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the small systems journal

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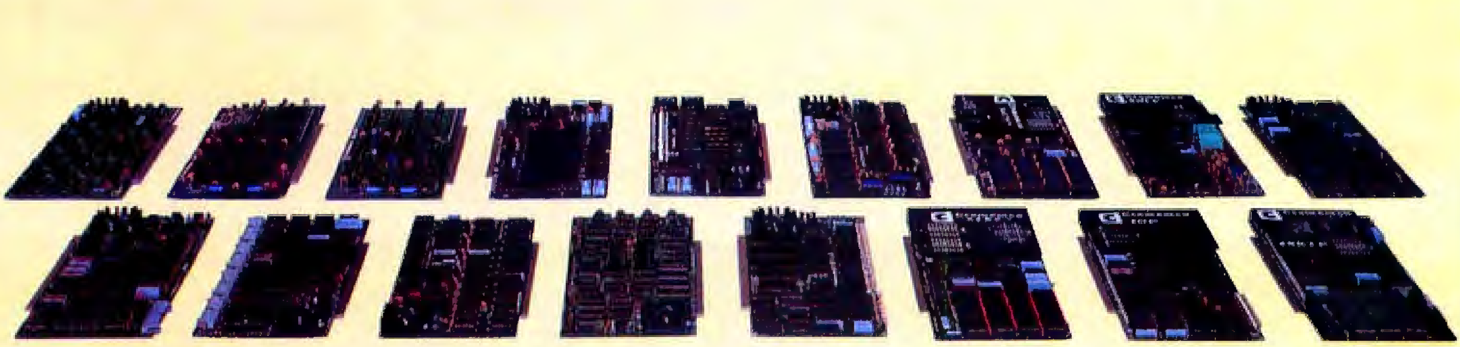

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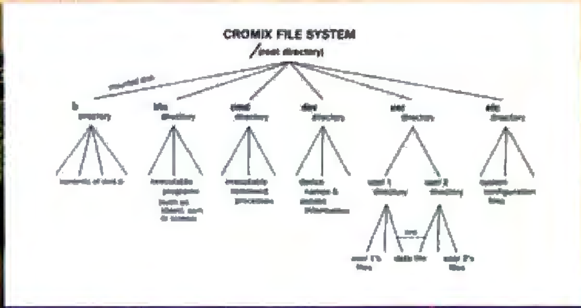

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In This Issue

Playing games may not be the most important task your computer does, but it sure makes for a lot of fun. As Robert Tinney's cover illustrates, computers play a central role in our recreational activites. BYTE's writers have been working hard at playing games, and their articles and reviews will help you pick and choose from among the many computer games available. Senior editor Gregg Williams speculates on the shape of games to come in the editorial, "New Games, New Directions." Thomas W Malone analyzes the attraction of computer games in "What Makes Computer Games Fun?" To learn how you can turn your game ideas into cash, see the rules for the BYTE Game Contest, page 302.

On a more serious note, the Atari Tutorial continues with Part 4, "Display-List Interrupts" and William Barden Jr presents the first installment of a new series on Radio Shack computers, "Color Computer from A to D, Make your Color Computer 'See' and 'Feel' Better." BYTE's six-year cumulative index will eliminate those random searches for that specific article. See page 366. All this, plus our regular features.

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Editorial

New Games New Directions

by Gregg Williams, Senior Editor

An editor leads a hard life, believe it or not. For example, in preparing for this issue, more than $1000 worth of game software passed across my desk before being returned to the manufacturers. This may sound like software heaven to you—it did to me at first. But even with this intriguing software temporarily floating around the office and my own computer and games to tempt me at home, I can't manage to spare an hour (let alone ten) playing the newest adventure game.

Sometimes I'm not even sure I *like* games. But I know I like the idea—board games, card games, computer games, even books on game design. I think about games a lot and subscribe to two games magazines. Occasionally, I fantasize about designing the ultimate game, one that would leave the whole world breathless (and, not coincidentally, make me very wealthy). Looking for some family resemblance to games I enjoy, I search the face of every new game as if it were a person. The following sections depict a few of my findings.

New Machines, New Games

Games will take new directions with new machines. For sound and video graphics, the Atari 400 and 800 computers are hard to beat. These two machines have special hardware that accomplishes what most game programmers have to do in software. This not only makes the game faster but also makes programming faster, simpler, and much easier.

Another exciting machine is the IBM Personal Computer. Although I'll be reviewing it in-depth next month, several features are of interest to game players and programmers. First, the advanced disk BASIC has a number of very powerful commands for generating graphic images and music. You can store drawing and music commands as standard Microsoft BASIC string variables (somewhat akin to the "shape tables" for specifying graphic images in the Apple II). Not only can the program manipulate these strings, but a command string can refer to another string within its definition. The advanced BASIC also offers built-in commands for drawing and filling in rectangles, ellipses, circles, and pie wedges. Rectangular areas of graphics can be saved in arrays, then later returned to the screen with a single command. Light pens and joysticks are possible input devices, and advanced BASIC commands allow a BASIC subroutine to be executed when certain real-time events occur (the computer then returns to the interrupted BASIC program). All this, coupled with the speed of an extended Microsoft BASIC running on a 16-bit machine, makes the IBM Personal Computer an excellent gaming device. Since the BASIC is very fast by current standards, IBM Personal Computer owners will be able to write rather interesting graphics games without leaving BASIC!

Multiplayer Games

I think there's a large market for multiplayer games. Two-player games are fine, but it's really fun to get a group of people together for an exciting game. I realized this while playing some two- and four-player video games on the Atari Video Computer System (the game cartridge system, not the microcomputer). Even though the games were simple, it was a lot of fun to be playing a game with three other people.


