON AT:',R4\ ! '  Yards    ',
1000 INPUT1 'SIGHT HEIGHT:',H\ ! '  Inches'
1010    FOR X=0 TO 10
1020    T(X,2)=T(R4/(50*R3),1)*T(X,0)/R4-T(X,1)-H*(R4-T(X,0))/R4
1030    NEXT
1040 ! 'RANGE Yards     ',\ FOR X=0 TO 8\ ! %7I,T(X,0),\ NEXT\ !
1050 ! 'TRAJECTORY In.  ',\ FOR X=0 TO 8\ ! %7F1,T(X,2),\ NEXT\ !
1060 !
1070   REM  ** RESET FOR ITERATION.  W=NEW WIND INFO, A=NEW AIR INFO,
1080   REM     F=PRINTER, T=TERMINAL **
1090    S=0\ T=0
1100 INPUT I$
1110    IF I$='W' THEN 140
1120    IF I$='A' THEN 320
1130    IF I$='T' THEN GOSUB 1540
1140    IF I$='P' THEN GOSUB 1550
1150    IF I$='P' THEN 1100\ IF I$='T' THEN 1100
1160    GOTO 460
1170   REM  *****  DATA  *****
1180   REM  ** BRITISH 1909 BALLISTIC CONSTANTS **
1190 IF V2>2600 THEN 1330
1200 IF V2>2000 THEN 1320
1210 IF V2>1460 THEN 1310
1220 IF V2>1190 THEN 1300
1230 IF V2>1040 THEN 1290
1240 IF V2>840 THEN 1280
1250 IF V2>0 THEN 1270
1260 END
1270 A=74422E-8\ M=1.6\ RETURN
1280 A=59939E-12\ M=3\ RETURN
1290 A=23385E-22\ M=6.45\ RETURN
1300 A=95408E-12\ M=3\ RETURN
1310 A=59814E-8\ M=1.8\ RETURN
1320 A=58495E-7\ M=1.5\ RETURN
1330 A=15366E-7\ M=1.67\ RETURN
1340   REM  ** INGALLS BALLISTIC CONSTANTS **
1350 IF V2>3600 THEN 1510
1360 IF V2>2600 THEN 1500
1370 IF V2>1800 THEN 1490
1380 IF V2>1370 THEN 1480
1390 IF V2>1230 THEN 1470
1400 IF V2>970 THEN 1460
1410 IF V2>790 THEN 1450
1420 IF V2>0 THEN 1440
1430 END
1440 A=4.6761777E-05\ M=2\ RETURN
1450 A=5.9353046E-08\ M=3\ RETURN
1460 A=6.3368148E-14\ M=5\ RETURN
1470 A=9.5697809E-08\ M=3\ RETURN
1480 A=1.3160125E-04\ M=2\ RETURN
1490 A=1.2479524E-03\ M=1.7\ RETURN
1500 A=4.0648825E-03\ M=1.55\ RETURN
1510 A=4.05E-03\ M=1.551\ RETURN
1520   REM  ** TERMINAL/PRINTER OUTPUT ROUTINES
1530   REM     FOR USE WITH NORTH STAR DOS 3.2 **
1540 FILL 10559,3\ FILL 10567,2\ RETURN
1550 FILL 10559,5\ FILL 10567,4\ RETURN
1560 GOSUB 1550\ END
```

over a suitably small change in velocity of $v = 10$ feet per second, or the program solves for the ballistic coefficient and form factor given muzzle velocity and remaining velocity at any range by calculating the performance of the standard projectile and comparing it with the actual performance of the bullet under consideration. The answers are interpolated for maximum accuracy.

These calculations are relevant for conditions of standard atmospheric density. Other conditions of air temperature, pressure, and water-vapor content may give a density different from standard. Changes in altitude will influence all three factors. These conditions have the effect of modifying the form factor. The factor for a temperature different from standard equals the ratio of the absolute value of the observed temperature to the absolute value of the standard temperature at the desired altitude. (In the English system of units, absolute temperature is measured in degrees Rankine. Degrees Rankine equals 459.4 + degrees Fahrenheit, $t_1°R = 459.4 + t_2°F$.) The factor for a difference in pressure equals 2 minus the ratio of the observed barometric pressure to the standard barometric pressure (again, as would be found at the altitude). The altitude factor is inferred from experimentation, and for this I have used the same factor as in the *Sierra Bullets Reloading Manual* (reference 2). Deviations from standard humidi-

A	Ballistic proportional part constant
A1	Crosswind angle
A2	Altitude above sea level
A3	Altitude factor
A4	Combined atmospheric factor
C	Current ballistic coefficient
C1	Standard ballistic coefficient
D	Bullet diameter (caliber)
D1	Drop
E	Energy
F	Flag to indicate calculation of ballistic coefficient
F1	Flag to indicate choice of constants
H	Sight height above bore
I	Form factor
K	Simplified term for calculations
M	Ballistic exponent constant
P1	Atmospheric pressure
P2	Pressure factor
R1	Final range
R2	Incremental range for tables
R3	Maximum range (in units of 500 yards)
R4	Range at which sights are on
S	Distance
S1	Previous distance
T	Time
T1	Previous time
T2	Interpolated time
T3	Temperature
T4	Temperature factor
V	Incremental velocity
V1	Muzzle velocity
V2	Average interval velocity
V3	Interpolated velocity
V4	Final velocity
W	Bullet weight
W1	Wind speed in mph
W2	Crosswind in fps
W3	Wind drift
X	Loop variable
T( )	Trajectory table array
C$	Cartridge identifier
I$	Response to input request

Table 1: *Table of variables used in the BALISTIC program.*

ty are best ignored. And, indeed, few shooters are likely to hazard whirling a sling psychrometer on the range anyway.

Standard conditions at sea level used for the Ingalls Tables are 30 inches of mercury, 60° F, and air 66% saturated with moisture. This compares with the standard conditions for the tables in the *Sierra Bullets Reloading Manual* of 29.53 inches of mercury, 59° F and 78% relative humidity. The product of these factors with the ballistic coefficient gives an amended ballistic coefficient.

Bullet Path

The trajectory of a bullet is conventionally taken to be the path traversed by the bullet in a vertical plane. This path, in turn, can be measured from various datum lines. When it is measured from the line of the bore and the bore is horizontal, the path is referred to as bullet drop.

In common parlance, the term "trajectory" is assumed to be referenced to the line of sight. This takes into account the offset and angular difference between the line of sight and the bore. As the crosswind effect usually has little or no component affecting the path of the bullet in the vertical plane, it can be treated separately. The combination of the motions of the bullet in the vertical and horizontal planes intersecting at the datum line fully describes its performance along the datum.

If a rifle could be fired on the Earth surrounded by a vacuum, the bullet would begin to fall, and over a time, the distance it falls would exactly equal one-half the gravitational constant times the square of the time of flight. The effect of the atmosphere is to restrict the fall of a bullet. This does not imply that shooting through an atmosphere gives better performance than shooting in a vacuum, because, though the bullet drops less for a given time of flight, it takes longer to reach a given range, and thus the total drop for a given range is greater. A bullet fired in a vacuum would retain its muzzle velocity, as the absence of air implies an absence of anything to impede its progress.

The *British Textbook of Small Arms*, 1929, likens the effect of the air to a simulation of a gravitational constant that decreases with range. Thereby the vacuum equation may be used, but using a different constant—f instead of g. This is approximated by the equation $f = g - 0.429g\,(M-W)/M$, where W equals the velocity at the given range, and M equals the velocity the bullet would have at the same range had it been fired in a vacuum; for all ranges M would be equal to the muzzle velocity. This equation is only a correlation with the facts and is not meant to actually explain the mechanism of bullet drop under the influence of air. But it is acceptably accurate down to velocities where $W > M/3$ (see reference 1).

To determine an actual trajectory, the curve of the bullet path versus range is tilted up just enough so that the curve crosses a horizontal line (from the muzzle) at the given range where the gun is to shoot on target. This is effectively accomplished for small angles of elevation by subtracting from the drop, at the range, an amount proportional to the product of the bullet drop at the targeted range times the ratio of any range to the targeted range ($o = d - Dr/R$, where o = modified ordinate relative to the horizontal, d=drop at any range, D=drop at targeted range, r=any range, R=targeted range). A table of discrepancies between the path of the bullet and the horizontal is modified for the difference between the angle of the line of sight and the horizontal (crossing at the targeted range). Thus $O = o - h(R-r)/R$, where O= the ordinate from the line of sight, and h= the separation of sight and bore; h usually varies from 0.75 to 2 inches.

For any given target range, the maximum height reached by the bullet above the horizontal while traveling to that range is $H = 48T^2$ inches. Maximum height and midrange trajectory are nearly identical over the limits of practical shooting distances.

Crosswind

Though the effect of air resistance on bullet drop is somewhat odd, the effect of a crosswind is downright confusing. One would think that a bullet in a crosswind might do one of three things: it might quickly begin drifting with the wind if it were light relative to its lengthwise sectioned area, or it might resist the wind tenaciously if it were massive relative to this area, or, most likely, it should do a little of both; drifting to the extent that it is light and resisting to the extent that it is massive. In any case its crosspath acceleration should appear to be smooth as its sideways speed approaches that of the wind.

In truth, though, a bullet will drift an amount equal to the product of the component of the wind perpendicular to the axis of the bullet multiplied by the difference between the time the bullet takes to reach any range and the time it would take to reach that range were it fired in a vacuum. This time of travel in a vacuum equals the range divided by the muzzle velocity. It is hard to believe that both a slow-moving bullet and a fast-moving bullet (ie: bullets moving slower or faster than the speed of sound) drift less for the same ranges than bullets moving more nearly at the speed of sound, even though the fast-moving bullet gets to the target sooner and the slow-moving bullet gets there later. A bullet fired at a speed faster than the speed of sound at first accelerates sideways moderately, then accelerates considerably in drift while

Listing 2: *This is a sample run of BALISTIC producing a calculation of bullet parameters. Note that the* Sierra Handbook *(reference 2) also gives the ballistic coefficient as 0.285. Compare the velocities for standard conditions.*

```
       RANGE      0      100      200      300      400      500
    VELOCITY   3800     3405     3045     2713     2405     2117


READY
RUN50

*
CALCULATE BALLISTIC COEFFICIENT (YES/NO)? YES
INGALLS OR BRITISH 1909 TABLES? BRITISH
WIND SPEED:8  Miles Per Hour
CROSS WIND ANGLE:32  Degrees From Broadside
CARTRIDGE:.22/250
WEIGHT:55  Grains
CALIBER:.224  Inch
NON STANDARD CONDITIONS (YES/NO) ?YES
TEMPERATURE:68  Degrees Fahrenheit
PRESSURE:29.00  Inches Mercury
ALTITUDE:2150  Feet
MUZZLE VELOCITY:3800  Feet Per Second
RANGE:400  Yards
FINAL VELOCITY:2460  Feet Per Second

BALLISTIC COEFFICIENT: .285
FORM FACTOR: .550
?
TO 500 OR 1000 YARDS? 500
MUZZLE VELOCITY:3800  Feet Per Second
 .22/250                                          55 Grains   .224 Caliber
                         BALLISTIC COEFFICIENT:   .285   FORM FACTOR:  .550
                              Based on BRITISH 1909 Ballistic Tables
 WIND    8.0 MPH   FROM  32.0 Degrees     CROSSWIND   10.0 FPS
 TEMPERATURE  59.0 Degrees F   PRESSURE 29.53 Inches Hg   ALTITUDE  0 Feet

RANGE  VELOCITY  ENERGY  MAX HEIGHT  DROP  DRIFT   TIME
YARDS   FT/SEC   FT--LBS     IN.      IN.    IN.    SEC.

  0      3800     1763        .0       .0     .0   .000
  50     3601     1583        .1       .3     .1   .041
 100     3409     1419        .3      1.3     .5   .083
 150     3224     1270        .8      3.0    1.2   .129
 200     3046     1133       1.5      5.5    2.2   .176
 250     2875     1009       2.5      8.9    3.6   .227
 300     2710      897       3.8     13.4    5.3   .281
 350     2552      795       5.5     18.9    7.4   .338
 400     2399      703       7.6     25.8    9.9   .399
 450     2250      618      10.3     34.2   12.9   .463
 500     2107      542      13.6     44.2   16.4   .532
SIGHT ON AT:200  Yards     SIGHT HEIGHT:1.5  Inches
RANGE Yards          0     50     100     150     200    250    300    350    400
TRAJECTORY In.     -1.5   -.1      .7      .8     -.0   -1.7   -4.4   -8.2  -13.3

?A
TEMPERATURE:68  Degrees Fahrenheit
PRESSURE:29.00  Inches Mercury
ALTITUDE:2150  Feet
MODIFIED C  .300
TO 500 OR 1000 YARDS? 500
MUZZLE VELOCITY:3800  Feet Per Second
 .22/250                                          55 Grains   .224 Caliber
                         BALLISTIC COEFFICIENT:   .300   FORM FACTOR:  .522
                              Based on BRITISH 1909 Ballistic Tables
 WIND    8.0 MPH   FROM  32.0 Degrees     CROSSWIND   10.0 FPS
 TEMPERATURE  68.0 Degrees F   PRESSURE 29.00 Inches Hg   ALTITUDE  2150 Feet

RANGE  VELOCITY  ENERGY  MAX HEIGHT  DROP  DRIFT   TIME
YARDS   FT/SEC   FT-LBS      IN.      IN.    IN.    SEC.

  0      3800     1763        .0       .0     .0   .000
  50     3611     1592        .1       .3     .1   .040
 100     3428     1435        .3      1.3     .5   .083
 150     3252     1291        .8      3.0    1.2   .128
 200     3082     1160       1.5      5.5    2.1   .175
 250     2918     1039       2.4      8.8    3.4   .225
 300     2760      930       3.7     13.2    5.0   .278
 350     2607      830       5.4     18.7    6.9   .334
 400     2460      739       7.4     25.4    9.3   .393
 450     2317      656      10.0     33.5   12.1   .456
 500     2178      579      13.1     43.2   15.3   .523
SIGHT ON AT:200  Yards     SIGHT HEIGHT:1.5  Inches
RANGE Yards          0     50     100     150     200    250    300    350    400
TRAJECTORY In.     -1.5   -.1      .7      .8      .0   -1.6   -4.3   -8.0  -12.9

?T
```

transiting the speed of sound (slowing down in its motion toward the target), and then settles back to drifting at small incremental velocities from there on.

The logic behind the observations is that the amount of deceleration affecting a bullet traveling close to the speed of sound is large (as a measure) due to turbulence. At both higher and lower speeds, the combined effects of base drag, skin friction, and nose drag are changing less over a given range, and so the bullet travels this distance nearer to the time it would take were it able to maintain its initial velocity. Were the bullet able to arrive at a given range in the time it would take if it could maintain its muzzle velocity, this would imply an absence of air resistance, an absence of wind, and thus no drift. This supports the dependence on the time difference.

Also affecting the horizontal path of a bullet is a gyroscopic effect causing the bullet to point away from its initial line of flight. As the bullet falls, additional air resistance appears on the bottom of the bullet. This leads to asymmetrical torques around the center of mass which cause the bullet to attempt to tilt around a horizontal lateral axis, but because the bullet is spinning, the gyroscopic effect resists the turning moment and redirects it by 90°, thus causing the bullet to yaw and veer away from the line of the bore. The effect is minor and only amounts to 6.7 inches at 1000 yards for a 150-grain, full-jacket 30-06 bullet.

The Program

BALISTIC, listing 1, is written in North Star BASIC for use on a North Star Horizon computer and may need modification for use with other BASICs. An exclamation point (!) is North Star BASIC shorthand for PRINT. The backslash (\ ) is the multiple-statement-per-line separator; commas separate print items. Line 60 of the program sends the clear-screen command for a Soroc IQ-120 terminal, an Escape-asterisk (ESC-*) sequence. Lines 1540 and 1550 modify the North Star BASIC disk operating system output routine so as to reconfigure output to either the standard serial port (terminal) or secondary serial port (printer), and thus doing away with the need for device designation parameters in all

PRINT statements. Lines 1540 and 1550 should be replaced with appropriate routines or just RETURNs on all computers where such execution might cause havoc. BALISTIC runs in 5300 bytes, but can be shortened by deleting spaces and remarks, and by merging statements onto fewer lines. BALISTIC may also be shortened by excising the routine for the constants of one or the other ballistic tables.

Operation

The program is self-prompting for the most part, as shown in listing 2. It operates in two major modes: simulating bullet performance based on parametric input or calculating normalized ballistic parameters based on experimental data (after which it returns to the simulation mode). Units are English, and terminology is characteristic of the shooting sports (7000 grains per pound). Pertinent information is repetitively printed so that it is not lost in the shuffle. A suitably placed GOTO statement bypassing these lines saves paper when you are compiling records such as handloading information.

When the computer prompts for the caliber, the bore diameter plus the depth of one groove is expected: the diameter of the bullet is a suitable alternate. If the ballistic coefficient, *C*, is not known, but the form factor, *i*, is known, entering 0 for *C* allows the computer to prompt for *i*. When the computer prompts for the maximum range to which to calculate, any range may be entered, not just 500 or 1000 yards. But when the program asks for the "SIGHT ON RANGE," a range listed in the table must be used (other than 0). The question mark following the trajectory table prompts for an "A", "P", "T", "W", or a carriage return—for new atmospheric data, printer or terminal output, new wind data, or reiterate.

Conclusions

I hope all the major factors that affect bullet performance have been included, so that accurate results are possible. The greatest, though unquantized, limitation is that the ballistic coefficient changes with velocity for projectiles differing from 1 in form factor. The farther from standard this deviation, the less accurately will the calculated results match the real bullet performance, since the standard projectile will be less of a model for the actual bullet. Even so, the calculations tend to match actual performance within 1% for velocity and 2% for bullet path out to 500 yards or more, and compare nicely with published cartridge manufacturers' information and reloading guide data. Do not expect especially accurate results for blunt-nosed bullets or slow-moving boattails, though. But the accuracy is probably consistent with random variations in the actual physical conditions such as spatial variations in wind speed and direction, air temperature and humidity, bullet imperfections and variations in weights, etc. Reduction of published data might indicate a mathematical relationship between bullet geometry and the way the ballistic coefficient changes with velocity, and thus the equations in the program might be modified for more universal simulations.

See the references for other sources and additional information. *Hatcher's Notebook* is extremely interesting reading on a variety of shooting subjects. Other reloading guides are also valuable.

So go ahead, load BALISTIC, and take your computer to the range.■

References

1. Hatcher, Maj Gen Ret Julian S, *Hatcher's Notebook*, Third Edition, The Telegraph Press, Harrisburg PA, 1966, Library of Congress number 62-12654.
2. *Sierra Bullets Reloading Manual*, First Edition, 1971, Sierra Bullets, 10532 S Painter Ave, Santa Fe Springs CA 90670.
3. Walters, Kenneth L, "Crosswind Deflections: a Cast Bullet Anomaly," *Gun Digest*, Thirty-third edition, 1979, DBI Books Inc Northfield IL.

An Interrupt-Driven Real-Time Clock for the TMS 9900

Thomas G Morris Jr
861 St Mary Ave
San Leandro CA 94577

One of the first things many computer enthusiasts feel the need for is a real-time clock for their personal computers.

With many different methods available for the computer to maintain the time of day, I decided that any real-time clock should have a reasonably low software overhead and simple hardware approach.

Processor Overview

One of the 16-bit microprocessors now readily available to computer users is the Texas Instruments TMS 9900.

The TMS 9900 is a 16-bit processor using a memory-to-memory architecture that allows multiple register files (known as workspaces) to reside in memory. A workspace is defined as sixteen contiguous words of memory, addressable as registers R0 thru R15. This method increases programming flexibility and produces a faster interrupt-response time than other processors have; a context switch may be performed without the use of a stack.

Registers

The processor contains three hardware registers. They are:

- program counter (PC)
- status register (ST)
- workspace pointer (WP)

The program counter contains the address of the instruction following the currently executing instruction. The status register contains the current state of the processor (ie: flags and interrupts). The workspace pointer register points to the first word of the current workspace.

Addressing

The TMS 9900 has both word and byte addressing capability. The byte-addressing mode is internal to the processor and references the leftmost byte of a workspace register. There are seven main addressing modes. These are given along with the assembler mnemonics in table 1.

Interrupts

The TMS 9900 utilizes sixteen vectored interrupts. The interrupt vectors are contained in hexadecimal memory locations 00 thru 3C and consist of the interrupt workspace pointer and a pointer to the interrupt code. When an interrupt has been

1. Register	(MOV R0,R1)
2. Register Indirect	(MOV *R0,R1)
3. Register Indirect with Auto-Increment	(MOV *R0+,R1)
4. Direct (Symbolic)	(MOV R0,@Label)
5. Indexed	(MOV R0,@Label(R1))
6. Immediate	(LI R0,>FFFF)
7. Relative	(JMP $+3)

Table 1: *The 7 main addressing modes of the Texas Instruments TMS 9900 16-bit processor, given with assembler- mnemonic representation. Additional addressing modes can be simulated by subroutines called through extended-operation (XOP) instructions.*

About the Author

Thomas G Morris Jr works for General Electric as a minicomputer systems software analyst. His personal computer is a Technico Super Starter system with 32 K bytes of programmable memory, 2 K bytes of programmable read-only memory, and 2 K bytes of read-only memory containing a monitor and disk handler. Peripherals include an 8-inch floppy disk, paper tape reader, a Southwest Technical Products AC-30 cassette unit, and a Texas Instruments 733KSR terminal.

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3. RENUMBERING ROUTINE. With a single keystroke your program is renumbered. Starting line number and increment may be changed.
4. BASIC BUFFER PROTECTOR. SYSTEM 2 sends a (CR) when the BASIC BUFFER is full. This prevents BASIC from crashing.
5. PRINTER DRIVER. Simply hit CTRL P to direct output to Centronics printer.
6. RIVIVAL ROUTINE. If NEW or CLOAD are typed, or RESET is hit by mistake, your program may be recovered. This is a safety device.

OTHER FEATURES

- RUNSTOP stops execution until any other key is hit.
- CLEAR clears screen then sends a (CR). Hit CLEAR to start on 'new page'.
- CTRL characters such as ESC, LF and CLEAR don't return ?SN ERROR.
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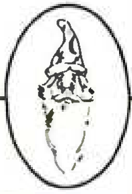

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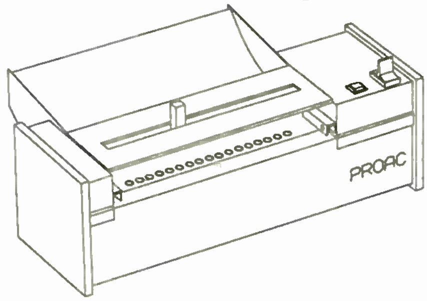

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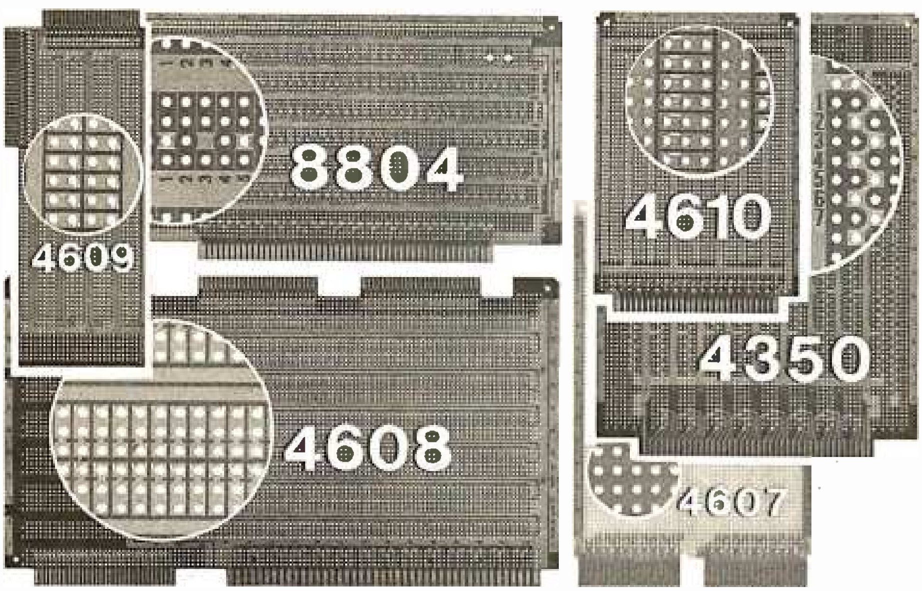

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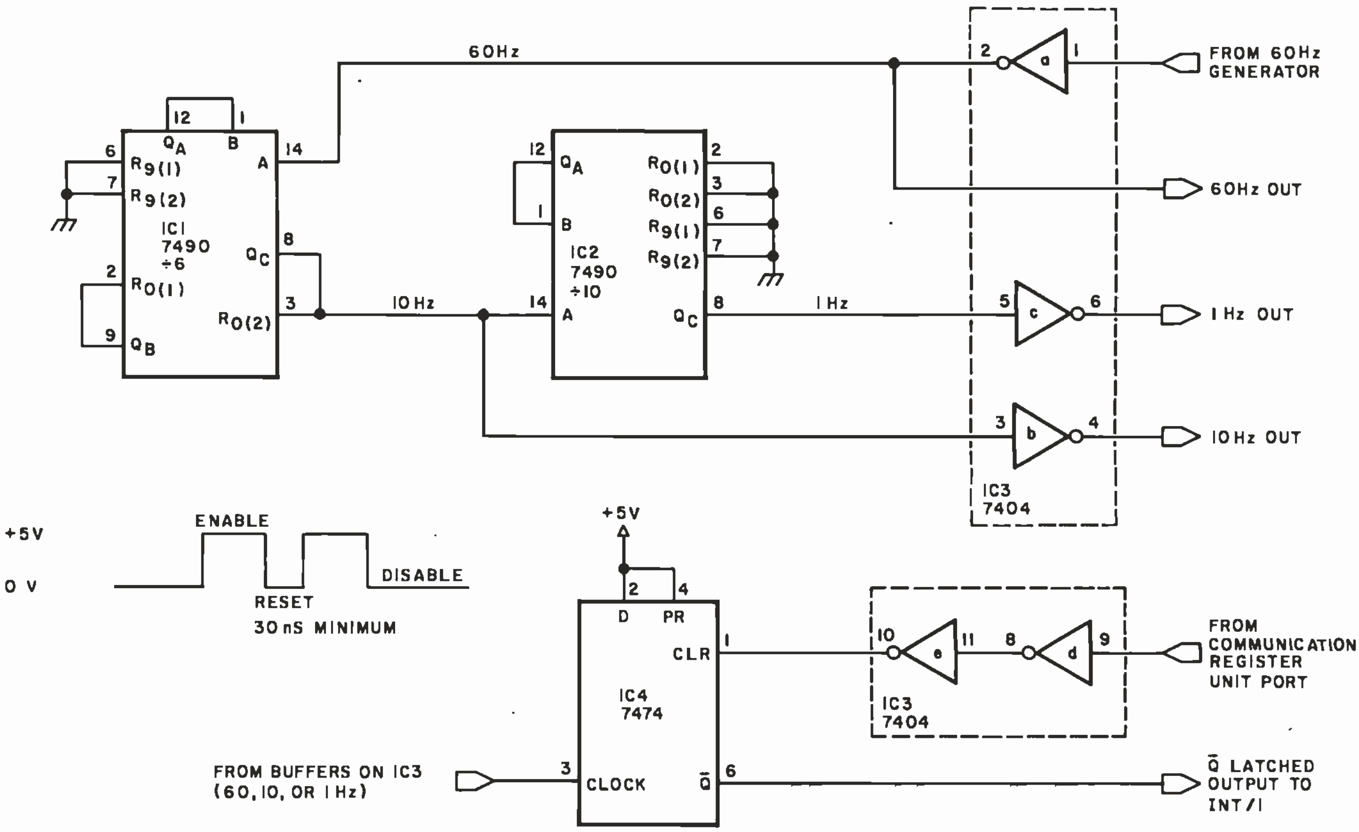

Figure 1: *Schematic diagram of the circuit for the real-time clock, with enable, reset, and disable states shown. IC1 (a 7490) is wired in a divide-by-6 configuration.*

Number	Type	+5 V	GND
IC1	7490	5	10
IC2	7490	5	10
IC3	7404	14	7
IC4	7474	14	7

detected, all lower-priority interrupts are inhibited until the current interrupt has been dismissed. The only exception to this is the reset function (which has a priority level of 0).

When an interrupt has been detected, a context switch is performed by fetching the new workspace pointer and program counter values from the appropriate interrupt vector locations. During this same time period, the old workspace pointer, program counter and status registers are saved in the new workspace registers R13, R14, and R15 respectively. When the interrupt has been dismissed by the interrupt subroutine, the processor is returned to its preinterrupt state by issuing a return (RTWP) instruction.

Input/Output

The TMS 9900 employs a direct input/output (I/O) interface method which is designated the communication register unit (CRU). The communication register unit provides for a maximum of 4096 bits of I/O capability. From 1 to 16 bits may be set or reset at a time; additionally, single bits may be tested for their value.

Clock Hardware

The heart of the clock assembly is a crystal-controlled, 60 Hz time-base generator sold by many electronic firms. The time-base generator produces an accurate square wave with a 50% duty cycle, which is fed through IC3, a 7404 inverter (see figure 1). This buffered signal is then directed to IC1 (7490), which is set up as a divide-by-6 counter. The resulting 10 Hz signal is then divided by IC2, producing the final 1 Hz frequency.

The 10 Hz and 1 Hz frequencies are buffered by IC3 and made available for use as the minimum interrupt rate. One of the three rates is then directed to the clock input of IC4, which produces the necessary latched output. IC4 (7474 dual-D flip-flop) is needed to guarantee that an interrupt will not be missed, regardless of the level chosen. The exception: if a higher-priority interrupt monopolizes

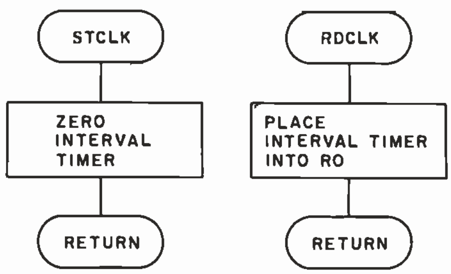

Figure 2: *Flowcharts of routines to operate interval timer.*

the processor for longer than the basic interrupt rate, the low-priority interrupt may suffer.

Hardware Interface

The clock interface to the computer consists of a simple 2-wire hookup. One wire from the communication register unit port is connected to pin 1 of IC4, clear (CLR), via two sections of the 7404 inverter IC3. This connection provides both the reset and the

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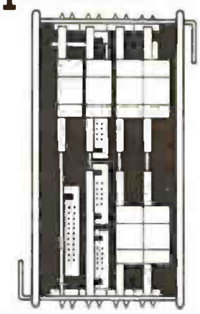

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disable signal to IC4. By momentarily bringing this line low, the current interrupt is dismissed, and further interrupts are enabled. However, if this line is *held* low, all clock interrupts are inhibited until pin 1 of IC4 is once again a logic 1. The other connection is made between pin 6 of IC4 ($\overline{Q}$) and one of the interrupt inputs of the computer, line 1 in this case. This line signals the processor that an interrupt has been requested by an external device, and is active low.

Software

The software necessary to drive the real-time clock is shown in listing 1. To set the time of day and enable the

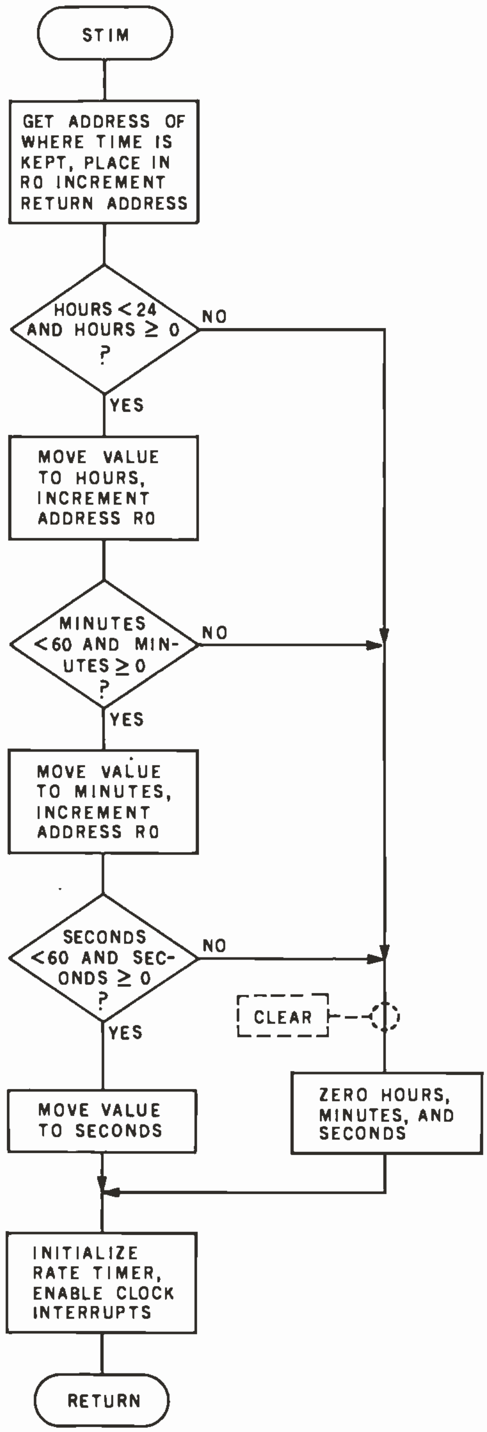

Figure 3: *Flowchart of procedure that sets the clock.*

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clock hardware, a call is made to the entry point STIM. This call instruction is followed in memory by the address of the memory location where the time of day may be found. This address pointer is placed into register R0 and the return address set by the first line of STIM code. The value to be used for hours is then compared to the maximum value allowed (eg: 24 for a 24-hour clock). The same sequence of events occurs for both the minutes and seconds values. If the number to be used is greater than the maximum allowed or is negative, no further testing is done. Instead, the clock is cleared, the hardware is enabled, and a return is made to the calling routine. The calling routine must then set the interrupt mask to allow interrupts at the chosen level.

To obtain the time of day, a call to the GTIM routine is made. The call instruction is followed by the address of the memory location where the time will be stored.

To access the interval timer, the entry points of STCLK and RDCLK are used. STCLK will reset the timer to 0, and RDCLK will place the current value of the interval timer into the caller's R0.

When the clock hardware generates an interrupt, control is transferred to

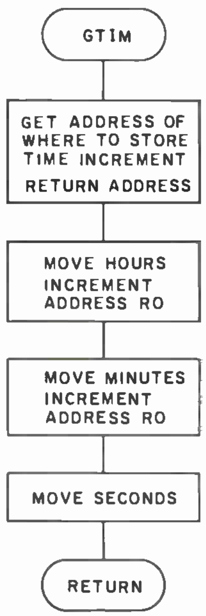

Figure 4: *Flowchart of routine that reads the clock.*

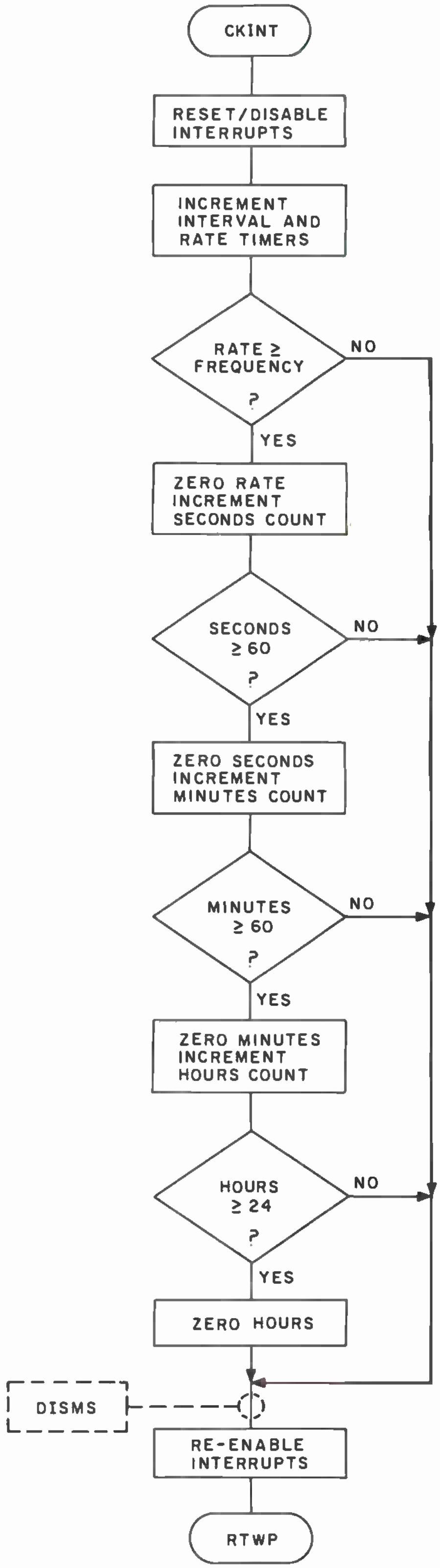

Figure 5: *Flowchart of procedure for dealing with a clock interrupt.*

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the entry point CKINT. The interrupt is then reset, and further clock interrupts are inhibited by holding the clock line of the communication register unit low. Next, the interval timer is incremented, as is the rate counter. The rate counter is then compared to the basic clock frequency. If the result of the comparison is less then 0, interrupts are reenabled and the interrupted program resumed. If the result is greater than or equal to 0, the rate counter is reset to 0 and the seconds counter is incremented. The same process that was used for the rate counter is then applied to the seconds, minutes, and hours counters. Lastly, interrupts are reenabled and the interrupted program resumed.

Conclusion

The method presented in this article will allow users a flexible and inexpensive way to maintain the time of day on their personal computer with low software overhead.■

Listing 1: *Routines that keep time using the real-time clock, written in assembler for the 9900 microprocessor.*

```
                *************************************************************
                *
                *  THIS IS A REAL TIME CLOCK DRIVER PROGRAM FOR THE
                *  TEXAS INSTRUMENTS TMS9900 MICROPROCESSOR.
                *  WRITTEN BY: TOM G. MORRIS
                *              861 ST. MARY AVE
                *              SAN LEANDRO, CA 94577
                *
                *  TO ESTABLISH THE CORRECT TIME OF DAY, ISSUE
                *  A CALL TO STIM. E.G.     BL   @STIM
                *                           DATA TOD
                *
                *  WHERE TOD POINTS TO AN OUTLINE LIST THAT
                *  CONTAINS THE TIME OF DAY IN THE FORMAT
                *  TOD      HOURS
                *  TOD+1    MINUTES
                *  TOD+2    SECONDS
                *
                *  IF ANY OF THE VALUES ARE INVALID, THE TIME IS
                *  SET TO MIDNIGHT (00:00:00).
                *
                *  TO OBTAIN THE CORRECT TIME OF DAY, ISSUE
                *  A CALL TO GTIM. E.G.     BL   @GTIM
                *                           DATA TOD
                *
                *  WHERE TOD POINTS TO AN OUTLINE LIST WHERE THE
                *  CORRECT TIME OF DAY WILL BE STORED. SEE ABOVE.
                *
                *  ALSO AVAILABLE TO THE USER IS AN INTERVAL TIMER
                *  THAT INCREMENTS AT THE INTERRUPT RATE, AND
                *  IS RESET BY A CALL TO STCLK. E.G.    BL @STCLK
                *
                *  TO READ THE INTERVAL TIMER, ISSUE A CALL TO
                *  RDCLK. E.G.    BL @RDCLK
                *
                *  THE CURRENT VALUE OF THE TIMER WILL BE RETURNED
                *  IN THE USERS R0.
                *
                *************************************************************
                *
                     TITL 'REAL TIME CLOCK DRIVER'
0000            RTC  IDT
                *
                *  DEFINE INTERRUPT VECTORS
                *
0004                 AORG >0004
0004 0000            DATA RTCWS              ;WORKSPACE POINTER
0006 0074            DATA CKINT              ;INTERRUPT HANDLER
                *
                *  DEFINE LINKING & REGISTERS
                *
0000                 RORG *
0000                 DREG
```

Listing 1 continued on page 292

Listing 1 continued:

```
                    *
                    *  DEFINE ENTRY POINTS
                    *
                            DEF   STCLK,RDCLK,STIM
                            DEF   GTIM,CKINT
                    *
                    *  THE FOLLOWING PARAMETERS WILL BE MAINTAINED
                    *  IN THE RTC WORKSPACE AREA (DEDICATED)
                    *
0000                RTCWS   BSS   4                ;RTC WORKSPACE (NEXT 32 LOCS)
0004                RATE    BSS   2                ;INTERNAL TIMER
0006                SECS    BSS   2                ;SECONDS
0008                MINS    BSS   2                ;MINUTES
000A                HRS     BSS   2                ;HOURS
000C                TIMER   BSS   2                ;INTERVAL TIMER
000E 003C           SIXTY   DATA 60                ;MINUTES/SECONDS CHECK
0010 0018           TFOUR   DATA 24                ;HOURS CHECK
0012 0001           HERTZ   DATA 1                 ;SET TO INT. RATE (1,10,60)
0014                        BSS   4                ;R10-R11
0018 0000                   DATA 0                 ;R12 CRU BASE
001A                        BSS   6                ;R13-R15
                    *
                    *  THE FOLLOWING EQUIVALENCES ARE USED
                    *  SINCE THE INTERRUPT HANDLING WORKSPACE
                    *  OVERLAYS THE VARIABLE STORAGE AREA
                    *
0002                XRATE   EQU   R2               ;INTERNAL TIMER
0003                XSECS   EQU   R3               ;SECONDS
0004                XMINS   EQU   R4               ;MINUTES
0005                XHRS    EQU   R5               ;HOURS
0006                XTIMER  EQU   R6               ;INTERVAL TIMER
0007                XSIXTY  EQU   R7               ;CLOCK CONSTANTS
0008                XTFOUR  EQU   R8
0009                XHERTZ  EQU   R9               ;INTERRUPT FREQUENCY
000F                CLOCK   EQU   15               ;CLOCK CRU OFFSET
                    *
                    *
                    *
                    *  STCLK: RESET THE INTERVAL TIMER TO ZERO
                    *
0020                STCLK   EQU   $
0020 04E0 000C              CLR   @TIMER           ;CLEAR TIMER
0024 045B                   B     *R11             ;RETURN TO CALLER
                    *
                    *
                    *
                    *  RDCLK: RETURN TIMER VALUE TO CALLER IN R0
                    *
0026                RDCLK   EQU   $
0026 C020 000C              MOV   @TIMER,R0        ;PLACE TIMER INTO R0
002A 045B                   B     *R11             ;RETURN TO CALLER
                    *
                    *
                    *
                    *  GTIM: GET THE TIME OF DAY
                    *
002C                GTIM    EQU   $
002C C03B                   MOV   *R11+,R0         ;GET ADDR PNTR,RETURN ADDR
002E CC20 000A              MOV   @HRS,*R0+        ;STORE HOURS
0032 CC20 0008              MOV   @MINS,*R0+       ;STORE MINUTES
0036 C420 0006              MOV   @SECS,*R0        ;STORE SECONDS
003A 045B                   B     *R11             ;RETURN TO CALLER
                    /
                    *
                    *  STIM: SET THE TIME OF DAY
                    *        ALSO, ENABLE THE REAL
```

Listing 1 continued on page 294

Listing 1 continued:

```
                    *          TIME CLOCK.
                    *
003C                STIM    EQU   $
003C C03B                   MOV   *R11+,R0          ;GET ADDR PNTR,RETURN ADDR
003E 8810 0010              C     *R0,@TFOUR        ;CHECK HOURS
0042 1411                   JHE   CLEAR             ;INVALID, CLEAR CLOCK
0044 C830 000A              MOV   *R0+,@HRS         ;SET THE HOURS
0048 8810 000E              C     *R0,@SIXTY        ;CHECK MINUTES
004C 140C                   JHE   CLEAR             ;INVALID, CLEAR CLOCK
004E C830 0008              MOV   *R0+,@MINS        ;SET THE MINUTES
0052 8810 000E              C     *R0,@SIXTY        ;CHECK SECONDS
0056 1407                   JHE   CLEAR             ;INVALID, CLEAR CLOCK
0058 C810 0006              MOV   *R0,@SECS         ;SET THE SECONDS
005C                RTRN    EQU   $
005C 04CC                   CLR   R12               ;PRESET CRU BASE
005E 04E0 0004              CLR   @RATE             ;INITIALIZE RATE
0062 1D0F                   SBO   CLOCK             ;ENABLE REAL TIME CLOCK
0064 045B                   B     *R11              ;RETURN TO CALLER
0066                CLEAR   EQU   $
0066 04E0 000A              CLR   @HRS              ;CLEAR OUT THE CLOCK
006A 04E0 0008              CLR   @MINS
006E 04E0 0006              CLR   @SECS
0072 10F4                   JMP   RTRN              ;ENABLE CLOCK, RETURN
                    *
                    *  THIS IS THE MAIN INTERRUPT HANDLING SECTION.
                    *  HERE THE TIME OF DAY IS KEPT, ALONG WITH THE
                    *  INTERVAL TIMER.
                    *
0074                CKINT   EQU   $
0074 1E0F                   SBZ   CLOCK             ;DISABLE/RESET
0076 0586                   INC   XTIMER            ;UPDATE TIMER
0078 0582                   INC   XRATE             ;INCREMENT INTERVAL
007A 8242                   C     XRATE,XHERTZ      ;CHECK AGAINST FREQ.
007C 110D                   JLT   DISMS             ;DISMISS INT
007E 04C2                   CLR   XRATE             ;RESET RATE
0080 0583                   INC   XSECS             ;SECONDS COUNT
0082 81C3                   C     XSECS,XSIXTY
0084 1109                   JLT   DISMS
0086 04C3                   CLR   XSECS             ;RESET SECONDS
0088 0584                   INC   XMINS             ;MINUTES COUNT
008A 81C4                   C     XMINS,XSIXTY
008C 1105                   JLT   DISMS
008E 04C4                   CLR   XMINS             ;RESET MINUTES
0090 0585                   INC   XHRS              ;HOURS COUNT
0092 8205                   C     XHRS,XTFOUR
0094 1101                   JLT   DISMS
0096 04C5                   CLR   XHRS              ;RESET HOURS
0098                DISMS   EQU   $
0098 1D0F                   SBO   CLOCK             ;ENABLE INTERRUPTS
009A 0380                   RTWP                    ;RETURN TO INT. LOC.
                    *
009C                        END


 0074 CKINT    0066 CLEAR    000F CLOCK    0098 DISMS   *002C GTIM
*0012 HERTZ    000A HRS      0008 MINS     0000 R0      *0001 R1
*000A R10      000B R11      000C R12     *000D R13     *000E R14
*000F R15      0002 R2       0003 R3       0004 R4       0005 R5
 0006 R6       0007 R7       0008 R8       0009 R9       0004 RATE
*0026 RDCLK   *0000 RTC      0000 RTCWS    005C RTRN     0006 SECS
 000E SIXTY   *0020 STCLK   *003C STIM     0010 TFOUR    000C TIMER
 0009 XHERTZ   0005 XHRS     0004 XMINS    0002 XRATE    0003 XSECS
 0007 XSIXTY   0008 XTFOUR   0006 XTIMER
OUTPUT READY?
```

Listing 1 continued on page 296

Circle 213 on inquiry card.

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Listing 1 continued:

```
00000RTC     A00009000 4C0000C0074A000EB003CB0018B0001A0018B0000A00207F1F6F
B04E0C000CB045BBC020C000CB045BBC03BBCC20C000ABCC20C0008BC420C00067F170F
B045BBC03BB8810C0010B1411BC830C000AB8810C000EB140CBC830C0008B88107F1ABF
C000EB1407BC810C0006B04CCB04E0C0004B1D0FB045BB04E0C000AB04E0C00087F18FF
B04E0C0006B10F4B1E0FB0586B0582B8242B110DB04C2B0583B81C3B1109B04C37F193F
B0584B81C4B1105B04C4B0585B8205B1101B04C5B1D0FB038050074CKINT 5002CGTIM  7EFD8F
50026RDCLK 50020STCLK 5003CSTIM  0009C        7F610F
:

EDIT/ASM/LOAD?
```

Listing 2: *A program to demonstrate the use of the real-time clock.*

```
                 ************************************************
                 *
                 *  DEMONSTRATION PROGRAM FOR THE
                 *  TIME OF DAY CLOCK ROUTINE
                 *
                 *  WRITTEN BY: TOM G. MORRIS
                 *              861 ST. MARY AVE
                 *              SAN LEANDRO, CA 94577
                 *
                 *  DEMONSTRATES THE USAGE
                 *  OF THE RTC SOFTWARE
                 *
                 ************************************************
                 *
                        TITL 'RTC DEMONSTRATION'
0000             EXIDT  IDT
                 *
                 *  DEFINE LINKING & REGISTERS
                 *
0000                    RORG *
0000                    DREG
                 *
                 *  DEFINE EXTERNALS & ENTRY
                 *
                        REF  STCLK,RDCLK
                        REF  STIM,GTIM
                        REF  RTC,DIO
                 *
                        DEF  EXMPL
                 *
2D48             DIN    DXOP 5              ;DECIMAL INPUT
2D88             DOUT   DXOP 6              ;DECIMAL OUTPUT
                 *
                 *  STORAGE FOR TIME OF DAY
                 *
0000             HRS    BSS  2              ;HOURS
0002             MINS   BSS  2              ;MINUTES
0004             SECS   BSS  2              ;SECONDS
0006             TICKS  BSS  2              ;INTERVAL TIMER
                 *
                 *  TEXT STORAGE
                 *
0008 0D0A 00     CRLF   BYTE >0D,>0A,0
000B 0D0A        MESS0  BYTE >0D,>0A
000D 454E 5445          TEXT 'ENTER TIME OF DAY (HH:MM:SS) ?'
0011 5220 5449
0015 4D45 204F
0019 4620 4441
001D 5920 2848
0021 483A 4D4D
```

Listing 2 continued on page 298

Circle 216 on inquiry card.

Circle 217 on inquiry card.

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See review in July 80 BYTE By Jerry Pournelle.

*CP/M is a TM of Digital Research. TRS-80 is a TM of Tandy Corporation.

Circle 218 on inquiry card.

Listing 2 continued:

```
0025 3A53 5329
0029 203F
002B 00                     BYTE 0
002C 0D0A         MESS1     BYTE >0D,>0A
002E 5448 4520              TEXT 'THE NUMBER OF TICKS ELAPSED IS: '
0032 4E55 4D42
0036 4552 204F
003A 4620 5449
003E 434B 5320
0042 454C 4150
0046 5345 4420
004A 4953 3A20
004E 00                     BYTE 0
004F 2041 4E44    MESS2     TEXT ' AND THE CORRECT TIME IS: '
0053 2054 4845
0057 2043 4F52
005B 5245 4354
005F 2054 494D
0063 4520 4953
0067 3A20
0069 00                     BYTE 0
0067              COLON     EQU  $-3
                  *
                  *  PROGRAM BEGINS HERE
                  *
006A                        EVEN
006A              EXMPL     EQU  $
006A 0300 0000              LIMI 0                  ;INHIBIT INTERRUPTS
006E 02E0 00D6              LWPI MYWS               ;GET A WORKSPACE
0072 06A0 00CA              BL   @TYPE
0076 000B                   DATA MESS0              ;GET TIME OF DAY
0078 2D60 0000              DIN  @HRS               ;HOURS
007C 2D60 0002              DIN  @MINS              ;MINUTES
0080 2D60 0004              DIN  @SECS              ;SECONDS
0084 06A0 00CA              BL   @TYPE
0088 0008                   DATA CRLF               ;ISSUE NEW LINE
                  * .
008A 06A0 0000              BL   @STIM              ;SET THE TIME OF DAY
008E 0000                   DATA HRS
0090 06A0 0000              BL   @ZTCLK             ;ZERO THE INTERVAL TIMER
0094 0300 0001              LIMI 1                  ;ALLOW LEVEL 1 INTERRUPTS
                  *
0098              WAIT      EQU  $
0098 2C40                   IN   R0                 ;WAIT FOR INPUT
009A 06A0 0000              BL   @RDCLK             ;READ THE TIMER
009E C140                   MOV  R0,R5              ;SAVE THE VALUE
00A0 06A0 0000              BL   @GTIM
00A4 0000                   DATA HRS                ;READ THE CLOCK
00A6 06A0 00CA              BL   @TYPE
00AA 002C                   DATA MESS1              ;PRINT 'THE NUMBER OF TICKS...'
00AC 2D85                   DOUT R5
00AE 06A0 00CA              BL   @TYPE
00B2 004F                   DATA MESS2              ;PRINT 'AND THE CORRECT...'
00B4 2DA0 0000              DOUT @HRS               ;PRINT HOURS
00B8 2CA0 0067              OUT  @COLON
00BC 2DA0 0002              DOUT @MINS              ;PRINT MINUTES
00C0 2CA0 0067              OUT  @COLON
00C4 2DA0 0004              DOUT @SECS              ;PRINT SECONDS
00C8 10E7                   JMP  WAIT
                  *
                  *  TYPE THE MESSAGE POINTED
                  *  TO BY THE RETURN ADDRESS
                  *
00CA              TYPE      EQU  $
```

Listing 2 continued on page 300

Circle 219 on inquiry card.

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Circle 222 on inquiry card.

Listing 2 continued:

```
00CA C03B              MOV   *R11+,R0         ;GET POINTER
00CC           TYPE1   EQU   $
PAGE-3 RTC DEMONSTRATION

   00CC D070              MOVB *R0+,R1          ;GET A CHARACTER
   00CE 1601              JNE  TYPE2
   00D0 045B              B    *R11             ;NULL IS END
   00D2           TYPE2   EQU  $
   00D2 2C81              OUT  R1               ;PRINT THE CHARACTER
   00D4 10FB              JMP  TYPE1
                  *
   00D6           MYWS    BSS  32               ;WORKSPACE AREA
                  *
   00F6                   END
 0067 COLON    0008 CRLF   *2D48 DIN    *0000 DIO    *2D88 DOUT
*0000 EXIDT   *006A EXMPL   00A2 GTIM    0000 HRS     000B MESS0
 002C MESS1    004F MESS2   0002 MINS    00D6 MYWS    0000 R0
 0001 R1      *000A R10     000B R11    *000C R12    *000D R13
*000E R14     *000F R15    *0002 R2     *0003 R3     *0004 R4
 0005 R5      *0006 R6     *0007 R7     *0008 R8     *0009 R9
 009C RDCLK   *0000 RTC     0004 SECS    0092 STCLK   008C STIM
*0006 TICKS    00CA TYPE    00CC TYPE1   00D2 TYPE2   0098 WAIT
OUTPUT READY?
00000EXIDT   A0000A0008B0D0AB000DB0A45B4E54B4552B2054B494DB4520B4F467F0FBF
B2044B4159B2028B4848B3A4DB4D3AB5353B2920B3F00B0D0AB5448B4520B4E557F178F
B4D42B4552B204FB4620B5449B434BB5320B454CB4150B5345B4420B4953B3A207F1ACF
B0020B414EB4420B5448B4520B434FB5252B4543B5420B5449B4D45B2049B533A7F1B9F
B2000B0300B0000B02E0C00D6B06A0C00CAC000BB2D60C0000B2D60C0002B2D607F1D1F
C0004B06A0C00CAC0008B06A0B0000C0000B06A0B0000B0300B0001B2C40B06A07F202F
B0000BC140B06A0B0000C0000B06A0C00CAC002CB2D85B06A0C00CAC004FB2DA07F18CF
```

Listing 2 continued on page 302

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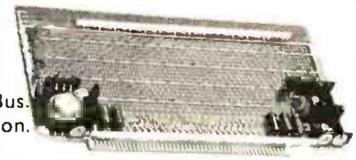

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Listing 2 continued:

```
C0000B2CA0C0067B2DA0C0002B2CA0C0067B2DA0C0004B10E7BC03BBD070B16017F188F
B045BB2C81B10FB40000DIO    5006AEXMPL 300A2GTIM   3009CRDCLK 40000RTC    7F02CF
30092STCLK 3008CSTIM   000F6          7F893F
:
EDIT/ASM/LOAD?
```

Listing 3: *Execution of the demonstration program of listing 2.*

```
ENTER TIME OF DAY (HH:MM:SS) ?20:49:40

THE NUMBER OF TICKS ELAPSED IS: 2 AND THE CORRECT TIME IS: 20:49:42
THE NUMBER OF TICKS ELAPSED IS: 16 AND THE CORRECT TIME IS: 20:49:56
THE NUMBER OF TICKS ELAPSED IS: 26 AND THE CORRECT TIME IS: 20:50:6
THE NUMBER OF TICKS ELAPSED IS: 430 AND THE CORRECT TIME IS: 20:56:50
THE NUMBER OF TICKS ELAPSED IS: 444 AND THE CORRECT TIME IS: 20:57:4
?G406A

ENTER TIME OF DAY (HH:MM:SS) ?23:59:30

THE NUMBER OF TICKS ELAPSED IS: 5 AND THE CORRECT TIME IS: 23:59:35
THE NUMBER OF TICKS ELAPSED IS: 17 AND THE CORRECT TIME IS: 23:59:47
THE NUMBER OF TICKS ELAPSED IS: 26 AND THE CORRECT TIME IS: 23:59:56
THE NUMBER OF TICKS ELAPSED IS: 38 AND THE CORRECT TIME IS: 0:0:8
?G406A

ENTER TIME OF DAY (HH:MM:SS) ?23:61:23

THE NUMBER OF TICKS ELAPSED IS: 2 AND THE CORRECT TIME IS: 0:0:2
THE NUMBER OF TICKS ELAPSED IS: 9 AND THE CORRECT TIME IS: 0:0:9
?
```

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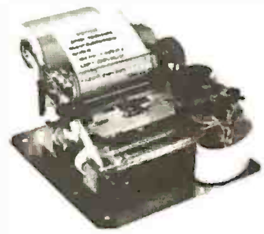

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Circle 229 on inquiry card.

Book Reviews

Microcomputers and Physiological Simulation

James E Randall
Addison-Wesley
Reading MA, 1980
234 pages, hardcover
$14.50

The observation of living systems is often a complex and difficult task; for those amateur or professional scientists who spend their time investigating the life signs and physiological responses of man and other animals, the use of laboratory computers in the data-gathering phase of their research has become a necessity. In most cases, the invasion of computers into the laboratory environment started with the advent of minicomputers such as the LINC (Laboratory Instrument Computer) and later, the Digital Equipment Corporation PDP-12. The relatively low-cost and single-user nature of these systems made them especially attractive to the scientist willing to learn computer science. A typical installation would be optimized for data acquisition and formatting, and sophisticated data analysis, simulation, and modeling would generally be done on large, centralized mainframes such as the IBM 360-91. Time on these large machines was not cheap, and the budgets required to support extensive simulation studies were often prohibitive. For these reasons, the study of biological systems by simulation has tended to be restricted and specialized in nature.

With the arrival of microprocessor hardware and software systems at much lower cost than minicomputers, and with the development of special-purpose, high-speed arithmetic-processing units, creative and generalized simulation studies may now be performed with a rather modest expenditure of money; of course, inexpensive computing tools do not necessarily reduce the total cost of developing the correct system for a particular application. Here is where Dr Randall's book is invaluable: the background information on microprocessors, combined with specific examples of biological data simulated with various hardware and software configurations, should allow any life-science experimenter to progress rapidly from the initial idea to a working simulation model.

The first chapters of the book describe the basic realities of the microcomputer world in a clear and comprehensive fashion; the various evolutionary trends in hardware and software design which gave rise to some of the more popular present-day microprocessor systems are explained in a cogent and enlightening manner that should orient the neophyte user amidst the growing maze of specifications and performance figures that seem to characterize the technical aspects of microprocessing. Thus, several years of practical experience have been condensed into what will soon be an indispensable reference for anyone considering the mathematical study of physiology.

In addition to people doing research, *Microcomputers and Physiological Simulation* should help those who would like to use interactive modeling as a teaching or demonstration device. All too often, an actual experiment may not turn out as expected, or the number of people observing the demonstration is so large that no one learns very much. Given these circumstances, a simulation approach for showing the dynamic realities of various physiological functions is both a clever and necessary approach. For example, in the study of cardiac output and central arterial pressure, a student could make a number of "experimental" manipulations of the circulatory system which would, on one hand, help to clarify what really goes on in an intact organism, but which, on the other hand, would be difficult to do within the confines of an experimental preparation. In addition, the time required to load a software model of the heart is much less than that needed to set up a live experiment (and, of course, the overall cost of simulation is likely to be much less than the real thing). So, given the desire to provide better instruction and reduce the time and money needed to give students first-hand experience in physiology, a teacher in the life sciences should consider carefully the interesting and useful techniques developed in this book.

Several of the examples in this book are extensions of topics that have been the subjects of articles in BYTE; the electrocardiogram (ECG) receives considerable attention, as does the nature of the neuronal axon potential and membrane conductances following various stimulation examples. In addition, the section on digital filtering and waveform distortion is relevant to a wide range of engineering and computer-science applications outside the life sciences. If you already have an Apple II, an S-100-based system, or a TRS-80 system, several BASIC language programs are provided so that you can get up and running immediately; acquisition of the appropriate arithmetic-processing option for your microprocessor will allow you to run more sophisticated and more dynamic simulation studies in a reasonable amount of time.

In a larger context, *Microcomputers and Physiological Simulation* is one more contribution to the field of personal, interactive microprocessor-based teaching tools which in specific circumstances offer numerous advantages over conventional methods; the creativity and breadth of investigation allowed by flexible and well-conceived software and hardware systems are in many ways much greater, and certainly achieved with less effort, than our present experimental and pedagogical methods support. Of course, for undergraduate or graduate education and research, having a group of students organize and implement one of the simulations described in this text will not only provide them with an interesting tool within their specific field of study, but will also allow them to know in some depth the basics of the microprocessor environment which has become an essential substrate of almost all avenues of scientific and laboratory undertaking. Judging by the possibilities offered in Dr Randall's present work, the contribution of the microprocessor to laboratory science and technical education will be enormous. Comprehensive guides of this sort serve to allow everyone easy access to a much more evolved set of teaching and experimental tools than has been available before. ■

Nicholas Bedworth
Microtex
45 Trowbridge St
Cambridge MA 02138

Microcomputer-Analog Converter Software and Hardware Interfacing

Titus, Titus, Rony, and Larsen
Blacksburg Continuing Education Series
Howard W Sams, 1978
286 pages, softcover
$9.50

Microcomputer-Analog Converter Software and Hardware Interfacing is a textbook intended for either class use or self-study. It includes learning goals for each chapter, a chapter of experiments, and a large number of hardware and software illustrations. All software in the book is for the 8080 microprocessor; conversion to other 8-bit microprocessors would range from trivial to moderately difficult.

The topics covered are: analog-to-digital (A/D) and digital-to-analog (D/A) conversion, interfacing digital panel meters, sample-and-hold and multiplexer circuits, and miscellaneous conversion techniques. Appendices include data sheets and applications notes for a wide range of D/A and A/D devices ranging in cost from a few dollars to a few hundred dollars.

The reader of the book is assumed to be familiar with analog circuitry, with digital circuitry, and with 8080 programming. The level of familiarity required for analog devices is about the same as any radio amateur above the Novice class would have. The digital and computer familiarity are at about the same level; anyone who knows what a three-state buffer is and what the difference is between polled and interrupt-driven I/O (input/output) should have no trouble with the text. Both polled and interrupt-driven systems are discussed, by the way, along with point graphics and measurement systems.

All in all, this is a good introduction to digital-to-analog interfacing, and a good reference book. The utility as the latter would be increased if there were a good descriptive index of the devices discussed. As with many of the books in this series, there are no blank pages in front or at the back for notes; most readers will probably want several pages of notes, so this is irritating. ■

John A Lehman
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Ann Arbor MI 48103

Engineer's Notebook: A Handbook of Integrated Circuit Applications

Forrest M Mims III
Radio Shack Technical Publications

128 pages, softcover
$1.99

Engineer's Notebook is a collection of hundreds of simple circuits using integrated circuits, each one neatly hand-drawn and labeled, with all of the details (resistor and capacitor values, transistor numbers, etc) filled in. The devices used are primarily TTL (transistor-transistor logic), CMOS (complementary metal-oxide semiconductor), and linear function circuits.

As a programmer, I keep a file of useful subroutines for each machine and language with which I work. As the file grows, programming gets easier because more chunks of new programs come straight out of the file. *Engineer's Notebook* is the start of my circuit file. Since I am a novice to electronics, I simply cannot say whether an experienced circuit designer will find this collection useful. I tend to doubt it; the book is not written for him. For beginners, however, the circuits are a real help. Not necessarily because they will fit right into the next project you build, but because of the help they provide in learning how to use integrated circuits.

After a *very* brief (four-page) introduction to basic electronics (where you are told what resistors, capacitors, and semiconductors are for), the book launches into CMOS circuits. In about forty pages it presents various circuits, starting with the use of simple gates and moving through switches and decoders, flip-flops and counters, memory devices, and a variety of music- and noise-generating devices including the SN76488N complex sound generator. The TTL section covers simple *gate* circuits (including a couple of very informative pages on the use of Schmitt triggers), oscillators, selectors and decoders, then counters and dividers. The linear circuits include pages and pages of op-amp applications, LED (light-emitting diode) bar displays, tone decoders, and uses for voltage-controlled oscillators.

If you do not know much about electronics and if you want to learn how to use integrated circuits, I suggest you buy one of Don Lancaster's "cookbooks" (or some other introductory text), and *Engineer's Notebook*. Use it as a workbook for the text; think of the circuits as answers to questions the text did not pose. Go through them using the text and figure out why they work. Answer the question: Why use this value resistor (capacitor, transistor)? Before very long, you will know what you need to know.

I bought the book primarily to learn about TTL. However, because of the variety of circuits presented, I find myself more interested in CMOS and somewhat intrigued by linear circuits. I'm studying all three now. The book is well worth its two-dollar price no matter what use you make of it. ■

Richard Fritzson
25 Callodine Ave
Amherst NY 14226

Circle 234 on inquiry card.

Book Reviews

Microcomputer Interfacing with the 8255 PPI Chip

Paul F Goldsbrough and Peter R Rony
Blacksburg Continuing Education Series
Howard W Sams, 1979
224 pages, softcover
$8.95

Those who remember the integrated circuits available a year or two ago may wonder how an entire book could be devoted to a single nonmicroprocessor device. The traditional documentation for such a component is "U25 on the System Monitor Board is a Motorola or equivalent 6820 PIA that contains two parallel I/O ports....In order to use it however, it must be set up with the proper software" (*TDL System Monitor Board Manual*). The 217 pages in this book are devoted to showing how the software and hardware for the Intel 8255 PPI (programmable peripheral interface) are set up. The general description (although not the details) is applicable to similar devices such as the above-mentioned 6820 (now 6821) or the Texas Instruments 6011.

The 8255 is a parallel interface device which allows software configuration of up to twenty-four I/O (input/output) lines. It has three basic modes: simple, handshaking I/O, and bidirectional. Up to three different ports may be used (depending on the mode), for input, output, or both. All of this makes the 8255 very flexible; it also makes it complicated.

The book discusses I/O schemes in general, and each of the 8255 modes in particular. Experiments are given for both port- and memory-mapped I/O. All hardware and software illustrated are for an 8080-based system, but the effort required to translate to another microprocessor is minor. Both polled-device

 Circle 235 on inquiry card.

and interrupt-driven I/O are treated, and the book ends with an excellent discussion of the hardware and software requirements for master/slave processors. This section alone is worth the price of the book.

There are, as usual, a few minor faults. On page 63, the diagram of the hex inverter is not labeled; it is a 74xx04. Numbers in the book are sometimes given in octal and sometimes in decimal radix; unfortunately the author often neglects to mention which base he is using. I suppose ideally he ought to give everything in octal, decimal, and hexadecimal, but this convenience is probably not needed by the relatively sophisticated audience at whom this book is aimed.

Personally, I find it hard to read an assembler output such as that in the text which runs the op codes and the operands together. PUSH PSW is much easier to read then PUSHPSW. Finally, I would like a *bookwide* index of the experiments; it would make the book more useful as a reference.

But all of this is quibbling; the book is more than worth the price if you fall into one of three groups of readers. The first group is made up of people who have an elementary knowledge of digital logic (perhaps gained from some of the other Blacksburg books) and who want to learn how to use programmable interfaces in general and the 8255 in particular. The second group is made up of those who would like a more readable reference to the 8255 than is provided by the data sheet, and who want to see sample hardware and software interfaces. Last, anyone putting together multiple-processor systems would do well to look at the last section of the book for a quick and dirty, but fairly simple, way to do it. Let's see, how many channels should I put on my Z80...?■

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Ann Arbor MI 48103

Book Reviews

Thrice Upon a Time

James P Hogan
Ballantine Books, New York NY, 1980
311 pages, softcover
$2.25

Technical books and journals are useful for reference facts. Magazine articles and "construction" books supply the latest in the microcomputing art to sharpen our faculties. But these all address the issue of "how," and nourish the intellect with data. Books such as James P Hogan's latest novel, *Thrice Upon a Time,* answer a far more primal need. When the soul is anguished by a floppy disk's stubborn recalcitrance; when the heart is discouraged by that elusive last bug in the sorting routine; when the mind is depressed by the manufacturer's twelfth postponement of his shipping date, the solace from this book's visions is a soothing balm that carries one through to try again tomorrow.

To be sure, Mr Hogan's intricate plot far transcends mere home computing. In his story, which is concerned with some natural disasters and some achievements of mankind, he intertwines causes and effects so that each nourishes the other in an exciting race to enjoy the benefits of achievement without having to bear the extreme price the consequences of the advances seem to engender. Exploring this theme, plus presenting it in a bolero of variations, is a most complex plot concerning a time communications machine. As distinct from the mysteriously operating transporting telephone booths of the H G Wells or Dr WHO variety, Hogan presents a rather well-documented, even plausible, invention that takes advantage of the Tau wave effect. Now I am sure that Tau waves are not familiar phenomena to many readers. Mr Hogan also is cognizant of this deficiency in the physics background of most of us, and so he presents an explanation of this effect, its discovery and usefulness, with such clarity and vividness that one would no more deny Tau wave existence than one would deny gravity, black holes, or positronic brains. Though I leave the details to Mr Hogan's characters, suffice it for the moment that Sir Charles has invented a means to send messages back in time.

Now imagine, if you will, that the world is faced with a problem; a big one. Say we notice by June, when we are already steeped to our knees in the problem (figuratively), that if we had known to do some "X" back in January, most of this trouble would be nonexistent. Say we do send a warning back. Would that mean that we are no longer troubled, or that we no longer are, at all? Then why, or who, would have sent the message?

Yes, this paradox has been explored before. But a marvelous craftsman and clear thinker such as James Hogan deserves his platform, and he exploits it with the quintessential detail and plausibility so reminiscent of the John W Campbell era.

So, you may concede, it's a gripping story. But where does my Altair or Apple come in? The answer is on just about every page. It is assumed in the story that at that time, 30 years from now, most people have a working knowledge of high-level languages. The elderly Sir Charles has a small computer in his home, and it is not a remarkable occurrence. When he needs extra computing power or common data, he doesn't think twice about linking into the national data grid, which offers such services, as any other utility would offer its resources to home users today. What is so all-fired exciting about this story is that Sir Charles, with a setup not too different from what is available right now to us in our computer rooms, has sat down and used that computer to make a *time machine.* Sure he has access to a Tau wave generator, which most of us still would have trouble acquiring. But if Sir Charles can move such mountains with his setup, surely we can at least move a few molehills with ours.

The book is top-notch. As a story, it's exciting and involving. As an inspiration, well I don't want to write any longer. My microcomputer awaits.

Jay P Lucas
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Alexandria VA 22304

Noise Reduction Techniques in Electronic Systems

Henry W Ott
John Wiley & Sons
New York NY, 1976
294 pages, hardcover
$24.50

Although frequently unrecognized, electrical noise is a serious problem in the microcomputing environment. The home microcomputer is a recognized source of electromagnetic interference (EMI) or radio-frequency interference (RFI). The sound effects of computer games produced on a nearby radio are the mark of clever programming and poor electromagnetic shielding. Further, many prototype or even final versions of digital and analog projects fail completely or suffer occasional untraceable glitches because of improper attention to noise sources. Additionally, the rush to marry the continuous, frequently low-level, analog signals to fast-switching, noisy digital microcomputers promises many tremendous EMI problems. Intolerably, from tens to hundreds of millivolts of digital noise may appear in analog signals that never exceed 10 V and are frequently in the 0.1 V to 1 V range.

The above problems can be solved by the application of information about noise—preferably done systematically in the initial design rather than as a patchwork correction after the fact. Ott's extremely well-written book contains this information and is one of the finest books on electrical noise, its sources, propagation, reception, and suppression. This book is an outgrowth of lectures at Bell Laboratories, and is directed at a technician-level two-year college program.

Chapter 1 is a lucid discussion of noise sources, their coupling into your system, and a summary of the elimination methods: shielding, grounding, balancing, filtering, isolation, separation and orientation, circuit impedance control, cable design, and cancellation. The remainder of the book expands on these points.

Chapter 2 discusses the theory of shielding conductors, and why it does not always work. The distinction between capacitive and inductive coupling is carefully made. Grounding schemes for cables are clearly shown along with their relative merits.

Chapter 3 discusses procedures for minimizing ground loops, low-frequency and high-frequency grounding (they are different), and grounding shields properly. Especially important, and carefully treated, is the elimination of ground loops.

Chapter 4, "Other Noise Reduction Techniques," discusses balancing, power-supply decoupling, the much misunderstood transmission impedance of a power distribution system and its effect on system performance, high-frequency decoupling filters and digital circuits. Chapter 5, "Passive Components," shows how these poorly appreciated components can dramatically affect system performance.

Chapter 6 is "Shielding Effectiveness of Metallic Shields" and is full of pleasant and unpleasant surprises about shielding properly. Ott discusses in detail how to really prevent EMI generation or reception.

Chapter 7 is on "Contact Protection" in switches and relays. This unlikely sounding chapter in a book on noise suppression is quite logical. Switches and relays are notorious sources of EMI, and contact protectors yield improved life and performance and also have the beneficial effect of reducing EMI.

Chapters 8 and 9 are about intrinsic noise sources and active-device noise. These two chapters are of greatest value for low-level analog measurements rather than for microcomputer uses.

This book is not easy to read, as it assumes familiarity with DC circuit theory as well as with capacitors, inductors, and the complex impedance treatment of AC circuits. This level of expertise is not required for the book to be exceedingly valuable, however. It is clearly written with a lot of examples and good problems with their solutions.

Like a good novel, it was difficult for me to put this book down. The physical significance of an equation is discussed clearly and at length; abundant graphs demonstrate concepts and provide valuable later reference. Finally, Ott is exceedingly practical. He has obviously spent long hours up to his elbows in wire and soldering irons tracing down and eliminating noise bugs, and he tells you his secrets.

The book is full of useful and interesting facts. For example, the switching of a single transistor-transistor logic (TTL) gate connected to a power supply through 10 inches of 22 gauge wire causes the ground connection of the integrated circuit to jump by 0.4 V. The synchronous switching of five gates could cause the ground to rise to 2 V! Since 2 V is the logic threshold for transistor-transistor logic, proper operation would be unlikely. This particular problem, a common cause of malfunctions in breadboarded circuits, is partially solved by bypass capacitors.

Do you know how a power-distribution bus strip works? Why a double-sided printed-circuit board can give far better performance than point-to-point wiring, even with very heavy wire, or even a single-sided printed-circuit board? How much ground area do you need on a printed-circuit board? Do you know what a ferrite bead is, and how it suppresses noise? Do you know what the best type of filter capacitor for filtering an input line is? (The answer is not ceramic disc.) Why is copper a better magnetic shield than steel at high frequencies? How do you seal a cabinet door to EMI? Why, in a cabinet, does a series of ventilating holes with a total area of 1 square inch leak far less EMI than a single crack in the door with an area of 0.1 square inches? Ott explains this plus much more.

The book has a few shortcomings. The author does not always tie separately presented concepts together, and the reader must perform this synthesis. I would also like to have seen more information on power-line EMI filters. The book was not written with computers in mind so there are no explicit references to them. The information on digital circuits is very brief. Counterbalancing these problems is the fact that the book does not deal with obsolete technologies, but handles fundamental principles which will always be a proper starting point for attacking a new area.

In summary, this is an excellent book. It should be read by every serious analog/digital designer. A careful reading and application of Ott's principles will save great pain, hours of labor, money, and in some cases even entire projects. ■

J N Demas
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BYTE's Bits

Tracking Down the Modem Filters

Since my article "An Answer/Originate Modem" was published in the June 1980 BYTE (page 24), I have found that the company which makes the CH1262 and CH1267 filters has moved. The current address and telephone number are:

Cermetek Microelectronics
1308 Borregas Ave
Sunnyvale CA 94086
(408) 734-8150

The filters are available as "miniModem" building blocks from this firm.

Ronald G Parsons
9001 Laurel Grove Dr
Austin TX 78758

The Source and Tymshare Sign Operations Agreement

Source Telecomputing Corporation and Tymshare Inc have entered into a development and pilot operation agreement under which Tymshare, a computer service company, will provide a variety of facilities and services to increase the user capacity of The Source, an information utility. Tymshare's subsidiary, Tymnet Inc, which operates the TYMNET public packet-communications network serving 200 cities, will be utilized in The Source's expansion program. The number of Source users, now approaching 5000, has increased beyond the system's present capabilities. Utilizing TYMNET's equipment and expertise will better serve existing users and permit The Source to accommodate thousands more.

Through The Source, owners of home computers, computer terminals, and word-processing equipment are able to access a variety of data bases and programs by telephone connection to computers of The Source network. For details, contact The Source, Source Telecomputing Corporation, 1616 Anderson Rd, McLean VA 22102, (703) 821-6660.

Heath Offers Source Code to Its Customers

Heath Company, Dept 350-390, Benton Harbor MI 49022, (616) 982-3210, is offering to its microcomputer customers source code for the company's internally developed system software and hardware. Source code to be released include those for Heath's cassette assembler, debugger, editor, and BASIC, and the source code for HDOS, Heath's disk operating system. Also being offered are the firmware for the H-17 and H-89 disk controllers and the firmware for the H-19 video terminal. The source code listings are $25 each except for HDOS, which is $195. The H-19 code will also include source on a Heath HDOS floppy disk and the character generator ROM (read-only memory) code. HDOS source code is available on floppy disk and includes the disk Assembler, Editor, BASIC, and DBUG, as well as PIP and other utilities. All products remain copyrighted, and even though source code is available, it is not being placed in the public domain. Heath welcomes licensing discussions for HDOS from other manufacturers.

Computer Bulletin Board for Radio Amateurs

A free access program, called HAMNET, was established by Donald Stoner, W6TNS, and The Peripheral People, POB 524, Mercer Island WA 98040, (206) 232-4505. HAMNET utilizes the extensive MicroNet communications network, which allows access through almost two hundred local telephone numbers. Checking into HAMNET permits users to post and retrieve messages for help wanted, equipment for sale, network news, schedules, and so on. Other features planned are propagation forecasts, Federal Communications Commission (FCC) news, new product announcements, and more. Public-domain programs are also available. HAMGAB is a ham "frequency" for two users to communicate or transfer programs. While the system is primarily oriented towards amateur radio buffs, it is open to all MicroNet customers. A subscription to MicroNet is $9 and $5 per connect hour. Customers are given a 128 K-byte block for storage of files. Information is available from Personal Computing Division, CompuServe Inc, 5000 Arlington Centre Blvd, Columbus OH 43220.

New TRS-80 Keyboards

Radio Shack has announced an important change in its TRS-80 Model I microcomputer. The new keyboard that uses a capacitive-contact system to eliminate the well-known keyboard debounce problem does not have removable key caps, which were on the older TRS-80 models. Any attempt to clean the keyboard by removing the key caps will result in damage to only those TRS-80s that have the new keyboard. TRS-80s with the new keyboard are distinguished by a dull (as opposed to a shiny) finish on the keys and a curved (as opposed to a straight) slope of the keyboard tops when viewed from the side.

Educational Software for the Apple

The Department of Natural Science at Eastern Kentucky University, Memorial Science 220, Richmond KY 40475 (606) 622-3735, has completed a search for educational courseware written for microcomputers. They have compiled a catalog of educational software for the Apple II computer. Schools may obtain a copy of this catalog by writing to Professor John Wernegreen at the above address. ■

BYTE's Bugs

Catching the Khachiyan Bug

In Part 1 of "Khachiyan's Algorithm" by Berresford, Rockett, and Stevenson (August 1980 BYTE), a typographical error occurred in an Editor's Note by Gregg Williams (GW) at the bottom of the first column on page 202. The error at the end of line 7 of the italicized paragraph is in the equation

$$t = K_n^p$$

The correction is

$$t = Kn^p.$$ ■

Technical Forum

A $5.25 Interface to the BSR X-10 Home Control System

Alan R Trimble, Tracon Corporation, 6615 Kentland Ave, Canoga Park CA 91307

The availability and reasonable cost of the BSR X-10 Home Control System, coupled with the ease of interfacing the system to a home computer, will undoubtedly spawn a revolution in home automation. (See Steve Ciarcia's article "Computerize a Home," January 1980 BYTE, page 28.) Already I have seen advertisements in BYTE and other computer magazines for interface equipment in the $100 to $200 range, offered by at least three different manufacturers. Eager to get my home under computer control, but not too eager to shell out $114.90 for the S-100 MicroMint system described in Steve's article, I was motivated to implement the system in software.

All that is needed is an ultrasonic transducer and a single bit from a parallel output port. The transducer is simply connected directly across the output port line (transistor-transistor logic [TTL] levels are sufficient to drive the capacitive transducer load) while the computer is used to generate the 40 kHz bursts that make up the coded message to be transmitted to the BSR X-10 command module.

The output port was easy to come by—I had a spare one—but even a single line from a dedicated port could be used, such as a bit from a parallel printer-interface port, provided that the printer is not strobed when data is output to the port. Finding a 40 kHz ultrasonic transducer did not seem quite as simple. After calling a few local electronic stores, however, I was able to locate one for $5.25 (Calectro catalog number J4-815).

All tools in hand, I set out to emulate Steve's command generator in software on my 4 MHz Z80-based S-100-bus system. The calling sequence was set up so that the routine could be called using Cromemco's FORTRAN, but it is a simple matter to modify this as required.

At the heart of the program are two subroutines: FORTY, which generates a 40 kHz signal of specific duration, and DLY, which provides a programmable delay. These make careful use of instruction execution times to provide accurate timing. As written, they will work only with Z80/8085 systems running at a basic clock rate of at least 4 MHz.

FORTY and DLY are used in subroutines SND1, SND0, and TERM, which generate the transmission codes for a logic 1, a logic 0, and the code-termination sequence, respectively.

These, in turn, are utilized by the main routine XMIT, which builds the message to be transmitted from the single-byte code passed as an argument. The code passed is exactly as described in table 1 of Steve's article.

Admittedly, the software required to drive the transducer is neither processor nor speed independent, but the concept is simple enough to be used on virtually any system.

Listing 1: *This software, called from Cromemco FORTRAN, is used to drive an ultrasonic transducer directly from a parallel output port. Output frequencies and timing are based on the 4 MHz clock rate of the author's Z80 system.*