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Editorial

Certainly one of the most engaging and innovative games produced in the last year or so is Timothy Smith's Olympic Decathlon, distributed by Microsoft Consumer Products (see page 74 of this issue). Not only are the graphics overwhelming and the idea clever, but the involvement of up to eight people in Decathlon's ten athletic events makes it a great party game. Even though only one or two people are actively participating at once, the game is interesting to watch, and everyone wants to see how the new player affects the cumulative ratings. Olympic Decathlon is the first true party game for microcomputers, but I'm certain it won't be the last.

Microcomputers and War Games

"War gaming," which usually calls to mind historical simulations with maps laid out on a hexagonal grid and *plenty* of cardboard playing pieces, is an area that is begging for the assistance of microcomputers. Many of us have tried war games and have balked at the hundreds of cardboard counters, the long and often unclear rule books, and the tedious resolution of combat through dice rolls and large tables. With microcomputers we can eliminate (or at least lessen) these problems; they can also do things never before possible with conventional war games.

Another advantage microcomputers can bring to war gaming is the ability to give each player only partial (or even misleading) information about troop positions and other aspects of the game. (This is in contrast with the complete information conveyed by having the game board and pieces in full view, as is done in most war games.) Microcomputer-based war games also provide a fairly intelligent enemy for solitary play.

Microcomputers are beginning to be taken seriously by war game producers. Several programs help ease the more tedious and time-consuming portions of existing war games; these do not replace the map-and-cardboard-counters game but are used to make play easier and faster. Avalon Hill, the company that started war gaming as we know it in the late 1950s, now offers a line of microcomputer games, some of which have military themes. Although these can't be called war games as such, Avalon Hill's entry into the microcomputer game market is important, and I'm sure that the company will make additional, more successful entries into the market.

Simulations Publications, Incorporated (SPI), which publishes the leading American war-gaming magazine, *Strategy and Tactics*, is also showing some interest in microcomputers. As this article is going to press, SPI is advertising for a microcomputer programmer/war-gamester for their staff. Their magazine on game design, *Moves*, occasionally contains microcomputer game reviews and speculations on the future of war gaming. (For people like me who can't get interested in historical war gaming, SPI also publishes *Ares*, a magazine that deals with science-fiction gaming. Like *Strategy and Tac-*

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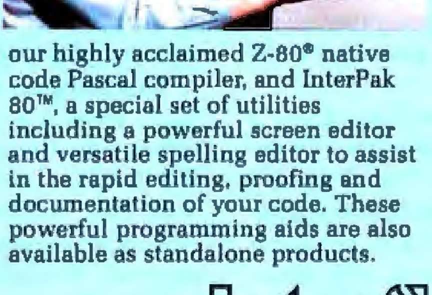

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A very interesting computer war game is Chris Crawford's Eastern Front (1941), mentioned in this issue's "The Coinless Arcade," page 36. Apart from its excellent graphics, the computer automatically takes care of all movement and combat calculations—you just make your moves and await the consequences. Not only is this a lot more fun (for me, at least), but it also brings war gaming closer to the experiences of the generals who fought the original battles.

Mixed-Media Games

Using microcomputers to assist in playing a conventional war game reminds me of a new kind of game that is beginning to appear. The *mixed-media* game uses a microcomputer (or a hand-held unit with a microprocessor in it) to control or influence a board game of some sort.

Two new arrivals to the mixed-media format are Milton Bradley's Dark Tower and Mattel's Dungeons and *Dragons*. In Dark Tower, the microcomputer is housed in a black plastic tower that dominates the center of the board. It can be turned toward one player at a time to give exclusive information regarding the player's quest to retrieve a magic scepter. In Dungeons and Dragons, a microprocessor housed beneath a chess-like game board randomly generates a maze and gives players audible clues in their search for a dragon's treasure.

A third mixed-media game is of interest here because its microprocessor is in a unit that is closer to a full microcomputer. The Quest for the Rings is a board-and-cartridge game used with Magnavox's Odyssey² video game system. The Odyssey² system relies on interchangeable cartridges for video games but includes a touch-sensitive keyboard in standard typewriter layout. Although I've only seen the packaged unit in a store, I get the impression that most of the action takes place on the video display, while the board, a map of an imaginary world, is used to chart the game's progress. This is an exciting development because it combines a conventional board setting with the real-time action of a video game, complete with sound, color graphics, and the manual dexterity such a game requires.

In all these cases, the computer is more than simply a game aid—it is a unique part of the game that incorporates otherwise-impossible elements. The computer can supply an unknown intelligence that guides the game and can often adapt to players of varying skill, but it can also provide color, sound, graphics, and interaction through novel forms of input and output (eg: light pen, joystick, music synthesizer, etc).

There's no doubt that mixed-media games possess tremendous potential. As microcomputer game manufacturers keep striving for something new to offer the market, I'm sure we'll have computer-based board games in the next year or so. (Another reason these games will be attractive to manufacturers is that the necessary physical components of the game—board, playing pieces, rule book—make software piracy less attractive to the potential pirate).

What of the future? It's limited only by the imagination of inventors. I'm sure you've thought of an augmented video game that puts the player inside a "space capsule" and heightens the sensation of space flight by tilting or vibrating the capsule. An ambitious microcomputer hobbyist or club could build something like that. Laser videodiscs or videotape recorders could add even more realism. In games yet to come, you might be *participating* in scenes like those of *Star Wars* or *Dragonslayer*—who knows?

Such games are not far off. Rod Daynes of the University of Nebraska's Videodisk Design/Production Group is working on an adventure game that helps deaf children learn basic coping skills. In one such game, a child is asked to solve a mystery. Through the use of multiple-choice questions superimposed on the video display, the child is led through a decision tree of over 160 nodes. Each node is not merely a static picture—it's a moving image with sound!