```
CROMEMCO CDOS Z80 ASSEMBLER version 02.15
XMIT:   TRANSMIT COMMAND TO HOME CONTROL SYSTEM

                 ; XMIT:          TRANSMIT COMMAND TO HOME CONTROL SYSTEM
                 ;
                 ; PURPOSE:       TO GENERATE THE SIGNALS REQUIRED TO DRIVE AN ULTRASONIC
                 ;                TRANSDUCER TO TRANSMIT COMMANDS TO THE BSR X-10 (OR SEARS)
                 ;                HOME CONTROL SYSTEM
                 ;
                 ; USAGE:         CALL XMIT
                 ;
                 ; WHERE:         HL CONTAINS THE ADDRESS OF THE COMMAND BYTE
                 ;
                 ;        COMMAND BYTE (DECIMAL):
                 ;        ALL OFF   = 1      CH1 = 12    CH7 = 10    CH13 = 0
                 ;        LIGHTS ON = 3      CH2 = 28    CH8 = 26    CH14 = 16
                 ;        ON        = 5      CH3 = 4     CH9 = 14    CH15 = 8
                 ;        OFF       = 7      CH4 = 20    CH10 = 30   CH16 = 24
                 ;        DIM       = 9      CH5 = 2     CH11 = 6
                 ;        BRIGHT    = 11     CH6 = 18    CH12 = 22
                 ;
                          ENTRY   XMIT
                 ;
0000' F5         XMIT:    PUSH    AF;             SAVE REGISTERS
0001' C5                  PUSH    BC
0002' D5                  PUSH    DE
0003' E5                  PUSH    HL
0004' 7E                  LD      A,(HL);         GET THE CODE WORD
0005' 07                  RLCA;                   POSITION THE CODE WORD
0006' 07                  RLCA
0007' 07                  RLCA
0008' 2F                  CPL
0009' 5F                  LD      E,A;            SAVE THE COMPLEMENT FOR LATER USE
000A' 2F                  CPL
                 ;
000B' CD2F00'             CALL    SND1;           TRANSMIT THE START BIT
000E' 1605                LD      D,5;            SETUP TO TRANSMIT THE NEXT 5 BITS
0010' 07         XLP1:    RLCA;                   SHIFT BIT TO BE TRANSMITTED INTO CARRY
0011' DC2F00'             CALL    C,SND1;         SEND A ONE IF CARRY IS SET
0014' D43D00'             CALL    NC,SND0;        SEND A ZERO IF CARRY IS CLEAR
0017' 15                  DEC     D
0018' 20F6                JR      NZ,XLP1;        LOOP UNTIL 5 BITS HAVE BEEN SENT
                 ;
001A' 1605                LD      D,5;            SETUP TO TRANSMIT ANOTHER 5 BITS
001C' 7B                  LD      A,E;            GET THE COMPLEMENTED DATA
001D' 07         XLP2:    RLCA;                   SHIFT BIT TO BE TRANSMITTED INTO CARRY
001E' DC2F00'             CALL    C,SND1;         SEND A ONE IF CARRY IS SET
0021' D43D00'             CALL    NC,SND0;        SEND A ZERO IF CARRY IS CLEAR
0024' 15                  DEC     D
0025' 20F6                JR      NZ,XLP2;        LOOP UNTIL 5 BITS HAVE BEEN SENT
                 ;
0027' CD4B00'             CALL    TERM;           TRANSMIT THE TERMINATION SEQUENCE
002A' E1                  POP     HL;             RESTORE THE REGISTERS
002B' D1                  POP     DE
002C' C1                  POP     BC
002D' F1                  POP     AF
002E' C9                  RET
                 ; SND1:          SEND (TRANSMIT) A ONE
                 ;
002F' F5         SND1:    PUSH    AF;             SAVE ACCUM
0030' 06A0                LD      B,160;          4MS OF 40KHZ
0032' CD5C00'             CALL    FORTY;          GENERATE 40KHZ BURST
0035' 21D703              LD      HL,03D7H;       DELAY FACTOR
0038' CD7100'             CALL    DLY;            DELAY REMAINING BIT TIME
003B' F1                  POP     AF;             RESTORE ACCUM
003C' C9                  RET
                 ;
                 ;
                 ; SND0:          SEND (TRANSMIT) A ZERO
                 ;
003D' F5         SND0:    PUSH    AF;             SAVE ACCUM
003E' 0630                LD      B,48;           1.2MS OF 40KHZ
0040' CD5C00'             CALL    FORTY;          GENERATE 40KHZ BURST
0043' 219506              LD      HL,0695H;       DELAY FACTOR
0046' CD7100'             CALL    DLY;            DELAY REMAINING BIT TIME
0049' F1                  POP     AF;             RESTORE ACCUM
004A' C9                  RET
                 ;
                 ;
                 ; TERM:          TRANSMIT TERMINATION SEQUENCE
                 ;
004B' 1604       TERM:    LD      D,4;            SEND 4 4MS BURSTS OF 40KHZ
004D' 3EA0       TLP1:    LD      A,160;          SETUP FOR 4MS
004F' CD5C00'             CALL    FORTY;          TRANSMIT 40KHZ
0052' 15                  DEC     D
0053' 20F8                JR      NZ,TLP1;        LOOP FOR 16MS
                 ;
0055' 215C17              LD      HL,175CH;       DELAY FACTOR
0058' CD7100'             CALL    DLY;            DELAY 24MS
005B' C9                  RET
                 ; FORTY:         GENERATE 40KHZ
                 ;
                 ; USAGE:         LD B,VALUE
                 ;                CALL FORTY
                 ;
                 ; WHERE:         B CONTAINS DURATION FACTOR
                 ;
                 ; NOTE:          DURATION = ( 100 * B + 33 ) * 0.25US
                 ;                ( INCLUDES LD & CALL INSTRUCTION TIMES )
                 ;
                 ; MODIFIED:      A, B, C, H, L
                 ;
                 ;
      (0000)     D0:      EQU     0;      OUTPUT DATA FOR ZERO
      (0004)     D1:      EQU     4;      OUTPUT DATA FOR ONE
      (0018)     PORT:    EQU     18H;    OUTPUT PORT
                 ;
                 ;
005C' 3E04       FORTY:   LD      A,D1
005E' D318                OUT     (PORT),A;       OUTPUT A HIGH
0060' 0E02                LD      C,2;            DELAY COUNT
0062' 0D         FLP1:    DEC     C
0063' 20FD                JR      NZ,FLP1;        DELAY BETWEEN OUTPUTS IS 12.5US
                 ;
0065' 3E00                LD      A,D0;           DATA FOR LOW OUTPUT
0067' D318                OUT     (PORT),A;       OUTPUT THE DATA
0069' 0E00                LD      C,0;            DELAY
006B' 0E00                LD      C,0;            DELAY
006D' 05                  DEC     B
006E' 20EC                JR      NZ,FORTY;       END OF CYCLE
0070' C9                  RET
                 ;
                 ;
                 ; DLY:           PROGRAMMED DELAY
                 ;
                 ; USAGE:         LD HL,VALUE
                 ;                CALL DLY
                 ;
                 ; WHERE:         HL CONTAINS DELAY FACTOR
```

Listing 1 continued on page 316

Listing 1 continued:

```
                    0130 ;
                    0131 ; NOTE:            DELAY = ( 4107*H + 16*L + 67 ) * 0.25US
                    0132 ;                  ( DELAY INCLUDES LD & CALL INSTRUCTION TIMES )
                    0133 ;
0071' 24            0134 DLY:    INC    H;          SETUP FOR DELAY LOOP
0072' 2C            0135         INC    L
0073' 2D            0136 DLP:    DEC    L;          MINOR DELAY LOOP
0074' 20FD          0137         JR     NZ,DLP;     DELAY THE SPECIFIED COUNTS
0076' 25            0138         DEC    H;          MAJOR DELAY LOOP
0077' 20FA          0139         JR     NZ,DLP;     DELAY THE SPECIFIED COUNTS
0079' C9            0140         RET
                    0141 ;
007A' (0000)        0142         END

Errors              0

Program Length  007A (122)



CROSS REFERENCE LISTING

D0       0104  0115
D1       0105  0109
DLP      0136  0137 0139
DLY      0134  0063 0074 0088
FLP1     0112  0113
FORTY    0109  0061 0072 0083 0120
PORT     0106  0110 0116
SND0     0070  0031 0046
SND1     0059  0034 0037 0045
TERM     0081  0050
TLP1     0082  0085
XLP1     0036  0040
XLP2     0044  0048
XNIT     0020 #0022
```

■

Steve Ciarcia's Comments

My compliments to Alan Trimble on his ingenuity. An ultrasonic transducer tied directly to one line of an output port is a very viable approach In fact, the first control circuit I designed employed an NE555 timer, used as a tone-burst generator, and an ultrasonic transducer attached as you describe. Thi additional $0.50 component (the NE555) further reduces the software overhead while maintaining minimum system cost.

When I wrote the article, I made a tough decision. Either I could present a $6 interface designed for use with a computer that has existing output ports, a particular system clock rate, and a particular processor, or I could make the hardware smarter (and more expensive) and yet usable on virtually any computer. With the first alternative, I would have gotten about 200 letters asking how to design a parallel output port; the second was the better way to proceed under the circumstances.

There are often many approaches to the design of an interface. My philosophy is to try to tender the one that has the greatest potential for being implemented by BYTE readers. I'd rather not be remembered for my great theoretical presentations. I depend on intelligent people like Mr Trimble to read between the lines and customize my interfaces to meet their individual system requirements.

Regarding the expense of buying the equipment, I am familiar with only the MicroMint unit (the Busy Box). For the purchase price, you get a unit that is assembled and tested; it includes a case, power supply, and instructions; and it comes with the cables equired to plug it in and use it.

Anyone wishing to build Mr Trimble's design for a control interface can get the 40 kHz transducer (part number MM 1002) for $6 postpaid from:

The MicroMint Inc
917 Midway
Woodmere NY 11598
(516) 374-6793

My thanks to Mr Trimble for pointing out this approach to interface design....**Steve Ciarcia**

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Technical Forum

More on Skip Chains

Mark S Williamsen, 3114 Central St, Evanston IL 60201

In regards to Geoffrey Gass's Technical Forum "Mining the Skip Chain" (February 1980 BYTE, page 148), I would like to add an alternative which has several advantages: a lookup table. A skip chain in its simplest form (testing a single byte to access routines located within a single page [256 bytes] of memory) uses a minimum of 4 bytes of 6800-microprocessor code per test. If the skip chain is to call routines outside of that one page, then 7 bytes are required for each comparison. (See listings 1 and 2.)

On the other hand, a lookup table needs a search routine (as in listing 3) of about 25 bytes and 3 additional bytes for each entry in the table if extended addressing is used. The break-even point is about 6 comparisons. Beyond that, the lookup table scheme uses less memory. It has the additional advantage that the program does not have to be reassembled to add new entries. In fact, if an end-of-table trap is used, as in listing 3, new entries can be written into a programmable read-only memory (PROM) without changing or erasing any previous data. This is ideal for use in a PROM monitor because new commands and routines can be added at any time if blank space is left following the table.■

Listing 1

```
                        NAM     SKIPCH
                *SIMPLEST FORM SKIP CHAIN ROUTINE
                *GOES TO ONE OF SEVERAL ROUTINES
                 DEPENDING ON
                *CONTENTS OF ACC. B
                *M. WILLIAMSEN 1/31/'80
                *DEFINITON OF DUMMY LABELS TO
                 SATISFY ASSEMBLER;
      FF00      INCH    EQU     $FF00
      0000      C1      EQU     0
      0000      C2      EQU     0
      0000      C3      EQU     0
      0000      R1      EQU     0
      0000      R2      EQU     0
      0000      R3      EQU     0
0000  BDFF00    START   JSR     INCH    GET
                                        CHARACTER IN
                                        ACC. B
0003  C100      FIRST   CMP B   #C1     B=CODE 1?
0005  27 F9             BEQ     R1      IF YES, GO TO
                                        ROUTINE 1
0007  C100      SEC     CMP B   #C2     B=CODE 2?
0009  27 F5             BEQ     R2      IF YES, GO TO
                                        ROUTINE 2
000B  C1 00     THIRD   CMP B   #C2     B=CODE 3?
000D  27 F1             BEQ     R3      IF YES, GO TO
                                        ROUTINE 3
                .
                .
                .
                *FURTHER COMPARISONS AS
                 NECESSARY
                .
                .
                .
```

Listing 1 continued on page 319

Listing 1 continued:

```
000F  20 EF                 BRA     START   GET NEW INPUT
                                            IF
                            END             CODE NOT
                                            FOUND

TOTAL ERRORS 00000
```

Listing 2

```
                            NAM     SKIPEX
                    *SKIP CHAIN ROUTINE WITH EXTENDED
                    ADDRESSING
                    *GOES TO ONE OF SEVERAL ROUTINES
                    DEPENDING ON
                    *CONTENTS OF ACC. B
                    *M. WILLIAMSEN 1/31/80
                    *DEFINITON OF DUMMY LABELS TO
                    SATISFY ASSEMBLER:
        FF00        INCH    EQU     $FF00
        0000        C1      EQU     0
        0000        C2      EQU     0
        0000        C3      EQU     0
        0000        CN      EQU     0
        0000        R1      EQU     0
        0000        R2      EQU     0
        0000        R3      EQU     0
        0000        RN      EQU     0
0000    BDFF00      START   JSR     INCH    GET
                                            CHARACTER IN
                                            ACC. B
0003    C1 00       FIRST   CMP B   #C1     B=CODE 1?
0005    26 03               BNE     SEC     CONTINUE IF NO
0007    7E 0000             JMP     R1      GO TO ROUTINE
                                            1 IF YES
000A    C1 00       SEC     CMP B   #C2     B=CODE 2?
000C    26 03               BNE     THIRD   CONTINUE IF NO
000E    7E 0000             JMP     R2      GO TO ROUTINE
                                            2 IF YES
0011    C1 00       THIRD   CMP B   #C2     B=CODE 3?
0013    26 03               BNE     NTH     CONTINUE IF NO
0015    7E 0000             JMP     R3      GO TO ROUTINE
                                            3 IF YES
                    *
                    *
                    *
                    *FURTHER COMPARISONS AS
                    NECESSARY
                    *
                    *
                    *
0018    C1 00       NTH     CMP B   #CN     B=CODE N?
001A    26 E4               BNE     START   GET NEW INPUT
                                            IF NO
001C    7E 0000             JMP     RN      GO TO ROUTINE
                                            N IF YES
                            END

TOTAL ERRORS 00000
```

Listing 3

```
                            NAM     LOOKUP
                    *COMMAND DECODER WITH LOOKUP
                    TABLE.
                    *GOES TO ONE OF SEVERAL ROUTINES
                    DEPENDING ON
                    *CONTENTS OF ACC. B
                    *M. WILLIAMSEN 1/31/80
                    *DEFINITON OF DUMMY LABELS TO
                    SATISFY ASSEMBLER:
        FF00        INCH    EQU     $FF00
        0000        C1      EQU     0
        0000        C2      EQU     0
        0000        C3      EQU     0
        0000        CN      EQU     0
        0000        R1      EQU     0
        0000        R2      EQU     0
        0000        R3      EQU     0
        0000        RN      EQU     0
0000    BD  FF00    START   JSR     INCH    GET
                                            CHARACTER IN
                                            ACC. B
0003    CE  0018            LDX     #TABLE  INITIALIZE
                                            POINTER.
```

Listing 3 continued on page 320

Listing 3 continued:

```
0006  A600     GC1    LDA A  X      GET CODE FROM
                                    TABLE.
0008  08              INX           INCREMENT
                                    POINTER.
0009  81 FF           CMP A  #$FF   IF END OF TABLE
000B  27 F3           BEQ    START  GET NEW INPUT.
000D  11              CBA           DOES ACC,
                                    B=CODE?
000E  27 04           BEQ    FOUND  IF YES, GO TO
                                    ROUTINE.
0010  08       NEXT   INX           INCREMENT
                                    POINTER TO
0011  08              INX           NEXT CODE IN
                                    TABLE
0012  20 F2           BRA    GC1    IF NO.
0014  EE 00    FOUND  LDX    X      LOAD POINTER
                                    FROM TABLE
0016  6E 00           JMP    X      AND GO TO
                                    ROUTINE,
               *LOOKUP TABLE STARTS HERE:
0018  00       TABLE  FCB    C1     CODE 1
0019  0000            FDB    R1     ADDRESS OF
                                    ROUTINE 1
001B  00              FCB    C2     CODE 2
001C  0000            FDB    R2     ADDRESS OF
                                    ROUTINE 2
001E  00              FCB    C3     CODE 3
001F  0000            FDB    R3     ADDRESS OF
                                    ROUTINE 3
               .
               .
               .
               *FURTHER TABLE ENTRIES AS
               NECESSARY
               .
               .
               .
0021  00              FCB    CN     CODE N
0022  0000            FDB    RN     ADDRESS OF
                                    ROUTINE N
                      END

TOTAL ERRORS 00000
```

Beware of Interrupts

Dave Feldman, 1856 Viking Way, La Jolla CA 92037

I have read with interest Michael McQuade's article "A Fast, Multibyte Binary to Binary-Coded-Decimal Conversion Routine" (February 1980 BYTE, page 106).

I wish to make the following comment regarding the program presented in listing 1, on page 110.

If the program is run in an environment in which interrupts exist, the user may experience difficulty in obtaining correct results should an interrupt occur when execution is just before RLOOP or just after LAB17 (in the area of the DCX SP instructions). The data on the stack (which is "recovered" by use of the two DCX SP instructions) will be overwritten by the return address saved when execution is transferred to the interrupt service routine. To prevent this problem, replace each occurrence of DCX SP DCX SP with a PUSH H or keep interrupts off while the subroutine is executing. I recommend the former. ■

Technical Forum is a feature intended as an interactive dialog on the technology of personal computing. The subject matter is open-ended, and the intent is to foster discussion and communication among readers of BYTE. We ask that all correspondents supply their full names and addresses to be printed with their commentaries. We also ask that correspondents supply their telephone numbers, which will not be printed.

Bending BASIC in a Recursive Form

Colin Newell, Newcastle, Australia

I read Stanley Swizer's "The Towers of Hanoi: Solution Using BASIC Recursion" ("Programming Quickies," March 1980 BYTE, page 240) with interest. He has shown us how to solve this problem in BASIC; however, my BASIC does not incorporate a stack. So here is my way of solving this problem (listing 1).

Listing 1

```
10  INPUT "NO OF DISKS ";N
20  LET I = 1
30  LET J = 3
40  GOSUB 100
50  GOTO 300
100  IF N = 0 THEN RETURN
110  LET N = N - 1
120  LET J = 6 - I - J
130  GOSUB 100
140  LET J = 6 - I - J
150  PRINT "MOVE TOP DISK ON TOWER ";I;" TO TOWER "; J
160  LET I = 6 - I - J
170  GOSUB 100
180  LET I = 6 - I - J
190  LET N = N + 1
200  RETURN
300  END

READY

RUN
NO OF DISKS ? 3
MOVE TOP DISK ON TOWER 1 TO TOWER 3
MOVE TOP DISK ON TOWER 1 TO TOWER 2
MOVE TOP DISK ON TOWER 3 TO TOWER 2
MOVE TOP DISK ON TOWER 1 TO TOWER 3
MOVE TOP DISK ON TOWER 2 TO TOWER 1
MOVE TOP DISK ON TOWER 2 TO TOWER 3
MOVE TOP DISK ON TOWER 1 TO TOWER 3
```

Programming in the Dark

Jeffrey Sainio, 143 N Moreland #106, Waukesha WI 53186

Robert Glaser's article on programming 2708-type read-only memories ("Program Those 2708s," April 1980 BYTE, page 198) is a boon to those of us who are interested in programmer boards with three-figure price tags. Having built a similar board, let me offer some pointers I have learned:

- 2708s program faster in the dark. This holds true for the devices manufactured by Intel, Texas Instruments, and Motorola that I have used. The speed difference between total darkness and bright incandescent light is over ten to one. The devices also read 0s more easily in the dark (ie: a marginally programmed bit may read correctly in the dark, but not in the light).
- Programming can be done interactively. By pulling the +26 V and CS (chip select) lines low, a byte of information can be read through an input port. If a logical exclusive-OR of the original data and the read data yields all 0s the byte does not need programming. The result of the exclusive-OR may be inverted and ORed with the desired data, then tested. If the result is anything other than hexadecimal FF, the device should be erased. If a programming pulse is to be applied, remember to set CS at +12 V before applying the +12 V; and remember that +26 V must be *turned off* before reading the device.

By using these techniques, I can program a 2708 in three to fifteen seconds. After an entire programming loop has been executed with no false bits indicated, I shine a high-intensity lamp through the device's window to catch any marginal bits. This ensures that all bits are programmed solidly.

Having used this programming technique on devices rated at 450 ns installed in a Z80 system (running at 4 MHz with no WAIT states), I can say that the method may not seem "kosher," but it is fast and error-free. ■

6502 Loop Control

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For clarity, the best way to loop through a field is to start at the beginning and stop at the end. It is important to be able to change the content or length of the field without having to change the code that handles it. Some people use a *marker byte* such as hexadecimal 00 to stop the loop; however, if you make your assembler work for you, this is unnecessary.

Listing 1 is an example of how to make your assembler perform this task. The X register is used to index through a field. The code is set up so that when the register hits zero, execution is terminated. Thus, begin by loading the register with 256 minus the length of the field. Then work through the field from start to end by loading the accumulator with the byte stored at the end of the message minus 256, plus the contents of the X register. The result is that when the X register hits zero, you are done.

The code shown has been used with two assemblers: Carl Moser's ASSM/TED, and Dan Fylstra's *6502 Assembler in BASIC*, published by Personal Software. Fylstra's assembler generates an error message on the first pass if MSG and MSGEND follow the code that uses them, but then produces correct object code. Of greater concern is the fact that both assemblers do not notice if MSG is greater than 256 bytes long. This should be an error condition that raises a diagnostic. In both cases the only result is that incorrect code is produced.

```
                                  .BA $7000
                                  .OS
                                  .LS
                    ; ** HOW TO SCAN A FIELD **
                    ; (MAKE YOUR ASSEMBLER WORK)
                    ;
                    ; THE OPTIMUM METHOD OF LOOP
                    ; CONTROL ON A 6502. MAXIMUM
                    ; OF 256 BYTES OF DATA.
                    ;
                    ;                 .
                    ;                 .
                    ;                 .
                    ;                 .
7000-  A2 F1                      LDX #MSG+256-MSGEND
7002-  BD 1B 6F       PRLOOP      LDA MSGEND-256,X
7005-  20 D2 FF                   JSR PRINT
7008-  E8                         INX
7009-  D0 F7                      BNE PRLOOP
                    ;                 .
                    ;                 .
                    ;                 .
700B-  00                         BRK
                    ;
700C-  50 4C 45       MSG         .BY 'PLEASE PRINT ME'
700F-  41 53 45
7012-  20 50 52
7015-  49 4E 54
7018-  20 4D 45
                      MSGEND
                    ;
                      PRINT       .DE $FFD2
                                  .EN

LABEL FILE:  [ / = EXTERNAL ]

PRLOOP=7002          MSG=700C          MSGEND=701B
/PRINT=FFD2
//0000,701B,701B
>
```


Sorting With a Catch

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So much has been said concerning various sorting algorithms that it hardly seems possible to be able to contribute to this topic; and yet, in a small business (a nature center, to be precise), we have developed a sorting routine that handles accounting entries, mailing list entries, etc, at a speed that leaves fancy algorithms in the dust. The special beauty of this technique is that it is very simple, and involves only a slight modification of the usually terribly inefficient brute-force *bubble* technique.

The routine has another advantage—it will not disturb the order of ties. For example, if one orders by zip code, it will not rearrange entries having the same zip code. This is an advantage if the list were previously alphabetized and you wanted to retain alphabetization within zip codes.

There is a catch. This routine is absolutely terrible for ordering a true random list. The routine is designed to handle a list that already is nearly in order, and you want to add a few extra items. But this is exactly the case in a mailing list, in which you add 20 names to a 1500-name list, or in accounting, in which you add 15 transactions to a 60-item list.

The Algorithm

The algorithm works as follows: assume that you have an array of L items, A(I), I = 1 to L. In the standard bubble sort, you compare A(1) with A(2). Assume that you want the list ordered from smallest to largest entry. Then, if A(1) < = A(2), leave them alone, but if A(1) > A(2), reverse them and proceed pairwise down the list. The last comparison made is between A(L−1) and A(L), reversing them if A(L−1) > A(L). You have just made L−1 pairwise comparisons.

For those unfamiliar with this method, a moment's thought should demonstrate that in this first pass you have guaranteed that the largest entry has sunk to the bottom. That is, A(L) now is the largest entry. In subsequent passes, it is no longer necessary to test anything against A(L). So, the second pass ends by comparing A(L−2) with A(L−1). But now, you have guaranteed that the second biggest entry is in the L−1 slot, so each successive pass requires one less comparison.

Even with the shortcut of cutting each pass to be one shorter than the previous pass, this method still takes a long time. But now consider the following. Suppose, during the first pass of L−1 comparisons, we check to see just how well ordered the list already is. We will set up a *window* in which W equals the first pair that was ordered, and X equals the last pair. Suppose the list contains 85 items, but after the first pass, W = 26 and X = 34. This means that everything beyond 34 is already ordered. Items earlier than 26 may not be completely in order when considering later items, but the very next pass can compare entry twenty-five with entry twenty-six; ie: at W−1. So, we have a window that will ascend to the top of the list. Further, on each successive pass we will reevaluate W and X. As soon as X < = 1, we can stop. (Note: X can equal zero in the special case that the entire list was already in order before you invoked the routine.)

The Program

This idea is so simple that it cannot be new; yet, I have not seen it mentioned, and even if it is published elsewhere, it is worth repeating. The code in listing 1 is for North Star BASIC, in which the semicolon separates statements on the same line. W and X have already been defined. T, T1, and T2 are temporary variables. I is an index variable, and A(I) is the array. The A(I) could also be pointers to string variables; the technique is clearly not limited to ordering numbers.

A final comment. This routine is at its very best if the list is already completely ordered before calling it; it makes one pass through the list, discovers that the list is already ordered (X=0 in statement 135), and quits. This is not at all a ridiculous situation. We have several programs that require ordered data in files, and call the sort routine whenever a "write" is called for, even if nothing was done to disturb the order. In such instances, the sort is only a momentary delay.

Listing 1: *A bubble sort with a window. This routine is designed specifically to sort lists with only a few entries out of order. It can even be used to check a list quickly to ensure that all entries are ordered. The main attraction, though, is its simplicity; the actual North Star BASIC code is only eight lines long.*

```
100 W=2;X=L;REM W=UPPER WINDOW BOUND, X=LOWER
105 FOR I=1 TO L
110 T1=X;X=0;IF W<2 THEN W=2;T2=W-1;W=0
115 FOR J=T2 TO T1-1;REM BEGIN AT T2. STMT 110
    ASSURES T2 >=1.
120 IF A(J) <= A(J+1) THEN 135
125 T=A(J);A(J)=A(J+1):A(J+1)=T;REM. OUT OF ORDER,
    REVERSE.
130 X=J;IF W=0 THEN W=J; REM W=0 IMPLIES FIRST
    REVERSAL.
135 NEXT;IF X <= 1 THEN EXIT 145;NEXT
140 STOP;REM FOR COMMENT ONLY - WILL NEVER BE
    REACHED.
141 REM WILL NEVER FINISH SECOND "NEXT" OF 135
145 REM ROUTINE ENDS HERE, LIST IS ORDERED.
```

■

Programming Quickies

Notes on Absolute Location Interfaces to Apple Pascal

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After seeing the March 1980 BYTE Editorial ("Hunting the Computerized Eclipse," page 6), I realized that many other users of Apple Pascal have encountered the same problem I have: the difficulty in accessing memory locations directly. I have written two programs that help to minimize this problem.

Listing 1: *A UCSD Pascal compilation unit called PEEKPOKE which provides the modules PEEK and POKE that allow access to arbitrary memory locations. Care should be exercised in using this routine, because data vital to the operating system may be inadvertently modified.*

```
(*$S+,LPRINTER:*)

(**********************************         This program has been designed
 *                                  *         to be added to the Pascal
 *        PEEK and POKE             *         SYSTEM.LIBRARY. See section
 *                                  *         4.2 in the reference manual
 *     Dan Sokol     3 Dec 79       *         for info on the Librarian.
 *                                  *
 **********************************)

unit PEEKPOKE; intrinsic code 26;             (* I used segment 26 *)

interface

procedure POKE(var ADDR,DATA:integer);        (* Format is :           *)
function PEEK(var ADDR:integer):integer;      (* POKE(addr,data);      *)
                                              (* data:=PEEK(addr);

                                                 Both addr and data
                                                 must be INTEGER variables
                                                 (not constants)

                                                 To use in a program you
                                                 must follow the program
                                                 name with :
                                                 USES PEEKPOKE;
                                                                   *)

implementation

type PA = packed array[0..1] of 0..255;       (* this defines a variant *)
     MAGIC = record case boolean of           (* record which will map  *)
              true : (INT: integer);          (* to an absolute hardware *)
              false : (PTR:^PA);              (* address in the Apple.   *)
              end;

var CHEAT:MAGIC;

procedure TEST(var DATA:integer); forward;

procedure POKE;
  begin
   TEST(DATA);
   CHEAT.INT:=ADDR;
   CHEAT.PTR^[0]:=DATA;
  end;

function PEEK;
  begin
   CHEAT.INT:=ADDR;
   PEEK:=CHEAT.PTR^[0];
  end;

procedure TEST;                               (* This procedure assures *)
  begin                                       (* only valid data will    *)
   DATA:=abs(DATA mod 256);                   (* get poked *)
  end;

(* MAIN PROGRAM *)

begin
(* DUMMY PROGRAM *)
end.
```

The first program, entitled UNIT.PEEK.TEXT (shown in listing 1), is a library *intrinsic* that performs the same functions as PEEK and POKE in BASIC. It uses the variant-record technique to access arbitrary addresses in memory.

The second program is called CALL.ASSY.TEXT (shown in listing 2). It is an assembly-language linkage which allows the user to call, from a Pascal routine, an external (non-Pascal) assembly-language program at an arbitrary address in memory. It is, of course, possible to call an assembly-language module that is linked into a Pascal program, such as this module itself, but the linker has no provision for fixing an absolute address of the called routine. Thus this routine is required as an escape to routines found at locations fixed by hardware, such as the read-only memory regions of the typical Apple input/output (I/O) cards.

Listing 2: *CALL, a UCSD Pascal system assembly-language program for a 6502 processor. This routine will call an arbitrary absolute address, such as an address associated with a read-only memory routine in an interface card, which is not normally accessible from Pascal. As in listing 1, care should be exercised in using this routine.*

```
;
; PROGRAM TO CREATE A CALL FUNCTION FOR PASCAL IN THE APPLE;
;
; Use this assembly lanquge program to call programs
; that are not normally accessable from Pascal.
;
; To use: ASSEMBLE this program and save the code file.
;         Define a PROCEDURE in your program as follows -
;               PROCEDURE CALL(addr); EXTERNAL;
;         addr must be an integer variable.
;
;         Compile your program and then run the linker.
;         When asked for the LIB.name type the name of the save code file.
;
; WARNING : ANY PROGRAM THAT CHANGES MEMORY LOCATIONS MAY INTERFERE WITH
;             THE PASCAL OPERATING SYSTEM.
;


        .TITLE " CALL SUBR - 15 FEB 80 - DAN SOKOL"

        .MACRO POP
        PLA
        STA     %1
        PLA
        STA     %1+1
        .ENDM

        .MACRO PUSH
        LDA     %1+1
        PHA
        LDA     %1
        PHA
        .ENDM

         PROC CALL.1
;
;       procedure CALL(ADDR:integer); external;
;


RETURN  .EQU    0
MYCALL  .EQU    2



         POP     RETURN   ; SAVE PASCAL RETURN ADDR;
#        PLA
#        STA     RETURN
#        PLA
#        STA     RETURN+1
         POP     MYCALL   ; SAVE OUR CALLING ADDR ;
#        PLA
#        STA     MYCALL
#        PLA
#        STA     MYCALL+1
         PUSH    RETURN   ; PUT BACK ON STACK;
#        LDA     RETURN+1
#        PHA
#        LDA     RETURN
#        PHA
         JMP    @MYCALL   ; JUMP TO USER PROGRAM

          .END        ■
```

A Lowercase-to-Uppercase Converter

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Many ASCII-encoded keyboards are capable of generating both uppercase and lowercase codes. Many of these contain a jumper option that will disable the lowercase characters, and generate their uppercase counterparts. But some keyboards do not offer this option, and trying to use an uppercase/lowercase keyboard on a system that requires only uppercase characters becomes very frustrating. Of course, the uppercase codes may be generated singly by pressing the shift key.

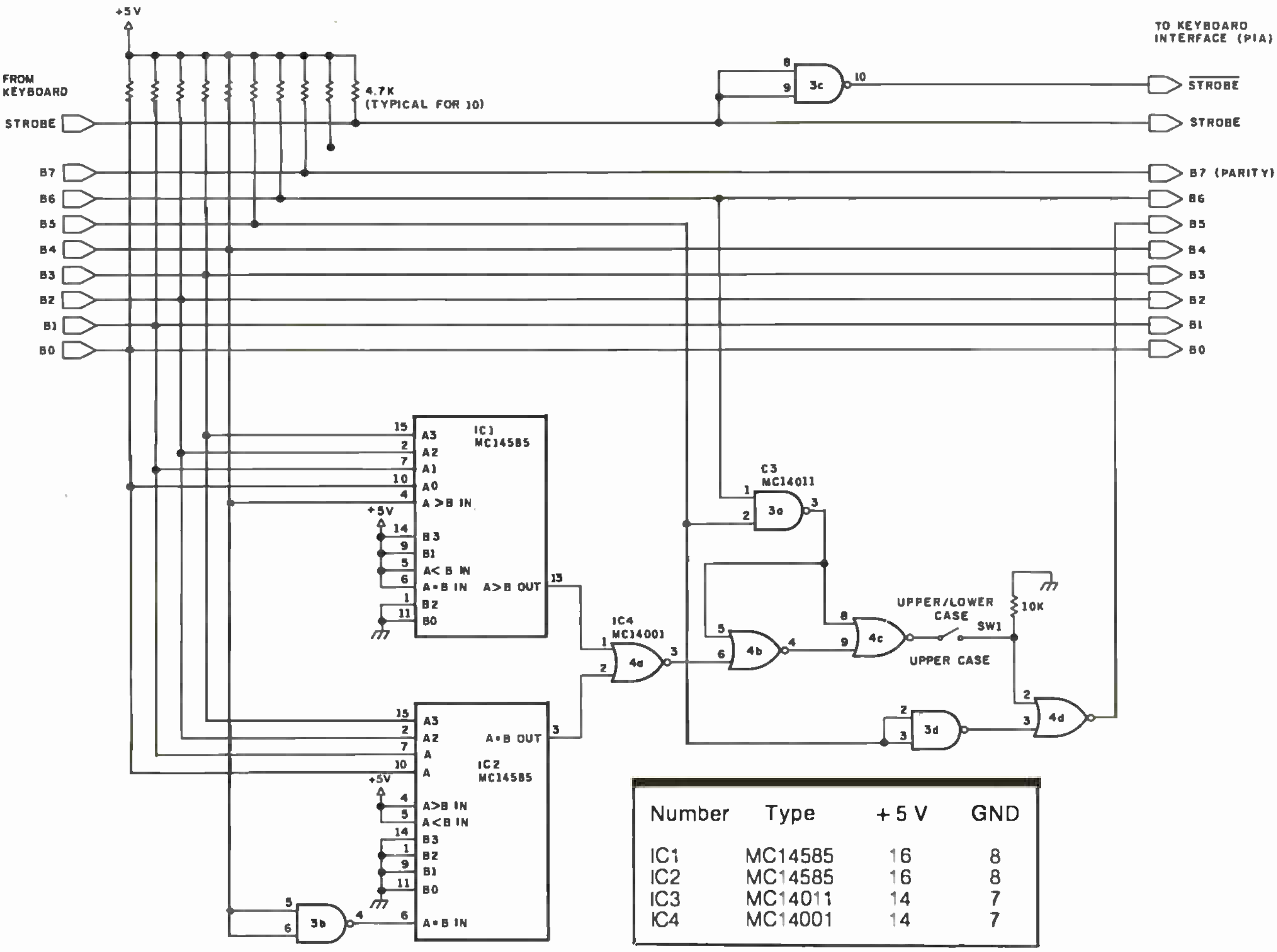
The problem with this is trying to remember to press the shift key every time you want to enter an uppercase letter and to leave it unpressed when you want to enter a number or lowercase symbol. Mistakes are inevitable. However, there are two possible solutions: convert the lowercase characters to uppercase with additional software in the character input routine; or perform the conversion with a hardware circuit between the keyboard and the computer.

The software approach is the better alternative. The software, shown in listing 1, is extremely simple and can be as versatile as the user desires it to be. For example, by setting or clearing a software-flag location, the lowercase characters may be enabled or disabled. This assumes that the user has access to the computer's character-input routine and that the routine can be modified.

The hardware conversion method, on the other hand, is somewhat less versatile and requires more effort to implement. Versatility is lost because alternation between the two modes, that is, allowing and disallowing lowercase, requires the physical act of

Listing 1: *Software routine to convert from lowercase to uppercase ASCII (American Standard Code for Information Interchange). This routine is relocatable to any address in memory. It assumes that the character to be converted resides in the accumulator; the result is left in the accumulator. The routine is written for the 6800 microprocessor and requires only 13 bytes.*

Hexadecimal Address	Hexadecimal Code	Label	Instruction Mnemonic	Operand	Commentary
0100	84 7F	CNVT	ANDA	#$7F	Mask to 7 bits.
0102	81 61		CMPA	#$61	Check for lowercase.
0104	2D 06		BLT	NOCNVT	Do not convert if not.
0106	81 7A		CMPA	#$7A	Do not convert special characters
0108	2E 02		BGT	NOCNVT	at end of ASCII code table.
010A	8A 5F		ANDA	#$5F	Convert to uppercase.
010C	39	NOCNVT	RTS		Return.



Number	Type	+5 V	GND
IC1	MC14585	16	8
IC2	MC14585	16	8
IC3	MC14011	14	7
IC4	MC14001	14	7

Figure 1: *Schematic diagram for the lowercase/uppercase hardware interface. This circuit assumes that there is a parallel interface between the keyboard and the microcomputer. All integrated circuits are complementary metal-oxide semiconductor (CMOS) types for low power consumption. IC1 and IC2 are 4-bit comparators. Switch SW1 transfers the keyboard between an uppercase-only mode and a mixed uppercase-and-lowercase mode. These two modes are achieved with SW1 closed and opened, respectively.*

				B6	0	0	0	0	1	1	1	1
				B5	0	0	1	1	0	0	1	1
				B4	0	1	0	1	0	1	0	1
				upper digit / lower digit	0	1	2	3	4	5	6	7
B3	B2	B1	B0									
0	0	0	0	0	NUL	DLE	SP	0	@	P	'	p
0	0	0	1	1	SOH	DC1	!	1	A	Q	a	q
0	0	1	0	2	STX	DC2	"	2	B	R	b	r
0	0	1	1	3	ETX	DC3	#	3	C	S	c	s
0	1	0	0	4	EOT	DC4	$	4	D	T	d	t
0	1	0	1	5	ENQ	NAK	%	5	E	U	e	u
0	1	1	0	6	ACK	SYN	&	6	F	V	f	v
0	1	1	1	7	BEL	ETB	'	7	G	W	g	w
1	0	0	0	8	BS	CAN	(	8	H	X	h	x
1	0	0	1	9	HT	EM	)	9	I	Y	i	y
1	0	1	0	A	LF	SUB	*	:	J	Z	j	z
1	0	1	1	B	VT	ESC	+	;	K	[	k	{
1	1	0	0	C	FF	FS	,	<	L	\	l	|
1	1	0	1	D	CR	GS	–	=	M	]	m	}
1	1	1	0	E	SO	RS	.	>	N	^	n	~
1	1	1	1	F	SI	US	/	?	O	_	o	DEL

Figure 2: *ASCII code table. When converting from lowercase to uppercase, by either hardware or software, only hexadecimal codes 61 thru 7A should be changed. The change to uppercase is made by setting bit B5 to 0 or, equivalently, by subtracting hexadecimal 20 from the code. All other codes should be left intact.*

flipping a switch. Thus, a program calling for large quantities of both uppercase and lowercase input will be inconvenient to run. But this should be no more trouble than shifting on a regular typewriter. In any case, hardware design should be kept as simple as possible.

The circuit in figure 1 meets these desirable requirements. Once constructed, it is connected between the keyboard and the computer. It will convert the lowercase letters "a" through "z" into their uppercase equivalents if switch SW1 is closed. If SW1 is open, all codes, whether uppercase or lowercase, are passed directly to the interface. Construction is noncritical, and very little power is needed due to the use of CMOS integrated circuits. ■

A BASIC Floppy-Disk Accounting System

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```
10 DIMB(19),I(2,19,11),T$(440),D$(33)
20T$(  1, 55)='CASH        SECURITIES RECEIVABLESINVENTORY  OTHER      '
30T$( 56,110)='PLANT       MACHINERY  EQUIPMENT  RAW STOCK  OTHER      '
40T$(111,165)='PAYABLES    TAXS PAY.  LOANS PAY. OTHER PAY. DEBENTURES '
50T$(166,220)='LT LOANS    NOTES      OTHER LT   STOCK $1PARR. EARNINGS'
60T$(221,275)='SERV. FEES ROYALTIES  ASSETS SOLDSOFTWARE   OTHER SALES'
70T$(276,330)='INVENTORY  ASSETS SOLDDEPRECIAT. OTHER      OTHER      '
80T$(331,385)='RENT        ELECTRIC   GAS        TELEPHONE  PUBLICATION'
90T$(386,440)='SUPPLIES   POSTAGE    TRANSPORT. SALARIES   OTHER      '
100 !'BALANCE SHEET ACCOUNTS == INCOME STATEMENT ACCOUNTS'
110 !'=================================================='
120 FORA=0TO19\B=A+20\T1=A\GOSUB1200\T2=T1\T1=B\GOSUB1200
130 !%5I,A,'  ',T$(T2-10,T2),'     == ',%5I,B,'  ',T$(T1-10,T1)\NEXT
140 INPUT' 0 TO END OR 1 TO ERASE A FILE ? ',A\IFA=0THENEND
150 GOSUB1000\GOSUB1300\!F$,' HAS BEEN ERASED'\END
1000 INPUT'FILE : ',F$\OPEN#0,F$\RETURN
1100 FORA=0TO19\READ#0,B(A)\NEXT
1110 FORA=0TO2\FORB=0TO19\FORC=0TO11
1120 READ#0,I(A,B,C)\NEXT\NEXT\NEXT\CLOSE#0\RETURN
1200 T1=(T1+1)*11\RETURN
1300 FORA=0TO19\WRITE#0,B(A)\NEXT
1310 FORA=0TO2\FORB=0TO19\FORC=0TO11
1320 WRITE#0,I(A,B,C)\NEXT\NEXT\NEXT\CLOSE#0\RETURN
READY
```

Listing 1: LIST1, a program designed to display the codes used in the author's floppy disk based accounting system. The program also allows the user to erase all data from a given file name. LIST1 is used in the article example to keep track of the business transactions of the JJR Company, a fictitious organization.

```
BALANCE SHEET ACCOUNTS == INCOME STATEMENT ACCOUNTS
==================================================
     0  CASH            ==    20  SERV. FEES
     1  SECURITIES      ==    21  ROYALTIES
     2  RECEIVABLES     ==    22  ASSETS SOLD
     3  INVENTORY       ==    23  SOFTWARE
     4  OTHER           ==    24  OTHER SALES
     5  PLANT           ==    25  INVENTORY
     6  MACHINERY       ==    26  ASSETS SOLD
     7  EQUIPMENT       ==    27  DEPRECIAT.
     8  RAW STOCK       ==    28  OTHER
     9  OTHER           ==    29  OTHER
    10  PAYABLES        ==    30  RENT
    11  TAXS PAY.       ==    31  ELECTRIC
    12  LOANS PAY.      ==    32  GAS
    13  OTHER PAY.      ==    33  TELEPHONE
    14  DEBENTURES      ==    34  PUBLICATION
    15  LT LOANS        ==    35  SUPPLIES
    16  NOTES           ==    36  POSTAGE
    17  OTHER LT        ==    37  TRANSPORT.
    18  STOCK $1PAR     ==    38  SALARIES
    19  R. EARNINGS     ==    39  OTHER
 0 TO END OR 1 TO ERASE A FILE ? BUD
 INPUT ERROR-RETYPE
 0 TO END OR 1 TO ERASE A FILE ? 1
FILE : BUD
BUD HAS BEEN ERASED
READY
```

Listing 2: A sample run of LIST1, showing codes used for the balance sheet accounts and income statement accounts.

The purpose of this article is to present a complete accounting system for a microprocessor equipped with a floppy disk or another storage device. This article gives complete listings for all programs and focuses on the operation rather than on the design of the system. The programs are written in North Star BASIC on an IMSAI 8080 system with 24 K of programmable memory.

As a model we use a fictitious company (JJR) that used the Micro Accounting System in 1976. During this period the journal entry, balance sheet, budget input and general list programs are introduced. Income statement and budget programs are examined later in the article. The magnitude of the figures used and the number of inputs shown are kept to a minimum for the sake of clarity.

In order to design an accounting svstem, one must decide how many accounts to handle. The system being presented has 20 balance sheet accounts and 20 income statement accounts. The computer automatically clears out all income statement items to retained earnings. For the 20 balance sheet items, only a year-to-date figure is maintained. However, all income statement items are broken down into three possible departments:

- 0 – Administration
- 1 – Local Sales
- 2 – National Sales

Furthermore, monthly activity is tracked for each income statement item. A file contains only one year's worth of data.