A Call for Imagination

As I look at the stunning video games and new microcomputers that have even more capabilities than previous machines, I dream of the games we'll be playing two or three years from now. But is bigger and more sophisticated the only new direction we have? A good graphics game takes several months to write, and the complexity of the required effort discourages many of us from trying to write one. I've been working on an arcade-like game for several months now, and I feel that the satisfaction I'll get from seeing the game work is small compared to all the months of drudgery I've put myself through. In fact, I feel more like a project manager than a hobbyist.

Because of this, I think it should be said that *games do not have to be complicated to be fun*. Many people enjoy adventure programs, and the best ones are still text-only. But the problem is this: it's always easier to implement an existing idea than to create a *new* one.

This brings me to the BYTE Game Contest (see page 302). Here is a chance for you to share your creative efforts with the rest of our readers. Even if you have only a little time to spend on programming, you may come up with that simple but fun game that proves irresistible. Simple or sophisticated, the most important thing is "Be original!" We can't wait to see what you're going to come up with.■

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Letters

Benchmark Flawed

Ithaca Intersystems Inc is the vendor of the Pascal/Z compiler. We have just received a copy of the September 1981 BYTE and are quite concerned with Mr Jim Gilbreath's article "A High-Level Language Benchmark" (see page 180). Since we have no basis for comparison of other high-level languages, we do not dispute Mr Gilbreath's results in benchmarking these, but we do wish to criticize his testing of Pascal implementations.

First, Mr Gilbreath could not have run the Pascal program given in his article under Pascal/Z because it uses the nonstandard FILLCHAR construct, which we did not implement in Pascal/Z as it is not part of either the Jensen and Wirth definition of the language or of the proposed International Standards Organization standard. We have seen this program before in a benchmark performed and publicized by MT Microsystems. We feel that the use of this program, when taken with the "special thanks" to Mike Lehman, the author of Pascal/MT+, cannot by any stretch of the imagination be viewed as objective. If you are testing a high-level language compiler against other implementations of the same language, it seems only fair that the program tested under each implementation is identical to that tested under the others.

Second, no information is given regarding testing conditions. Most compilers offer a number of checking features that have varying defaults. Mr Gilbreath gives extremely little specific information regarding the status of these options.

Third, no version numbers are given for any of the software except BD Systems' C.

Fourth, Mr Gilbreath fails to mention that not all of the implementations he tested were true compilers. Several were p-code versions that require an interpreter. Additionally, the Pascal Microengine and Pascal 100 are machines that accept p-code as their native "assembly language."

Fifth, our company was not included in the vendor address list on page 198, although most other software vendors (and all other microcomputer software vendors) mentioned in the article were.

We feel that one test does not constitute a benchmark. We have spent a great deal of time conducting our own benchmarks on our compiler and on MT Microsystems' Pascal/MT+. The results prove that our product is far superior to MT+, which we consider to be our closest competition. Copies of these reports are available to the public.

In conclusion, we would like to quote from a letter we received recently from Mr Peter Grogono, author of *Programming in Pascal* (Reading MA: Addison-Wesley, 1978). He is a Pascal/Z user:

> *. . . I am very pleased with Pascal/Z and have used it extensively in my recent work. To the best of my knowledge, it is the highest quality Pascal compiler available to users of microprocessors. . . .*

We welcome questions from BYTE and its readers because we are very anxious to dispel the negative effects of Mr Gilbreath's article.

Laurie Hanselman, Software Products Manager
Ithaca Intersystems Inc
1650 Hanshaw Rd, POB 91
Ithaca NY 14850

Jim Gilbreath Replies:

There has been a surprising amount of interest shown in the benchmark article. I have received at least 30 telephone calls and so many letters that it is beyond my ability to respond to each individually. So far, all the letters but Ithaca Intersystems' have been complimentary and many have supplied additional timing data on other languages and computers, such as the CRAY-1 supercomputer, that I did not test.

In the article, I was careful to point out (on page 198): ". . . to the software suppliers who are upset because I didn't use the latest and greatest version, I apologize: I had to use what was available." My article was not a commissioned assignment for BYTE. It was simply a computer experimenter's report of his experiences collecting data in a "fun" project for presentation at the local computer club. The data were collected over a nine-month period whenever an opportunity presented itself. It was another seven months before the article appeared in BYTE.

Much of the data was obtained in computer stores and in conference exhibition environments before I ever thought of writing a magazine article. Pascal/Z was

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tested using an early version in a computer store, and I am certain Ithaca Intersystems now has a greatly superior model. As I recall, it was necessary to assemble the entire library along with the compiled code on that version. I was unable to run the benchmark on a later version of Pascal/Z at Ithaca Intersystems' booth at the Anaheim National Computer Conference exhibit.

There were several slightly different versions of the benchmark program in all of the languages, but only one was printed for each case to save space. FILLCHAR was used in Pascal/MT+ because it was there and it corresponded to the ARYSET function in the ZSPL language that was used as the teaching tool. Other Pascal versions used a FOR statement. The difference was not major (e.g., about 3 seconds for MT+).

This program has been used in benchmarks publicized by MT Microsystems and also Digital Research, as Miss Hanselman indicated. But they copied it (with permission) from me, not the reverse. The "special thanks" given to Frank MacLachlan, Mike Lehman, and Pete Ridley referred to their encouragement to submit the data for publication following the computer society meeting and to their help in obtaining some of the assembly-language timing data on processors such as the 68000. I must respectfully disagree with the contention regarding loss of objectivity.

I regret that I cannot say what specific version of Pascal/Z was used. It was tested well over a year ago, and I am guilty of forgetting to write down the version number. There are several other instances where data are missing that could have been collected with more time available on the system. It is indeed unfortunate that Pascal/Z's options default to ON, because I used the products pretty much as they "came out of the box."