The North Star Microfloppy Disk I used has a capacity of 35 tracks. Each track contains ten sectors or blocks, with 256 bytes of data on each sector. Every numerical variable written out to disks using the standard North Star Basic requires five bytes. Therefore, each data file is subdivided as follows:

Balance sheet items =	
20 X 5 bytes	= 100
Income items =	
20 X 3 subdepartments X	
12 months X 5 bytes	= 3600
	= 3700

The size of a data file is 15 blocks (3700 divided by 256). Listing 1 shows the first program of the system (LIST1). Listing 2 shows the output of LIST1. This program merely shows the codes (numerical between 0 and 39) used for each account and also allows us to erase all data from a given file name. A 15 block data file is created (using the North Star disk operating system commands: CR JJR76 15, TY JJR76 3) to keep track of the JJR Company for the year 1976. The company was formed in December of 1976 and has very limited transactions. These are entered into the accounting system via program ENTRY1 (shown in listing 3). Listing 4 details the entry of these transactions which is as follows:

1. Start business by purchasing 1000 shares of stock for $1000.
2. Buy $500 worth of machinery for cash.
3. Obtain a $250 piece of equipment for cash.
4. Purchase raw stock for $50.

ENTRY1, like the rest of the system's update programs, always asks for a data file at the beginning and a date file at the end of

```
10 DIMB(19),I(2,19,11),T$(440),D$(33)
15 DIM J(100,4)
20T$(  1, 55)='CASH        SECURITIES RECEIVABLESINVENTORY  OTHER      '
30T$( 56,110)='PLANT       MACHINERY  EQUIPMENT  RAW STOCK  OTHER      '
40T$(111,165)='PAYABLES    TAXS PAY.  LOANS PAY. OTHER PAY. DEBENTURES '
50T$(166,220)='LT LOANS    NOTES      OTHER LT   STOCK $1PARR. EARNINGS'
60T$(221,275)='SERV. FEES ROYALTIES  ASSETS SOLDSOFTWARE   OTHER SALES'
70T$(276,330)='INVENTORY  ASSETS SOLDDEPRECIAT. OTHER      OTHER      '
80T$(331,385)='RENT        ELECTRIC   GAS        TELEPHONE  PUBLICATION'
90T$(386,440)='SUPPLIES   POSTAGE    TRANSPORT. SALARIES   OTHER      '
100 GOSUB1000\GOSUB1100
140 INPUT'MONTH : ',M\M=M-1
150 IFM<0ORM>11THEN140
160 !'INPUT: $AMOUNT, DEBIT ACC#, CREDIT ACC#, DEPT#, REF#'
170 !'0,0,0,0,0 ENDS INPUT'\A=0
180 !'ENTRY #',%4I,A+1,\INPUT' ? ',J(A,0),J(A,1),J(A,2),J(A,3),J(A,4)
182 IFJ(A,1)>39ORJ(A,1)<0THEN189
184 IFJ(A,2)>39ORJ(A,2)<0THEN189
186 IFJ(A,3)>2ORJ(A,3)<0THEN189\GOTO190
189 !'INVALID ENTRY REJECTED'\GOTO180
190 IFJ(A,0)=0THEN200\A=A+1\IFA<100THEN180
195 A=A-1
200 A=A-1
205 INPUT'SET PRINTER FOR LIST OF ENTRIES ? ',A$\!''
210 !'JOURNAL ENTRIES MONTH #',%3I,M+1
220 FORB=1TO27\!'=',\NEXT\!''\!''
230 !'ENTRY  $ AMOUNT   DEBIT        CREDIT       DEPT   REFERENCE'
240 FORB=1TO60\!'=',\NEXT\!''\!''
250 FORB=0TOA\T1=J(B,1)\GOSUB1200\T2=T1\T1=J(B,2)\GOSUB1200
260 !%5I,B+1,'  ',%$10F2,J(B,0),' ',T$(T2-10,T2),' ',
265 !T$(T1-10,T1),%6I,J(B,3),%12I,J(B,4)
270 NEXT\C=0
280 !'0 ENDS PROGRAM AND KILLS ALL ENTRIES'
290 !'1-100 CORRECTS AN ENTRY'
300 INPUT'OVER 100 ENTERS THE ENTRIES INTO THE FILE ? ',B\IFB=0THENEND
310 IFB>100THEN400\C=1\D=B-1\GOTO330
320 INPUT1'ENTRY NUMBER ?',D\D=D-1
330 IFD<0ORD>ATHEN320
340 INPUT'$,DEBIT,CRE,DEPT,REF ?',J(D,0),J(D,1),J(D,2),J(D,3),J(D,4)
350 IFJ(D,1)<0ORJ(D,1)>39THEN360
352 IFJ(D,2)<0ORJ(D,2)>39THEN360
354 IFJ(D,3)<0ORJ(D,3)>2THEN360\GOTO280
360 !'CORRECTION REJECTED'\GOTO340
400 IFC>0THEN205
410 FORB=0TOA\E=J(B,3)\FORC=1TO2\D=J(B,C)\IFC=2THENJ(B,0)=0-J(B,0)
420 IFD>19THEN430\B(D)=B(D)+J(B,0)\GOTO440
430 D=D-20\I(E,D,M)=I(E,D,M)+J(B,0)\B(19)=B(19)+J(B,0)
440 NEXT\NEXT\GOSUB1000\GOSUB1300\!''\!F$,' UPDATED'\END
1000 INPUT'FILE : ',F$\OPEN#0,F$\RETURN
1100 FORA=0TO19\READ#0,B(A)\NEXT
1110 FORA=0TO2\FORB=0TO19\FORC=0TO11
1120 READ#0,I(A,B,C)\NEXT\NEXT\NEXT\CLOSE#0\RETURN
1200 T1=(T1+1)*11\RETURN
1300 FORA=0TO19\WRITE#0,B(A)\NEXT
1310 FORA=0TO2\FORB=0TO19\FORC=0TO11
1320 WRITE#0,I(A,B,C)\NEXT\NEXT\NEXT\CLOSE#0\RETURN
READY
```

Listing 3: ENTRY1, a program enabling the user to enter business transactions into the computer.

```
FILE : JJR76
MONTH : 12
INPUT: $AMOUNT, DEBIT ACC#, CREDIT ACC#, DEPT#, REF#
0,0,0,0,0 ENDS INPUT
ENTRY #    1 ? 1000,0,18,0,1
ENTRY #    2 ? 500,6,0,0,2
ENTRY #    3 ? 200,7,0,0,3
ENTRY #    4 ? 50,8,0,0,4
ENTRY #    5 ? 0,0,00,0,0
SET PRINTER FOR LIST OF ENTRIES ?


JOURNAL ENTRIES MONTH #  12
===========================

ENTRY  $ AMOUNT   DEBIT        CREDIT       DEPT   REFERENCE
============================================================

    1    $1000.00 CASH         STOCK $1PAR     0           1
    2     $500.00 MACHINERY    CASH            0           2
    3     $200.00 EQUIPMENT    CASH            0           3
    4      $50.00 RAW STOCK    CASH            0           4
0 ENDS PROGRAM AND KILLS ALL ENTRIES
1-100 CORRECTS AN ENTRY
OVER 100 ENTERS THE ENTRIES INTO THE FILE ? 111
FILE : JJR76

JJR76 UPDATED
READY
```

Listing 4: A sample run of ENTRY1. The amounts and transaction codes (see listing 2) indicate that the company sold 1000 shares of stock for $1000, bought $500 worth of machinery for cash, obtained a $250 piece of equipment for cash, and purchased raw stock for $50.

```
10 DIMB(2,19),T$(440),Y(1),T(2,6),W(1,4),L(1,16),L$(77)
15 LINE80
16 L$(1,44)='  C. ASSETS  L. ASSETS  C. LIAB.   L. LIAB. '
18 L$(45,77)='  EQUITY   TOT. ASSETS TOT. LIA&EQ'
20T$(  1, 55)='CASH         SECURITIES RECEIVABLESINVENTORY  OTHER      '
30T$( 56,110)='PLANT        MACHINERY  EQUIPMENT  RAW STOCK  OTHER      '
40T$(111,165)='PAYABLES     TAXS PAY.  LOANS PAY. OTHER PAY. DEBENTURES '
50T$(166,220)='LT LOANS     NOTES      OTHER LT   STOCK $1PARR. EARNINGS'
60T$(221,275)='SERV. FEES ROYALTIES  ASSETS SOLDSOFTWARE   OTHER SALES'
70T$(276,330)='INVENTORY  ASSETS SOLDDEPRECIAT. OTHER      OTHER      '
80T$(331,385)='RENT         ELECTRIC   GAS        TELEPHONE  PUBLICATION'
90T$(386,440)='SUPPLIES     POSTAGE    TRANSPORT. SALARIES   OTHER      '
92 FORA=0TO4\READW(0,A),W(1,A)\NEXT
94 DATA0,4,5,9,10,13,14,17,18,19
96 INPUT'O TO TRANSFER YEAR TO YEAR ?',A
98 IFA=0THENGOSUB4000
100 FORD=0TO1\GOSUB1000\GOSUB1100\INPUT'WHAT YEAR WAS THAT ? ',Y(D)
110 NEXT
120 INPUT'DATE ? ',D$\INPUT'GET PRINTER READY ? ',A$
130 !'BALANCE SHEET AS OF ',D$
132 !%21I,Y(0),%9I,Y(1),'    DIFF = ',
134 !%21I,Y(0),%9I,Y(1),'    DIFF'
136 FORA=1TO8\!'==========',\NEXT\!''
140 FORA=0TO19\B(2,A)=B(0,A)-B(1,A)\IFA>16THEN145\READL(0,A),L(1,A)
145 NEXT
150 FORA=0TO4\C=W(0,A)\D=W(1,A)\FORB=0TO2
160 FORE=CTOD\T(B,A)=T(B,A)+B(B,E)
170 NEXTE\NEXTB\NEXTA
180 FORA=0TO2\T(A,5)=T(A,0)+T(A,1)
190 T(A,6)=T(A.2)+T(A,3)+T(A,4)\NEXT
200 FORA=0TO16\FORB=0TO1
210 IF200>L(B,A)THEN230
220 !'                                          ',\GOTO400
230 IF100>L(B,A)THEN260
240 T3=L(B,A)-100\T1=T3\GOSUB1200
250 !L$(T1-10,T1),' ',%9F2,T(0,T3),T(1,T3),%8F2,T(2,T3),\GOTO400
260 T3=L(B,A)\T1=T3\GOSUB1200
270 !T$(T1-10,T1),' ',%9F2,B(0,T3),B(1,T3),%8F2,B(2,T3),
400 IFB=1THEN410\!' = ',\GOTO420
410 !''
420 NEXT\NEXT\!''\END
1000 INPUT'FILE : ',F$\OPEN#0,F$\RETURN
1100 FORA=0TO19\READ#0,B(D,A)\NEXT\CLOSE#0\RETURN
1200 T1=(T1+1)*11\RETURN
2000 DATA0,10,1,11,2,12,3,13,4,102,100,200,200,14,200,15,200,16
2002 DATA5,17,6,103,7,200,8,18,9,19,101,104,200,200,105,106
4000 INPUT'GIVE FILE TO BE TRANSFERED ? ',F$
4010 OPEN#0,F$\FORA=0TO19\READ#0,B(0,A)\NEXT\CLOSE#0
4020 INPUT'GIVE FILE TO RECEIVE DATA ? ',F$
4030 OPEN#0,F$\FORA=0TO19\WRITE#0,B(0,A),NOENDMARK\NEXT
4035 CLOSE#0\RETURN
READY
```

Listing 5: BAL1, a program that calculates a year end balance sheet. The program is capable of transferring the previous year's records to the current year.

the program. This makes it possbile to save the original file and to produce a new file, which is the original plus any updates. In the example, only one file (JJR76) is used.

Since the transactions shown were the only transactions for the year, it is now possible to run a year end balance sheet. Program BAL1 (listing 5) is executed. Listing 6 shows a sample run of the program. BAL1 first asks if any of the balance sheet items are to be transferred to a new file. This is important because all of 1976's year-end assets, liabilities and equity balances must be transferred to the new year, 1977. Therefore, the user should instruct the program to transfer 1976 balance sheet items (file JJR76) to 1977 (file JJR77).

The balance sheet program also allows for comparisons to be made and asks for two files to be compared. Since this is JJR's first year of operation, we are forced to compare 1976 to 1976. The balance sheet is now produced.

Note that the balance sheet is printed by lines 200 to 420 of the program. A programming trick has been used to shorten the length of the actual program. As the example shows, the balance sheet is composed of 17 lines with two entries per line, or 34 total entries. There are 20 individual items, seven totals and seven blank items. Array L(1,16) determines which items appear on each line. An L(1,16) value of 0 to 19 refers to a particular account, 100 to 106 is linked to a total, and 200 is used to generate blanks. Lines 2000 and 2002 show the values of L(1,16). I point this out because most of the financial statements were produced using this method.

During 1977 our small business has expanded by hiring a local salesperson. However, sales do not take place until November, and our proprietor wants to segregate the revenue generated by himself from the sales brought in by the sales-

```
O TO TRANSFER YEAR TO YEAR ?0
GIVE FILE TO BE TRANSFERED ? JJR76
GIVE FILE TO RECEIVE DATA ? JJR77
FILE : JJR76
WHAT YEAR WAS THAT ? 1976
FILE : JJR76
WHAT YEAR WAS THAT ? 1976
DATE ? 12/31/76
GET PRINTER READY ?


BALANCE SHEET AS OF 12/31/76
                  1976      1976     DIFF =                  1976      1976     DIFF
================================================================================
CASH            250.00    250.00      .00 = PAYABLES          .00       .00      .00
SECURITIES         .00       .00      .00 = TAXS PAY.         .00       .00      .00
RECEIVABLES        .00       .00      .00 = LOANS PAY.        .00       .00      .00
INVENTORY          .00       .00      .00 = OTHER PAY.        .00       .00      .00
OTHER              .00       .00      .00 =   C. LIAB.        .00       .00      .00
  C. ASSETS     250.00    250.00      .00 =
                                          = DEBENTURES        .00       .00      .00
                                          = LT LOANS          .00       .00      .00
                                          = NOTES             .00       .00      .00
PLANT              .00       .00      .00 = OTHER LT          .00       .00      .00
MACHINERY       500.00    500.00      .00 =   L. LIAB.        .00       .00      .00
EQUIPMENT       200.00    200.00      .00 =
RAW STOCK        50.00     50.00      .00 = STOCK $1PAR  -1000.00  -1000.00      .00
OTHER              .00       .00      .00 = R. EARNINGS       .00       .00      .00
  L. ASSETS     750.00    750.00      .00 =   EQUITY     -1000.00  -1000.00      .00
                                          =
TOT. ASSETS    1000.00   1000.00      .00 =  TOT. LIA&E  -1000.00  -1000.00      .00

READY
```

Listing 6: A sample run of BAL1.

```
10 DIMB(2,19,11)
100 !'USE BUDGET FILES ONLY ? ',\GOSUB1000\GOSUB1100
110 !' 0 TO ADD TO EXISTING BUDGETS'
120 !'1 TO OVER RIDE EXISTING BUDGETS'
130 INPUT'2 TO END ? ',A\IFA<2THEN140\GOSUB1000\GOSUB1300\END
140 INPUT'DEPT,FIRST MONTH, END MONTH ? ',B,C,D
142 IFB<0ORB>2THEN300
144 IFD<CTHEN300
146 IFD<1ORD>12THEN300
148 IFC<1ORC>12THEN300
150 INPUT'ACCOUNT, AMOUNT ($.01 RETURNS TO START) ? ',E,F
155 E=E-20
160 IFF=.01THEN110\IFE<0ORE>19THEN300
170 FORG=CTOD\IFA=0THEN190
180 B(B,E,G-1)=F\GOTO200
190 B(B,E,G-1)=F+B(B,E,G-1)
200 NEXT\GOTO150
300 !'LAST ENTRY INCORRECT'\GOTO110
1000 INPUT'FILE : ',F$\OPEN#0,F$\RETURN
1100 FORA=0TO19\READ#0,B\NEXT
1110 FORA=0TO2\FORB=0TO19\FORC=0TO11
1120 READ#0,B(A,B,C)\NEXT\NEXT\NEXT\CLOSE#0\RETURN
1300 FORA=0TO19\WRITE#0,Z9\NEXT
1310 FORA=0TO2\FORB=0TO19\FORC=0TO11
1320 WRITE#0,B(A,B,C)\NEXT\NEXT\NEXT\CLOSE#0\RETURN
READY
```

Listing 7: BUD-IN1, a program that generates budgets and enables the user to keep separate records of, for instance, the sales generated by each salesperson in the organization.

```
LOAD BUD-IN1
READY
RUN

USE BUDGET FILES ONLY ? FILE : BUD
 0 TO ADD TO EXISTING BUDGETS
1 TO OVER RIDE EXISTING BUDGETS
2 TO END ? 1
DEPT,FIRST MONTH, END MONTH ? 1,11,12
ACCOUNT, AMOUNT ($.01 RETURNS TO START) ? 23,-90
ACCOUNT, AMOUNT ($.01 RETURNS TO START) ? 25,15
ACCOUNT, AMOUNT ($.01 RETURNS TO START) ? 38,40
ACCOUNT, AMOUNT ($.01 RETURNS TO START) ? 0,.01
 0 TO ADD TO EXISTING BUDGETS
1 TO OVER RIDE EXISTING BUDGETS
2 TO END ? 2
FILE : BUD
READY
```

Listing 8: A sample run of BUD-IN1.

```
FILE : JJR77
MONTH : 11
INPUT: $AMOUNT, DEBIT ACC#, CREDIT ACC#, DEPT#, REF#
0,0,0,0,0 ENDS INPUT
ENTRY #   1 ? 500,2,21,0,5
ENTRY #   2 ? 0,0,0,0,0
SET PRINTER FOR LIST OF ENTRIES ?

JOURNAL ENTRIES MONTH # 11
==========================

ENTRY  $ AMOUNT   DEBIT        CREDIT       DEPT   REFERENCE
============================================================

    1     $500.00 RECEIVABLES ROYALTIES       0           5
0 ENDS PROGRAM AND KILLS ALL ENTRIES
1-100 CORRECTS AN ENTRY
OVER 100 ENTERS THE ENTRIES INTO THE FILE ? 111
FILE : JJR77

JJR77 UPDATED
READY
RUN

FILE : JJR77
MONTH : 12
INPUT: $AMOUNT, DEBIT ACC#, CREDIT ACC#, DEPT#, REF#
0,0,0,0,0 ENDS INPUT
ENTRY #   1 ? 100,27,6,0,6
ENTRY #   2 ? 150,30,10,0,7
ENTRY #   3 ? 200,1,23,1,8
ENTRY #   4 ? 50,25,8,1,9
ENTRY #   5 ? 100,38,200,1,10
INVALID ENTRY REJECTED
ENTRY #   5 ? 100,38,1,1,10
ENTRY #   6 ? 0,0,0,0,0
SET PRINTER FOR LIST OF ENTRIES ?


JOURNAL ENTRIES MONTH # 12
==========================

ENTRY  $ AMOUNT   DEBIT        CREDIT       DEPT   REFERENCE
============================================================

    1     $100.00 DEPRECIAT.   MACHINERY      0           6
    2     $150.00 RENT         PAYABLES       0           7
    3     $200.00 SECURITIES   SOFTWARE       1           8
    4      $50.00 INVENTORY    RAW STOCK      1           9
    5     $100.00 SALARIES     SECURITIES     1          10
0 ENDS PROGRAM AND KILLS ALL ENTRIES
1-100 CORRECTS AN ENTRY
OVER 100 ENTERS THE ENTRIES INTO THE FILE ? 111
FILE : JJR77

JJR77 UPDATED
READY
```

Listing 9: Updated accounting sheet of the company's activities for November and December 1977, generated by ENTRY1.

person. Therefore, the salesperson's activities are placed in department 1: local sales. Listing 7 shows the budget input program BUD-IN1 (see also listing 8).

The budgets are coded like the journal entries and the file containing budget information is identical to the other actual data files, JJR76 and JJR77. For ease of entry, there are two options for entering budget data. One option allows us to add incremental amounts to existing budgets; the other allows for the entry of brand new absolute budget amounts. The amounts entered can be for one or more months. In our sample, the local sales department will be assigned specific budgets for:

1. $90 of software sales in November and December.
2. Inventory usage of $15 for both months.
3. November and December salary costs of $40.

These figures are entered into file BUD. The system, by asking for both read and write files, allows you to save as many versions of a budget as you desire. That ends the 1976 transaction.

No activity took place in our small business between January 1977 and October 1977. However, in November the following item is entered via the ENTRY1 program:

1. The proprietor receives $500 in cash for royalties.

This, as well as December's activity, is shown in listing 9. During December, the following journal entries are made for administration, department 0:

1. Depreciation of $100 is booked.
2. A rent liability of $150 is incurred.

The salesman's department 1 has the following activity:

3. $200 in software is sold for securities.
4. The software was written on $50 worth of raw stock.

```
0 TO TRANSFER YEAR TO YEAR ?1
FILE : JJR77
WHAT YEAR WAS THAT ? 1977
FILE : JJR76
WHAT YEAR WAS THAT ? 1976
DATE ? 12/31/77
GET PRINTER READY ?

BALANCE SHEET AS OF 12/31/77
                    1977      1976      DIFF =                    1977      1976      DIFF
=====================================================================================================
CASH              250.00    250.00       .00 = PAYABLES        -150.00       .00   -150.00
SECURITIES        100.00       .00    100.00 = TAXS PAY.           .00       .00       .00
RECEIVABLES       500.00       .00    500.00 = LOANS PAY.          .00       .00       .00
INVENTORY            .00       .00       .00 = OTHER PAY.          .00       .00       .00
OTHER                .00       .00       .00 =    C. LIAB.     -150.00       .00   -150.00
   C. ASSETS      850.00    250.00    600.00 =
                                             = DEBENTURES          .00       .00       .00
                                             = LT LOANS            .00       .00       .00
                                             = NOTES               .00       .00       .00
PLANT                .00       .00       .00 = OTHER LT            .00       .00       .00
MACHINERY         400.00    500.00   -100.00 =    L. LIAB.         .00       .00       .00
EQUIPMENT         200.00    200.00       .00 =
RAW STOCK            .00     50.00    -50.00 = STOCK $1PAR    -1000.00  -1000.00       .00
OTHER                .00       .00       .00 = R. EARNINGS     -300.00       .00   -300.00
   L. ASSETS      600.00    750.00   -150.00 =    EQUITY      -1300.00  -1000.00   -300.00
                                             =
TOT. ASSETS      1450.00   1000.00    450.00 =  TOT. LIA&E    -1450.00  -1000.00   -450.00

READY
```

Listing 10: Year end balance sheet for the JJR company and a comparison with the previous year.

```
10 DIMB(19),I(3,19,12),T$(440),D$(33),T(3,3,12),W(1,2),O$(44)
12 D$(1,33)='ADMINIST.  LOCAL SALESNAT. SALES '
15 LINE132
20T$(  1, 55)='CASH        SECURITIES RECEIVABLESINVENTORY  OTHER      '
30T$( 56,110)='PLANT       MACHINERY  EQUIPMENT  RAW STOCK  OTHER      '
40T$(111,165)='PAYABLES    TAXS PAY.  LOANS PAY. OTHER PAY. DEBENTURES '
50T$(166,220)='LT LOANS    NOTES      OTHER LT   STOCK $1PARR. EARNINGS'
60T$(221,275)='SERV. FEES ROYALTIES  ASSETS SOLDSOFTWARE   OTHER SALES'
70T$(276,330)='INVENTORY  ASSETS SOLDDEPRECIAT. OTHER      OTHER      '
80T$(331,385)='RENT        ELECTRIC   GAS        TELEPHONE  PUBLICATION'
90T$(386,440)='SUPPLIES   POSTAGE    TRANSPORT. SALARIES   OTHER      '
100 GOSUB1000\GOSUB1100
120 FORA=0TO2\READW(0,A),W(1,A)\NEXT
124 DATA0,4,5,9,10,19
126 O$(1,44)='TOTAL SALESCOST OF GS OTHER EXP. -PROF./LOSS'
130 FORA=0TO3
132 !'INCOME STATEMENT       '\IFA=3THEN138
134 T1=A\GOSUB1200\!D$(T1-10,T1),' DEPARTMENT'\GOTO140
138 !'TOTAL OF ALL DEPARTMENTS'
140 !'ITEM          ',\FORF=1TO12\!'  MON-',%2I,F,\NEXT
150 !'     TOTAL'\GOSUB1500
170 FORB=0TO2\C=W(0,B)\D=W(1,B)\FORE=CTOD
180 T1=E+20\GOSUB1200\!T$(T1-10,T1),' ',
190 FORF=0TO11\!%8F2,I(A,E,F),\I(A,E,12)=I(A,E,12)+I(A,E,F)
195 IFA=3THEN205
200 I(3,E,F)=I(3,E,F)+I(A,E,F)
205 T(A,B,F)=T(A,B,F)+I(A,E,F)
210 NEXTF\!%9F2,I(A,E,12)\NEXTE\T1=B\GOSUB1200\GOSUB1500
215 !O$(T1-10,T1),' ',
220 FORF=0TO11\!%8F2,T(A,B,F),\T(A,B,12)=T(A,B,12)+T(A,B,F)\NEXTF
230 !%9F2,T(A,B,12)\!''
235 FORF=0TO12\T(A,3,F)=T(A,3,F)+T(A,B,F)\NEXT
238 NEXTB\!''
240 !O$(34,44),' ',\FORF=0TO11
245 !%8F2,T(A,3,F),\NEXT\!%9F2,T(A,3,12)
247 FORF=1TO33\!' '\NEXT
250 NEXTA\END
1000 INPUT'FILE : ',F$\OPEN#0,F$\RETURN
1100 FORA=0TO19\READ#0,B(A)\NEXT
1110 FORA=0TO2\FORB=0TO19\FORC=0TO11
1120 READ#0,I(A,B,C)\NEXT\NEXT\NEXT\CLOSE#0\RETURN
1200 T1=(T1+1)*11\RETURN
1500 FORZ=1TO117\!'=',\NEXT\!''\RETURN
READY
```

Listing 11: INCOME1, a program designed to show assets and liabilities for any or all company departments over a 1 year period.

5. An invalid account number 200 is disallowed by the program.
6. $100 of securities is paid to the salesperson as salary.

Listing 9 shows an update of the company's activities for 1977. In listing 10 the year end 1977 balance sheet is run and compared to year end 1976. Program INCOME1 (listing 11) is loaded and run. Listing 12a shows the administration account, listing 12b the local sales department, listing 12c is the consolidation of the three accounts (national sales, unused account in these examples, was not shown). This program requires as input only the data file's name.

Listings 14a and 14b show the budget program (BUD1) in action (see also listing 13). Since the file structure remains the same throughout, you can compare any quantities you like, and since all 12 months are stored on disk, any month can be printed. Like the 12 month income statement, all three departments and a summary can be produced.

The inputs for this program are:

1. MONTH: the particular month of the report.
2. ACT File: file name for the current data.
3. BUD File: file name for a budget or prior year's results that you want to compare to the current year's.
4. L.Y. File: last year's file name or any other file.
5. 0,0 for department 0.
   1,1 for department 1.
   2,2 for department 2.
   0,1 for departments 0 and 1.
   1,2 for departments 1 and 2.
   0,2 for departments 0, 1 and 2.
   0,3 for all departments and a summary.

About the Author

Joseph J Roehrig is currently manager of budgets, operations and engineering for the NBC Television Network. He was previously in charge of television network systems at NBC, during which time he worked with hardware configurations. Mr Roehrig is also president of JJR Data Research, a computer software service.

FILE : JJR77
INCOME STATEMENT
ADMINIST. DEPARTMENT

ITEM	MON- 1	MON- 2	MON- 3	MON- 4	MON- 5	MON- 6	MON- 7	MON- 8	MON- 9	MON-10	MON-11	MON-12	TOTAL
SERV. FEES	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
ROYALTIES	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	-500.00	.00	-500.00
ASSETS SOLD	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
SOFTWARE	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
OTHER SALES	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
TOTAL SALES	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	-500.00	.00	-500.00
INVENTORY	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
ASSETS SOLD	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
DEPRECIAT.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	100.00	100.00
OTHER	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
OTHER	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
COST OF GS	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	100.00	100.00
RENT	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	150.00	150.00
ELECTRIC	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
GAS	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
TELEPHONE	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PUBLICATION	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
SUPPLIES	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
POSTAGE	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
TRANSPORT.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
SALARIES	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
OTHER	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
OTHER EXP.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	150.00	150.00
-PROF./LOSS	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	-500.00	250.00	-250.00

Listing 12a: An example of a typical INCOME run, showing the yearly record for the administrative department of the JJR company for 1977.

INCOME STATEMENT
LOCAL SALES DEPARTMENT

ITEM	MON- 1	MON- 2	MON- 3	MON- 4	MON- 5	MON- 6	MON- 7	MON- 8	MON- 9	MON-10	MON-11	MON-12	TOTAL
SERV. FEES	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
ROYALTIES	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
ASSETS SOLD	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
SOFTWARE	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	-200.00	-200.00
OTHER SALES	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
TOTAL SALES	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	-200.00	-200.00
INVENTORY	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	50.00	50.00
ASSETS SOLD	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
DEPRECIAT.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
OTHER	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
OTHER	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
COST OF GS	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	50.00	50.00
RENT	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
ELECTRIC	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
GAS	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
TELEPHONE	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PUBLICATION	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
SUPPLIES	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
POSTAGE	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
TRANSPORT.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
SALARIES	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	100.00	100.00
OTHER	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
OTHER EXP.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	100.00	100.00
-PROF./LOSS	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	-50.00	-50.00

Listing 12b: An INCOME run for the JJR company's local sales department for 1977.

INCOME STATEMENT
TOTAL OF ALL DEPARTMENTS

ITEM	MON- 1	MON- 2	MON- 3	MON- 4	MON- 5	MON- 6	MON- 7	MON- 8	MON- 9	MON-10	MON-11	MON-12	TOTAL
SERV. FEES	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
ROYALTIES	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	-500.00	.00	-500.00
ASSETS SOLD	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
SOFTWARE	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	-200.00	-200.00
OTHER SALES	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
TOTAL SALES	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	-500.00	-200.00	-700.00
INVENTORY	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	50.00	50.00
ASSETS SOLD	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
DEPRECIAT.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	100.00	100.00
OTHER	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
OTHER	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
COST OF GS	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	150.00	150.00
RENT	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	150.00	150.00
ELECTRIC	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
GAS	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
TELEPHONE	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PUBLICATION	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
SUPPLIES	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
POSTAGE	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
TRANSPORT.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
SALARIES	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	100.00	100.00
OTHER	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
OTHER EXP.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	250.00	250.00
-PROF./LOSS	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	-500.00	200.00	-300.00

Listing 12c: An INCOME run for all departments for the JJR company in 1977.

```
10 DIMR(2,19,12),T$(220),D$(33),T(3,3,8),W(1,2),O$(44),I(3,19,7)
12 D$(1,33)='ADMINIST.  LOCAL SALESNAT. SALES '
15 LINE80
17 Z$='ACTBUDL-Y'
60T$(  1, 55)='SERV. FEES ROYALTIES  ASSETS SOLDSOFTWARE   OTHER SALES'
70T$( 56,110)='INVENTORY  ASSETS SOLDDEPRECIAT. OTHER      OTHER      '
80T$(111,165)='RENT       ELECTRIC   GAS        TELEPHONE  PUBLICATION'
90T$(166,220)='SUPPLIES   POSTAGE    TRANSPORT. SALARIES   OTHER      '
92 INPUT'MONTH ?',M\M=M-1
94 FORA1=1TO3\B=A1*3\!Z$(B-2,B),'   ',
95 GOSUB1000\GOSUB1100\A=A1
96 E=A+4\FORB=0TO2\FORC=0TO19\FORD=0TOM
98 I(B,C,E)=I(B,C,E)+R(B,C,D)
100 IFM=DTHENI(B,C,A)=R(B,C,D)
102 NEXTD\NEXTC\NEXTB\NEXTA1
106 FORA=0TO4STEP4\FORB=0TO2\FORC=0TO19
108 I(B,C,A)=I(B,C,A+2)-I(B,C,A+1)
110 NEXTC\NEXTB\NEXTA
115 INPUT'A DEPARTMENT #, SAME # OR 0,3 ? ',A1,A2
120 FORA=0TO2\READW(0,A),W(1,A)\NEXT
124 DATA0,4,5,9,10,19
126 O$(1,44)='TOTAL SALESCOST OF GS OTHER EXP. -PROF./LOSS'
130 FORA=A1TOA2
132 !'BUDGET STATEMENT'\IFA=3THEN138
134 T1=A\GOSUB1200\!D$(T1-10,T1),' DEPARTMENT'\GOTO140
138 !'TOTAL OF ALL DEPARTMENTS'
140 !TAB(26),'MONTH #',%3I,M+1,
141 !TAB(55),'YEAR TO DATE'
142 !'                  ===========================    ',
143 !                  '=============================='
144 !'ITEMS                VAR.     ACT.     BUD     L.Y.     VAR.',
146 !'     ACT.     BUD.     L.Y.'\GOSUB1500
170 FORB=0TO2\C=W(0,B)\D=W(1,B)\FORE=CTOD
180 T1=E    \GOSUB1200\!T$(T1-10,T1),' ',
190 FORF=0TO7\!%8F2,I(A,E,F),
195 IFA=3THEN205
200 I(3,E,F)=I(3,E,F)+I(A,E,F)
205 T(A,B,F)=T(A,B,F)+I(A,E,F)
210 NEXTF\!''\NEXTE\T1=B\GOSUB1200\GOSUB1500
215 !O$(T1-10,T1),' ',
220 FORF=0TO7\!%8F2,T(A,B,F),\NEXTF\!''
230 !''\FORF=0TO7\T(A,3,F)=T(A,3,F)+T(A,B,F)\NEXT
238 NEXTB\!''
240 !O$(34,44),' ',\FORF=0TO7
245 !%8F2,T(A,3,F),\NEXT\!''
247 FORF=1TO33\!' '\NEXT
250 NEXTA\END
1000 INPUT'FILE : ',F$\OPEN#0,F$\RETURN
1100 FORA=0TO19\READ#0,B\NEXT
1110 FORA=0TO2\FORB=0TO19\FORC=0TO11
1120 READ#0,R(A,B,C)\NEXT\NEXT\NEXT\CLOSE#0\RETURN
1200 T1=(T1+1)*11\RETURN
1500 FORZ=1TO80 \!'=',\NEXT\!''\RETURN
READY
```

Listing 13: BUD1, a program designed to give a more detailed picture of individual departments' performance than is found in the INCOME program (see listing 11).

```
MONTH ?11
ACT   FILE : JJR77
BUD   FILE : BUD
L-Y   FILE : JJR76
A DEPARTMENT #, SAME # OR 0,3 ? 1,1
BUDGET STATEMENT
LOCAL SALES DEPARTMENT
                       MONTH # 11                          YEAR TO DATE
              ==============================    ==============================
ITEMS          VAR.     ACT.     BUD     L.Y.     VAR.     ACT.     BUD.     L.Y.
==================================================================================
SERV. FEES      .00      .00      .00     .00      .00      .00      .00      .00
ROYALTIES       .00      .00      .00     .00      .00      .00      .00      .00
ASSETS SOLD     .00      .00      .00     .00      .00      .00      .00      .00
SOFTWARE     -90.00      .00   -90.00     .00   -90.00      .00   -90.00      .00
OTHER SALES     .00      .00      .00     .00      .00      .00      .00      .00
==================================================================================
TOTAL SALES  -90.00      .00   -90.00     .00   -90.00      .00   -90.00      .00

INVENTORY     15.00      .00    15.00     .00    15.00      .00    15.00      .00
ASSETS SOLD     .00      .00      .00     .00      .00      .00      .00      .00
DEPRECIAT.      .00      .00      .00     .00      .00      .00      .00      .00
OTHER           .00      .00      .00     .00      .00      .00      .00      .00
OTHER           .00      .00      .00     .00      .00      .00      .00      .00
==================================================================================
COST OF GS    15.00      .00    15.00     .00    15.00      .00    15.00      .00

RENT            .00      .00      .00     .00      .00      .00      .00      .00
ELECTRIC        .00      .00      .00     .00      .00      .00      .00      .00
GAS             .00      .00      .00     .00      .00      .00      .00      .00
TELEPHONE       .00      .00      .00     .00      .00      .00      .00      .00
PUBLICATION     .00      .00      .00     .00      .00      .00      .00      .00
SUPPLIES        .00      .00      .00     .00      .00      .00      .00      .00
POSTAGE         .00      .00      .00     .00      .00      .00      .00      .00
TRANSPORT.      .00      .00      .00     .00      .00      .00      .00      .00
SALARIES      40.00      .00    40.00     .00    40.00      .00    40.00      .00
OTHER           .00      .00      .00     .00      .00      .00      .00      .00
==================================================================================
OTHER EXP.    40.00      .00    40.00     .00    40.00      .00    40.00      .00


-PROF./LOSS  -35.00      .00   -35.00     .00   -35.00      .00   -35.00      .00
```

Listing 14a: A sample run of BUD1, showing a breakdown of activities for November 1977. ACT stands for actual, BUD for budgeted amounts, L.Y. for last year, and VAR for variance. VAR indicates the difference between the budgeted amount and the actual amount taken in or paid out. L.Y. indicates the amounts for the previous November and is included for reference only.

File Name	Starting Block	Size (in blocks)	Type (2 = program, 3 = data)
ENTRY1	22	10	2
ENTRY2	32	10	2
ENTRY3	42	10	2
LIST1	4	6	2
LIST2	10	6	2
LIST3	16	6	2
BAL1	52	10	2
BAL2	62	10	2
BAL3	72	10	2
JJR76	82	15	3
JJR77	97	15	3
INCOME1	112	10	2
INCOME2	122	10	2
INCOME3	132	10	2
BUD1	142	10	2
BUD2	152	10	2
BUD3	162	10	2
BUD	172	15	3
BUD-IN1	187	4	2
BUD-IN2	191	4	2
BUD-IN3	195	4	2

Table 1: Table of contents for the floppy disk showing the locations of all programs used in this accounting system.

Listing 14a shows the November results for local sales, and listing 14b shows the December results. A listing of the table of contents for the disk containing all of the accounting information is shown in listing 15. The data shown consists of file name, starting block, size in blocks and type (2 = program and 3 = data).

The file structure described earlier is fairly simple. Therefore, it is easy to add more programs to the system. The programs can calculate salaries, depreciation and accounts receivable, and enter this information directly into the data files. The account titles used in the programs are generally found in lines 20 to 90 and can be modified for other usages. The number of accounts can be easily expanded within the current 24 K programmable memory space by limiting the income statement subdivisions or by eliminating the monthly history. Quarterly type reports can also be added.

If you plan to enter these programs into your system, start with program LIST1. Most of the other programs can be formed by editing this particular program.■

```
MONTH ?12
ACT   FILE : JJR77
BUD   FILE : BUD
L-Y   FILE : JJR76
A DEPARTMENT #, SAME # OR 0,3 ? 1,1

BUDGET STATEMENT
LOCAL SALES DEPARTMENT
                        MONTH # 12                         YEAR TO DATE
              ==============================    ==============================
ITEMS          VAR.     ACT.     BUD     L.Y.     VAR.     ACT.     BUD.     L.Y.
==================================================================================
SERV. FEES      .00      .00      .00     .00      .00      .00      .00      .00
ROYALTIES       .00      .00      .00     .00      .00      .00      .00      .00
ASSETS SOLD     .00      .00      .00     .00      .00      .00      .00      .00
SOFTWARE     110.00  -200.00   -90.00     .00    20.00  -200.00  -180.00      .00
OTHER SALES     .00      .00      .00     .00      .00      .00      .00      .00
==================================================================================
TOTAL SALES  110.00  -200.00   -90.00     .00    20.00  -200.00  -180.00      .00

INVENTORY    -35.00    50.00    15.00     .00   -20.00    50.00    30.00      .00
ASSETS SOLD     .00      .00      .00     .00      .00      .00      .00      .00
DEPRECIAT.      .00      .00      .00     .00      .00      .00      .00      .00
OTHER           .00      .00      .00     .00      .00      .00      .00      .00
OTHER           .00      .00      .00     .00      .00      .00      .00      .00
==================================================================================
COST OF GS   -35.00    50.00    15.00     .00   -20.00    50.00    30.00      .00

RENT            .00      .00      .00     .00      .00      .00      .00      .00
ELECTRIC        .00      .00      .00     .00      .00      .00      .00      .00
GAS             .00      .00      .00     .00      .00      .00      .00      .00
TELEPHONE       .00      .00      .00     .00      .00      .00      .00      .00
PUBLICATION     .00      .00      .00     .00      .00      .00      .00      .00
SUPPLIES        .00      .00      .00     .00      .00      .00      .00      .00
POSTAGE         .00      .00      .00     .00      .00      .00      .00      .00
TRANSPORT.      .00      .00      .00     .00      .00      .00      .00      .00
SALARIES     -60.00   100.00    40.00     .00   -20.00   100.00    80.00      .00
OTHER           .00      .00      .00     .00      .00      .00      .00      .00
==================================================================================
OTHER EXP.   -60.00   100.00    40.00     .00   -20.00   100.00    80.00      .00


-PROF./LOSS   15.00   -50.00   -35.00     .00   -20.00   -50.00   -70.00      .00
```

Listing 14b: A similar breakdown for December 1977.

What's New?

PERIPHERALS

Disk Controller from Shugart

A microprocessor-based disk controller with on-board data separator logic capable of controlling up to four Winchester hard- or floppy-disk drives is available from Shugart, 435 Oakmead Pky, Sunnyvale CA 94086, (408) 733-0100. The SA1400 features automatic copying of disks, sector interleaving, error correction code autonomous to the microprocessor, and optional microdiagnostics. Data transfer between the controller and the host microprocessor is improved by sector buffering. The SA1400 is based on a bit-slice microprocessor and works with Shugart SA1000 8-inch and SA4000 14-inch Winchester drives and SA800/850 8-inch floppy-disk drives. Other functions include overlapped seek operations, integral data separators, automatic switching of head and cylinder, and optional track formats. Write precompensation is also included on the board. The Shugart standard floppy-disk protocol and either of the SA1000 or SA4000 fixed-disk protocols are used for the interface to the drive. A general-purpose interface is used to transfer commands and data between the host processor and the controller. In original equipment manufacturer's quantities, the SA1400 is $1125.

Circle 539 on inquiry card.

Drum-Type Graphics Plotter

Strobe Inc has introduced a drum-type graphics plotter with a 0.004-inch step size, and a 21.6 by 28 cm (8.5 by 11 in) paper capacity. The interactve digitizing mode allows the user to enter directly into the host computer X,Y coordinate data corresponding to pen location. The Model 100 plotter is controlled by the computer through two parallel output ports and one parallel input port. Hardware interfaces and software drivers are available for the Apple II, TRS-80, PET, and S-100 machines. An optional plot software package, providing vector generation and alphanumerics, that runs with most versions of BASIC and FORTRAN is also available. The price of the Model 100 plotter is $680. For details, contact Strobe Inc, 897-5A Independence Ave, Mountain View CA 94043, (415) 969-5130.

Circle 540 on inquiry card.