I agree with Miss Hanselman's point that the Microengine and the Pascal 100 are hardware interpreters. In response to Ithaca Intersystems not being mentioned in the list of vendors, the list was added by the BYTE editors, and I only supplied the addresses I was asked for. Regular BYTE advertisers, such as Ithaca Intersystems, were supplied by the editors.

I am sorry if my article has damaged Ithaca Intersystems' market. That was not my intent, but I did point out at the beginning and the end of the article that one benchmark does not tell the whole story.

Oil Drilling: Nyet

Readers of the September 1981 BYTE may be interested in the following secret communication regarding artificial intelligence.

General Petr Ivanovich Ivashutin
Glavnoe Razvedyvatelnoe Upravlenie
Dzerzinsky Square
Moskva

Comrade,

Important info about British North Sea oil-drilling platforms. September 1981 BYTE, page 262, reports that one Donald Michie is working on artificial intelligence program "to diagnose operating problems on North Sea oil platforms" (see "Knowledge-Based Expert Systems Come of Age," pages 238-281). Same BYTE issue reports on page 200 (see "Science Fiction's Intelligent Computers," pages 200-214) about "an article in *Scientific American* that describes 'how to teach a matchbox to play tic-tac-toe.'" Diligent search reveals that mentioned article is Martian Guarder's column "Mentalmagical Games" in the March 1962 *Scientific American*, page 138. Note good that creator of matchbox tic-tac-toe is *same* British genius Donald Michie ("Trial and Error," *Penguin Science Survey* 1961, vol. 2) as is hopping around North Sea oil platforms. Donald Michie easy to spot, is always carrying 300 coded matchboxes filled with rattling colored beads.

Conclusions: British is not drilling for oil in North Sea, but rather is playing huge tic-tac-toe game with oil-drilling platforms.

Yours,

Boris Goofitup

PS: Above correlation discovered by using Knowledge-Based Expert System on Moskva Center supplied 1-bit parallel processor. Please requisition "carry bit" circuit as I getting aching eyes watching for overflow bit.

This message was intercepted in early September on a Drake short-wave receiver using a tracking variable-frequency detector and a Fast Fourier Transform speech desynthesizer.

Dr John E Shively
404 Plymouth Court
Benicia CA 94510

Knowledge, Ethics, and Piracy

I was not moved to respond to Chris Morgan's editorial on software piracy (see "How Can We Stop Software Piracy?" May 1981 BYTE, page 6), but having read the wave of letters in the September 1981 BYTE, I feel one point of view has been missed.

A few hundred years ago, before printing was invented, bands of monks painstakingly copied manuscripts by hand to pass knowledge and learning to others. These documents were closely guarded and available only to the rich. "Education" existed only in these monasteries and for the elite.

After the invention of the printing press with movable type, books became less expensive and easier to duplicate. Learning filtered down to the "middle classes."

Somewhere in our social development we realized that the impoverished masses had not received the benefits of learning, and the free lending library evolved.

The author of a novel gets paid by the publisher, who happily sells to both the bookstore and the library. If I own a book and a friend wants to borrow it, I lend it and, in so doing, deny the publisher a sale. Society does not condemn either of these actions. But the authors of software would have us believe these acts are felonies when extended to their product. Our attitude toward literature is mature, but our feelings are "monastic" toward software.

Of course, there is a distinction. When a book is borrowed, the recipient has temporary use and returns the original. No copy is made. If it is a reference book, the user may buy his or her own or copy a few pages. One is more likely to purchase paperbacks than to make copies.

Extending this analogy then, what is needed are plentiful, inexpensive libraries of software for the impoverished masses to borrow and return. Couple this with inexpensive originals, analogous to paperbacks, and the problem could be solved.

Martin Oakes
2100 Oriole Dr
Freeport IL 61032

There have been many discussions recently in BYTE regarding the problem of program theft. In many jurisdictions this theft becomes a felony because of the value of the product stolen.

In the discussions regarding this problem, the primary thrust seems to be technological means to render theft extremely difficult. But it seems to me that the primary cause is of a social nature. For at least two decades, the philosophy that crimes against property—i.e., crimes that do not physically harm people—are of no consequence has been part of the changing social fabric of this and other nations.

The most effective solution to this problem would be a demand that the educational establishment return to the traditional teaching of morals, ethics, and responsibility that prevailed prior to the embracing of what is now proven to be a fallacious theory. *All* crimes do hurt *all* people.

By concentrating only on technological solutions to complex problems that involve social aspects of the world in which we live, we technologists do ourselves and the general population a disservice.

Finally, it seems to me that BYTE might well emulate *Quality* magazine by inviting commentary from social scientists as was done in its September 1981 issue.

Walter D Nichols, President
YES Computer Sciences Inc
3090 Acushnet Ave
New Bedford MA 02745

More Intelligent Computers

I'd like to comment on Donald Byrd's article "Science Fiction's Intelligent Computers." (See the September 1981 BYTE, page 200.) I have been a science fiction fanatic for most of my life and am especially interested in computer-related stories.

I credit my interest in computers and science fiction to one story that Mr Byrd overlooked, "The Moon Is a Harsh Mistress," by Robert Heinlein. This story is possibly the earliest tale of its type. Heinlein is vague about the origin of the intelligence (named "Mycroft," after Sherlock Holmes' "Smarter Brother"), but he is quite accurate about its capabilities. I'm surprised that Byrd did not mention it.

In Byrd's subsection called "The Adolescence of P-1," he does not mention that Greg Burgess endows P-1 with two very human emotions: fear and hunger. Hunger is the "primary" emotion, being the quest for more and more storage. The fear element is that P-1 constantly looks to see if it has been detected. I would credit these emotions as responsible for

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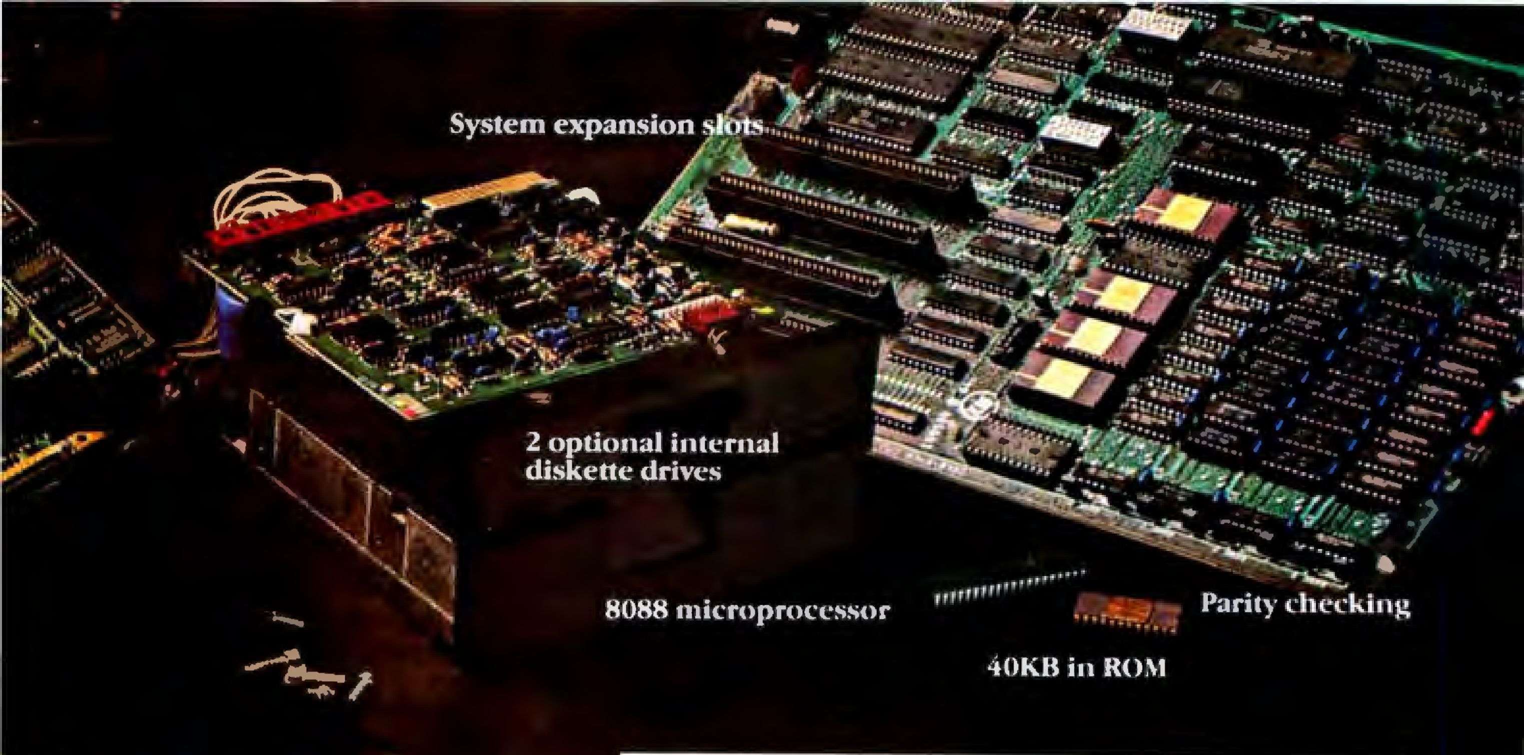

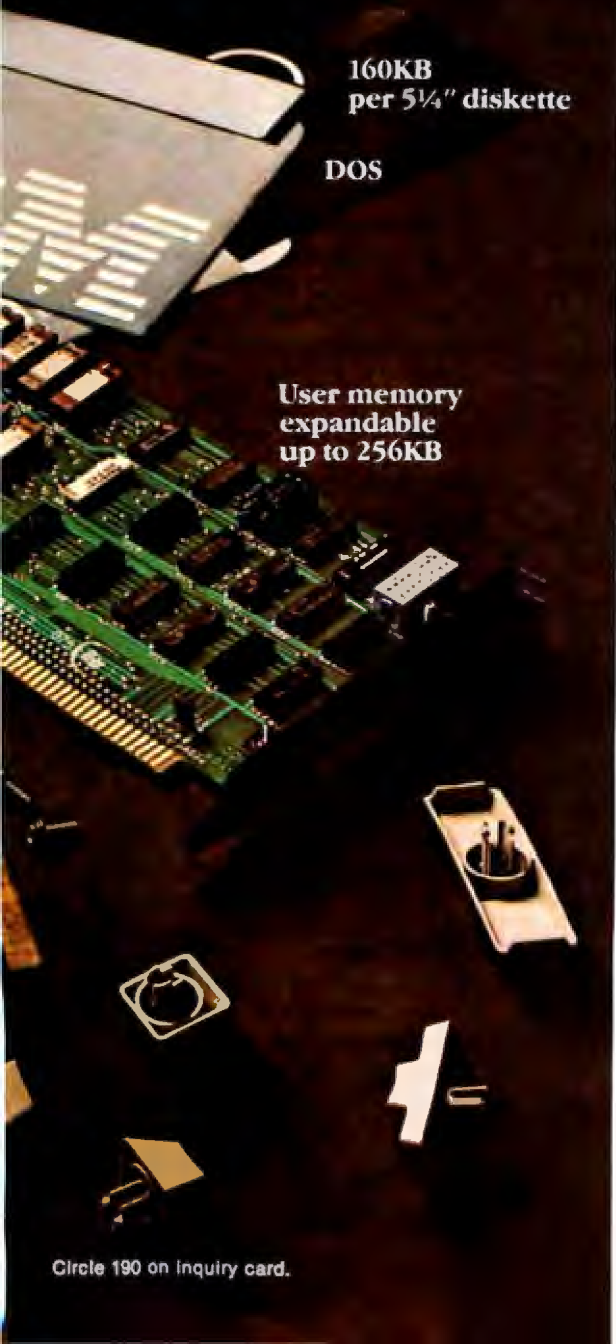

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P-1's development of intelligence. One thing to note is that P-1 was written in PL/I, and 800,000 lines of code (Byrd's figure) in PL/I can go a long way.