Ectype Floppy Disks from Syncom

The Ectype 8- and 5-inch floppy disks have a wear life exceeding 10 million passes for both hard- and soft-sector operations. The disks are 100% certified, and are made for IBM and non-IBM equipment with other formats available. Syncom also manufactures Ectype MC/ST magnetic cards and Ectype 3348-70 Data Modules. For more information, contact Bozell & Jacobs Public Relations, Butler Sq, 100 N 6th St, Minneapolis MN 55403, (612) 371-5500.

Circle 541 on Inquiry card.

DC 100A Tape Cartridge Drive

The Moya Corporation, located at 6311 DeSoto Ave, Unit H, Woodland Hills CA 91367, (213) 533-5993, has introduced the MicroDrive/OEM series of tape drives which offer up to 1.344 megabytes of storage in a package that measures 467 cubic cm (28.5 cubic inches). The transport is available with the mechanism-only board or the minimum-electronics board. Both models include a maximum data capacity of 1.344 megabytes, a transfer rate of 48 K bytes per second, read/write speed of 30 ips (inches per second), and search/rewind speed of 90 ips. The mechanism-only board contains the circuitry required to interface the transport mechanism. The minimum-electronics board provides a switching power amplifier to drive the motor, a digital interface on control and status lines, a write amplifier, and a read preamplifier. The units are $99 in original equipment manufacturer's (OEM) quantities.

Circle 542 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.

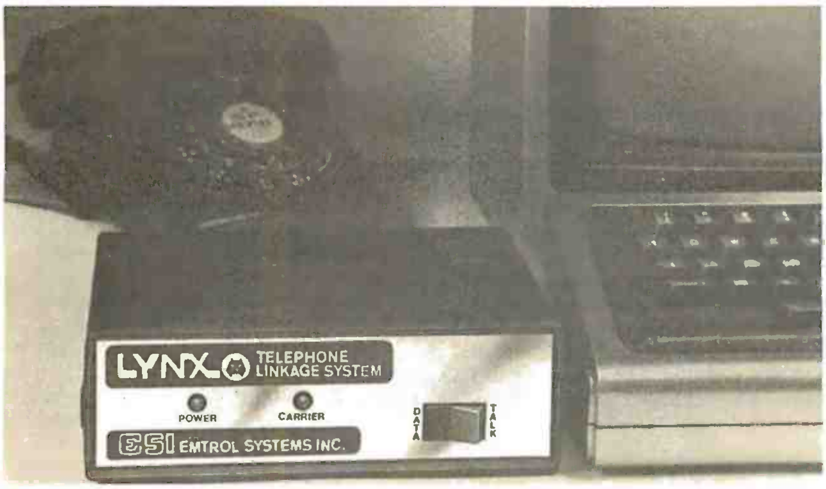
What's New?

PERIPHERALS

Vector Graphic's MP Printer

The Vector Graphic MP is a 5-by-7 dot-matrix, software-driven printer that can print at a speed of 150 cps (characters per second). The price of the MP is under $1000 from Vector Graphic Inc, 31364 Via Colinas, Westlake Village CA 91361, (213) 991-2302.

Circle 543 on inquiry card.



Direct-Connect Modem for the TRS-80

Emtrol Systems Inc, 1262 Loop Rd, Lancaster PA 17604, (717) 392-2105, has introduced Lynx, a direct-connect telephone modem for the TRS-80. Lynx connects with the TRS-80 keyboard and the telephone line—no acoustic coupler is used. It includes originate and answer capability, and is programmable for word length, parity, number of stop bits and full- or half-duplex. The minimum requirements are a TRS-80 Level I or II with at least 4 K bytes of programmable memory. The Lynx is priced at $239.95.

Circle 544 on inquiry card.

Coosol's Printer Kits

Coosol has announced the availability of its 40-column friction-feed and 80-column tractor-feed dot-matrix impact printers in kit or assembled-and-tested forms. The units are microprocessor-controlled and programmable with thirty-two system-level software commands. They feature graphics dot-plotting mode, ninety-six ASCII (American Standard Code for Information Interchange) characters with uppercase and lowercase, nine software-selectable sizes, reverse-font printing capability, parallel and serial interfaces, data rates from 110 to 9600 bps (bits per second), and adjustable tractor width for paper size selection. Prices for kits are $295 for the 40-column and $455 for the 80-column printer. Assembled and tested impact printers are $325 for the 40-column and $485 for the 80-column, both without enclosures. For further information, contact Coosol Inc, 1585-200 Adams Ave, Costa Mesa CA 92626, (714) 545-2216.

Circle 545 on inquiry card.

Music Synthesizer for the H-8 from Heath

The Heath Company has introduced a music synthesizer system for the H-8 computer. The HA-8-2 music synthesizer system includes a circuit board and software. The software allows the user to enter any song into the system from conventional sheet music. The synthesizer board, which connects to any stereo system with two shielded cables, produces a 27.5 to 6600 Hz frequency response with up to nine harmonics. An H-8 with at least 24 K bytes of memory, a floppy-disk drive, and video terminal are required. The HA-8-2 is priced at $159 from Heath Company, Benton Harbor MI 49022, (616) 982-3210.

Circle 546 on inquiry card.

Storage Control Unit for the TI990 Bus

The ISC 4000 supports up to four 14- or 29-megabyte Shugart Winchester disk drives. The unit will also support floppy-disk or high-density tape backup devices. Compatibility with Texas Instruments' TI990 software is maintained by emulating existing TILINE bus devices. A complete 29-megabyte system, including a floppy disk, sells for $7000 from Data Management Labs, 2148 Bering Dr, San Jose CA 95131, (408) 946-9424.

Circle 547 on inquiry card.

What's New?

PERIPHERALS

Speech Recognition Unit

The Heuristics 7000 speech recognition unit, which sells for approximately $3000, will interface with all RS-232 terminals. The 7000 enables users to enter information into their computers directly and with few errors. By eliminating the need for hand entry, busy businesspeople and the handicapped will benefit. The unit can recognize up to sixty-four words or phrases, each up to 3 seconds in length, and it is compatible with all common programming languages. It enables computers to take keyboard or voice input, or both simultaneously. The 7000 comes with a noise-cancelling headset microphone. Contact Heuristics, 1285 Hammerwood Ave, Sunnyvale CA 94086, (408) 734-8532.

Circle 548 on inquiry card.

Interactive Video

The Cavri III computer/video player integrator enables users to index and later access videotape frames or segments or to interact with videotaped materials. In addition to integrating computer-aided instruction with videotape, the system is useful for storage and retrieval of text and audio-visual information. The system also allows a user to control all remote functions of the video machine from the computer keyboard or from within a program. Access time to a desired point on a video cassette is less than 5 seconds. The average time required to find randomly distributed segments of tape on a 30-minute cassette is about 45 seconds. Search accuracy is ±7 frames.

The Cavri III consists of an Apple I/O (input/output) board, cables and connectors, systems software in Applesoft BASIC on disk, and a user's manual. It is available for video cassette recorders that carry a control pulse or that interface with manufacturers' search units. Users can convert already made videotapes, produce new tapes, or arrange to have Cavri produce materials. For information, contact Cavri Systems Inc, 26 Trumbull St, New Haven CT 06511, (203) 562-9873.

Circle 549 on inquiry card.

Floating-Point Board for the Apple

Increased speed is now available for the Apple II. The Computer Station Am9511 fast floating-point processor board plugs into the Apple II and relieves it of the task of doing transcendental functions in software. Instead, it uses a version of the standard floating-point BASIC, called Applefast, that allows the user to run existing programs without modifications. Taking 5000 square roots normally takes 250 seconds running Applesoft, but with Applefast it takes 15 seconds. Details can be obtained from Computer Station, 12 Crossroads, Granite City IL 62040, (618) 452-1860.

Circle 550 on inquiry card.

Reduce the Cost of Memory for the PET

The PH-001 2114 programmable memory adapter for the 2001-8 PET allows the use of lower-cost 2114 programmable memory integrated circuits to replace one to eight of the 6550's 1 K by 4 circuits used in the 8 K-byte PET. The board alone is $8.95, and the entire unassembled kit is $13.95, or $24.95 assembled. Contact Optimized Data Systems, POB 595, Placentia CA 92670, (714) 996-3201.

Circle 551 on inquiry card.

MSC-8100 Features Hard- and Floppy-Disk Storage

The MSC-8100 system incorporates an intelligent controller/formatter with a universal IEEE-488 bus protocol, a Winchester technology hard-disk drive with a 19.1-megabyte capacity, and a backup floppy-disk drive with a capacity of 1.6 megabytes per disk. The MSC-8100 is useful for word-processing and small-business applications. The average access time of the hard-disk drive is below 30 ms. The controller features a full-sector data buffer, error detection and correction, error recovery including automatic retry, automatic position verification, automatic seek to alternate track, parallel or serial interrupt, relative sector addressing, programmable sector interleaving, implied seeks, and more. Self-testing diagnostics are also provided. The MSC-8100 is priced at $9250. For information, contact Microcomputer Systems Corporation, 432 Lakeside Dr, Sunnyvale CA 94086, (408) 733-4200.

Circle 552 on inquiry card.

What's New?

MISCELLANEOUS

Pensée Pascal Computer

Computer Interface Technology's Pensée system is a stack-oriented, 16-bit computer with a dual floppy-disk subsystem capable of storing up to 2 megabytes. It features 64 K bytes of programmable memory; floating-point hardware; floppy-disk controller; 8-inch single- or double-sided, single- or double-density floppy-disk drives; two serial RS-232 asynchronous/synchronous ports; two unidirectional 8-bit parallel ports; and self-test diagnostics. Pensée utilizes the UCSD Pascal operating system version III.0, which includes the Pascal compiler, BASIC compiler, file manager, screen-oriented editor, and debugger. Some UCSD language extensions are also included. Prices range from $3500 to $9000, depending on peripheral subsystems. Obtain information from Computer Interface Technology, 201 W Dyer Rd, Santa Ana CA 92707, (714) 979-9920.

Circle 553 on inquiry card.

Peelings

Peelings is devoted exclusively to reviews of software for the Apple II and Apple II Plus microcomputers. Each bimonthly issue contains reviews of twelve to fifteen programs or software packages. Subscriptions are $15 from *Peelings*, Ed Burlbaw, 945 Brook Cr, Las Cruces NM 88001, (505) 523-5088.

Circle 554 on inquiry card.

The Flex-File System

The Flex-File is a nonglare vinyl page having pockets on each side to house two 8-inch floppy disks plus a center pocket to store 22 by 28 cm (8.5 by 11 inch) paper, computer printouts, or other documentation. The pages are three-hole punched for storage in standard three-ring binders. Flex-File pages are priced at $8.95 for a package of ten pages and are available from BIS Inc, POB 969, Brentwood TN 37027

Circle 555 on inquiry card.

Elementary Math Edu-Disk

The Elementary Math Edu-Disk contains an arithmetic-readiness test and four interactive lessons designed to teach elementary addition, subtraction, multiplication, and division, in nine skill levels. These lessons use color graphics and a computer-simulated voice to maintain student interest and reinforce basic concepts. The student's scores are maintained on disk and are accessible only through a special teacher's program. The system is self-demonstrating and is recommended for the student with no prior arithmetic experience, and as a supplement in higher-level remedial situations. The requirements for the program are an Apple II computer with 48 K bytes of programmable memory with Integer BASIC. The price for the program is $39.95, from Muse Software, 330 N Charles St, Baltimore MD 21201, (301) 659-7212.

Circle 556 on inquiry card.

What's New?

MISCELLANEOUS

Dust Covers for Computer Terminals

These dust covers are designed to protect video terminals, printers, and keyboards from dust and dirt. They are made of heavy-gauge clear plastic that will protect against water damage. The covers are custom made to fit any specific model of computer terminal, keyboard, or printer for all computer systems. When ordering, specify the system being used. The price for a cover for a video terminal including keyboard is $9.95. For a keyboard only, it is $8.95, and for a printer it is $9.95. For details, contact The Computer Accessories Company, 20 Boat Ln, Port Washington NY 11050, (516) 767-0366.

Circle 557 on inquiry card.

Burst-Error Processor from AMD

Advanced Micro Devices (AMD) has announced a general-purpose burst-error processor (BEP). This LSI (large-scale integration) device, the AmZ8065, can detect and allows correction of up to 12-bit burst errors in serial data streams moving at up to 20 million bps (bits per second). The codes implemented in the BEP include 48- and 56-bit polynomials used by IBM and 32- and 35-bit polynomials favored by minicomputer manufacturers. The BEP provides two read modes, normal and high-speed, that determine the correction methodology if an error is found. The AmZ8065 user can select the correction method based on the Chinese Remainder Theorem. This method computes the error location and the correction needed. The BEP employs a reciprocal polynomial that approaches the data stream from the check-bits side. This reduces worst-case correction time to the length of the data stream. The device accepts data as serial bytes which allows a single-phase clock requirement of 2.5 MHz. It operates from a single +5 V supply and comes in a 40-pin integrated circuit. Prices start at $69 each in one hundred-unit lots. Contact Advanced Micro Devices Inc, 901 Thompson Pl, Sunnyvale CA 94086, (408) 732-2400.

Circle 560 on inquiry card.

Accounts Receivable Program for the TRS-80

Radio Shack has an accounts receivable system for use on the TRS-80 Model I. Accounts receivable provides end-of-month billing, statements ready for mailing, automatic customer-record updating, totals for general ledger posting, optional message lines on billing statements, and full accounts receivable analysis including activity status, and more. Reports printed by this system are complete transaction file report, general ledger recap report, complete accounts listing, account listing by activity status, accounts receivable analysis by activity status, and posting report. A Model I Level II system with 16 K bytes of programmable memory, plus an expansion interface with at least 16 K bytes of programmable memory, an 80-column printer, and a minimum of two disk drives are required. The accounts receivable system is priced at $149.95 from Radio Shack dealers and stores.

Circle 558 on inquiry card.

Computer/Typewriter Interface

The I/O Pak from Rochester Data consists of an array of coils positioned in the same pattern as a typewriter's keyboard, in a unit that fits directly over the keyboard. These coils are wired into an electrical decoding matrix. The I/O Pak is designed to generate hard copy directly from a computer through any electric typewriter with a powered carriage return. No modification to the typewriter is required, and all adjustments to compensate for different key heights are incorporated in the I/O Pak. Available options include interfaces and software for the TRS-80 Level I and II, the Apple II, and a 6-bit parallel interface for general operation with other computers. Centronics-compatible and PET interfaces are also available. The I/O Pak retails for $469; the interface board and power supply required for packaged operation are priced at $145. Contact Rochester Data Inc, 3100 Monroe Ave, Rochester NY 14618, (716) 385-4338.

Circle 559 on inquiry card.

OKI 4 K Static Programmable-Memory Integrated Circuits

OKI Semiconductor, 1333 Lawrence Expy, Suite 401, Santa Clara CA 95051, (408) 984-4840, has introduced the MSM 2114L series of 4 K static programmable memory integrated circuits. The MSM 2114L, MSM 2114L-2, and MSM 2114L-3 are n-channel silicon-gate MOS (metal-oxide semiconductor) circuits that use fully static circuitry which does not require clocks or refreshing. The circuits are interchangeable with all standard 2114L parts and feature TTL-compatible (TTL is transistor-transistor logic) I/O (input/output), and a single +5 V power supply. They feature maximum access times of 200 ns for the 2114L-2, 300 ns for the 2114L-3, and 450 ns for the 2114L, and maximum power dissipation of 370 mW. Prices are $5.45 for the 2114L, $5.65 for the 2114L-3, and $6.75 for the 2114L-2. These prices are for 100-unit quantities.

Circle 561 on inquiry card.

What's New?

MISCELLANEOUS

Model 460 Paper Tiger Printer from IDS

The Model 460 addition to the IDS Paper Tiger family of printers produces letter-quality printing at a speed of 160 cps (characters per second). It also provides high-resolution graphics capability and includes proportional character spacing and automatic text justification. The Model 460 is a dot-matrix printer that utilizes a horizontal and vertical dot overlay to achieve letter-quality printing. It can print in 80-, 96- and 132-column formats. Foreign and custom character sets are optional and up to four 96-character sets can reside in the 460 at the same time. Paper-handling features include pin-feed tractor drives. A microprocessor provides an automatic test of the printer's memory and electronics each time the power is turned on, and a full character-set print capability test. A 2 K-byte buffer allows the Model 460 to accept the contents of a 1920-character video screen. The 460 has a standard RS-232C serial interface as well as a Centronics-compatible parallel interface. Serial transmission rates from 110 to 9600 bps (bits per second) are switch selectable. The Model 460 costs $1295 from Integral Data Systems, 14 Tech Cir, Natick MA 01760, (617) 237-7610.

Circle 562 on inquiry card.

Aspen Ribbons

Aspen Ribbons has announced the addition of four cartridge ribbons to its line of ribbon products. Aspen now manufactures Hytype I and II ribbons in nylon and carbon. Aspen molds its own cartridges by injection. Colors and private labels are available. The company also has a Wang multistrike cartridge ribbon and Qume 2 and 3 multistrike ribbons. For additional information, contact Aspen Ribbons, 1700 N 55th St, Boulder CO 80301, (303) 444-4054.

Circle 563 on inquiry card.

Music Synthesizer for the Apple

The Juke Box is a music synthesizer designed for any 48 K-byte Apple using Applesoft BASIC. It can produce three simultaneous voices and one channel of white noise. Pitch, rhythm, tempo, attenuation, and envelope can be selected and controlled for each voice independently from the other channels. The synthesizer has a five-octave range. Each card has an on-board amplifier capable of directly driving an 8-ohm speaker. As many as six cards can be installed to generate a total of eighteen notes. Multiple boards can create stereophonic, quadraphonic, and polyphonic operation. The devices can be daisy-chained to create more voices per speaker. A graphics music editor is also provided so the music can be seen and heard as it is input and edited. The price for the Juke Box is $129.95. Contact American Micro Products Inc, 705 N Bowser, MS 107, Richardson TX 75080, (214) 238-1815.

Circle 564 on inquiry card.

What's New?

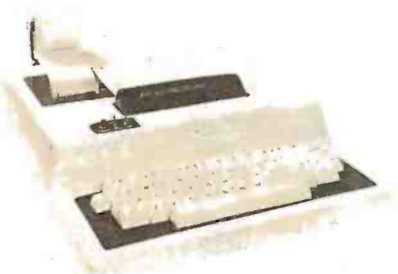
MISCELLANEOUS

OSI C1P Superboard II Modification Kit

The Super-Mod Kit provides a 48-character by 26-line video display and software selection of 300 or 1200 bps (bits per second) for cassette and RS-232 operation. The kit also provides an RS-232 port, start and stop control of the cassette, and doubling of system clock speed. Voice cuing and a listening function can be added. The kit contains all parts and documentation. Among the kit's contents are a regulated multiple-voltage power supply, a programmed monitor PROM (programmable read-only memory) compatible with all existing Ohio Scientific Instruments' functions and capable of formatting the video display with screen clear function callable under BASIC or assembly language, and sample programs. The price is $95 from A H Systems Inc, 9710 Cozycroft Ave, Chatsworth CA 91311, (213) 998-0223.

Circle 565 on inquiry card.

AIM-65 Enclosure



This enclosure is designed for the AIM-65 microcomputer. It is made out of high-strength ABS plastic and comes with mounting hardware, wire, and switches. All parts are pre-cut and drilled, and there is room for two additional boards. The color is white with a blue base. The enclosures are $49.95 plus $2.50 for shipping and handling. Contact Don-El Enterprises, 3261 Michigan Ave, Costa Mesa CA 92626, (714) 546-7481.

Circle 566 on inquiry card.

Modem Microphone from Novation

Super Mike was engineered specifically to eliminate data-distorting second harmonics. This Federal Communications Commission (FCC) registered microphone slips into your telephone handset, replacing the existing carbon microphone. The device eliminates the carbon granule packing problems that can cause a difference in reproduction level from telephone to telephone. Priced at $9.95, Super Mike is available from hobby stores, retail electronic outlets, and industrial distributors. For complete information contact Novation, 18664 Oxnard St, Tarzana CA 91356, (213) 996-5060.

Circle 567 on inquiry card.

The Nobus-Z

The Nobus-Z contains a 4 MHz Z80A microprocessor, the CP/M operating system, 64 K bytes of dynamic programmable memory, dual-density 8-inch floppy-disk drives with 600 K bytes per side, and a 6 K-byte color text and graphics feature. Console configurations range from a keyboard and television set to separate word-processing display terminals. A typical 70 K-byte system with 600 K bytes of disk storage costs under $3000. For more information, contact Exo Electronics Company, POB 3571, Culver City CA 90230, (213) 390-6527.

Circle 568 on inquiry card.

AIM-65 Expansion

The Memory-Mate, a 16 to 48 K-byte programmable-memory expansion board offers AIM-65 expansion for development system and process-control applications. The memory is assignable in 4 K blocks, with each of the blocks positionable anywhere in the system. The board also features full parity check circuitry and includes protection for AIM's 4 K on-board programmable memory. Another feature is programmable write protection in 4 K blocks. Four 8-bit bidirectional, 6522-type I/O (input/output) ports are included on the board. In addition, the board includes a programmable tone generator for audible warnings and sockets for up to 4 K PROM (programmable read-only memory). Price of the Memory-Mate with 16 K bytes of storage, connector to AIM, and manual is $475. Write AIM-Mate Series, Forethought Products, 87070 Dukhobar Rd, Eugene OR 97402, (503) 485-8575.

Circle 569 on inquiry card.

Floppy Disk Insurance?

Micro Lab has instituted a new plan for microcomputer users: Micro Lab Disk Insurance. The policy is being offered with the purchase of its Data Factory product line. The package is sold to the user with two locked versions of the master disk. If a master disk becomes damaged during the policy period, the policyholder may return the inoperative copy to Micro Lab for immediate free replacement. Users can switch to the backup master disk without any break in service. In addition, if an update in the program should occur, users will be notified, and the older versions will be revised at no cost. The policy sells for $17.50 per year. The Data Factory, a data-base management system, is offered in Applesoft and other forms. The program can run with one or two disk drives, but needs 48 K bytes with Applesoft in read-only memory. Information can be obtained by writing or calling Micro Lab, 811 Stonegate Dr, Highland Park IL 60035, (312) 433-7877.

Circle 570 on inquiry card.

The PMC-80—Compatible with the TRS-80

Personal Micro Computers Inc, 475 Ellis St, Mountain View CA 94043, (415) 968-1604, is offering a software- and hardware-compatible equivalent of the Radio Shack Model I, Level II TRS-80. The PMC-80 has a cassette tape recorder, 16 K bytes of programmable memory, Level II Microsoft BASIC interpreter in ROM (read-only memory), a power supply, computer, and keyboard. The system will display on either a television monitor or on a television set using a built-in VHF channel 3 modulator. All software available for the TRS-80 will operate in the PMC-80. Level II BASIC or SYSTEM cassettes will load in the PMC-80 without volume adjustments. All peripherals designed for the TRS-80 parallel port interface to the PMC-80 through an interface adapter available from the company. The price for the PMC-80, according to the manufacturer, is about $200 less than a comparably equipped TRS-80.

Circle 571 on inquiry card.

MISCELLANEOUS

Multibus-Compatible Multimemory Board

A Multibus-compatible memory module that can accommodate industry-standard ROMs (read-only memory), EPROMs (erasable programmable read-only memory), and static programmable-memory integrated circuits in any combination is available from Artec Electronics Inc, 605 Old County Rd, San Carlos CA 94070, (415) 592-2740. The board contains sockets and memory interface logic for up to sixteen twenty-four-pin memory devices. It can contain a maximum of 64 K bytes of EPROMs or 32 K bytes of static programmable-memory circuits. The board can operate with only one socket filled. Memory addresses are independently assigned for each socket with wire-wrap jumpers. Any multiple of 1 K bytes can be addressed within a 64 K-byte address space. Memory access time is wire-wrap selectable. The low-power interface circuitry contains inhibit logic for each of two banks of eight memories. The multimodule board can interface with any 8-bit Multibus-compatible microcomputer. The price of the board is $175, not including memory circuits.

Circle 572 on inquiry card.

Printer from Matchless

The MS-204 printer is compatible with the TRS-80, Apple, PET, or any Centronics-type system. This 132-column, bidirectional, 9-by-7 dot-matrix printer has a printhead life of 100 million characters. Among the features are a print speed of 125 cps (characters per second) and throughput print speed of 63 lines per minute. The adjustable sprocket feed mechanism allows the use of forms from 6.4 to 24 cm wide (2.5 to 9.5 inches), with loading from either the bottom or rear. Uppercase and lowercase characters are provided. The printer provides preprogrammed and programmable tab postions, and top of form and bottom of form functions. The retail price is $795 from Matchless Systems, 18444 Broadway, Gardena CA 90248, (213) 327-1010.

Circle 575 on inquiry card.

PDP-11 FORTH

This FORTH system runs on any PDP-11 or LSI-11 microprocessor and requires less than 24 K bytes of memory. The floppy disk contains an RT-11 directory with FORTH in Macro-11 source, with extensive comments; this source can be assembled and run under RT-11, or under RSX-11M, or stand-alone, with or without EIS. The disk is single-density, but will run on a dual-density drive under RT-11. PDP-11 FORTH implements the FORTH Interest Group (FIG) language model, with full-length names to 31 characters, and extensive compile-time checks. In addition, an editor, a FORTH assembler, and a string package in FORTH source, are included. The system on disk, the *PDP-11 FORTH User's Guide, A FORTH Primer, FORTH Introduction Reprints,* an installation manual, and an assembly listing comprise the entire system. The cost is $140 from John S James, POB 348, Berkeley CA 94701, (415) 526-8815.

Circle 576 on inquiry card.

Desk-Top Calculator with a Voice

The Model SP1260-D, a talking calculator from Canon, is expected to be used in general business offices, banks, brokerage houses, schools, hospitals and factories. The unit's speech synthesizer is used when the operator wants to check entries on the roll paper. The voice feature eliminates the need for two employees to check lists of numbers. The calculator can store up to 128 items of data, including the final result of the input. The SP1260-D incorporates the voice feature, a 12-digit capacity, memory for accumulating results, item counting, decimal point selection, and more, for $399. Contact Canon Calculator Division, Canon USA Inc, 10 Nevada Dr, Lake Success NY 11042.

Circle 573 on inquiry card.

All-CMOS Single-Board Microcomputer

Pacific Cyber/Metrix Inc, 6800 Sierra Ct, Dublin CA 94566, (415) 829-8700, has announced availability of an all-CMOS (complementary metal-oxide semiconductor) single-board microcomputer capable of plugging directly into the Intel-originated Multibus card cage. The PPS-1201 features a CMOS 6100 microprocessor, 4 K bytes of memory that can be configured as any combination of CMOS programmable memory and CMOS EPROM (erasable programmable read-only memory), a programmable real-time clock, memory expansion controller, three 12-bit-wide parallel ports, and a single serial port. Also included is a transparent 1 K-byte monitor and debugger plus a binary bootstrap for loading on-board programmable memory through the serial port. The 6100 microprocessor employs a binary instruction set identical to that of the Digital Equipment Corporation PDP-8 and VT-78 DECstation minicomputers, so software development can be carried out on any of these machines. The price for the 1201 is $995.

Circle 574 on inquiry card.

PUBLICATIONS

Report on Personal Computers Covers Trends, Systems, Software, and Vendors

Datapro Research Corporation's *All About Personal Computers*, traces the development of personal computers, discusses the future of the devices, and outlines how to buy a system. Also featured are reports on fifteen of the top personal computers, plus directories listing vendors of computers, software, peripherals, and publications. *All About Personal Computers* is available for $25 from Datapro Research Corporation, 1805 Underwood Blvd, Delran NJ 08075, (609) 764-0100.
Circle 577 on inquiry card.

Report on Voice Processing

The technologies of speech recognition and speech synthesis have been implemented into computer systems and have been employed in transportation, quality control, auto assembly, bank deposit transfer, and consumer products. In the April 1980 issue of *Data Entry Awareness Reports*, MIC (Management Information Corporation) discusses the voice-processing state of the art, its applications, and how to use it. This report is available to subscribers of *Data Entry Awareness Reports* or can be purchased separately by check for $15. Contact *Voice Processing Report*, Management Information Corporation, 140 Barclay Center, Cherry Hill NJ 08034, (609) 428-1020.
Circle 578 on inquiry card.

A Catalog from Wintek

A catalog containing information and specifications on Wintek's Sprint 68 development system/control computer with Wizrd multitasking DOS (disk operating system), macro editor, assembler, C compiler, 12 K BASIC, and 4 K industrial BASIC, is now available. The catalog also discusses alternatives for software development, Wintek's design and educational services, and cross software products. Contact Wintek Corporation, 1801 South St, Lafayette IN 47904, (317) 742-8428.
Circle 579 on inquiry card.

Computer Selection Handbook

Written specifically for small businesses and consultants, the *Computer Selection Handbook* presents a nontechnical method for selecting computer systems. This book concentrates on the practical and business aspects of choosing the right computer for your small business. The *Computer Selection Handbook* explains how to document small-business computer needs, solicit and evaluate vendor proposals, make the selection decision, and manage the installation and operation of the new system. The handbook is available directly from Decision Resources Corporation, 28203 Ridgefern Ct, Rancho Palos Verdes CA 90274, (213) 377-3533, for $35.
Circle 580 on inquiry card.

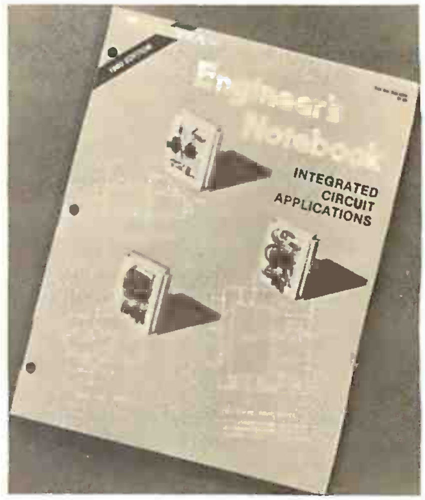
BASIC Training for Compucolor Computers

BASIC Training for Compucolor Computers, by Joseph J Charles, is intended for beginning users of the Compucolor II computer and is designed to serve as an introduction to Compucolor II BASIC. There are over 100 example programs and dozens of exercises in the book. The topics covered include the first steps of entering and listing programs, BASIC statements, functions, graphics, random-access files, flow-charting, subroutines, and more. The price of the book is $14.95, and it is available from Joseph J Charles, Dept B, POB 750, Hilton NY 14468.
Circle 581 on inquiry card.

Back Issues of Dr Dobb's Journal

Dr Dobb's Journal of Computer Calisthenics and Orthodontia: Running Light Without Overbyte, volumes 1, 2, and 3, are available from Hayden News. Almost everything from all issues of *Dr Dobb's Journal* for a particular year have been gathered into these volumes. They are priced at $18.95 each from Hayden Book Company, 50 Essex St, Rochelle Park NJ 07662, (201) 843-0550.
Circle 582 on inquiry card.

Archer Engineer's Notebook



Radio Shack has published a handbook of 415 electronic circuits for electronics hobbyists, experimenters, technicians, and engineers. Applications are included for most of the integrated circuits sold by Radio Shack. Dozens of problem-solving circuits are described. Tips and techniques for beginners are included. The book is divided into two major sections: digital and linear. It was compiled and hand-executed by Forrest M Mims III. The Archer *Engineer's Notebook* is available from participating Radio Shack stores and dealers for $1.99.
Circle 583 on inquiry card.

AIM-65 Newsletter from Rockwell

A newsletter for owners of AIM-65 microcomputers is available on a subscription basis from the Newsletter Editor, Rockwell International, POB 3669, RC55, Anaheim CA 92803, (714) 632-2321. *Interactive* responds to readers' questions, publishes articles by users, reports on the activities of AIM-65 users groups, and supplies articles on novel applications. The cost is $5 for six issues.
Circle 584 on inquiry card.

BITS Catalog

The fall issue of the BITS catalog is available. BITS is a distributor of computer publications located at 25 Rt 101 W, POB 428, Peterborough NH 03458, (603) 924-3356. This catalog features publications from BYTE, Osborne/McGraw-Hill, Scelbi, and others. The catalog is priced at $0.50.
Circle 585 on inquiry card.

What's New?

PUBLICATIONS

Health Planning Publication

Hapenney Associates has announced a publication entitled *Data Bits*. It is written for health planners, and is designed to coordinate the data and automation efforts of health planners within the 205 health-systems agencies and 51 state health planning and development agencies in the US. It examines technological advances in automated data processing that may affect health planners. Items of interest regarding happenings at the federal level are provided, as well as information regarding current activities of different agencies. *Data Bits* is published monthly. Subscriptions are available at $60 per year. Single issues are $5 per copy. Contact the Assistant to the Editor, POB 1076, Columbia MD 21044, (301) 596-0874.

Circle 586 on inquiry card.

User Ratings of Computer Systems

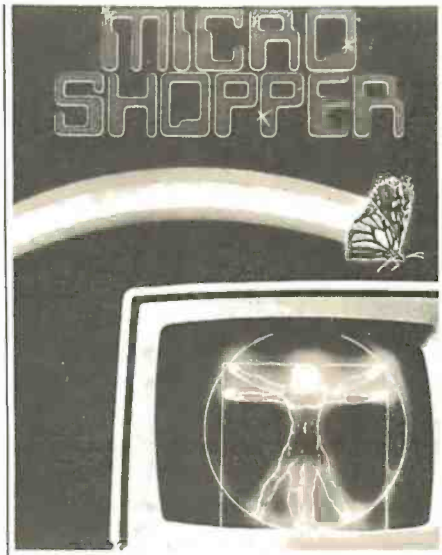
User Ratings of Computer Systems, from Datapro Research Corporation, 1805 Underwood Blvd, Delran NJ 08075, (609) 764-0100, details the results of a survey of 14,900 computer users that produced 4614 usable responses that provided ratings of 7871 installed systems from sixty-four vendors, along with information on applications, software, languages, problems, and future user plans. The survey covers personal computers, mainframes, minicomputers, and small-business computers. The report also includes summaries of ratings for various software applications, which languages are most commonly used on different systems and configurations, and how users felt about documentation for systems. Copies are available for $25.

Circle 587 on inquiry card.

Bulletin on DC-to-DC Power Supplies

A data sheet introducing a selection of thirty new 5 and 6 watt, DC-to-DC power supplies is available from Sola Electric, 1717 Busse Rd, Elk Grove Village IL 60007, (312) 439-2800. The low-profile switching converters are designed for printed-circuit board mounting. Specification charts provide basic technical data, operational and physical descriptions.

Circle 588 on inquiry card.



The MicroShopper Guide to Microcomputers

MicroShopper 80: The New Computers is a 192-page business and personal guide to microcomputer hardware and software, published by P G I Publishing, a division of The Phoenix Group, 1425 W 12th Pl, Tempe AZ 85281, (602) 967-1421. This fifth edition features photographs of microcomputer systems, peripherals and accessories, plus industry literature from more than 100 manufacturers representing over 500 products. It is designed for first-time computer users, consultants, dealers, and data-processing professionals. Definitions, explanations, and reviews of equipment are provided. *MicroShopper* is priced at $9.95 retail or $11 including postage and handling, direct from P G I.

Circle 589 on inquiry card.

TRS-80 Supply Catalog

The TRS-80 DOSHS (Directory of Software, Hardware, and Services) is designed to help users locate software, hardware, and support services for the TRS-80 microcomputer. The catalog contains hundreds of listings for S-100 adapters for the TRS-80, books, color-graphic units, TRS-80 units, consulting services, floppy disks, expansion interfaces, RS-232 interfaces, light pens, lowercase modification kits, magazines, newsletters, plotters, printers, rentals, repair services, speech synthesizers, and more. It is available for $6 from Pen-Ter Research, 9633 Rosehill Rd, Lenexa KS 66215.

Circle 590 on inquiry card.

International Directory of Software

The International Directory of Software is a one-volume directory featuring over 3200 independently marketed software products available from American and European suppliers. Each product is indexed within as many as five categories. Systems and applications software are listed in the directory under a total of 107 categories, including communications, compilers, data management, development aids, systems software for mainframes, systems software for microprocessors, utilities, accounting, administration, production and distribution, modeling, and other categories for various specialized applications software. Data on each product describes its date of origin, installed base, function, terms for purchase or leasing, operational mode, configuration requirements, and the names and addresses of suppliers worldwide. *The International Directory of Software* is priced at $140. Contact CUYB Publications Inc, First Federal Bldg, Suite 401, Pottstown PA 19404, (215) 326-5188.

Circle 591 on inquiry card.

The BOOK: Accessing the TRS-80 ROM, Volume I

The BOOK is the first of three volumes on machine- and assembly-language access to the Level II BASIC ROM (read-only memory) in the TRS-80 Model I microcomputer. This volume details the mathematic subroutines and data formats. A fully commented listing of these routines is provided. Included in the book is a memory map of the entire machine that provides descriptions of over 500 memory locations. *The BOOK* is available at computer stores or from Insiders Software Consultants, POB 2441, Springfield VA 22152, (703) 960-2998, for $14.95 plus postage and handling.

Circle 592 on inquiry card.

Catalog from OK Machine and Tool Corporation

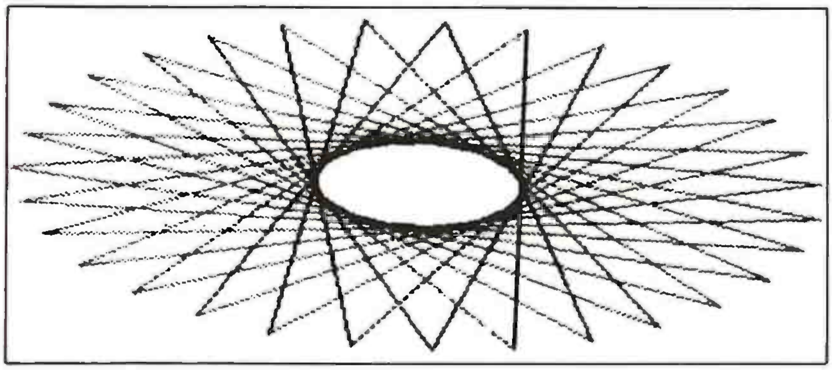
This catalog from OK Machine and Tool Corporation, 3455 Conner St, Bronx NY 10475, (212) 994-6600, features numerous wire-wrap tools and supplies, controllers, tape readers, circuit boards, and other items for homebrewers. A price list is also available.

Circle 593 on inquiry card.

What's New?

SOFTWARE

High-Resolution Package for the AIM-65



The MTU K-1009-1C Text/Graphics Printout program permits the AIM-65 to print text and high-resolution graphics without modifications to the computer or the printer. The contents of the AIM-65 text buffer are reproduced as ten lines of up to 127 characters per line. The display is created as a 320-by-200 dot matrix. The program provides the Quick Print mode that generates the image on one paper strip, and the Quality Print mode that generates the image as two 320-by-100 strips to be taped together. The program is priced at $25 from Micro Technology Unlimited, 2806 Hillsborough St, POB 12106, Raleigh NC 27605, (919) 833-1458.

Circle 594 on inquiry card.

Genealogy Program

AppleRoots is a genealogy software package that can be used for human or animal genealogy. It has seventeen user-definable fields. Functions include system initialization; record entry, change, delete; print index or records; print list of children, family records, or four-generation pedigree chart. All printer functions can be displayed on the screen or sent to the printer. All functions are menu-oriented and no programming is required to customize the system for personal use. The package is written in Applesoft and requires one disk drive and an Apple II with 24 K bytes of programmable memory. The system sells for $39.95 from Computer Data Systems Corporation, 695 E 10th N, Logan UT 84321, (801) 753-6990.

Circle 595 on inquiry card.

Educational Software

Educational Software, 801 E 6th Ave, Helena MT 59601, developers of educational software for the preschool thru eighth grade student, has announced a line of programs for the home-computer user. The programs provide positive feedback and cover a wide group of subjects for the young home-computer user. The programs measure the user's performance during each session and are designed for easy modification by the consumer.

Circle 596 on inquiry card.

XYBASIC Interpreter for 8080, 8085, and Z80 Systems

XYBASIC is a language designed specifically for measurement and process control. It offers the standard features of BASIC plus machine-language linking, software interrupts, and bit manipulation commands. Versions are available for SBC/80, CP/M, ISIS-II, Intellec 8 Mod 80, and MDS-800 systems. The nonstandard XYBASIC versions, with a patchable I/O (input/output), make the language adaptable for 8080, 8085, and Z80 sytems.

By allowing XYBASIC and the user's program to be placed in ROM (read-only memory), a program can be developed on the target system, put in ROM, and run. This eliminates the problems of floppy-disk program storage in hostile environments. XYBASIC options include a 9511 version utilizing the floating-point circuit, an EDIT version providing edit commands, an extended disk version for use with CP/M systems, and a real-time clock version for SBC/80s. XYBASIC is available in integer or extended forms. Versions start at $350. Custom versions can be made. For information, contact Mark Williams Company, 1430 W Wrightwood, Chicago IL 60614, (312) 472-6659.

Circle 597 on inquiry card.

Apple Users Gain Access to Dow Jones News and Stock Quotes

Apple Computer Inc, 10260 Bandley Dr, Cupertino CA 95014, (408) 996-1010, has introduced the *Dow Jones News and Quotes Reporter*, a software package that puts Apple users in touch with financial news. The program retrieves, displays, and optionally prints selected news stories from the *Dow Jones News Service*, the *Wall Street Journal*, and *Barron's* magazine, plus it can list price quotations for more than 6000 securities.

The user gains access through a telephone and modem, and, to access news stories, the user selects News Retrieval Service from the menu. Once a password has been verified, the user can select a news category or company, scan a list of headlines about it, and view the story. Stock quotes can be gained in the same way. The system will run on an Apple II or Apple II Plus with a minimum of 48 K bytes of programmable memory. Also required are a 16-sector format Apple Disk II with a controller, a modem, a video monitor, and a telephone. A printer is optional. Owners will receive $25 of connection time when they purchase the package, which retails for $95.

Circle 598 on inquiry card.

CP/M Advanced BASIC Compiler

This compiler, called the Topaz Compiler, produces a relocatable object file that is auto-linked with several libraries to produce a CP/M-compatible .COM file. Two types of floating points are available as well as integer and a fixed-point format. The compiler supports REPEAT...UNTIL, WHILE...DO, IF...THEN...ELSE, BEGIN...END, and CASE...OF techniques. All structured statements may be nested. The compiler supports double- and single-precision floating point, fixed-point packed binary-coded decimal, integer, string and character data types. Disk files may use a packed binary format or an ASCII (American Standard Code for Information Interchange) storage format. Any .COM file can be loaded and executed from control of a BASIC program. Commands can be executed under program control after the .COM file is finished. The price is $249.95 from Midwest Digital, 863 Wood Ave, Wichita KS 67212, (316) 721-1671.

Circle 599 on inquiry card.

What's New?

SOFTWARE

Symbolic Dissassembler for 6809 Computers

The 6809 symbolic disassembler is written for users of the 6809 microprocessor. DISASM6809 is reentrant, able to be put in ROM (read-only memory), and position-independent. It is called as a subroutine once for each instruction to be disassembled. All necessary parameters, including the address of the user's output routine, are passed in registers. The disassembler can produce alphanumeric symbols in both the label and operand fields. Invalid op codes are detected. The program requires under 2 K bytes of space and uses approximately 32 bytes of memory on the calling stack. Output format is syntactically identical to Motorola's assembly-language definition. DISASM6809 is available as a commented assembly listing with instructions for $25. Contact C R Bilbe, 6933 Cedarwood Cir, Colorado Springs CO 80918.