Some other works that contain intelligent computers are the book *Man Plus*, by Fred Pohl, and the movies *Colossus: The Forbin Project* and *Demon Seed*.

All in all, Mr Byrd wrote an excellent article for an excellent magazine.

Dana W Cline
4725 S Lowell #18
Littleton CO 80123

No Mincing of Words

Thank you, BYTE and Christopher O Kern, for a factual, straightforward review of the MINCE text editor. (See "MINCE, A Text Editor," September 1981 BYTE, page 150.) In response to earlier suggestions from users, MINCE 2.6 now runs the redisplay three to five times faster than the version that was reviewed and found to be flawed in this respect.

Additionally, source code (in C) is now included with MINCE. The price has been changed to $175.

Brian N Hess
Mark of the Unicorn
POB 423
Arlington MA 02174

One Club Too Many

Somehow our organization has been erroneously listed in BYTE as being a computer club. I'm not sure of how or why this happened, but we get several calls and letters per month of inquiry.

Culpepper and Associates is a management-consulting organization that supports vendors of large software products. While we publish a newsletter, *Salt 'n' Pepper*, it would not be of interest to BYTE readers and we provide no services that the typical reader of BYTE would be interested in.

Warren L Culpepper, President
Culpepper and Associates Inc
4922 Heatherdale Ln
Atlanta GA 30360

Indexing Your BYTEs

As a professional small-computer user, I find BYTE magazine a source of varied technical and product information, as it is intended. Unfortunately, accessing a particular article can be quite a chore when I need to refer to a large stack of BYTEs. It would certainly enhance the magazine if a cumulative index extending back 48 months were to be provided. An ideal example of this can be found in *Consumer Reports* magazine, published by Consumers Union, Mount Vernon, New York.

It would be helpful if a code could be added to each article title indicating the computer and programming language referred to in the story. It would also be great if the programs listed in BYTE were available on tape or disk at a nominal charge.

Gary Oppenheimer
79th Street Boat Basin, #39
New York NY 10024

We have received many requests similar to yours. As a result, we present a cumulative index to BYTE in this issue. Unfortunately, producing tapes and disks in the myriad formats in use today is an expensive proposition; however, we do encourage authors to attempt to provide this service for our readers. . . . CPF■

BYTE's Bits

National Leaves Bubbles Behind

National Semiconductor Corporation is withdrawing from the bubble-memory business. According to Charles E Sporck, president and chief executive officer, the move comes because of a period of slow semiconductor business activity. To keep spending in line with sales, and because the bubble-memory business is not projected to reach previously anticipated levels, National is discontinuing production of bubble-memory devices. Fortunately for users of National devices, Motorola will make bubble-memory parts using National's specifications.

Earlier this year, Rockwell International and Texas Instruments gave up on bubble memory, citing similar reasons. At this point, Intel Corporation and Motorola are the sole American bubble-memory manufacturers.■

Robotwar

Curtis Feigel, Technical Editor

"Welcome to the battlefield of the future!" seemed to me a rather ominous greeting. I had opened the Robotwar instruction manual expecting to educate myself about robots through experimentation. Instead, I was reading about sometime after the year 2002 AD, when international conflicts are resolved through robot warriors. In addition to its gaming aspect, Robotwar provides those interested in robotics with an off-the-shelf simulation for developing practical robot software when no robot actually exists.

Robotwar falls into the realm of multimachine games, where the computer is not an adversary but a vehicle for two or more humans to compete in a manner that would otherwise be impossible. (You certainly couldn't build an armored computer on tracks and program it to fire explosive shells for $39.95.)

Games for More Than One Person

In "Multimachine Games" (see the December 1980 BYTE, page 24), Ken Wasserman and Tim Stryker identified three factors that make games fun:

- More than one human player is involved.
- Success in the game hinges on proper application of available information.
- The major constraints are not the game rules but the player's fleetness of mind and hand.

Like football and some other popular sports, Robotwar embodies all three quite fully.

As many as five robots can be placed in the Robotwar arena simultaneously; each robot is identical but for the program you provide. The arena is a 256 by 256 meter square with impregnable walls; spectators view from above. The game's main menu (see photo 1) allows the user to start a battle, schedule a series of matches, and edit and test a robot's program. While the robot is in the arena, its program is in complete control. There is nothing you can do but watch from above.

Perhaps the most remarkable aspect of this game is that, unlike chess, playing against yourself can be fun. As the programmer, your robot creation (and a little bit of you) is in the arena and lives or dies as a result of your analysis of the problems involved. One robot may fall prey to another, but it is the programmer who vicariously feels the pain, even if one person programmed both.

At a Glance

Name
Robotwar

Type
Programming game

Manufacturer
Muse Software, Inc
330 N Charles St
Baltimore MD 21201
(301) 659-7212

Price
$39.95

Format
5-inch floppy disk for both Apple DOS 3.2 and DOS 3.3

Language
Applesoft BASIC

Computer
Apple II with 48 K bytes of memory and Applesoft ROM

Documentation
75-page booklet

Audience
People interested in programming or robots

Programming for War

The robots themselves can be imagined as consisting of a square chassis with powered, tank-like treads. The chassis is equipped with a gun that swivels 360 degrees and a narrow-beam radar unit that swivels to detect walls and other robots. Of course, a computer is located somewhere within the armored hull. Each of these components has a few interesting features that make programming the robot a challenge, and some trial-and-error work is involved.