Circle 600 on inquiry card.

Order-Entry Software Package for Small Businesses

Order Entry will handle the documentation and control of purchasing and sales. The information from Order Entry can be processed through the accounts payable, accounts receivable, inventory control, and general ledger programs from Compumax, updating these modules to reflect purchase and sales activity. Order Entry includes generation and printing of purchase and sales orders, computation of tax and registration of deliveries against outstanding purchase orders and of shipments against outstanding sales orders, along with complete purchase and sales order history reports. The program is available in Micropolis 1053/II (48 K), Apple II, PET (DOS 2.0), and Microsoft under CP/M versions. For further information, contact Compumax, POB 1139, Palo Alto CA 94301, (415) 321-2881.

Circle 601 on inquiry card.

Microsoft BASIC Interpreter for the Z8000

BASIC-Z8000 is an interpreter for the 16-bit Z8000 microprocessor. This interpreter uses an expanded internal notation that takes advantage of the Z8000's 32-bit instructions. The accuracy of internal calculations is in excess of eight digits for single precision and eighteen digits for double precision. Variables are stored using the proposed IEEE (Institute of Electrical and Electronics Engineers) standards, allowing for a double-precision range of exponents from −308 to +308. BASIC-Z8000 is fully language-compatible with Microsoft's BASIC-80 and -86 interpreters, Release 5.0. Microsoft BASIC progams can be run on the 8080, 8086, Z8000 interpreters without modification. Evaluation copies of BASIC-Z8000 may be purchased for $350 (extended) or $600 (disk), from Microsoft, 10800 NE 8th St, Suite 819, Bellevue WA 98004, (206) 455-8080.

Circle 602 on inquiry card.

Be a BYTE Author

With BYTE's recent growth, we are now able to offer you more of the best articles and features about personal computing. Since much of the information in BYTE is supplied by you, the reader, you now have an even better chance to be a **paid** BYTE author. Our current needs include:

- Articles: BYTE is always looking for well-written articles that cover the field of microcomputing.
- Hardware/Software/System Reviews: BYTE is expanding its review of hardware, software, and computer systems. We are looking for detailed, comprehensive reviews as well as short (one- to three-page) reviews.
- Technical/Education/Languages Forums: These forums allow readers to take a stand on various issues or to clarify points made in the magazine.
- Programming Quickies: Do you have a program you'd like to share as a Programming Quickie? Send it in with a page or two of explanation.
- Systems Notes, a new feature, is devoted to sharing both hardware and software tips and techniques that you've found useful for any microcomputer brand or homebrew design. We will pay $20.00 for short submissions and the standard BYTE rate for articles that are one typeset page or longer.

We are interested in material about the Apple, Radio Shack TRS-80, Commodore PET/CBM, Exidy Sorcerer, Atari, Ohio Scientific, Compucolor, Microsoft BASIC, CP/M, and S-100-bus computers, as well as other computer brands and homebrew designs. Undocumented information about a particular computer (eg: machine-language routine entry points) is also useful.

General Format and Treatment

All submissions, including letters and other nonpaid material, should be typed, double spaced, and on white paper. All listings should be computer printouts using a fresh ribbon and unlined white paper only. (Look closely at your printout to make sure that the typeface is as dark and solid as possible so that we can photo-reproduce it for the magazine printing.) Cassette tapes or 5-inch floppy disks are acceptable, as are 8-inch CP/M floppy disks. No unused submissions can be returned without a self-addressed envelope and sufficient postage.

We will accept or reject each submission within three months of receipt, four months for articles. Full payment for short submission or advance partial payment for articles and larger submissions will be sent with the letter of acceptance. Completing payment for articles and longer submissions will be sent at the time of publication. Standard BYTE payment, except where noted above, is $50 per magazine page of material.

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70 Main St
Peterborough NH 03458

What's New?

SOFTWARE

Civil Engineering Package

The USA Civil Engineering package from Universal Software Applications Inc, 13001 Cannes Dr, St Louis MO 63141, (314) 878-1277, consists of three independent programs. The first is the USA COGO Civil Engineering Coordinate Geometry program that can be used for right of way surveys, highway design, bridge geometry, interchange design, construction layout, airport design, and other applications. Some of the COGO commands included are distance, locate/azimuth, locate/bearing, inverse/azimuth, points/intersect, azimuth/intersect, arc/line/points, arc/arc/intersect, area, simple/curve, and deflection/LS.

The second program is available for roadway design or subdivision design; it is entitled the USA Earth Design Earthwork Quantities program. It features independent input files for vertical curve, existing ground, proposed section, and design requirements files. Output is by section and includes the station, elevation of profile grade, assumed factors for cut and fill, area, volume and accumulated volume.

Finally, there is the USA Stress Structural Engineering Systems Solver which performs linear analysis of elastic, statically-loaded plane-framed structures. Structure, number of joints/members/loadings, joint coordinates, member incidences and properties, loading, member and joint loads, tabulate, solve, and stop, and a host of other commands are included. Output consists of the input structure data for each loading condition, the horizontal, vertical, and rotation components of deflection at each joint, the axial forces, shear forces, and moments at the ends of each member or optionally at interior points. The programs will run on Z80, 8080, and 6502 systems with a minimum of 32 K bytes of memory. The one-time lease price is $1000 for individual programs, $2250 for all three programs, and $1750 for any two.

Circle 603 on inquiry card.

Apple II Statistical Program

Rosen Grandon Associates has announced A-STAT 79, a general-purpose statistical package for the Apple II. The system is a subset language of the P-STAT 78 package for mainframe computers. The program can have as many as forty-five variables for each of 2000 cases. A-STAT is designed for market research, survey analysis, social and economic modeling, simulations, or teaching statistics. Statistical procedures include file definition and descriptive statistics, frequency distributions, bivariate frequency distributions, the ability to create square correlation matrices, multiple regression and path analysis of linear combinations of variables, permanent file modification, variable transformations, and descriptive statistics file production, and more. A-STAT runs on the Apple II or Apple II Plus systems with 32 K bytes of memory and Applesoft in ROM (read-only memory), or 48 K bytes and Applesoft software. One or more floppy-disk drives are required. It is priced at $100 from Rosen Grandon Associates, 296 Peter Green Rd, Tolland CT 06084.

Circle 604 on inquiry card.

COBOL for the TRS-80

Radio Shack COBOL can make the TRS-80 Model II compatible with many existing COBOL programs, including some written for mainframe computers. This development system offers multikey ISAM (index sequential-access method) files. Features include a one-pass compiler, full screen formatting, full ANSI (American National Standards Institute) Level 2 I/O (input/output), program linkage, and segmentation. The Radio Shack COBOL development system, with a reference manual, user's guide, sample program, and floppy disk is priced at $299 from participating Radio Shack stores and dealers, and Radio Shack Computer Centers.

Circle 607 on inquiry card.

polyFORTH-CP/M

polyFORTH-CP/M from FORTH Inc can run on nearly any 32 K-byte or larger CP/M-based system. The program resides on a CP/M floppy disk as a command file. When loaded, it finds and links up to the CP/M I/O (input/output) drivers, initializes itself, and responds "up" on the system console. The program runs in place of CP/M, utilizing only the CP/M I/O drivers. FORTH Inc's 8080 polyFORTH system on a floppy disk and a manual containing the interface material are provided. A CP/M utility that allows transferring polyFORTH blocks to a CP/M file and transferring a CP/M file to polyFORTH blocks is also provided. Source code is supplied for the entire system. polyFORTH-CP/M is available from M & B Design, 820 Sweetbay Dr, Sunnyvale CA 94086, (408) 243-0834, for $4750.

Circle 608 on inquiry card.

Inventory-Control System for Cromemco Computers

Feith Software has announced the release of its inventory-control system for manufacturers, wholesalers, and retailers. It is designed to run on any Cromemco- or CP/M-compatible system having dual floppy-disk drives, 48 K bytes of programmable memory, and a 132-column printer. It features parts explosions of finished goods and assemblies, automatic generation of pull sheets, and it will remove parts from stock after a production run. A full audit trail of inventory transactions is maintained. The capacity of the system on a double-density 8-inch floppy disk is over 2000 inventory items and 2000 transactions per disk. Reports are provided for economic order quantities, reordering, ABC analysis, and stock status. The package comes on an 8-inch floppy disk, with a manual and program listings for $250. For details, contact Feith Software, Cedarbrook Hills A-1103, Wyncote PA 19095, (215) 887-9780.

Circle 605 on inquiry card.

Z8000 Software from Hemenway

The RAZ8002ML resident assembler, which includes the LINKZ8002 linking loader, comprises a two-pass macroassembler and a one-pass linking loader. They are designed to run under Hemenway Associates Inc (located at 101 Tremont St, Suite 208, Boston MA 02108, (617) 426-1931) HA-CP/Z8000 operating system in a 32 K-byte system. The RAZ8002ML has full macroassembler facilities and conditional assembly of up to eight nested levels. It produces a listing and a sorted-symbol table that generates relocatable and linkable object code. The program uses a hash-coded symbol table and binary search of the mnemonic table, and it allows separately assembled routines to share data for production of programs suitable for ROM (read-only memory) circuits. All Zilog-defined op codes are recognized, and a set of pseudo-operation instructions is included. The program is priced at $350.

Circle 606 on inquiry card.

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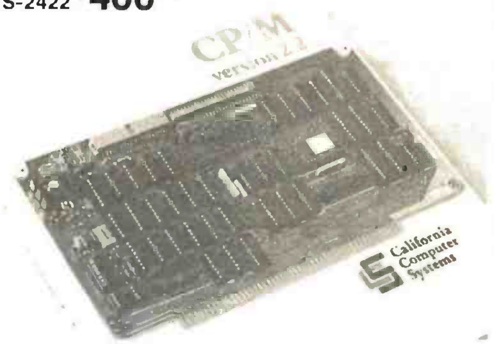
California Computer Systems

CCS-2422 $400.00



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Drive Compatibility
Interfaces to both 5.25" and 8" double- and single-sided drives in any combination up to four drives total. Is bus-compatible with Shugart and Memorex 5.25" and 8" drives and can be made compatible with a wide variety of soft-sectored drives. For voice coil drives, fast seek operation can be either software or hardware enabled.

Disk Controller Chip
Uses the powerful Western Digital 1793 disk controller chip. This chip provides IBM-compatible single and double density formatting, performs the read data separation, provides comprehensive track and sector status information, etc.

Bank Select
Can be hardware-assigned to one of eight banks. Bank then software-selected by outputting bank select byte to port 40h. Bank-select system can be disabled entirely or just at power-on and reset so that board comes up enabled.

On-board ROM
Comes with on-board 2K EPROM containing both monitor firmware and a bootstrap loader for loading CP/M from disk. Board can be configured to either load in CP/M on system, system power-on and reset or on a monitor command. After CP/M is loaded, monitor and bootstrap loader are disabled. The monitor firmware contains routines for reading and writing to/from disks, for dumping, moving, and changing memory, etc. ROM, when selected, generates the PHANTOM line for memory overlay. ROM's selection handled by address decoding ROM.

Accessible Registers
Internal to the 1793 are the Command, Status, Track, Sector, and Data registers. External are the board Control/Status registers 1 and 2. Control registers allow software specification of double or single density formatting, drive size, disk side, drive number, etc. Decoding of register addresses handled by ROM; optional ROM available for memory mapped I/O.

Wait State Generation
Software-enabled Auto Waits allow 2422 to force the CPU into a Wait state when data register is busy during either a board status register read or a data register read/write. User can select which register access generates Auto Waits. Board can also be set to request one Wait state per cycle in which the ROM is selected, or if user's system supports this feature, per cycle in which the ROM is selected and the CPU is operating at 4 MHz.

On-board Read Clock Generation
On-board circuitry supplies the controller chip with the Read clock signal it needs to perform read data separation.

Write Precompensation
Write precompensation provided for double density formatting.

Power Supply
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Physical Description
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MMM-741-0	3M Scotch Double Density Diskettes (Box of 10)	$ 59.95
MMM-KS10	Diskette Storage Box	$ 4.50
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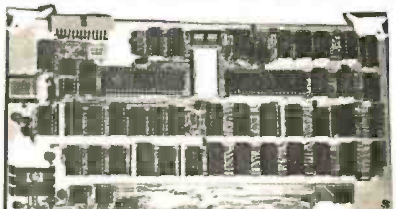

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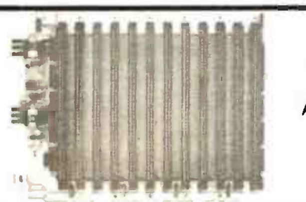
GBT-2024 AT 24K A&T	$539.00	$479.00
GBT-2032 UKT 32K UNKIT	$649.00	$598.00
GBT-2032 AT 32K A&T	$729.00	$649.00



SHIELDED/TERMINATED MOTHERBOARDS

A Must for Reliable System Operation!!!

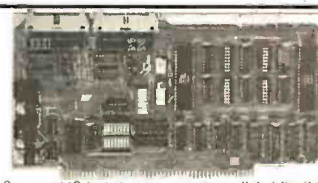
NEW

These are third generation micro-motherboards set up to exceed the latest S-100 specs. Designed with operation of the newest 5 to 10 MHz MPUs in mind — with any of these motherboards, you won't have to start from scratch when you want to upgrade your system from 2 or 4 MHz operation.

True active termination — with split termination — half of the termination load at each end of every buss line. Grounded Faraday shield between all buss signal lines to minimize cross-talk. Heavy duty power traces for minimal power loss. Power connectors supplied. All edge connectors & termination resistors supplied soldered to board in "UNKIT" versions. All sizes fit Godbout, Vector, IMSAI, TEI, etc. enclosures.

All boards are double sided fiberglass epoxy, G10/FR4, with plated through holes & solder mask on both sides. A parts legend on the component side makes assembly a snap.

	Reg.	Sale
GBT-CK024 UK 19 SLOT UNKIT	$174.00	$159.00
GBT-CK024 AT 19 SLOT A&T	$214.00	$189.00
GBT-CK025 UK 12 SLOT UNKIT	$129.00	$119.00
GBT-CK025 AT 12 SLOT A&T	$169.00	$149.00
GBT-CK026 UK 6 SLOT UNKIT	$ 89.00	$ 79.95
GBT-CK026 AT 6 SLOT A&T	$129.00	$119.00



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, Inter upt 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.

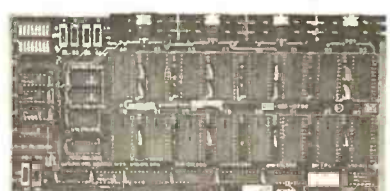
	Reg.	Sale
GBT - INTERFACER I UKT	$199.00	$189.00
GBT - INTERFACER I A&T	$249.00	$219.00

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

ECONOROM 2708



Has provisions for wait states for 4MHz operations. Configured as four 4K blocks - each independently addressable and disable-able. 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
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GBT - ECONORAM XIV A&T	$349.00	$298.00

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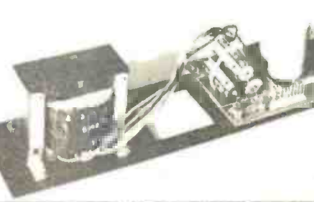

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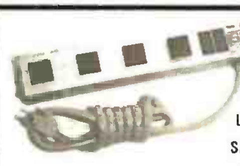

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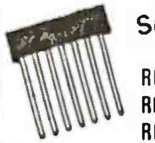

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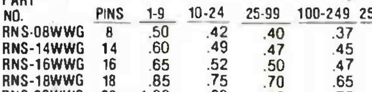

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RNS-14WWG	14	.60	.49	.47	.45	.42
RNS-16WWG	16	.65	.52	.50	.47	.44
RNS-18WWG	18	.85	.75	.70	.65	.60
RNS-20WWG	20	1.00	.90	.80	.75	.70
RNS-22WWG	22	1.25	1.15	1.10	1.05	1.00
RNS-24WWG	24	1.25	1.15	1.10	1.05	1.00
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P = Plug, Male Type - S = Socket, Female Type - C = Cover; Hood

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CND-DE9P	9 PIN MALE	$ 2.10	$ 1.90	$ 1.70
CND-DE9S	9 PIN FEMALE	$ 2.70	$ 2.40	$ 2.10
CNO-OE9C	9 PIN COVER	$ 1.50	$ 1.25	$ 1.10
CND-OA15P	15 PIN MALE	$ 2.75	$ 2.45	$ 2.15
CND-DA15S	15 PIN FEMALE	$ 3.95	$ 3.60	$ 3.20
CND-DA15C	15 PIN COVER	$ 1.50	$ 1.30	$ 1.10
CND-DB25P	25 PIN MALE	$ 3.50	$ 3.25	$ 3.00
CND-DB25S	25 PIN FEMALE	$ 4.60	$ 4.35	$ 4.20
CND-0B51212	1 PC. GREY HOOD	$ 1.60	$ 1.45	$ 1.30
CND-P25H	2 PC. GREY HOOD	$ 1.50	$ 1.25	$ 1.10
CND-DB51226	2 PC. BLACK HOOD	$ 1.90	$ 1.65	$ 1.45
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CND-0C37S	37 PIN FEMALE	$ 8.70	$ 7.70	$ 6.70
CND-DC37C	37 PIN COVER	$ 1.80	$ 1.55	$ 1.30
CND-DD50P	50 PIN MALE	$ 8.75	$ 7.75	$ 6.70
CND-D050S	50 PIN FEMALE	$11.65	$10.25	$ 8.90
CND-0D50C	50 PIN COVER	$ 2.00	$ 1.80	$ 1.60
CNO-020418	HARDWARE SET 2 PR.	$ 1.00	$ 0.80	$ 0.70
CNO-RS2328F	RS232, DB25P, EIA CLASS 1 CABLE 8 CON. 8FT.	$19.95	$17.95	$15.95
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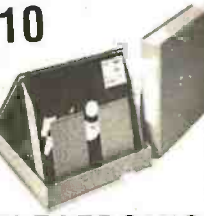

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SN7423N	.29	SN74156N	.89
SN7425N	.29	SN74157N	.89
SN7426N	.29	SN74158N	1.65
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74LS92N	.75	74LS290N	1.29
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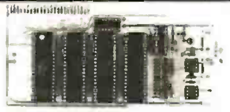

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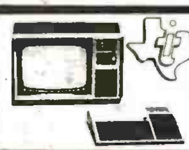

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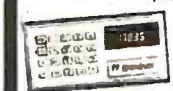

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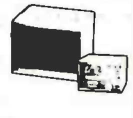

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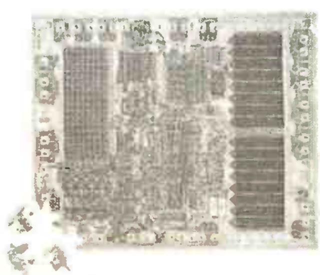

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2.4576 A	6.15030 B	10.8255 B	27.000 B	39.3128 B	43.1858 B	48.8768 B
2.500-A	6.29780 B	10.8386 B	27.0006 B	39.5038 B	43.2598 B	49.7006-B
2.6657-B	6.400 B	11.1360 B	27.6506 B	39.6668 B	43.3338 B	49.7338-B
2.9950 B	6.5536 B	11.155 B	28.4006 B	39.7538 B	43.3708 B	49.8128 B
3.000-A	6.72530 B	11.2186-B	28.6276 B	39.8768 B	43.4078 B	50.2505 B
3.067 B	6.75840 B	11.2890 B	28.7538 B	39.9628 B	43.4378 B	51.0556 B
3.200 B	6.9003 B	11.4776 B	29.8758 B	40.4448 B	43.4448 B	51.3128 B
3.2768 A	7.0063-B	11.6566 B	29.9378 B	40.5928 B	43.5558-B	51.7778 B
3.500-B	7.0336 B	11.6816-B	30.0648-B	40.8128 B	43.6298 B	51.8506-B
3.579 B	7.0916 B	12.440 B	30.3606 B	40.8336 B	43.6668-B	52.8128 B
4.000 B	7.1836 B	14.3182 B	30.6258 B	40.8758 B	43.7778 B	56.7506 B
4.1943 B	7.2586 B	14.4304 B	30.8768 B	40.8888 B	43.8128 B	60.6006 B
4.3426 B	8.000 B	15.000 B	31.4378 B	40.9258-B	43.8148-B	60.7508-B
4.4803 B	8.0556 B	15.4408 B	31.7538 B	41.0008-B	43.8518 B	66.7506 B
4.6103 B	8.1416 B	15.5066 B	31.9008 B	41.1666 B	43.8888 B	70.4006 B
4.6503 B	8.1818 B	16.000 B	32.000 B	41.3768-B	43.9258 B	75.0005 B
4.8303 B	8.3303-B	16.3848 B	33.2006 B	41.9378 B	44.0008 B	90.8338 B
4.9152 B	8.4998 B	17.2248 B	33.6258 B	42.0008 B	44.0378-B	99.9668 B
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5.0688-B	8.6056 B	18.000 B	34.7538 B	42.6268 B	44.7778 B	101.4668 B
5.1203 B	8.9608 B	18.4320-B	34.9776 B	42.7006 B	45.1256 B	103.0668 B
5.1850 B	8.9906 B	19.4690-B	35.9256 B	42.7538 B	46.3006 B	103.4668 B
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14	.14	24	.35
16	.16	28	.42
18	.27	36	.58
20	.29	40	.57

2 level 14 pin ww .20

WIRE WRAP LEVEL 3

PIN		PIN	
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16	.33	28	1.00
18	.57	40	1.23

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RCA Cosmac 1802 Super Elf Computer $106.95

Compare features before you decide to buy any other computer. There is no other computer on the market today that has all the desirable benefits of the **Super Elf** for so little money. The Super Elf is a small single board computer that does many **big** things. It is an excellent computer for training and for learning programming with its machine language and yet it is easily **expanded with additional memory, Full Basic, ASCII Keyboards, video character generation, etc.**

Before you buy another small computer, see if it includes the following features: ROM monitor; State and Mode displays; Single step; Optional address displays; Power Supply; Audio Amplifier and Speaker; Fully socketed for all IC's; Real cost of in warranty repairs; Full documentation.

The **Super Elf** includes a **ROM** monitor for program loading, editing and execution with **SINGLE STEP for program debugging** which is not included in others at the same price. With **SINGLE STEP** you can see the microprocessor chip operating with the **unique Quest address and data bus displays before, during and after executing** instructions. Also, CPU mode and instruction cycle are decoded and displayed on 8 LED indicators.

An RCA 1861 **video graphics** chip allows you to connect to your own TV with an inexpensive video modulator to do graphics and games. There is a **speaker system** included for writing your own music or using many music programs already written. The speaker amplifier may also be used to drive relays for control purposes.

A 24 key **HEX keyboard** includes 16 HEX keys plus **load, reset, run, wait, input, memory protect, monitor select and single step.** Large, on board displays provide output and optional **high and low address.** There is a 44 pin standard connector slot for PC cards and a 50 pin connector slot for the Quest Super Expansion Board. Power supply and sockets for all IC's are included in the price plus a detailed 127 pg. instruction manual which now includes over 40 pgs. of software info. including a series of lessons to help get you started and a music program and graphics target game. Many schools and universities are using the Super Elf as a course of study. OEM's use it for training and R&D.

Remember, other computers only offer Super Elf features at additional cost or not at all. **Compare before you buy. Super Elf Kit $106.95, High address option $8.95, Low address option $9.95. Custom Cabinet** with drilled and labelled plexiglass front panel **$24.95.** All metal Expansion Cabinet, painted and silk screened, with room for 5 S-100 boards and power supply **$57.00. NiCad Battery Memory Saver Kit $6.95.** All kits and options also completely assembled and tested.

Questdata, a software publication for 1802 computer users is available by subscription for $12.00 per 12 issues. Single issues $1.50. Issues 1-12 bound $16.50.

Tiny Basic Cassette **$10.00**, on ROM **$38.00**, original Elf kit board **$14.95. 1802 software;** Moews Video Graphics **$3.50.** Games and Music **$3.00**, Chip 8 Interpreter **$5.50.**

Super Expansion Board with Cassette Interface $89.95

This is truly an astounding value! This board has been designed to allow **you** to decide how you want it optioned. **The Super Expansion Board comes with 4K of low power RAM** fully addressable anywhere in 64K with built-in memory protect and a **cassette interface.** Provisions have been made for all other options on the same board and it fits neatly into the hardwood cabinet alongside the **Super Elf.** The board includes slots for up to 6K of **EPROM** (2708, 2758, 2716 or TI 2716) and **is fully socketed.** EPROM can be used for the monitor and Tiny Basic or other purposes.

A 1K Super ROM Monitor $19.95 is available as an on board option in 2708 EPROM which has been preprogrammed with a program loader/editor and error checking multi file cassette read/write software. (relocatable cassette file) another exclusive from Quest. It includes register save and readout, block move capability and video graphics driver with blinking cursor. Break points can be used with the register save feature to isolate program bugs quickly, then follow with single step. If you have the **Super Expansion Board and Super Monitor** the monitor is up and running at the push of a button.

Other on board options include **Parallel Input and Output Ports with full handshake.** They allow easy connection of an ASCII keyboard to the input port. **RS 232 and 20 ma Current Loop** for teletype or other device are on board and if you need more memory there are two **S-100** slots for static RAM or video boards. Also a 1K Super Monitor version 2 with video driver for full capability display with Tiny Basic and a video interface board. **Parallel I/O Ports $9.85, RS 232 $4.50, TTY 20 ma I/F $1.95, S-100 $4.50. A 50 pin connector set with ribbon cable** is available at $15.25 for easy connection between the **Super Elf and the Super Expansion Board.**

Power Supply Kit for the complete system (see Multi-volt Power Supply).

Announcing Quest Super Basic— *SECOND GENERATION*

A new enhanced version of **Super Basic** now available. Quest was the first company worldwide to ship a full size Basic for 1802 Systems. A complete function **Super Basic by Ron Cenker** including floating point capability with scientific notation (number range $\pm .17E^{38}$), 32 bit integer ± 2 billion; multi dim arrays, string arrays; string manipulation; cassette I/O; save and load, basic, data and machine language programs; and over 75 statements, functions and operations.

Enhancements include increased speed, built-in provisions for Stringy Floppy, Floppy Disc, Printer Driver, I/O, user definable command library and statement renumbering.

Easily adaptable to most 1802 systems. Requires 16K RAM minimum for Basic and user programs. Source listing for both Serial and Parallel I/O included.

Super Basic on Cassette $40.00.

PROM Eraser

assembled. 25 PROM capacity **$37.50** (with timer **$69.50**). 6 PROM capacity OSHA/UL version **$69.50** (with timer **$94.50**).

Z80 Microcomputer

16 bit I/O, 2 MHz clock, 2K RAM, ROM Breadboard space. Excellent for control. Bare Board **$28.50.** Full Kit **$99.00.** Monitor **$20.00.** Power Supply Kit **$35.00. Tiny Basic $30.00**

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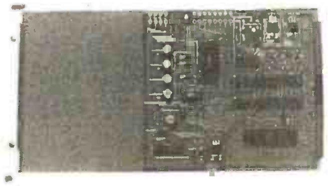

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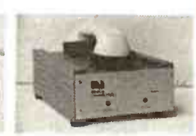

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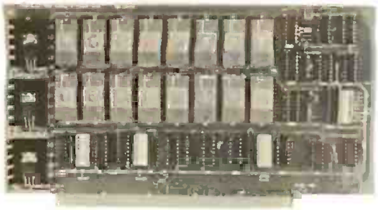

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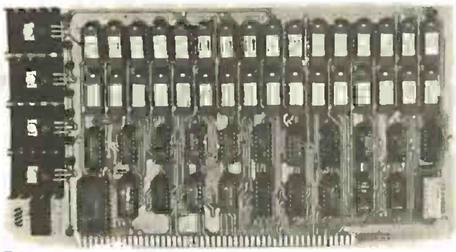

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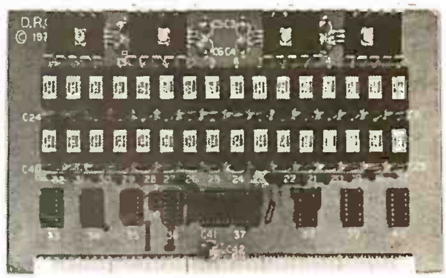

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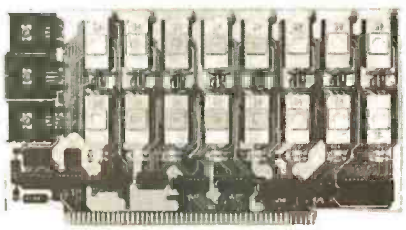

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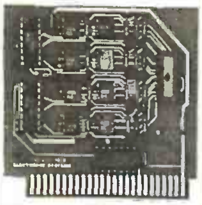

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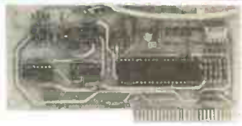

Baud rate is continuously adjustable from 0 to 30,000 • Plugs into any peripheral connector • Low current drain. RS-232 input and output • On board switch selectable 5 to 8 data bits, 1 or 2 stop bits, and parity or no parity either odd or even • Jumper selectable address • SOFTWARE • Input and Output routine from monitor or BASIC to teletype or other serial printer • Program for using an Apple II for a video or an intelligent terminal. Also can output in correspondence code to interface with some selectrics. • Also watches DTR • Board only $15.00 Part No. 2, with parts $42.00 Part No. 2A, assembled $62.00 Part No. 2C

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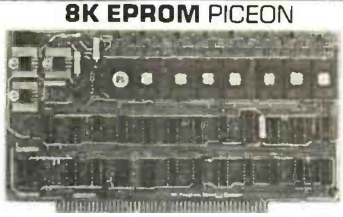

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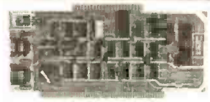

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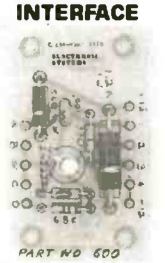

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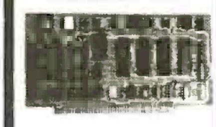

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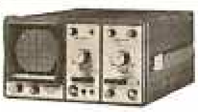

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Model	Vdc	Amps
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APS 12-4	12	5.0
APS 15-3	15	3.0
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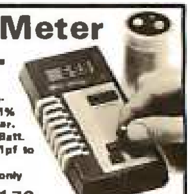

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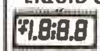

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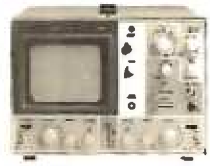

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Abbreviations: S/E Solder Eye . S/T Sold Tail: W/W Wire Wrap.

PART #	DESCRIPTION.	Row Sp.	1-9pc.	10-24pcs.	25pcs. Up.
BRAND: TEXAS INST.					
4070	50/100 Imsai/Crom.	.250	$3.95ea.	$3.55ea.	$3.15ea.
4090	50/100 Imsai W/W	.250	4.30ea.	3.65ea.	3.45ea.
BRAND: SULLINS: U.L Reg.					
129665	50/100 Solder Eye	.140	6.60ea.	6.10ea.	5.45ea.
129670	50/100 S/T Imsai	.250	4.50ea.	4.10ea.	3.70
129875	50/100 W/W Imsai	.250	5.25	4.75	4.20
129685	50/100 S/T Altair	.140	4.95	4.45	3.95
129990	50/100 S/T Cromem.	.250	4.75	4.25	3.80
OTHER .125" CONTACT CTR CONNECTORS:					
12305	22/44 S/E No Ears	.140	4.15	3.75	3.35
12759	36/72 S/T	.140	5.40	4.85	4.35
12790	40/80 W/W	.250	6.30	5.65	5.00
.100" CONTACT CTR CONNECTORS:					
10046	13/26 S/E No Ears	.140	3.40	3.05	2.15
10280	25/50 S/E TRS 80	.140	4.50	4.05	3.60
10175	20/40 S/E TRS 80	.140	5.85	5.35	4.75
10180	20/40 W/W TRS 80	.200	3.30	3.00	2.15
10190	20/40 S/T TRS 80	.140	3.20	2.90	2.55
10485	36/72 S/E Vector	.140	5.50	4.90	4.40
10490	36/72 W/E Vector	.200	5.80	5.25	4.65
10500	36/72 S/T Vector	.140	5.70	4.20	4.60
10535	40/80 S/E PET	.140	5.85	5.35	4.75
10540	40/80 W/W PET	.200	6.00	5.40	4.80
10550	40/80 S/T PET	.140	5.80	5.25	4.65
10585	43/86 S/E COS/ELF	.140	6.95	6.25	5.55
10605	43/86 S/T COS/ELF	.140	6.60	5.95	5.30
10595	43/86 W/W COS/ELF	.200	6.90	6.20	5.95
10615	43/86 S/T COS/ELF	.200	6.80	8.10	5.40

.156" CONTACT CENTER CONNECTORS.

PART #	DESCRIPTION.	Row Sp.	1-9pc.	10-24pcs.	25pcs. Up.
15105	6/12 S/E PET/NSC	.140	$1.80	$1.65	$1.45
15110	6/12 S/T PET/NSC	.140	1.65	1.65	1.50
15137	6/12 S/T PET/NSC	.200	1.60	1.54	1.45
15175	6/- S/E Sgle Row	- -	1.70	1.50	1.30
15270	10/20 S/E	.140	2.15	1.95	1.70
15275	10/20 S/T	.140	2.00	1.85	1.60
15435	12/24 S/E PET	.140	2.60	2.35	2.10
15440	12/24 S/T PET	.140	2.65	2.40	2.15
15445	12/24 S/T PET	.200	2.75	2.50	2.20
15505	15/30 S/E GRI Key	.140	2.50	2.25	2.00
15510	15/30 S/T GRI Key	.140	2.40	2.15	2.95
15515	15/30 W/W GRI Key	.200	2.60	2.35	2.10
15600	18/36 S/E	.140	3.35	3.05	2.70
15610	18/36 S/T	.140	3.00	2.70	2.40
15615	18/36 W/W	.200	3.60	3.20	2.90
15700	22/44 S/E KIM/VEC	.140	2.98	2.90	2.75
15705	22/44 S/T KIM/VEC	.140	3.98	3.30	3.00
15710	22/44 W/W KIM/VEC	.200	3.49	3.20	2.85
15875	25/50 S/E	.140	4.65	4.20	3.75
15880	25/50 S/T	.140	4.55	4.10	3.65
15885	25/50 W/W	.200	4.85	4.35	3.90
16115	36/72 S/E	.140	6.50	5.85	5.20
16120	36/72 S/T	.140	8.55	5.90	5.25
16125	36/72 W/W	.200	6.75	6.10	5.40
16145	36/72 S/T	.200	6.50	5.85	5.20
16235	43/86 S/T Mot 6800	.140	6.60	5.95	5.30
16240	43/86 W/W Mot 6800	.200	7.80	7.05	6.25
16260	43/86 S/T Mot 6800	.200	6.50	5.85	5.20
16725	43/86 S/E Mot 6800	.140	7.20	6.50	5.75
K-1	Pol-Keys		.15	.12	.10

'D' TYPE SUBMINIATURE CONNECTORS.

PART NUMBER		DESCRIPTION.	QUANTITY 1-9pcs.	10-24pcs.	25-99pcs.
DE	9P	Male	$1.60ea.	$1.40ea.	$1.30ea.
DE	9S	Female	2.25ea.	2.00ea.	1.90ea.
DE	110963-1	2 pc. Grey Hood.	1.50ea.	1.35ea.	1.20ea.
DA	15P	Male	2.35ea.	2.15ea.	2.00ea.
DA	15S	Female	3.25ea.	3.10ea.	2.90ea.
DA	51211-1	1. pc. Grey Hood	1.40ea.	1.20ea.	1.15ea.
DA	51226-1	2 pc. Black Hood	2.50ea.	2.25ea.	2.00ea.
DA	110963-2	2 pc. Grey Hood	1.60ea.	1.35ea.	1.30ea.
DB	25P	Male	2.60ea.	2.60ea.	2.40ea.
DB	25S	Female	3.60ea.	3.40ea.	3.20ea.
DB	51212-1	1 pc. Grey Hood	1.50ea.	1.30ea.	1.10ea.
DB	51226-1	2 pc. Black Hood	1.90ea.	1.65ea.	1.45ea.
DB	110963-3	2 pc. Gray Hood	1.75ea.	1.50ea.	1.35ea.
DC	37P	Male	4.20ea.	4.00ea.	3.70ea.
DC	37S	Female	6.00ea.	5.75ea.	5.50ea.
DC	110963-4	2 pc. Gray Hood	2.25ea.	2.00ea.	1.75ea.
DD	50P	Male	5.50ea.	5.10ea.	4.75ea.
DD	50S	Female	9.40ea.	8.60ea.	8.00ea.
DD	51216-1	1 pc. Grey Hood	2.40ea.	2.20ea.	2. 00ea.
DD	110963-5	2 pc. Grey Hood	2.60ea.	2.40ea.	2.10ea.
D	20418-2	Hardware Set (1 Hood Set)	.90ea.	.80ea.	.70ea.

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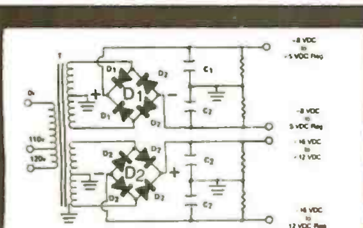

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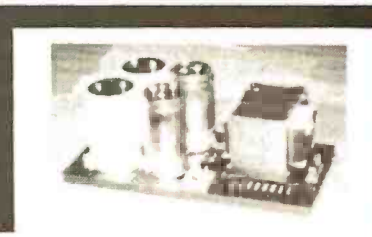

POWER TRANSFORMERS (WITH MOUNTING BRACKETS)

ITEM NO.	USED IN KIT NO.	PRI. WINDING TAPS	SECONDARY WINDING OUTPUTS 2×8 Vac	2×14 Vac	2×24 Vac	SIZE W×D×H	UNIT PRICE
T_1	1	0V, 110V, 120V	2×7.5A	2×2.5A	———	3¾"×3⅝"×3⅛"	21.95
T_2	2	0V, 110V, 120V	2×12.5A	2×3.5A	———	3¾"×4⅜"×3⅛"	27.95
T_3	3	0V, 110V, 120V	2×9A	2×2.5A	2×2.5A	3¾"×4⅜"×3⅛"	29.95
T_4	4	0V, 110V, 120V	2×4A	(28V, CT)	48V, CT, @3A	3¾"×3⅝"×3⅛"	22.95

POWER SUPPLY KITS (OPEN FRAME WITH BASE PLATE, 3 HRS. ASSY. TIME)

ITEM	USED FOR	@+8 Vdc	@−8 Vdc	@+16 Vdc	@−16 Vdc	@+28 Vdc	SIZE W×D×H	UNIT PRICE
KIT 1	15 CARDS SOURCE	15A	———	2.5A	2.5A	———	12"×6"×4⅞"	51.95
KIT 2	SYSTEM SOURCE	25A	———	3A	3A	———	12"×6"×4⅞"	58.95
KIT 3	DISC SYSTEM	15A	1A	2A	2A	4A	14"×6"×4⅞"	66.95
KIT 4	DISC SOURCE	8A	1A	*(SEE OPTION BELOW)		5A	10"×6"×4⅞"	49.95

EACH KIT INCLUDES: TRANSFORMER, CAPACITORS, RESIS., BRIDGE RECTIFIERS, FUSE & HOLDER, TERMINAL BLOCK, BASE PLATE, MOUNTING PARTS AND INSTRUCTIONS. *OPTION OF KIT 4: **REPLACE +28V @ 5A BY +16 @ 6A.**

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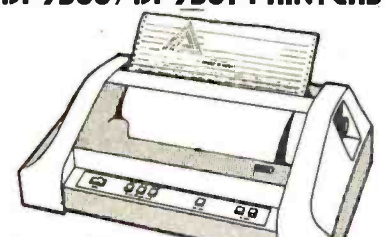
ANADEX
DP9500/DP9501 PRINTERS



$1650[00]

New from Anadex! Two low cost, high performance printers designed for all applications, including standard high-density graphics capability. Both models feature a 9 wire print head with an incredible life expectancy of 650 million printed characters! Full 96 character ASCII set with lower case descenders, double width printing, bi-directional with shortest distance sensing logic. Adjustable-width tractor feed, forms control, horizontal and vertical tabbing, and print up to five copies. Easy interfacing with parallel, RS-232 serial or current loop choices.

The DP9500 is the choice when you require mostly printing and occasional graphics. Select between a 9 x 9 character font and 132 columns, or a 7 x 9 font for 175 columns. Printer speed: 150/200 CPS. Wt. 35 lbs.

The DP9501 is mainly for graphics applications. The 11 x 9 character font produces superb graphics reproduction in 132 columns, and the 7 x 9 character font in 220 columns provides maximum graphics potential. Both models operate at 110VAC, and 220 VAC for European use. Wt 35 lbs.