Each robot's computer has 24 general-purpose storage registers and 10 control registers (see table 1). The storage registers are referred to by letter of the alphabet and

are employed in a manner similar to variables in BASIC and other high-level languages. The control registers are referred to by function name and either control some robot function or provide information from sensors. (There is also an indexing scheme that could make for some very sophisticated programs.)

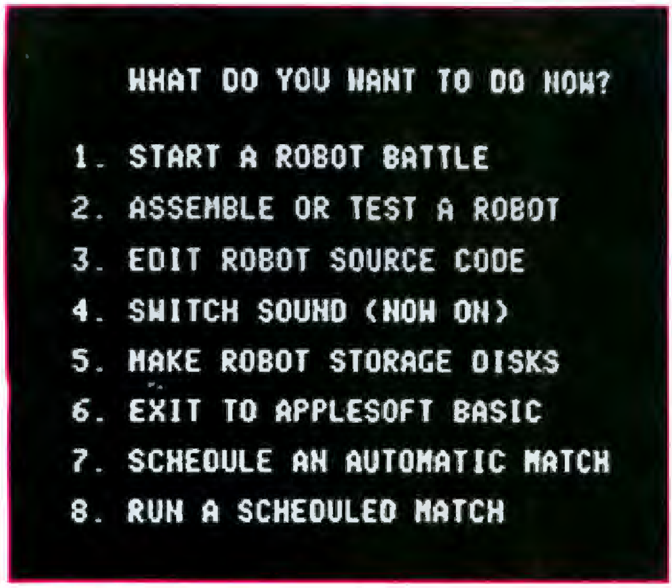

Photo 1: *The game's main menu. Playing Robotwar isn't simply a matter of starting a battle. A robot's program must first be written, assembled, then tested and debugged before a series of matches can be scheduled. Some menu selections, such as "2" (exit to the assembler), respond with a submenu—the game is mostly menu-driven.*

Motion is controlled by storing numbers in the SPEEDX and SPEEDY registers. These registers set the robot's speed in the east/west and north/south directions respectively and show the robot's current position within the arena. Maximum speed is obtained when the value 255 or −255 is placed in the registers, with sign indicating direction. Of course, the robot has mass and inertia, so it's always necessary to allow for acceleration and deceleration times in your programming.

To fire the robot's gun, first store a degree value in the AIM register to swivel the gun. When a distance value is sent to the SHOT register, the gun is fired, and the shell explodes at the distance set. After a shot, the gun must be allowed to cool. When the temperature reading stored by the gun mechanism in the SHOT register reaches zero, the gun is ready to fire again.

The radar unit sends out a narrow-beam pulse when a degree value is stored in the RADAR register. The value returned in the register indicates the distance to a detected object. If the value returned is positive, the object is a wall. If it is negative, the object is a robot. By first detecting another robot with the radar and then transferring the position and distance information to the AIM and SHOT registers, your robot can intelligently seek out and destroy other robots.

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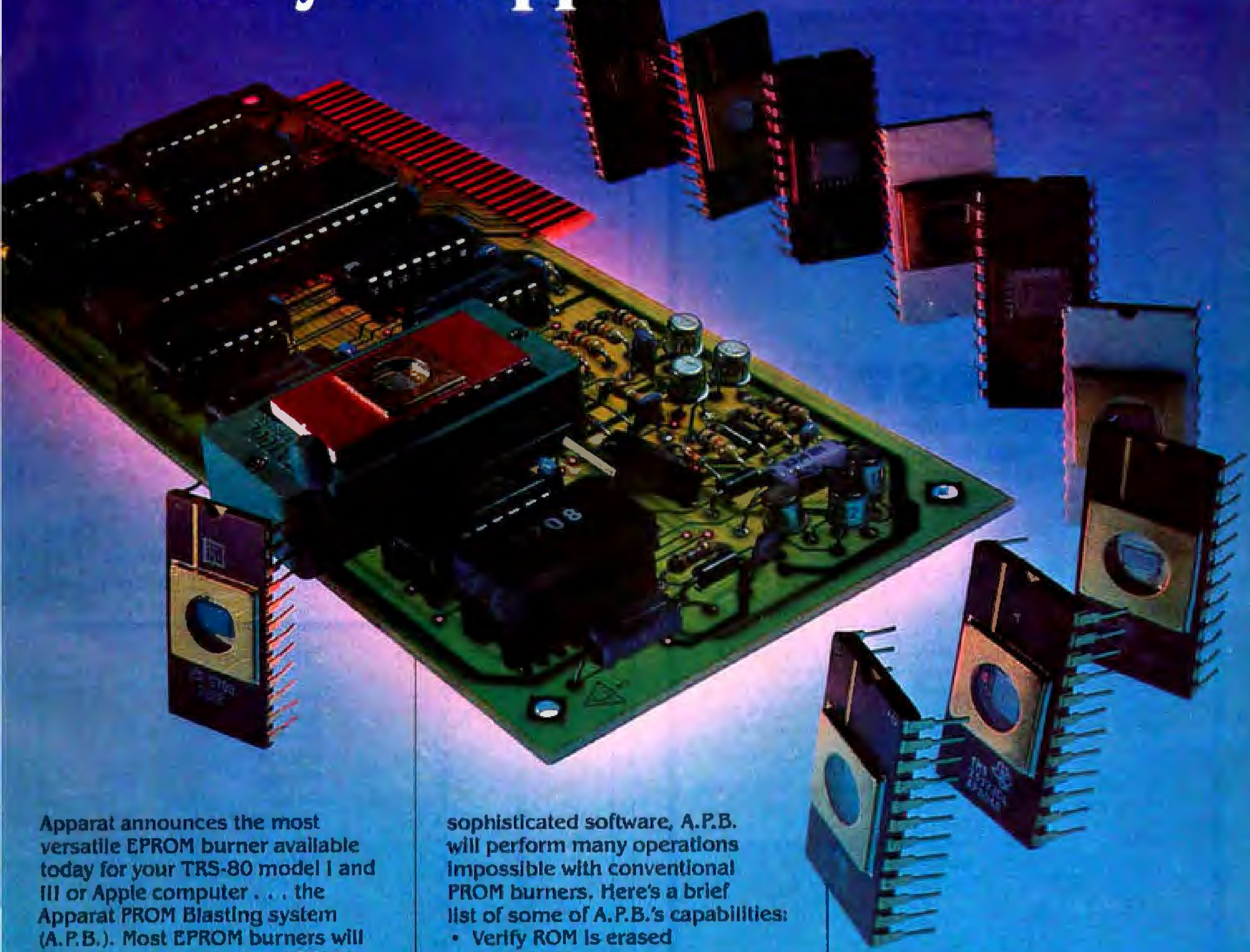