Cat No. 2551 DP9500 printer
Cat No. 2552 DP9501 printer

74L$ Order by Cat No. 999 and Type

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74LS01	$ .29	74LS75	$ .59	74LS162	$1.19	74LS258	$ .66
74LS02	$ .49	74LS76	$ .44	74LS163	$1.15	74LS259	$1.99
74LS03	$ .29	74LS83	$ .88	74LS164	$1.15	74LS260	$ .66
74LS04	$ .49	74LS85	$1.15	74LS165	$1.69	74LS261	$2.50
74LS05	$ .35	74LS86	$ .99	74LS166	$3.95	74LS266	$ .66
74LS08	$ .44	74LS90	$ .59	74LS168	$1.29	74LS273	$3.25
74LS09	$ .29	74LS92	$ .75	74LS169	$3.33	74LS275	$4.95
74LS10	$ .44	74LS93	$ .75	74LS170	$2.25	74LS279	$ .49
74LS11	$ .29	74LS95	$ .88	74LS173	$1.25	74LS283	$1.75
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74LS22	$ .29	74LS123	$1.15	74LS193	$1.15	74LS367	$ .99
74LS26	$ .77	74LS124	$1.55	74LS194	$1.15	74LS368	$ .99
74LS27	$ .55	74LS125	$ .88	74LS195	$1.15	74LS373	$3.25
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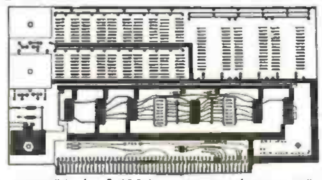
74LS32	$ .66	74LS138	$1.25	74LS221	$1.99	74LS378	$1.69
74LS33	$ .69	74LS139	$ .99	74LS240	$3.95	74LS386	$ .77
74LS37	$ .39	74LS145	$1.99	74LS241	$2.95	74LS393	$2.25
74LS38	$ .59	74LS147	$2.95	74LS242	$1.95	74LS395	$1.99
74LS40	$ .33	74LS151	$ .88	74LS243	$2.95	74LS399	$2.95
74LS42	$ .88	74LS153	$ .88	74LS244	$3.25	74LS424	$3.25
74LS47	$ .88	74LS154	$3.50	74LS245	$5.00	74LS670	$2.25
74LS48	$ .88	74LS155	$ .99	74LS247	$ .88	81LS95	$1.95
74LS51	$ .39	74LS156	$1.25	74LS248	$ .99	81LS96	$1.95
74LS54	$ .29	74LS157	$1.25	74LS251	$1.99	81LS97	$1.95
74LS55	$ .55	74LS158	$1.49	74LS253	$ .99	81LS98	$1.95
74LS73	$ .44	74LS160	$ .99	74LS256	$2.25		

TTL's Order by Cat No. 999 and Type

7400	$.35	7445	$ .77	74109	$ .55	74176	$ .79
7401	$.35	7446	$ .69	74116	$1.89	74177	$ .77
7402	$.35	7447	$ .66	74120	$ .99	74179	$1.88
7404	$.44	7448	$ .77	74121	$ .44	74180	$ .77
7405	$.44	7450	$ .20	74122	$ .50	74181	$1.88
7406	$.39	7451	$ .50	74123	$ .52	74182	$1.99
7407	$.39	7453	$ .50	74125	$ .52	74184	$1.99
7408	$.35	7454	$ .20	74126	$ .49	74185	$1.99
7409	$.35	7460	$ .29	74132	$ .69	74190	$1.19
7410	$.35	7470	$ .29	74141	$ .77	74191	$1.19
7411	$.39	7472	$ .29	74143	$3.33	74192	$ .77
7412	$.49	7473	$ .36	74145	$7.77	74193	$ .89
7413	$.44	7474	$ .49	74148	$1.29	74195	$ .69
7414	$.66	7475	$ .49	74150	$ .88	74196	$ .88
7416	$.45	7476	$ .38	74151	$ .59	74197	$ .88
7417	$.29	7479	$3.99	74153	$ .69	74198	$1.49
7420	$.35	7480	$ .50	74155	$ .49	74199	$1.49
7422	$.44	7481	$ .99	74156	$ .99	74221	$1.99
7423	$.44	7483	$ .59	74157	$ .63	74251	$ .77
7425	$.38	7485	$ .85	74160	$ .77	74273	$1.10
7426	$.39	7486	$ .35	74161	$ .79	74278	$2.95
7427	$.35	7489	$1.66	74162	$ .79	74279	$ .82
7430	$.35	7490	$ .44	74163	$ .88	74365	$ .69
7432	$.39	7491	$ .59	74164	$ .88	74366	$ .69
7437	$.39	7492	$ .45	74165	$ .88	74367	$ .69
8438	$.39	7493	$ .45	74166	$1.29	74368	$ .69
7440	$.20	7495	$ .65	74170	$1.59	74393	$2.50
7441	$.77	7496	$ .65	74173	$1.09	8T26	$2.50
7442	$.49	74100	$1.69	74174	$ .79	8T97	$2.25
7433	$.69	74107	$ .44	74175	$ .79		

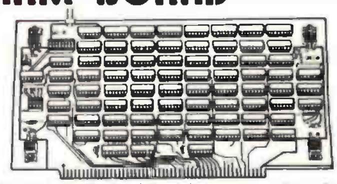
SSM OB1
VECTOR JUMP & PROTOTYPING CARD
$41.25*



Plug compatible for S-100 bus systems, features full 16 bit vector jump address with dip selection of 8080 or Z80. Can be set to jump on power-on-clear, reset, or both. Prototyping areas on the card for ten 16-pin IC's three 24-28 pin IC's and two spare regulator patterns.

*Cat No. 1429 OB1 kit	$41.25
Cat No. 1430 OB1 a & t	$85.00
Cat No. 1431 OB1 bareboard	$32.00

SSM MB6B
8K STATIC RAM BOARD



8K bytes by 8 bits, fully buffered, compatible with 8080, 8085, and Z80. Dip switch addressing of independant 4K halves lets the MB6B think like two 4K boards, or one 8K board. Independent 4K addressing allows the flexibility to meet varying software memory needs. Uses low power 21L02 RAM's, operates at 2 or 4MHZ, and is compatible with direct memory access controllers.

Cat No.	Description	Price
*1400-A	450ns kit	$135.00
*1400-B	250ns kit	$147.50
1401-A	450ns a & t	$209.00
1401-B	250ns a & t	$225.00
*1402	Bareboard	$ 23.75

GALACTIC TRILOGY
by BRODERBUND

GALACTIC EMPIRE

Your superior ability in planning, logistics and tactical maneuvering, along with building the manufacturing and military capabilities of the planets that you control, can bring the central galactic empire under one flag. A special "save" routine gives you the option storing a game in progress. Fun and educational!
Cat No. 2584 TRS-80 L2, 16K, cassette

GALACTIC TRADER

Gives you the opportunity to be a big time wheeler dealer. You will seek out the origins of various commodities, and buy cheap. You may then sell them at exhorbitant rates or barter for local goods. Your good business sense and level head allow you to out-think the sharpest business creatures in the galaxy! Ten levels of difficulty allow you to increase your skill without out growing the game.
Cat No. 2585 TRS-80 L2, 16K, cassette

GALACTIC REVOLUTION

In the final game of this galactic trilogy, you will be a diplomat and administrator of unequalled accomplishments. Your prowess at manipulation will decide if various power groups will be swayed to your side, and your military leadership will put the finishing touches on a successful revolution.
Cat No. 2586 TRS-80 L2, 16K, cassette

$11[95] each
All 3 for $29[95]

SOUNDING BOARD
for Apple II

Enter the world of microcomputer music and sounds! One board will turn your apple into a fine musical instrument and, in addition, produce sound effects which will spice up any program. Each board has three programmable voices, and on-board generator and built-in amplifier which can drive an 8 ohm speaker. The Sounding Board has a five octave range starting at 55hz which is (a) below the bass clef, to 1760hz which is 2 octaves above the treble clef. The apple will hold 6 boards which would give you the capacity to create 18 simultaneously programmable voices. Music can be composed, edited, played and then stored. Musical notes can be entered directly from the keyboard, included with your board is an interactive music editor, sample music, and a demonstration program which plays continuous music. Wt 3 oz.
Cat No. 2561 **$129[95]**

NEWDOS + TRS-80 DOS

Contains the following: NEWDOS provides fixes for many of TRSDOS 2.1's problems. Enhancements to BASIC include built-in renumbering, some abbreviated commands, scrolling of listings up or down, screen printing, clears up keyboard bounce, append now works, direct call to DOS without leaving BASIC, and display of all variables used; DIRCHECK tests and lists disk directories; DISASSEM, which is a disassembler; EDTASM allows the use of the Radio Shack Editor-Assembler on disk with disk I/O Level 1 in Level 2. This allows you to use or create Level 1 programs and also save or retrieve them from disk using LVIDSKSL. LMOFFSET helps save and load machine language tapes from disk, even if in the same memory as DOS; SUPERZAP allows you to display, print, and modify disks or memory. Complete with extensive documentation, requires TRSDOS and the Radio Shack Editor-Assembler. **$99[00]**
Cat No. 1549 TRS-80 L2, 16K w/disk

"PIRATES COVE" ADVENTURE

In addition to being a challenging and innovative game, Pirates Cove is designed so that different adventures can be created by changing the data base. While playing the game you wander thru various rooms and, by manipulating the objects, you try to find the hidden "treasures". You may have to defeat a wild animal to get to the treasure, or figure out how to get it out of the bog. A game in progress may be saved on tape and used later.
Cat No. 2505 TRS-80 L2, 16K cassette **$24[95]**

APPLE INVADERS

You have mobile bases, the invaders have missiles. As the game progresses the invaders get closer with every pass across the screen . . . the more you destroy, the faster those remaining will attack! This game can continue for quite some time, as there is a never ending supply of invaders.

Cat No.	2420	24K Apple Disk Version	6 oz.	$19.95
Cat No.	2421	24K Apple Cassette	6 oz.	$13.95

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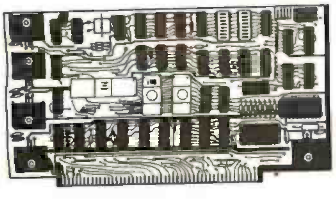


SSM CB1-A

8080 CPU BOARD

$159 kit

Just add an I/O board and it's a computer! 256 bytes of on board RAM, with option for 2K of on board PROM. Includes a power-on, preset jump circuit, and MWRITE is available, allowing use without a front panel. There's a parallel input port with status, and AIP controlled addressing; or PROM in 2K blocks; vector jump in 2K increments; RAM in 256 byte increments; RAM in 256 byte increments; input port for addresses 0 = 31 in decimal.

*Cat No. 1403	CB1-A kit	$159.00
*Cat No. 1441	CB1-A bareboard	$28.75

* Denotes excess Inventory sale. No further discounts shall apply

TEAC FD-50A

MINI DISK DRIVE

$295

The engineering expertise of TEAC has been incorporated into a new mini-disk drive for personal computer owners who demand the best from their investment.

The FD-50A has a unique "brushless" DC motor that is designed to run continuously and noise-lessly to provide faster track-to-track access time. (Less than 25ms access time!) The FD-50A will access 35 or 40 tracks providing 110/125k bytes storage capacity and may be ordered pin to pin compatible with either the Shugart SA-400 or the MPI-51 disk drives.

With its ONE FULL YEAR warranty, the FD-50A is certainly a sensible alternative. Compare the new TEAC FD-50A before you purchase your next mini-disk drive. Wt. 5 lbs.

Cat No. 2680	FD-50A Compatible w/SA-400 Format
Cat No. 2681	FD-50A Compatible w/MPI-51 Format

ATARI

HOME VIDEO SYSTEM

$183.00

The nation's best selling home video entertainment center is here! Currently supports a library of 32 game cartridges with over 1500 game variations and options. Now you can enjoy all the fun and excitement of an arcade in your own home whenever you wish. Terrific for party entertainment, developing coordination and dexterity, education, or just plain family fun. Comes with interchangeable joystick and paddle controllers, special circuits to protect home T.V., and ATARI'S realistic "combat" game with 108 variations and options. ATARI'S realistic sound effects and crisp, bright colors make the home video center your number one entertainment choice.

Note: Not for use with ATARI Programmable Computers

CAT NO.	DESCRIPTION	WT	PRICE
2375	ATARI Home Video System	8 lb.	183.00
2206	Driving Controller-Pair	2 lb.	19.95
2207	Paddle Controller-Pair	2 lb.	19.95
2208	Joystick Controller-Pair	2 lb.	19.95

ATARI GAME CARTRIDGES

2376	Starship	6 oz.	19.50
2377	Black Jack	6 oz.	18.75
2378	Space War	6 oz.	12.95
2379	Surround	6 oz.	12.95
2380	Slot Machine	6 oz.	18.75
2381	Outlaw	6 oz.	19.50
2382	Slot Racer	6 oz.	19.50
2383	Video Olympics	6 oz.	19.50
2384	Breakout	6 oz.	19.50
2385	Canyon Bomber	6 oz.	19.50
2386	Street Racer	6 oz.	19.50
2387	Homerun	6 oz.	19.50
2388	Basketball	6 oz.	19.50
2389	Football	6 oz.	19.50
2390	Bowling	6 oz.	19.50
2391	Skydiver	6 oz.	19.50
2392	Fun with Numbers	6 oz.	18.75
2393	Brain Game	6 oz.	19.50
2394	Superman	6 oz.	25.00
2395	Casino	6 oz.	25.00
2396	Backgammon	6 oz.	37.95
2397	Video Chess	6 oz.	37.95
2500	Space Invaders	6 oz.	25.00
2609	Adventure	6 oz.	25.00
2611	Indy 500	6 oz.	37.50
2634	Human Cannon Ball	6 oz.	19.50
2635	Codebreaker	6 oz.	19.50
2636	Flag Capture	6 oz.	19.50
2637	Air-Sea Battle	6 oz.	19.50
2638	Hunt and Score	6 oz.	19.50
2639	Miniature Golf	6 oz.	19.50
2640	Hangman	6 oz.	18.75
2653	Tic Tac Toe	6 oz.	19.50
2654	Circus	6 oz.	19.50

CCS

32K STATIC RAM BOARD

Uses 2114, 250ns fully Static RAM's. 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.

Cat No. 2644 Assembled & Tested **$710.00**

CCS

64K DYNAMIC RAM BOARD

Check the features, then compare the price of this memory board from CCS. Uses low power 4116 Dynamic RAM's. Bank Selectable in 16K blocks, bank Enable/Disable on power-up or reset. "fail safe" modes for transparent refresh on 8080 or Z-80, 4mhz operation, phantom line capability and compatible with front panel systems. Wt. 12 oz.

Cat No. 2647 Assembled & Tested **$699**

CCS

Z-80 CPU BOARD

California Computer Systems has done it again! An all new Z-80 CPU board loaded with such great features as S-100/Altair/Imsai compatibility. Power-on jump to any Memory address, selectable Z-80 monitor ROM, selectable MI wait states, full handshake, auto band (2 baud-56K baud) selection, selectable port address, separate baud rate oscillator and on-board RS-232 100% disable option serial port. This board also boasts front panel support compatability, Z-80 refresh capability, Z-80 NMI capability, phantom line capability, Z-80 interrupt capability and status valid on Data Lines during psync. Wt. 3 lbs.

Cat No. 2646 **$299**

CCS 2422

DISK CONTROLLER

This disk controller is equipped with a soft sector format, will support single and double density formats, supports up to four 5¼" and/or 8" single or double sided drives. It has ROM controlled addressing for I/O mapped and/or (optional) memory mapped operation, fast seek capability for voice-coil type drive, adjustable write precompensation, digital phase-locked data separator, selectable auto-wait on Data or Control port and on-board 2K Byte Boot/program ROM (2716). A copy of CP/M 2.2 is included.

Cat No. 2645 **$399**

LEEDEX **VIDEO 100**

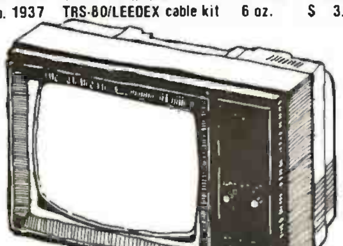
12" MONITOR

$139

- *Compatible with many home computers, including TRS-80 (no interfacing required)*
- *High resolution*

One of the most popular low cost, high resolution monitors available, comparable with units costing much more! Utilizes standard composite video input, which eliminates the need for an RF modulator. An extremely sharp and stable picture in a rugged, attractive package. 12MHz video bandwidth +/- 3db with 750 ohm input impedance.

Cat No. 1204	Video 100 monitor	18 lbs.	$139.00
Cat No. 1937	TRS-80/LEEDEX cable kit	6 oz.	$ 3.00



LEEDEX

VIDEO 100-80 MONITOR

Features Industrial-grade metal cabinet with built-in disk mounting capability, and space for an 11 x 14" PC board. Solid State circuitry assures a sharp, stable picture. Front panel controls include power, contrast, horizontal and vertical hold, and brightness. Wt 20 lbs.

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MICROMODEM 100

The Micromodem 100 is a complete data communications system for S-100 microcomputers. It combines the capabilities of a serial interface card and an acoustic coupler with the addition of a programmable automatic dialing and answer. Includes 16 bit machines and a 4 MHz processors, two software selectable baud rates, 300 baud and a jumper selectable speed from 45 to 300 baud. Direct connect microcoupler through your local telephone company system, auto answer/auto call. Software compatible with D.C. Hayes 80-103A data communications adapter.

Cat No. 2656 **$399**

D.C. HAYES ASSOC.

MICROMODEM II For APPLE II

This is a sophisticated computer to computer or terminal to computer modem for use in Apple II personal or small business systems. It provides all the capabilities of a Serial Interface card and an acoustic coupler with the addition of programmable automatic dialing and answer. On board ROM firmware provides for remote console, terminal mode and simplified implementation of more sophisticated applications with BASIC programs. The Micromodem II comes with the "Microcoupler", an exclusive new device that allows you to connect your Apple II directly to a modular jack provided by your local telephone Co.

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Fast data retrival.

Minimum hardware requirements: APPLE II Plus with 48K, one disk drive and 80 column printer.

Introductory Price: **$99.00** Including comprehensive manual.

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includes: Z19 Display, a built in 5¼" Floppy Disk, 2 serial ports, and 16K of memory. **2295.00** 48K Memory **2595.00** Also 48K Z-19 has a Z80 Micro-processor, numeric keypad and 8 function key. **895.00**

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Packed with: Computer Console, Basic Language Card, Education System Master Cartridge, Cassette Recorder, TV Modulator, 8K Memory (expandable to 48K), Power Supply & all Books and Manuals **$799.95**

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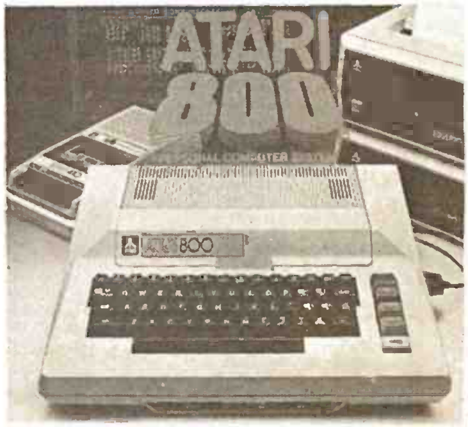

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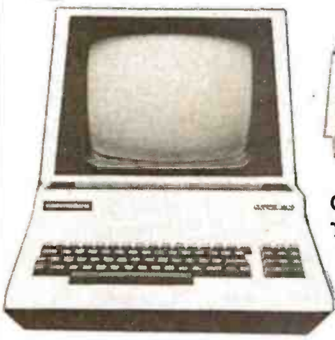

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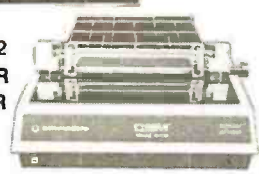
CBM 8050 DUAL DRIVE FLOPPY DISK



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CBM 2001 SERIES BUSINESS COMPUTER

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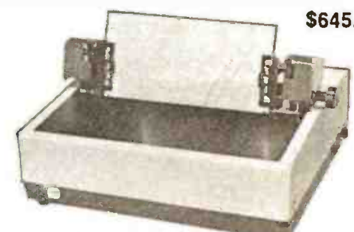
The new Model MX 80 is a high-speed bidirectional, impact printer capable of printing 9x9 dot matrix characters. Prints enlarged, condensed, condensed/enlarged, normal characters with 40,132, 66, 80 columns per line logical seeking function.

$645.



EPSON TX-80 . . .
DOT MATRIX PRINTER
with graphics **$795.**

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16K RAM set of 8 4116's
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TELEVIDEO 912C $699
TELEVIDEO 920C 799
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Siemens FDD 100-8D

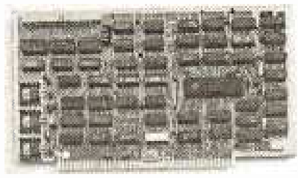
Single sided 8" floppy drive, the latest & greatest revision. Features double density plus much more. An extremely reliable drive $439 2/$409
Hard sector option kit... $9.95
Data separator option kit... $9.95

The following 5¼" mini-floppies share most features with their 8" cousins, so without further ado...

Siemens FDD 100-5D............ $279.
Qume Datatrak 5 (double sided).... 399.
BASF Mini mini................ 279.
SA 400....................... 299.

All the above mini-floppies are fully SA400 compatible.

Manuals for all drives are $10, refundable against future purchase of drives. Also, all 8" drives can be ordered with 220 v/50 hz for worldwide use.



Disk controllers

Delta Products double density	$349
Micromation doubler	439
Tarbell single density, A & T	225
Tarbell single density, kit	184
Tarbell double density, DMA	425
Sorrento Valley 8" single density for Apple	375

Data Display Monitors

used 12" Sylvania monitors. Composite video, 12 MHz, 120 VAC. with new P-39 or P-4 tube, $79, used tube $59, OEM style (without case), subtract $12. U-fix model, 10/$300.

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CII HB 10 MBY fully REMOVEABLE cartridge drive. Complete with controller, personality card, media, power supply, cabling, connectors and documentation. Highlighted by stylish & modern cabinetry. $6995.

Shugart SA4008 20MBY fixed disk system. S-100, includes controller, power supply, and all that is necessary to run $6995.

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Cable kits for 8" drives with 10' 50 cond. flat cable, power cable, and all connectors. Assembled if desired. One drive 27.50, two 33.95, three 38.95 for mini floppies (34 cond): one 24,95, two, 29.95

CP-206 Power-one power supply. Powers two drives more than adequately, top quality. 2.8A/24V, 2.5A/5V,.5A/-5V................ $99.

mini-floppy power supply $79

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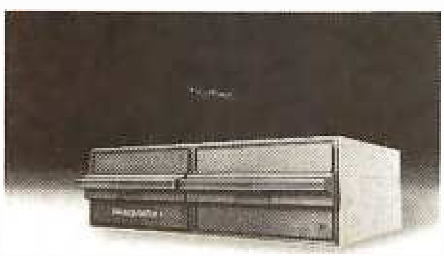

PRAGMATIX 1

Incredible!! — Two 8" Shugart compatible single sided floppy disk drives (double density), CP-206 power supply, in handsome color coordinated cabinet, with full cabling, connectors, and documentation, plus one box diskettes!!! All for an unprecedented $1295. Up to one MBY of storage.

with Qume Datatrak 8" double-sided drive $1695

ENCLOSURES

Rackmount Mainframe MT-200. This gorgeous beast is so appealing that it can easily function also as stand-alone mainframe. Very modern styling with fully actively terminated S-100 bus.

With two 8" single-sided disk drives... $1899.
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Desktop Mainframe MT-100. Contemporary styling, a handsome cabinet coated with durable epoxy finish colors (blue, beige, off-white & silver). Easy to fit into an office environment. The proper way to start your system.

Above plus two 8" single sided disk drives.............. $1599.
Above with two 8" double sided disk drives in place of single-sided variety .... $2199.

$25 min. order. Calif. residents add 6% sales tax. Orders under $75, add 5% shipping and handling, over $75 add 2.5%. All pricing subject to change without notice.

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Hard Plastic enclosure 49.00
BOTH only $152.00

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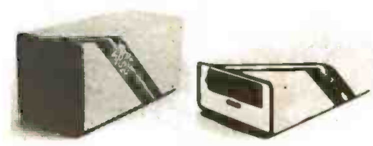
CHERRY "PRO" Keyboard $119.00
Streamlined Custom Enclosure 34.95
BOTH only $134.95

Disk Subsystem

Matchmaker Technology
TURNKEY DISK SUBSYSTEMS



APPLE ...... Single density disk controller. Expanded Apple DOS

TRS-80 .... Single or double density. Expansion interface necessary. Space for 48K dynamic RAM on controller card RS232 port

SORCERER .. Full RS-232 Interface. One S-100 slot for memory expansion. Single or double density

All above units come as follows: Complete, assembled and tested, with two 8" floppy disk drives (Apple available in one drive model). Includes all cabling, connectors and documentation in a stunning color coordinated cabinet with power supply. Ready to go, plug in and run!!!

• • •

When ordering specify single or double sided drives

• • •

Software available for above disk add-ons

• • •

TRS-80 & Sorcerer operate on all CP/M compatible software

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NEC Spinwriter 5510/2 $2899
NEC Spinwriter 5520/2 call
NEC Spinwriter 5530/2 for prices

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Sprint 5/45 KSR	3029
Sprint 5/55 KSR	3159
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Pinfeed platen	155
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paper basket	50

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Qume Sprint 3\45

(requires self assembly)

printer mechanism	$1499
power supply	349
combination special	1699
cases	200
S-100 interface card	149

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Telex: 345567 (Electrolab Pla)
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DC Hayes Micromodem 11 (for apple) $344
DC Hayes Micromodem 100 $349

SOFTWARE LABS

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MDBS A large computer DBMS with hierarchical and full network data structures (CODASYL Oriented). Explicit representation of one to one, one to many, many to one and many to many sets. Routines are callable from BASIC, PASCAL' COBOL or Machine Language.

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BISYNC-80/3780 A full function IBM 2780/3780 emulator that provides one of the most widely used communications protocols. 550.00

BISYNC-80/HASP A full function Hasp Multi-leaving Workstation package. 800.00

BISYNC-80/ASYNC An asynchronous communications package that uses the full error correcting BISYNC protocol. 95.00

BISYNC-80/3270 A full function IBM 3275 or 3271/3277 terminal emulator that converts a "dumb" terminal into a very smart one. 550.00

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- Upon Inquiry -

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Whitesmith's "C"	600.00

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Important Note: Please specify complete system hardware and software configuration with each order.

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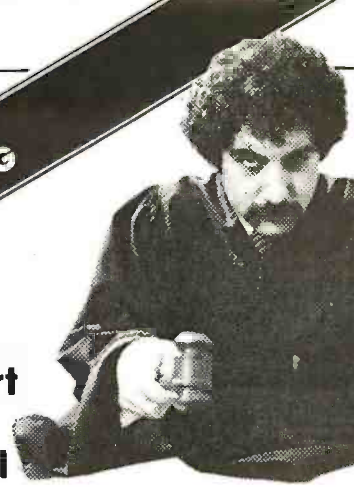

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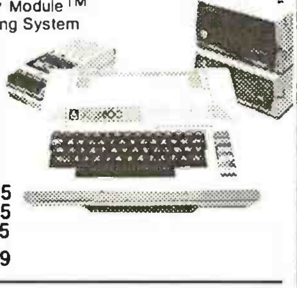

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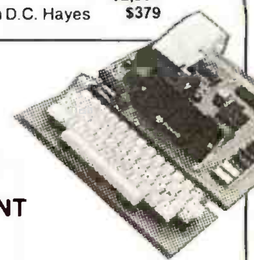
THE SINGLE BOARD DEVELOPMENT SYSTEM



6502 Microprocessor • 20-character, alpha-numeric LED display • Full-size 54-key keyboard with 3 user-defined functions • Fast, on-board 20-column thermal printer • 8K Advanced Interactive Monitor program • Dual cassette interface board • On-board timer • On-board ROM expansion to 12K • 4K on-board RAM • On-board TTY interface • 16 parallel I/0 lines • One serial I/0 port • KIM compatible edge connectors for even further memory or I/0 expansion.

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CompuMart Aim System	$850.00
4K AIM-65	$515.00
Paper for the AIM	$4.75

SEE OUR AD ON PAGE 316

Zenith Z-89
The All-In-One-Computer
This is the famous computer system which takes up no more space than a terminal alone. The 12" screen is beautiful and lends itself perfectly to professional applications thanks to its 25 lines of 80 characters. We know of no other computer which gives you this many features at such a low price.

Zenith 48K Z-89 Dual Port	List $2,895
CompuMart	**$2,695**
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Introducing the HP-85 $3,250
Hewlett-Packard's Personal Computer for Industry. This extremely portable computer features extended BASIC to solve your problems quickly and efficiently along with an advanced graphics system to enhance communication.

New from Novation! -D-CAT
The only direct modem that's FCC approved for hardset jack connection with any modular phone. $199

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ACCOUSTIC MODEM

- Answer Originate
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Looks good, works great! $179.00

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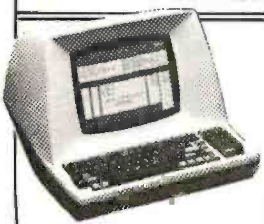
Terminals



Televideo 912C
820 x 24—Lower case descenders. Teletype or telewriter keyboard. 110/220 VAC. 50 to 19.2K Baud Item entry pad. Great looking and no fan noise. $950

Televideo 920C
Similar to the TV 912 but has programmable function keys across top. Excellent for text editing. $1,030

We've got the following Lear Siegler Terminals In Stock at prices too low to print—**Call** for quotes.

ADM-3A Industries favorite dumb terminal for some very smart reasons.

ADM-3A.+ New from Lear Siegler. CALL!

ADM-31. The terminal that's too smart to be considered dumb.

ADM-42. Available with keyboard or without, semi-intelligent terminal offering tremendous user flexibility. The optional configurations are amazing.

Call for details.

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Add convenient versatile printing capabilities to your TI Programmable 58C or 59 calculator with the PC-100C thermal printer, plotter.

TI PC-100C $168.00

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CompuMart judges Mountain Hardware the Buy-of-the-Month.

CompuMart Exclusive

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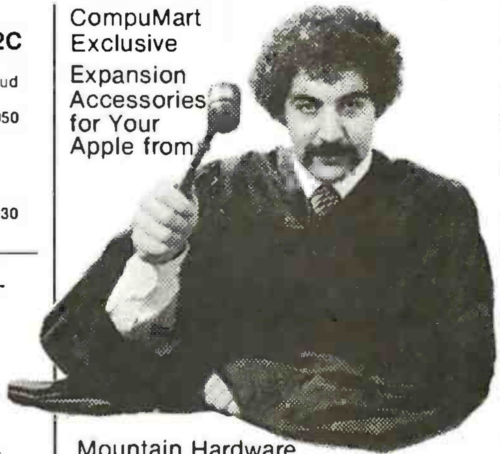

Mountain Hardware

For the ultimate in energy saving devices for your home get the BSR X-10. This system allows you to remotely control lights and electrical appliances in your home. The CompuMart package comes complete with Mountain Hardware software allowing your Apple to control home devices on a predetermined schedule.

Intro/X-10 System $289

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SuperTalker $299

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New From Microsoft The Z-80 SoftCard
Just plug the Z-80 SoftCard into your Apple and instantly you will have more versatility than any other computer user. The Z-80 SoftCard package allows you to add FORTRAN, COBOL, and BASIC as versions are introduced over the next few months. With this card you can run any standard LP/M software and much more. Call us and we'll tell you exactly how much more.

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The perfect monitor for Apple, Atari and Texas Instruments owners.

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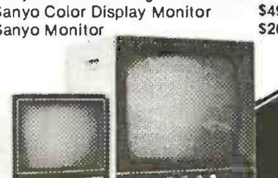

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40 characters per line
Speed: 40 characters per second
UL approved
High resolution dot matrix impact printer

Roar!

Standard features include: 4 character 8.3 to 16.5 cpi • 56 cps at 10 char. per in. • Selectable line spacing • 8 switch-selectable form sizes.

The IDS Graphics Option for the Paper Tiger allows full dot pattern control and includes and expanded 2048-byte buffer (a 256-type buffer is standard).

IDS Paper Tiger Printer $995

IDS Graphics Paper Tiger Printer $1,094

NEW! From Integral Data. The IDS 460.
We saw this new desktop printer at the NCC 80 and when we saw its features: Correspondence quality printing, High-resolution graphics capability, programmable print control functions, and automatic text justification—we knew that we had to offer this printer to our cost/features conscious customers $1,295

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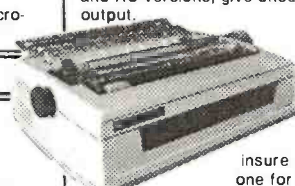
CompuMart offers beautiful print quality with NEC Spinwriter terminals. The Spinwriters, both KSR and RO versions, give unsurpassed hard copy output.



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Length	100/Bag	500/Bag	1K/Bag	Length	100/Bag	500/Bag	1K/Bag
2.5"	$1.25	$3.58	$ 6.19	6.5"	$1.92	$6.44	$11.81
3.0"	1.30	3.86	6.78	7.0"	1.99	6.76	12.44
3.5"	1.37	4.15	7.37	7.5"	2.08	7.07	13.09
4.0"	1.42	4.44	7.94	8.0"	2.14	7.38	13.73
4.5"	1.48	4.74	8.54	8.5"	2.18	7.69	14.36
5.0"	1.54	5.04	9.13	9.0"	2.24	8.11	15.01
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6.0"	1.65	5.66	10.31	10.0"	2.39	8.71	16.28

Kynar precut wire. All lengths are overall, including 1" strip on each end. Colors and lengths cannot be mixed for quantity pricing. Choose from colors Red, Blue, Black, Yellow, White, Green, Orange, and Violet.

Kit No. 1	$9.95		
250	3"	100	4½"
250	3½"	100	5"
100	4"	100	6"

Kit No. 2	$24.95		
250	2½"	250	5"
500	3"	100	5½"
500	3½"	250	6"
500	4"	100	6½"
250	4½"	100	7"

Kit No. 3	$32.95		
500	2½"	500	4½"
500	3"	500	5"
500	3½"	500	5½"
500	4"	500	6"

Kit No. 4	$59.95		
1000	2½"	1000	4½"
1000	3"	1000	5"
1000	3½"	1000	5"
1000	4"	1000	6"

★ ★ Truckload SALE ★ ★

FREE WIRE KIT

Kit #1 on orders over $50
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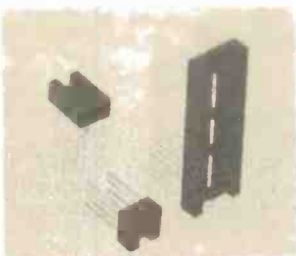

RN WIRE WRAP IC SOCKETS

3-level Gold
Closed Entry
Design

*Sockets sold at these prices by the tube only.

Size	Quantity/Tube	Price ea.*	Price/Tube
08 pin	52	.39	**$20.28**
14	30	.46	**$13.80**
16	26	.50	**$13.00**
18	23	.68	**$15.64**
20	21	.85	**$17.85**
22	19	.92	**$17.48**
24	17	.94	**$15.98**
28	15	1.23	**$18.45**
40	10	1.60	**$16.00**

Above prices include gold up to $800/oz.

IDC CRIMP STYLE CONNECTORS

Card Edge Connectors

IDE 10	**$3.25**
IDE 20	**$3.50**
IDE 26	**$4.05**
IDE 34	**$4.85**
IDE 40	**$5.65**
IDE 50	**$5.90**

IDC Sockets

IDS 10	**$1.25**
IDS 20	**2.02**
IDS 26	**2.65**
IDS 34	**3.50**
IDS 40	**4.05**
IDS 50	**5.06**

Cable Plugs

IDP 14	1.25
IDP 16	1.40
IDP 24	2.25
IDP 40	3.65

DB25 Connectors

Male	$4.95
Female	$5.25

Right Angle Headers

Wire Wrap		Solder Tail	
IDH10WR	1.75	IDH10SR	.80
IDH20WR	2.75	IDH20SR	1.25
IDH26WR	3.60	IDH26SR	1.85
IDH34WR	4.15	IDS34SR	2.15
IDH40WR	4.90	IDH40SR	2.50
IDH50WR	6.15	IDH50SR	3.15

CABLE

	10 ft.	100 ft.
10	**2.90**	**17.00**
14	**3.40**	**23.80**
16	**3.70**	**27.20**
20	**4.40**	**34.00**
24	**5.00**	**40.80**
26	**5.40**	**44.20**
34	**6.80**	**57.80**
40	**7.80**	**68.00**
50	**9.50**	**85.00**

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- All prices good through cover date.
- Most orders shipped next day.
- Byte must be mentioned to get sale prices.

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★ Vector Boards & Pins
★ Bishop Drafting Aids
★ OK Tools
★ RN IDC Crimp Connectors

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from
INTEGRAL DATA
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Paper Tiger

**** All the features of the 440 and more ****

The 460 uses a dot matrix character formation technique in which the placement of the dots overlap both horizontally and vertically to achieve a correspondence-quality printing.

The printer's nine-wire print head uses staggered needle rows to create the vertically overlapping dots. The head is driven bi-directionally under microprocessor control by a stepper motor driven mechanism with logic-seeking look ahead capability.

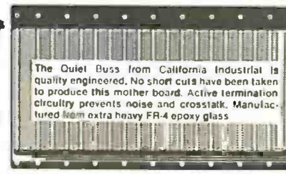
Standard "Two-K Byte" buffer allows the printer to accept the entire content of a 1,920-character CRT screen. Weight 27 lbs.

suggested list price $1,295. Calif. Digital price **$1,076**

S-100 Mother Board

Quiet Buss

$29.95
8803-18
18 slot
IMSAI



The Quiet Buss from California Industrial is quality engineered. No short cuts have been taken to produce this mother board. Active termination circuitry prevents noise and crosstalk. Manufactured from extra heavy FR-4 epoxy glass

TELETYPE® MODEL 43

4320 KEYBOARD

TTL . . . . . . AAA	$ 950	
RS232 . . . . AAK	1050	plus
Friction . . . AAE	1100	shipping
103 Modem AAB	1575	

WESTERN UNION ENCLOSURE

These enclosures were manufactured for Western Union by Universal Technology. The exact purpose of the product is still a mystery but the enclosure is ideally suited for an S-100 motherboard with shielded power supply. Removable hood and plexiglas front make this enclosure an attractive home for any hobby product.

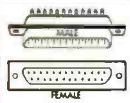
New surplus in factory boxes supplied with three 22/41 edge connectors: DB 25S communications connector; six foot grounded power cord and more. Inside dimensions: 19" x 10 1/2" x 6 7/8" Shipping weight 8 lbs. **$24.95**

FREE
PLASTIC LIBRARY CASE with purchase of each box of . . . . Memorex mini-diskettes. $5 value.

$27 BOX of TEN
10 Boxes $24.95
100 Boxes $22.25
forty track

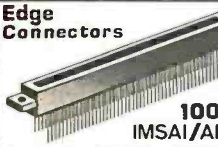
DISKETTES

DB25



	each	10+
male	$2.50	1.95
female	3.25	3.05
hood-2p	1.25	.98
Centronic	6.95	

Edge Connectors



GOLD
100 PIN
IMSAI/ALTAIR

Imsai solder.125x.250	$2.95	3/$ 7.50
Imsai w/w.125centers	$4.95	3/$13.00
Altair soldertail.140row	$5.95	3/$15.00

SPECIALS

22/44 Kim eyelet.156"	$1.95	3/$5.00
25/50 solder tab.156"	$1.09	3/$2.00
36/72 wide post w/w.156	$1.95	3/$5.00

BCD Thumbwheel Switch 1.95

Ten Position
Mfg. by Digiswitch
1 7/8" high 1/2" wide

COMPUTERS

Apple II standard 16K	$988
Apple Plus 16K	988
Atari 400	450
Atari 800	850
Texas Instruments 99/4	895.
Northstar Quad 32k Horizon	2995
Vector MZ	
Compucolor II Model 3	1305
Rockwell Aim 65 (1K)	375

CRT TERMINALS

ADDS Regent 25 (ten key pad)	850
ADDS Regent 40	1195
ADDS Regent 60	1495
Hazeltine 1420	850
Hazeltine 1500	995

MONITORS

Sanyo 9" black & white monitor	179
Leedex Video 100 12"	125
Leedex Video100.80 12"	170

PRINTERS

IDS440G Tiger with Graphics	$995
Printronix P-300 (300 L P M)	4900
Printronix P-600	
Teletype Model 43 (RS232)	1150
Teletype Model 40(132 col.)	
NEC Spinwriter 5510 R/O	2595
Texas Instruments 810	1050
Centronics 730 friction	695
Centronics 779-2 tractor	995
Centronics 704	1950
Anadex DP8000	885
Anadex DP9500	
Anadex DP9501	
Diablo 1540 R/O plastic wheel	2750
Diablo 1540 KSR plastic wheel	3150

MODEMS

Universal Data Systems LP300 Direct coupled • FCC Approved powered from phone line.	169
Novation Cat Acoustic	169

DISK DRIVES

Shugart SA800R 8" floppy	$449
Shugart SA801R 8" hard sec.	479
Lobo / Two Shugart 801's with power supply and enclosure	1195
One Shugart 801 with power supply and enclosure	795
Lobo hard drive for Apple 10 meg/byte 7710s	3995
Lobo hard drive for TRS80	3995
Lobo 400st 5 1/4" for TRS80	388
Vista V-80 for TRS80 (40trk)	388
Corvus Systems hard drive	

APPLE COMPATIBLE PRODUCTS

Apple disk drive with controller	560
Apple drive without controller	495
Apple Parallel Interface	179
Ten Key Data Pad for Apple	119
Mountain Hardware Supertalk	279
Mountain / Intro X-10 for BSR	239
••••• Memorex Special ••••••••••	
8" soft sector diskettes (10)	27
8" double density for TRS80	30

S-100 PRODUCTS

Godbout Rack Enclosure	$289
Godbout Desk Top Enclosure	329
Electronic Controls ECT 100F	250
Cal. Digital 18 slot motherbd.	30

S-100 BOARDS

Think/Toys Switchboard I/O	219
Godbout Econoram Products	
Multin TB-2 Extend. & Logic	49
Artec WW100 WireWrap Proto	25
SD64K Expandoram Memory	

16 BIT S-100 BOARDS

Cal. Digital CAL-86	650
Tecmar 8086	650
Seattle Computers 8086	850
Godbout 8088/8085	
Ithaca Intersystems Z-8000	

MISCELLANEOUS

Cherry Pro ASCII Keybd.	129
Maxiswitch HEX Keyboard	49
UV Eraser 11-E	65
Super Mod II RF Modulator	30

Authorized Distributor
Scotch Data Products

		10 Pak	50+
740-0	IBM soft format.	$39.00	$3.50
740/2	Double side soft	65.00	6.00
741-0	Double density	53.00	4.90
743-0	Double/Double	70.00	6.60
740-32	8" Hard sector	39.00	3.50
744-(0)(10)(16)	5 1/4" mini	39.00	3.50
Library case for any above:		Add $3.00	
834 A	Data Cassette	5.50	
DC 100	Mini Cartridge	16.00	
DC300	Data Cartridge	20.00	
920( )	Disk Cartridge	39.00	

Shugart Associates

SA800-R Floppy Disk Drive

The most cost effective way to store data processing information, when random recall is a prime factor. The SA800 is fully compatible with the IBM 3740 format. Write protect circuitry, low maintenance & Shugart quality.

$449.50

XEROX 800 WORD PROCESSING KEYBOARD ASCII ENCODED

This 77 key word processing keyboard was manufactured by Microswitch for use in the Xerox 800 word processing system. The keyboard outputs a seven bit ASCII code along with an eighth bit that allows most keys to shift and double function as special characters. Extra large " Tab & Return " keys are designed into the layout of the keyboard to emulate the IBM Selectric. 17 illuminated keys serve for special word processing codes. The keyboard is equipped with two thumbwheel switches for defining line width.

Original Xerox acquisition over $400.00. California Digital USED price only $49.00. Excellent cond. Documentation Included.

MEMORY

TRS-80 APPLE II $49
16k memory (8) 4116's

Installation is simple. Anyone who has ever changed a spark plug should be able to up-grade his microcomputer.

How can California Digital offer these memory up-grade sets at 25% below our competition? Simple, we buy in volume, wholesale to dealers and sell the balance directly to owners of personal micro-systems. These 16K dynamic memory circuits are factory prime and unconditionally guaranteed for one full year. NOW, before you change your mind, pick up the telephone and order your up-grade memory from California Digital. Add $3 for TRS80 jumpers.

STATIC	1-31	32-99	100-5C	-999	1K+
21L02 450nS.	1.19	.99	.95	.90	.85
21L02 250nS.	1.49	1.39	1.25	*	*
2114 1Kx4 450	5.95	5.50	5.25	4.75	4.50
2114 1Kx4 300	8.95	8.50	8.00	*	*
4044 4Kx1 450	5.95	5.50	5.25	*	*
4044 4Kx1 250	9.95	9.50	9.00	*	*
4045 1Kx4 450	8.95	8.50	8.00	*	*
4045 1Kx4 250	9.95	9.50	9.00	*	*
5257 low pow.	5.95	5.50	5.00	4.80	4.60

2716 EPROM SALE $13

*** THOUSANDS ***

We have slashed price in an effort to reduce our over stocked inventory. These are Single Five Volt Eproms, manufactured by one of the Worlds largest producers of semiconductors. Please phone for volume pricing.

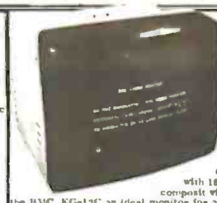
DATA INPUT TERMINAL

This Keystation terminal was recently acquired from the CMC division of the Pertec Corporation. The unit was originally designed for inputing data directly onto magnetic tape.

The system is comprised of a premium cast aluminum and fiberglass enclosure, along with a Honeywell / Microswitch hall effect keyboard. Thirty display lamps advise the operator of the systems status. Four inch loud speaker acknowledges acceptance of data and alerts the operator of pending problems.

But most of all this "USED" terminal, with a little imagination, can be engineered to make the perfect home for an S-100 computer and video display; or with slight modification will accept the Rockwell AIM-65 micro/computer.

Five volt regulated power supply is available for an additional $20. (see June Byte) All units are in excellent condition. Original acquisition over $700. 22 lbs.



BMC VIDEO MONITOR $259

Green phosphor with 18 MHz bandwidth. composit video input make the BMC KG-12C an ideal monitor for anyone requiring a high resolution display with an 80 character by 25 line video format. 12" 90° deflection.

High impact plastic enclosure assures that the BMC monitor is a rugged take anywhere instrument.

For added protection the unit is equipped with a removable smoked non-glare fitted plexiglas screen. Shipping 18 lbs.

MINIATURE SWITCHES

your choice

	10	50
$.98	$.88	.81

SPDT Miniature Toggles

7101 C&K	ON-NONE-ON
7107 jbt	ON-OFF(mnt.ON)
7108 CK	ON-(moment ON)
7103 CK	ON OFF ON
Rotary	3P-4-Pos.
Rotary	3P-6-Pos.
Push B (N.O.)	$.39ea.4/$1

direct connect MODEM
Universal Data 103

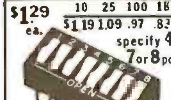
Connects directly to the new modular phone jack. Fully powered from your existing telephone line. No need to locate external AC power. Crystal control prevents frequency drift. Direct connect feature eliminates loss of information due to carbon compression that is associated with acoustic modems. Runs circles around those other "Domesticated" modems.

$169

KEYBOARD $24.95

This classic Hytek keyboard is similar to the module used in the Decwriter Terminal. 62 non-encoded contacts three locking. Factory boxed Altair surplus. Shipping 3 lbs.

DIP Switch



	10	25	100	1K
$1.29 ea.	$1.19	1.09	.97	.82

specify 4, 7 or 8 pos.
SPST

$139.50

PORTABLE DATA ENTRY SYSTEM

These used data terminals were originally designed for chain store inventory control and order entry systems. The operator enters the inventory control number, merchandise on hand and the unit price. After all pertinent data has been entered into the recorder, the main warehouse is telephoned, the handset is placed in the acoustic coupler and all the recorded information is transmitted back to the master computer. With a little imagination and one of these portable entry systems, you should be able to exchange programs and computer information with associates across the country. All units were removed from service in working condition. Original cost $2,500. Each system comes complete with:

- Portable Cassette Drive Unit
- Removable Entry Keyboard with LED Display
- Five Gould "D" NiCads
- Acoustical Coupler
- Battery Charger
- DB25 Cable
- Shoulder starp
- Full Documentation

BSR SYSTEM X-10

The new BSR timer runs your home like clockwork. Turns on lamps and appliances while your away from home. Completely compatible with your existing system X-10 devices.

BSR Timer	$65.00
Master Console	34.95
Ultrasonic Controller	19.95
Modules: Appliance. Lamp or Wall Switch	13.95

VISA
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All merchandise sold by California Digital is premium grade.
Shipping: First five pounds $2.00; each additional add $.40
Foreign orders 10% shipping. Excess will be refunded.
California residents add 6% sales tax. COD's discouraged.
Open accounts extended to state supported educational institutions and companies with a "Strong Dun & Bradstreet."
Warehouse: 15608 Inglewood Blvd. Visitors by appointment.

TOLL FREE ORDER LINE
(800) 421-5041
TECHNICAL & CALIFORNIA
(213) 679-9001

Circle 344 on inquiry card.

CB2 Z-80 CPU

Kit	$195.00
Assembled & Tested	$275.00

•2MHz, 4MHz, Mixed • Type—2716 or 2732 (not incl.) • Dip switch addressing • One wait state added • Dip switch disable • Type—TMS 4016 (not incl.) • 8 additional address lines • Power on/reset firmware jump using first instruction in EPROM

IO4 2P + 2S I/O Interface

Kit	$134.95
Assembled & Tested	$199.95

• Two serial ports with status • Two parallel inputs • Two parallel outputs • Current-loop by optical isolators • UART presets by dip switch: —stop bits —word length —parity even and odd • Dip switch addressing of serial I/O to any four port boundary • Dip switch addressing of parallel I/O to any two port boundary

S-100 BARE BOARDS

CB1A 8080 CPU	$33.00
VB2 I/O Mapped Video Interface	$33.00
102 Parallel I/O Interface	$33.00
104 2P + 2S I/O Interface	$33.00
SB1 Music Synthesizer	$40.00
OB1 Vector Jump & Prototyping Board	$29.95
MB3 4K 1702 EPROM Board	$30.00
MB6B 8K Static RAM	$27.00
MB7 Low Power 16K Static RAM	$30.00
MB8A 16K 2708 EPROM Board	$30.00
T1 Terminator	$26.00
MTI 15 Slot Motherboard	$40.00
XB1 Extender Board	$13.50

S-100 KITS & ASSEMBLED BOARDS

CB1A 8080 CPU

Kit	$149.95
Assembled & Tested	$199.95

SSM PRODUCTS

PB1 2708/2716 EPROM Programmer

Kit with Textool sockets	$134.95
Assembled & Tested w/Textools sockets	$174.95

• 2708 EPROM (not included) • 2716 EPROM +5V type (not included) • Any 4K boundary • Separate 2708 and 2716 sockets • Any 4K/8K boundary above 8000 Hex • Optional Textool sockets (for programming only) • Programming software & bit for bit verify routines provided

IO2 Parallel I/O Interface

Kit	$ 59.00
Assembled & Tested	$ 89.00

MB3 4K 1702 EPROM Board

Kit - without EPROMS	$ 65.00
Assembled & Tested	$125.00

MB6B 8K Static RAM

450 ns RAM

Kit	$139.95
Assembled & Tested	$199.95

250 ns RAM (MB6B)

Kit	$179.95
Assembled & Tested	$245.00

MB7 Low Power 16K Static RAM

Kit	$325.00
Assembled & Tested	$375.00

MB8A 16K 2708 EPROM Board

Kit - without EPROMS	$ 99.00
Assembled & Tested	$159.00

QT TECHNICAL HOTLINE
(213) 973-2619

VB3 80 Character Video Interface

80x24 Display, 2 MHz

Kit	$324.95
Assembled & Tested	$399.95

80x24 Display, 4 MHz

Kit	$369.95
Assembled & Tested	$439.00

• 80 char. per line, up to 51 lines • Graphics up to 160 x 204 matrix • Upper & lower case characters • Software controlled timing, top & bottom margins, horiz. position • U.S. & European T.V. timing • 4096 Bytes (8192 bytes optional) • Switch addressing, 8K increments • CP/M compatible driver routine

MT1 15 Slot Motherboard

Kit (with Connectors)	$119.95
Assembled & Tested	$149.95

OB1 Vector Jump & Prototyping Board

Kit	$ 55.00
Assembled & Tested	$ 85.00

SB1 Music Synthesizer (4)

Kit	$199.00
Assembled & Tested	$279.00

T1 Active Terminator

Kit	$ 34.00
Assembled & Tested	$ 64.00

VB1B Memory Mapped Video Interface

LIMITED SUPPLY — DISCONTINUED BOARD

Kit	$149.95
Assembled & Tested	$180.00

VB2 I/O Mapped Video Interface

Kit	$160.00
Assembled & Tested	$210.00

XB1 Extender Board

Kit (with Connector)	$ 19.95
Assembled & Tested	$ 29.95

EXPANDORAM I

EXPANDABLE TO 64K USING 4116 RAMS

• For S-100 boards • Bank selectable, PHANTOM provision • Designed to work with Z-80, 8080, and 8085 systems • No wait states required • 16K boundaries & protect via dip switches • Invisible refresh

MEM-16K (16K KIT)	$199.00
MEM-16AT (16K A&T)	$249.00
MEM-32K (32K KIT)	$250.00
MEM-32AT (32K A&T)	$300.00
MEM-48K (48K KIT)	$309.00
MEM-48AT (48K A&T)	$359.00
MEM-64K (64K KIT)	$364.00
MEM-64AT (64K A&T)	$410.00

EXPANDORAM II

• For S-100 Bus • 4Mhz Operation • Expandable Memory from 16K to 256K • Dip Switch Selectable Boundaries • Uses 16K (4116) or 64K (4164) Memory Devices • Page Mode Operation Allows up to 8 Memory Boards on Bus • For Z80 CPU's • Phantom Output Disable • Invisible Refresh

MEMII-16K (KIT)	$250.00
MEMII-16AT (A&T)	$300.00
MEMII-32K (KIT)	$309.00
MEMII-32AT (A&T)	$360.00
MEMII-48K (KIT)	$369.00
MEMII-48AT (A&T)	$409.00
MEMII-64K (KIT)	$425.00
MEMII-64AT (A&T)	$475.00

QT LOW PRICES!

5¼" DISK DRIVES

MPI B-51	$295.00
SHUGART SA400	$295.00

8" DISK DRIVES

SHUGART 8" 801R	$475.00
REMEX RFD 4000	$635.00

SD SYSTEMS

VERSAFLOPPY II

DOUBLE DENSITY DISK CONTROLLER

• For single or double density • 985600 bytes on 8" double sided diskettes • 259840 bytes on double sided 5¼" diskettes • S-100 bus • IBM 3740 format in single density • 8" and 5¼" drives controlled simultaneously • Operates with Z-80, 8080, and 8085 CPU's • Controls up to 4 drives

VF-2K (KIT)	$300.00
VF-2AT (A&T)	$369.00

SBC-100/200

2 OR 4 MHz SINGLE BOARD COMPUTER

• S-100 bus Z-80 CPU BD • 1K of on-board RAM • 4 EPROM sockets accommodates 2708, 2716, or 2732 • One parallel and one serial I/O port • 4-channel counter timer chip (Z-80 CTC) • Software programmable serial baud rates

SBC-100K (2 MHz KIT)	$255.00
SBC-100AT (2 MHz A&T)	$325.00
SBC-200K (4 MHz KIT)	$289.00
SBC-200AT (4 MHz A&T)	$369.00

SSM APPLE SERIAL/PARALLEL INTERFACE

AI/O Kit	$125.00
AI/O A&T	$165.00

TEXTOOL
ZIP* DIP II SOCKETS

16 PIN ZIP* DIP II	$ 5.50
24 PIN ZIP* DIP II	$ 7.50
40 PIN ZIP* DIP II	$10.25

*ZERO INSERTION PRESSURE

PROM-100

• For S-100 Bus • Programs the Following EPROMs: 2708, Intel 2758, 2716, 2732 and TI 2516 • Dip Switch Selection of EPROM type • 25 VDC Programming Pulse Generated On Board • Maximum Programming Time: 16,384 Bits in 100 seconds • Software Provides for Reading of Object File from SDOS, CP/M or PROM and Programming into EPROM • Program Verification • Verification of Erasure • Zero Insertion Force Socket

PROM-100K (KIT)	$175.00
PROM-100AT (A&T)	$225.00

Z-80 STARTER KIT

COMPLETE Z-80 MICROCOMPUTER

• On-board keyboard, display, EPROM Programmer, and cassette interface • On-board S-100 interface interface • Wire-wrap area and room for 2 S-100 connectors • Two 8-bit parallel I/O ports, 4-channel CTC, 5 programmable breakpoints • Examine and change memory, I/O ports, or register

Z-80K (KIT)	$289.00
Z-80AT (A&T)	$349.00

$25 REBATE

on any SD Systems microcomputer board

Offer expires 10-31-80

STATIC RAM BOARDS

SR-8K BARE BD (Ithaca Audio) 21L02	$ 19.00
SR-16K BARE BD (Problem Solvers) 2114	$ 19.00
SR-16K A&T (Cal. Comp Sys) 2114L 4MHz	$269.95
SR-32K KIT (Uses 2114L) 4MHz	$475.00
SR-32K A&T (Uses 2114L) 4MHz	$500.00

COMPUTER SYSTEMS INC.
15335 South Hawthorne Boulevard
Lawndale, California 90260
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Prices subject to change without notice.
International sales in American dollars only

VISA

master charge

Circle 346 on inquiry card.

$2130.00 COMPUTER
GET A JADE INFLATION

JADE Saves You $1130

4 MHz BOARD SET

	SD Systems A & T Price
SBC-200 *CPU with I/O*	$400.00
Versafloppy II *Dbl density controllr*	$430.00
ExpandoRAM II *64K RAM 4 MHz*	$1300.00
Total price	$2130.00
JADE KIT PRICE	$1074.95
Less SD Systems Rebate	$75.00
YOUR COST ONLY	$999.95

S-100 Boards

THE BIG Z - Jade
2 or 4 MHz switchable Z-80 CPU with serial I/O
CPU-30201K *Kit* $145.00
CPU-30201A *A & T* $199.00
CPU-30200B *Bare board* $35.00

SBC-100 - SD Systems
2.5 MHz Z-80 CPU with serial & parallel I/O ports
CPC-30100K *Kit* $257.50
CPC-30100A *A & T* $325.00

SBC-200 - SD Systems
4 MHz Z-80 CPU with serial & parallel I/O ports
CPC-30200K *Kit* $299.95
CPC-30200A *A & T* $375.00

CB2 - S.S.M.
2 or 4 MHz switchable Z-80 CPU with RAM, ROM, & I/O
CPU-30300K *Kit* $185.00
CPC-30300A *A & T* $249.95

ExpandoRAM I - SD Systems
2.5 MHz RAM board expandable from 16K to 64K
MEM-16130K *16K kit* $189.00
MEM-16130A *16K A & T* $249.00
MEM-32131K *32K kit* $234.00
MEM-32131A *32K A & T* $294.00
MEM-48132K *48K kit* $279.00
MEM-48132A *48K A & T* $339.00
MEM-64133K *64K kit* $324.00
MEM-64133A *64K A & T* $384.00

ExpandoRAM II - SD Systems
4 MHz RAM board expandable from 16K to 256K
MEM-16630A *16K kit* $249.95
MEM-16630A *16K A & T* $299.95
MEM-32631K *32K kit* $309.95
MEM-32631A *32K A & T* $359.95
MEM-48632K *48K kit* $369.95
MEM-48631A *48K A & T* $409.95
MEM-64633K *64K kit* $429.95
MEM-64633A *64K A & T* $479.95

32K STATIC RAM - Jade
2 or 4 MHz expandable static RAM board uses 2114L's
MEM-16150K *16K 2 MHz kit* $249.95
MEM-16150A *16K 2 MHz A & T* ... $299.95
MEM-16151K *16K 4 MHz kit* $259.95
MEM-16151A *16K 4 MHz A & T* ... $309.95
MEM-32150K *32K 2 MHz kit* $399.95
MEM-32150A *32K 2 MHz A & T* ... $449.95
MEM-32151K *32K 4 MHz kit* $409.95
MEM-32151A *32K 4 MHz A & T* ... $459.95

16K STATIC RAM - Cal Comp Sys
2 or 4 MHz 16K static RAM - a real memory bargain
MEM-16160K *16K 2 MHz kit* $249.95
MEM-16160A *16K 2 MHz A & T* ... $279.00
MEM-16162K *16K 4 MHz kit* $279.95
MEM-16162A *16K 4 MHz A & T* ... $309.00
MEM-16160B *Bare board* $29.95

Call for your free 1980 catalog

DOUBLE-D - Jade
Double density controller with the inside track
IOD-1200K *Kit* $299.95
IOD-1200A *8" A & T* $389.95
IOD-1205A *5¼" A & T* $389.95
IOD-1200B *Bare board* $65.00

VERSAFLOPPY I - SD Systems
Versatile floppy disk controller for 8" or 5¼"
IOD-1150K *Kit* $219.95
IOD-1150A *A & T* $269.95

VERSAFLOPPY II - SD Systems
New double density controller for both 8" & 5¼"
IOD-1160K *Kit* $309.95
IOD-1160A *A & T* $369.95

I/O-4 - S.S.M.
2 serial I/O ports plus 2 parallel I/O ports
IOI-1010K *Kit* $129.95
IOI-1010A *A & T* $189.95
IOI-1010B *Bare board* $29.95

PB-1 - S.S.M.
2708, 2716 EPROM board with built-in programmer
MEM-99510K *Kit* $119.95
MEM-99510A *A & T* $169.95

PROM-100 - SD Systems
2708, 2716, 2732, 2758, & 2516 EPROM programmer
MEM-99520K *Kit* $175.00
MEM-99520A *A & T* $225.00

32K BYTESAVER - Cromemco
32K EPROM board with on-board 2716 programmer
MEM-32550A *A & T* $295.00

100K DAY CLOCK - Mtn Hardware
Crystal controlled S-100 clock with NiCad backup
IOK-1400A *A & T* $329.95

SB1 - S.S.M.
15 Hz to 25K Hz music synthesizer for S-100
IOS-1005K *Kit* $189.95
IOS-1005A *A & T* $269.95

TB-4 - Mullen
Extremely versatile extender board with logic probe
TSX-180K *Kit* $55.00
TSX-180A *A & T* $75.00

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Can be used as both an S-100 extender and terminator
TSX-150K *Kit* $39.95

S-100 EXTENDER - Cal Comp Sys
Puts problem boards within easy reach
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80 x 24 I/O mapped video board with keyboard I/O
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VB3 - S.S.M.
80 x 24 or 80 x 48 memory mapped with graphics
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IOV-1095A *A & T, 4 MHz* $399.00
IOV-1096K *80 x 48 upgrade, 4 MHz* . $89.00

VIDEO BOARD - Jade
64 x 16 assembled & tested S-100 video board
IOV-1050B *Bare board* $29.95
IOV-1050A *A & T sale price* $99.95

8K RAM BOARDS - Special Sale
Uses 21L02 RAM chips
2 boards & manual for $30.00

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AIM-65 - Rockwell
6502 computer with printer, display, & keyboard
CPK-50165 *1K AIM* $374.95
CPK-50465 *4K AIM* $449.95
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PSX-030A *Power supply* $59.95
ENX-000002 *Enclosure* $49.95
4K AIM, 8K BASIC, power supply, & enclosure
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Dynamic memory board to expand your AIM-65
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MEM-32170A *A & T w/32K* $375.00
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Add 5¼" or 8" disk drives to your AIM-65
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CPS-30010K *Kit* $289.95
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Accessories for Apple

16K MEMORY UPGRADE
Add 16K of RAM to your TRS-80, Apple, or Exidy
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5¼" disk drive with controller for your Apple
MSM-12310C *with controller* $495.00
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Controller, DOS, two 8" drives, cabinet, & cable
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Z-80 CPU card with CP/M for your Apple
CPX-30800A *A & T* $345.00

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IOM-2010A *Apple modem* $349.95
IOM-1100A *S-100 modem* $375.00

SUP'R'MOD II - M & R Assoc
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NOW ONLY $999.95 (JUST ADD SOLDER) FIGHTING KIT TODAY

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132 cps, bi-directional, tractor feed, & graphics
PRM-13100 .... $625.00

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9 x 9 dot matrix, 176 column, 200 cps, & graphics
PRM-10500 *Standard DP-9500* $1495.00
PRM-10510 *with graphics & 2K* .. $1595.00

LP-80 - Matchless
9 x 7 matrix, 132 column, 125 cps, bi-directional
PRM-37204 .... $775.00

PAPER TIGER - Integral Data
132 column, parallel & serial, 150 cps, graphics
PRM-33440 *IDS-440* $950.00
PRM-33441 *IDS-440 w/graphics* .. $1050.00

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Intelligent graphics plotter uses 7 bit ASCII code
PRP-10800 .... $1075.00

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Silent, simple, and on sale - a better motherboard

6 Slot (5¼" x 8¾")
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MBS-061A *A & T* $49.95

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MBS-181A *A & T* $139.95

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ENC-112105 *Kit* $309.95
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Dual 8" drive cutouts with 8 slot motherboard
ENS-112320 *with 30 amp p.s.* $699.95

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12" B & W video monitor with 12 MHz bandwidth
VDM-801210 .... $139.95

VIDEO 100-80 - Leedex
81 x 24 version of Video 100 with metal cabinet
VDM-801230 .... $179.95

B & W MONITOR - Sanyo
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VDM-700901 *9" monitor* $209.95
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The hi res color you've been promising yourself
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Double-D controller kit, two 8" double density disk drives, cabinet, power supply, & cables
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Protect your valuable software from spindle damage
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MP/M - Digital Research
Multi-user operating system for Z-80 computers
SFC-52507000F *8" disk & manual* $295.00

PASCAL/MT - MetaTech
A powerful language for CP/M systems
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SDOS - SD Systems
DOS, CBASIC-2, Z-80 assembler/editor/linker
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SFX-55001002M *5¼" disks & man* $149.95
SFX-55001006F *8" disk & manual* $149.95

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Make back-up disks with just a single Disk II
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Professional word-processing package for Apple
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EPROM ERASER - L.S.Engineering
UV eraser for up to 48 EPROMs
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6800 .... $11.95
6802 .... $17.95
6809 .... $39.95
8035 .... $24.00
8035-8 .... $24.00
8080A .... $ 6.95
8085 .... $15.95
TMS9900J1 .. $39.95

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2708 (450ns) $ 8.95
2716 (450ns) $29.95
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2732 (5v) ...$69.95
2758 (5v) ...$29.95

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211.02 (4 MHz) ... $ 1.50
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8214 .... $ 4.65
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8226 .... $ 3.85
8228 .... $ 4.95
8238 .... $ 4.95
8243 .... $ 8.00
8250 .... $14.95
8251 .... $ 6.50
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8259 .... $17.95
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AY3-1014A .. $8.25
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BAUD RATE GENERATORS
MC14411 .. $12.95
CRYSTAL .. $ 4.95

Z80 SUPPORT
3881 (PIO) .... $ 9.50
3881-4 (PIO-4 MHz) .. $14.50
3882 (CTC) .... $ 9.50
3882-4 (CTC-4MHz) .. $14.95
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3884 (SIO) $49.50

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6821P . $ 5.95
6828P . $11.95
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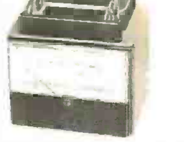
ULTRAVIOLET INTENSITY METER

new

by BLAK-RAY



TWO MODELS:
LONG WAVE
AND
SHORT WAVE

Meter consists of a sensor cell attached to a compact (3" x 3¼" x 3") metering unit. Can be hand-held or placed directly on surface for measuring. Can be used remotely, while connected to a meter housing by a 4-foot extension cord. Two models available — one for long wave and one for short wave ultraviolet. Readings are in microwatts per square centimeter. Weight: 1 lb.

Completely assembled (includes sensor cell, reduction screen, extension cord, contrast filter and certification report.)

J-221 LONG WAVE (300nm-400nm) **$242.00**
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EPROM Erasing Lamp

- Erases 2708, 2716, 1702A, 5203Q, 5204Q, etc.
- Erases up to 4 chips within 20 minutes
- Maintains constant exposure distance of one inch
- Special conductive foam liner eliminates static build-up
- Built-in safety lock to prevent UV exposure
- Compact — only 7-5/8" x 2-7/8" x 2"
- Complete with holding tray for 4 chips

UVS-11E $69.95

Jumbo 6-Digit Clock Kit

- Four .630"ht. and two .300"ht. common anode displays
- Uses MM5314 clock chip
- Switches for hours, minutes and hold functions
- Hours easily viewable to 30 feet
- Simulated walnut case
- 115VAC operation
- 12 or 24 hour operation
- Includes all components, case and wall transformer
- Size: 6¾ x 3⅛ x 1¾

JE747 .... $29.95

- Bright .300 ht. comm. cathode display
- Uses MM5314 clock chip
- Switches for hours, minutes and hold modes
- Hrs. easily viewable to 20 ft.
- Simulated walnut case
- 115 VAC operation
- 12 or 24 hr. operation
- Incl. all components, case & wall transformer
- Size: 6¾" x 3-1/8" x 1¾"

JE701
6-Digit Clock Kit $19.95

Regulated Power Supply

Uses LM309K. Heat sink provided. PC board construction. Provides a solid 1 amp @ 5 volts. Can supply up to ±5V, ±9V and ±12V with JE205 Adapter. Includes components, hardware and instructions. Size: 3½" x 5" x 2"H

JE200 .... $14.95

ADAPTER BOARD —Adapts to JE200— ±5V, ±9V and ±12V

DC/DC converter with +5V input. Toriodal hi-speed switching XMFR. Short circuit protection. PC board construction. Piggy-back to JE 200 board. Size: 3½" x 2" x 9/16"H

JE205 .... $12.95

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8080A	CPU	$ 7.95
8212	8-Bit Input/Output	3.25
8214	Priority Interrupt Control	5.95
8216	Bi-Directional Bus Driver	3.49
8224	Clock Generator/Driver	3.95
8226	Bus Driver	3.49
8228	System Controller/Bus Driver	4.95
8238	System Controller	5.95
8251	Prog. Comm. I/O (USART)	7.95
8253	Prog. Interval Timer	14.95
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8257	Prog. DMA Control	19.95
8259	Prog. Interrupt Control	19.95
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MC6821	Periph. Inter. Adapt (MC6820)	7.49
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Z80(780C)	CPU	$13.95
Z80A(780-1)	CPU	15.95
CDP1802	CPU	19.95
2650	MPU	19.95
6502	CPU	11.95
8035	8-Bit MPU w/clock, RAM, I/O lines	19.95
P8085	CPU	19.95
TMS9900JL	16-Bit MPU w/hardware, multiply & divide	49.95
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MM500H	Dual 25 Bit Dynamic	.50
MM503H	Dual 50 Bit Dynamic	.50
MM504H	Dual 16 Bit Static	.50
MM506H	Dual 100 Bit Static	.50
MM510H	Dual 64 Bit Accumulator	.50
MM5016H	500/512 Bit Dynamic	.89
2504T	1024 Dynamic	3.95
2518	Hex 32 Bit Static	4.95
2522	Dual 132 Bit Static	2.95
2524	512 Static	.99
2525	1024 Dynamic	2.95
2527	Dual 256 Bit Static	2.95
2528	Dual 250 Static	4.00
2529	Dual 240 Bit Static	4.00
2532	Quad 80 Bit Static	2.95
3341	Fifo	6.95
74LS670	4X4 Register File (TriState)	2.49
UART'S		
A-Y-5-1013	30K BAUD	5.95

MICROPROCESSOR MANUALS			
M-Z80	User Manual		$7.50
M-CDP1802	User Manual		7.50
M-2650	User Manual		5.00
ROM'S			
2513(2140)	Character Generator(upper case)		$9.95
2513(3021)	Character Generator(lower case)		9.95
2516	Character Generator		10.95
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1101	256X1	Static	$1.49
1103	1024X1	Dynamic	.99
2101(8101)	256X4	Static	3.95
2102	1024X1	Static	1.75
21L02	1024X1	Static	1.95
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5101	256X4	Static	7.95
5280/2107	4096X1	Dynamic	4.95
7489	16X4	Static	1.75
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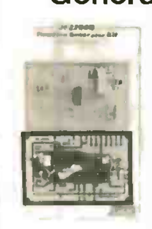
93421	256X1	Static	2.95
UPD414 (MK4027)	4K	Dynamic 16 pin	4.95
UPD416 (MK4116)	16K	Dynamic 16pin 250ns	7.95
TMS4044-45NL	4K	Static	14.95
TMS4045	1024X4	Static	14.95
2117	16,384X1	Dynamic 350ns (house marked)	9.95
MM5262	2KX1	Dynamic	4/1.00
PROM'S			
1702A	2048	FAMOS	$5.95
2716INTEL	16K*	EPROM	59.95
TMS2516 (2716)	16K*	EPROM	24.95
	*Requires single +5V power supply		
TMS2532	4KX8	EPROM	89.95
2708	8K	EPROM	10.95
2716T.I	16K**	EPROM	29.95
	**Requires 3 voltages, -5V, +5V, +12V		
5203	2048	FAMOS	14.95
6301-1(7611)	1024	Tristate Bipolar	3.49
6330-1(7602)	256	Open C Bipolar	2.95
82S23	32X8	Open Collector	3.95
82S115	4096	Bipolar	19.95
82S123	32X8	Tristate	3.95
74186	512	TTL Open Collector	9.95
74188	256	TTL Open Collector	3.95
74S287	1024	Static	2.95

Function Generator Kit



Provides 3 basic waveforms: sine, triangle and square wave. Freq. range from 1 Hz to 100K Hz. Output amplitude from 0 volts to over 6 volts (peak to peak). Uses a 12V supply or a ±6V split supply. Includes chip, P.C. Board, components & instructions.

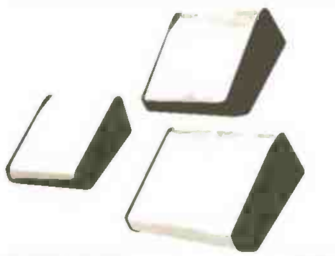
JE2206B $19.95

DIGITAL THERMOMETER KIT

- Dual sensors—switching control for indoor/outdoor or dual monitoring
- Continuous LED .8" ht. display
- Range: -40°F to 199°F / -40°C to 100°C
- Accuracy: ± 1° nominal
- Set for Fahrenheit or Celsius reading
- Sim. walnut case - AC wall adapter incl.
- Size: 3-1/4"H x 6-5/8"W x 1-3/8"D

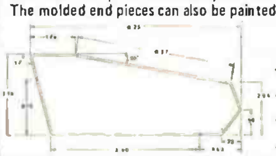
JE300 .... $39.95

DESIGNERS' SERIES
Blank Desk-Top Electronic Enclosures



- High strength epoxy molded end pieces in mocha brown finish.
- Sliding rear/bottom panel for service and component accessibility.
- Top/bottom panels .080 thk alum. Alodine type 1200 finish (gold tint color) for best paint adhesion after modification.
- Vented top and bottom panels for cooling efficiency.
- Rigid construction provides unlimited applications.

CONSTRUCTION:
The "DTE" Blank Desk Top Electronic Enclosures are designed to blend and complement today's modern computer equipment and can be used in both industrial and home. The end pieces are precision molded with an internal slot (all around) to accept both top and bottom panels. The panels are then fastened to ¼" thick tabs inside the end pieces to provide maximum rigidity to the enclosure. For ease of equipment servicing, the rear/bottom panel slides back on slotted tracks while the rest of the enclosure remains intact. Different panel widths may be used while maintaining a common profile outline. The molded end pieces can also be painted to match any panel color scheme.



Enclosure Model No.	Panel Width	PRICE
DTE-8	8.00"	$29.95
DTE-11	10.65"	$32.95
DTE-14	14.00"	$34.95

The Incredible "Pennywhistle 103"

$139.95 Kit Only

The Pennywhistle 103 is capable of recording data to and from audio tape without critical speed requirements for the recorder and it is able to communicate directly with another modem and terminal for telephone "hamming" and communications. In addition, it is free of critical adjustments and is built with non-precision, readily available parts.

Data Transmission Method .....Frequency-Shift Keying, full-duplex (half-duplex selectable).
Maximum Data Rate.............300 Baud.
Data Format ....Asynchronous Serial (return to mark level required between each character).
Receive Channel Frequencies ...2025 Hz for space; 2225 Hz for mark.
Transmit Channel Frequencies ..Switch selectable: Low (normal) = 1070 space, 1270 mark; High = 025 space, 2225 mark.
Receive Sensitivity ....-46dbm accoustically coupled.
Transmit Level ....-15 dbm nominal. Adjustable from -6 dbm to -20 dbm.
Receive Frequency Tolerance ...Frequency reference automatically adjusts to allow for operation between 1800Hz and 2400 Hz.
Digital Data Interface ....EIA RS-232C or 20 mA current loop (receiver is optoisolated and non-Polar).
Power Requirements ....120 VAC, single phase, 10 Watts
Physical ....All components mount on a single 5" by 9" printed circuit board. All components included.
Requires a VOM, Audio Oscillator, Frequency Counter and/or Oscilloscope to align.

TRS-80 16K Conversion Kit

Expand your 4K TRS-80 System to 16K.
Kit comes complete with:
- 8 each UPD416-1 (16K Dynamic Rams) 250NS
- Documentation for conversion

TRS-16K $59.95

JE610 ASCII Encoded Keyboard Kit

The JE610 ASCII Keyboard Kit can be interfaced into most any computer system. The kit comes complete with an industrial grade keyboard switch assembly (62-keys), IC's, sockets, connector, electronic components and a double-sided printed wiring board. The keyboard assembly requires +5V @ 150mA and -12V @ 10mA for operation. Features: 60 keys generate the full 128 characters, upper and lower case ASCII set. Fully buffered. Two user-define keys provided for custom applications. Caps lock for upper-case-only alpha characters. Utilizes a 2376 (40-pin) encoder read-only memory chip. Outputs directly compatible with TTL/DTL or MOS logic arrays. Easy interfacing with a 16-pin dip or 18-pin edge connector.

JE610 (Case not included) **$79.95**

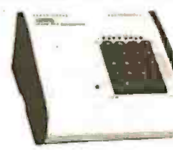
Desk-Top Enclosure for JE610 ASCII Encoded Keyboard Kit
Compact desk-top enclosure: Color-coordinated designer's case with light tan aluminum panels and molded end pieces in mocha brown. Includes mounting hardware. Size: 3½"H x 14¾"W x 8¾"D.

DTE-AK $49.95

SPECIAL: JE610/DTE-AK PURCHASED TOGETHER (Value $129.90) $124.95

JE600 Hexadecimal Encoder Kit

FULL 8-BIT LATCHED OUTPUT 19-KEY KEYBOARD



The JE600 Encoder Keyboard Kit provides two separate hexadecimal digits produced from sequential key entries to allow direct programming for 8-bit microprocessor or 8-bit memory circuits. Three additional keys are provided for user operations with one having a bistable output available. The outputs are latched and monitored with 9 LED readouts. Also included is a key entry strobe. Features: Full 8-bit latched output for microprocessor use. Three user-define keys with one being bistable operation. Debounce circuit provided for all 19 keys. 9 LED readouts to verify entries. Easy interfacing with standard 16-pin IC connector. Only +5VDC required for operation.

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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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ONLY $799

with anti-glare CRT
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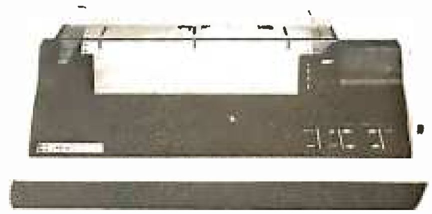

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32K, DD, List $2399	2034	48K, DD, List $3590	3039
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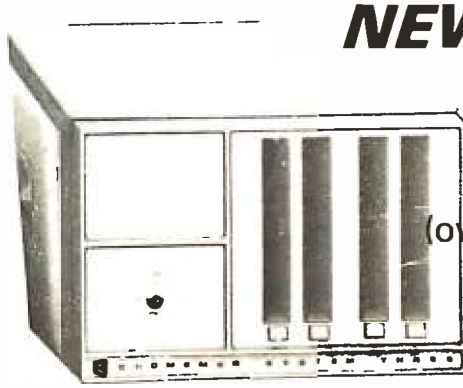

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XITEX SCT-100K, Kit .... ONLY $154.95
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SSM VB2 I/O, Kit, List $169 .... $ 144
Assembled & Tested, List $234 ...... $ 199
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SSM VB1C, 16x64, Kit, List $179 ...... $145
Assembled & Tested, List $242 .... $196
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INTERSYSTEMS, 16x64, A&T, List $165 $149

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Complete w/microprocessor controller and power supply. Factory built. User installs solenoid assembly or it can be done at Escon factory at nominal cost.

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CB2 Z-80, A&T, List $275 .... $234
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SBC-200 Kit, List $320 .... $272†

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ONLY $159 without RAM chips
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INTERSYSTEMS (formerly Ithaca Audio)
8K Static 2 MHz, A&T, List $165 ...... $149
8K Static 4 MHz, A&T, List $195 ...... $176
16K Static 2 MHz, A&T, List $475 ..... $427
16K Static 4 MHz, A&T, List $495 ..... $445
64K Dynamic, List $995 .... $895
CALIFORNIA COMPUTER
16K Static, A&T, List $349.95 .... $259

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Disk Jockey 2D, A&T, List $479 .... $429
SD Versafloppy 1, Kit, List $250 .... $212†
Versafloppy II, DD Kit, List $350 ...... $297†
Versafloppy II, DD, A&T, List $430 .... $365†
DELTA double density A&T ($385) $345
CONDUCTOR, double density A&T . . . $269
INTERSYSTEMS FDC-2, A&T, $495 . . . $439
MICROMATION Doubler, DD, A&T . . . $399
TARBELL Floppy Disk Interface Kit $199
double density, A&T, List $495 .... $444

SHIPPING AND INSURANCE: Add $2.50 for boards, $6 for Selectric Converter or Floppy Disk Drives, $7.50 for Floppy Disk Systems, $15 for Horizon. SHIPPED FREIGHT COLLECT: SuperBrain, Centronics and T.I. printers. Contact us for shipping information on other terminals and printers.

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FOR SALE: TDL Xitan system including TDL ZPU Z80 processor card; TDL SMB containing two serial ports, one parallel port, cassette interface, and 2 K Zapple monitor; Processor Technology VDM-1 video board; 16 K static programmable memory 250 ns; George Risk keyboard. Software includes 12 K BASIC, macro assembler, text editor, and text output processor. All documentation. $1200 or best offer. Paul Bajorek, 5482 Durrell Rd, Columbus OH 43229, (614) 436-0091.

FOR SALE: S-100 North Star Z80A processor board; $145. Godbout Econoram II 8 K programmable-memory board; $100. SD Systems VDB-8024 80 by 24 video display board; $275. Ithaca Audio 2708/2716 programmable read-only memory board; $50. Vector Pak enclosure with Vector Graphics mother board and power supply, fan, and 12 edge connectors; $290. Keyboard with ASCII encoder; $30. Everything assembled and tested. Will consider offers. Harry Haddon, 301 Orchard St, Apt A12, Fayetteville NY 13066, (315) 637-9229.

FOR SALE: XITEX video board with manual, new, assembled and tested, Model SCT-100; Jade Big Z processor with manual, assembled and tested by Jade, 2 MHz; 15-inch black and white monitor, like new; Sperry-Univac terminal/printer; new TEI 22-slot frame with Intersystems front panel, new; Tarbell floppy controller; KIMSI S-100 to KIM board with manuals. Ken Wong, 56 Hollywood Ave, Clifton NJ 07014, (201) 773-9033.

FOR SALE: Soroc IQ 140 terminal in original box; $995. IBM Selectric 731 I/O; $450. Bob Flaming, 6519 Jetta Ave, Bakersfield CA 93308, (805) 399-8968.

FOR SALE: Cromemco Z-2D computer. Factory assembled with extras. $3000 or best offer. Gregory Clifford, (305) 725-0562.

FOR SALE: Altair S-100 micro system, 17 slots, full display, control front panel, fan, 36 K programmable memory, 2 K programmable read-only memory (½ K unprogrammed), parallel I/O, video display interface, cassette interface, keyboard with power supply, serial I/O, real-time clock board, 8-channel priority interrupt, paper-tape reader mechanism, 5 K BASIC listing. All boards assembled and with documentation. $1185 or will accept offers on individual boards. Thomas T Moore, 505 Fulton Pl, Lansing MI 48915, (517) 485-6783.

FOR SALE: BYTE back issues; #1 thru #16, in binder, excellent condition, make offer. 1977 and 1978 complete, $15/year. T Good, 3 Bergen Ave, Hillsdale NJ 07642.

DONATION: Will donate a Clary DE-60 computer with IBM Model B typewriter printout for eligible charitable deduction. Includes program boards for general engineering and surveying, mahogany console. H K Friedland, POB 893, Solana Beach CA 92075, (714) 481-9339.

FOR SALE: TDL with 8-inch disk drives. TDL Alpha-2 with Z80 ZPU, SMB with Zapple monitor, dynamic 16 K programmable memory, iCOM disk board, case, 8-slot mother board. iCOM FD3712 dual 8-inch disk drives with cabinet, power supply. TDL BASIC, text editor, macro assembler, word processor; iCOM's FDOS, DEBBI BASIC, assembler, text editor; and CP/M. Hardware and software manuals included. $2700. John French, 8045 Alida St, La Mesa CA 92041, (714) 466-5915.

FOR SALE: 2400 bps synchronous modems. Tele-Signal 883P; 2.0, 1.2, and 1.0 k bps options, switched network or leased. RX: echo delay, compromise delay, slope equalization. TX: answer tone, manual or automatic control. Equivalent to Bell 201. SASE for data sheet. Single units (3) $135; double unit in rack panel (1) $200. Full documentation. Dan Dolan, POB 23191, Lexington KY 40503.

WANTED: Copy of documentation or manual of Digital Group Phi-Deck controller, version A. Ray Johnson, 2758 Sheridan Way, Stockton CA 95207.

WANTED: Back issues of BYTE. All issues of Volume 1 and November 1978 issue. Must be in excellent condition. R Tellier, 943 Dyer Ave, Cranston RI 02920.

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WANTED: I wish to purchase a Z80, 8080 S-100 type computer. It does not need to work. It could have dual disk and a video display. I have ham equipment for trade. Dale Hutchinson, 10818 Brentway Dr, Houston TX 77070, (713) 469-2584.

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FOR SALE: 16 K Level II TRS-80 with keypad. New; under warranty. $700. John Abraham or Joe Gutierrez, POB 3945, McAllen TX 78501, (512) 687-2329 or (512) 682-6731.

FOR SALE: Trendcom 100 printer with interface for the Apple II, including four rolls of paper for $300. Art Mena, 10414 Rutgers Ct, Cypress CA 90630, (714) 761-2585.

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FOR SALE: SwTPC CT-64 terminal, assembled and tested; $250. SwTPC 8 K static programmable memory, assembled and tested; $100. Chuck Duff, 7007 N Sheridan Rd, Apt 317, Chicago IL 60626, (312) 996-5523 days, (312) 465-8152 evenings.

FOR SALE: SD Expandoram 64 K unassembled kit; $210. Uses 4116s. Call for shipping arrangements. Sanjeev K Katyal, 990 Fairfield Dr, Marietta GA 30067, (404) 971-4636.

WANTED: For Video Brain Model 101A: APL/S cartridge, documentation, schematics, and information. Will correspond with other owners. Kendall Stambaugh, 5009 Guide Meridian Rd, Bellingham WA 98225.

WANTED: TRS-80 Level I programs to swap. Games, home, business programs. Send tape or listing with your address. Douglas Collimore, 31 Melisa Ct, Southington CT 06489.

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June BYTE readers communicated their approval of Steve Ciarcia's "I/O Expansion for the TRS-80, Part 2: Serial Ports." An above-average number of responses gave Steve a well deserved first place at 1.51 standard deviations above the mean. Congratulations are also in order to Ronald Parsons for his excellent article "An Answer/Originate Modem," which placed a close second at 1.35 standard deviations above the mean.

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