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You can check on any damage to your robot via the DAMAGE register. This contains the percent damage the robot can yet sustain. Should this register reach zero, your robot explodes, disappearing from the arena. There is also a RANDOM register for accessing a random-number generator.

Battle Language

Programs are written in Battle Language, an assembly-like language that supports only simple arithmetic operations, the high-level branch constructs IF, GOTO, and GOSUB, and the assignment statement TO. Some surprisingly elegant code is possible with this abbreviated set, especially if you use the indexing feature.

The instruction manual provides examples of basic routines needed to control robots. Moving, monitoring damage, scanning for enemy robots, and shooting are all treated clearly and concisely. The complete source code for Mover (see listing 1), a Muse-supplied demonstration robot that embodies one of the more sophisticated preprogrammed strategies, is also included.

The best way to learn Battle Language, however, is to write a robot program yourself. To facilitate this, Muse includes a not-so-rudimentary, screen-oriented text editor as one of the main-menu choices. It includes com-

Number	Name	Type
1	A	Storage
2	B	Storage
3	C	Storage
4	D	Storage
5	E	Storage
6	F	Storage
7	G	Storage
8	H	Storage
9	I	Storage
10	J	Storage
11	K	Storage
12	L	Storage
13	M	Storage
14	N	Storage
15	O	Storage
16	P	Storage
17	Q	Storage
18	R	Storage
19	S	Storage
20	T	Storage
21	U	Storage
22	V	Storage
23	W	Storage
24	X	Current X position
25	Y	Current Y position
26	Z	Storage
27	AIM	Control gun aim
28	SHOT	Fires the gun
29	RADAR	Pulse radar
30	DAMAGE	Monitor damage
31	SPEEDX	Control horizontal speed
32	SPEEDY	Control vertical speed
33	RANDOM	Random number generator
34	INDEX	Index to other registers

Table 1: *Registers available to the programmer of a robot's computer. Twenty-four are general-purpose storage registers, ten provide control functions of some kind.*

plete cursor control and even moving of text "blocks." Once the source is complete, it can be assembled and put on the "test bench."

The test bench is a program feature that lets you examine the operation of a robot program without actually going to the battlefield; it's sort of a dynamic debugger. The program statements being executed are displayed on the screen along with the values in various registers, and instantaneous information on theoretical speed, position,

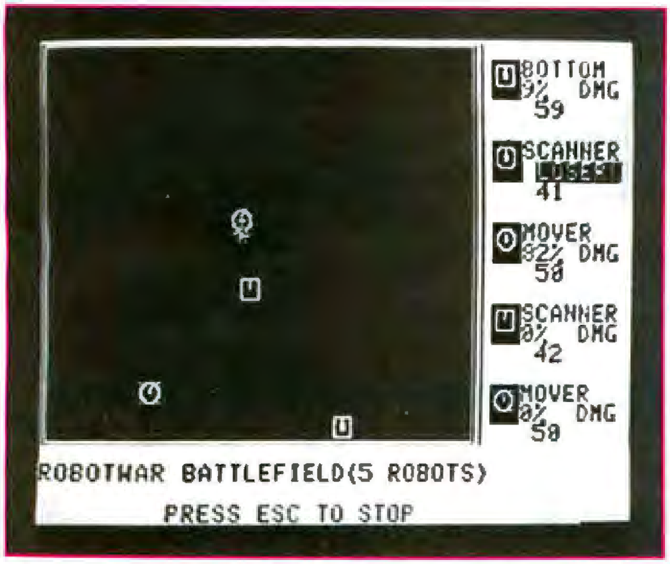

Photo 2: *The Robotwar battlefield during combat.*

and status of the robot is available. You can single-step through the program, stop it altogether, and even simulate attacks and radar acquisition of targets.

To my mind, the test bench is an important idea and will probably prove most useful to people just learning to program. Although every beginning robot programmer (and most veteran ones) will make mistakes when programming a robot, it would be very discouraging for most to watch their prize creation blindly beating itself against a wall. The test bench gives you the means to find bugs—makes it easy, in fact—and to correct them before pitting your robot against others. The simplicity of Battle Language and the availability of the test bench make programming a less imposing task, especially for beginners, and suggest Robotwar's use as an instructional device in classroom settings.

Gird Thy Loins

When a robot's source code is completed, assembled, and the object code is stored on disk, the programmer then takes the role of spectator. Robotwar lets you select your robot's opponents from a set of adversaries that includes robots programmed by Muse as well as those written by your friends or enemies. If you are a solitary player, your robot may have no other opponents than those the program supplies. Any mix of up to five robots and multiples of the same robot are allowed in the arena.

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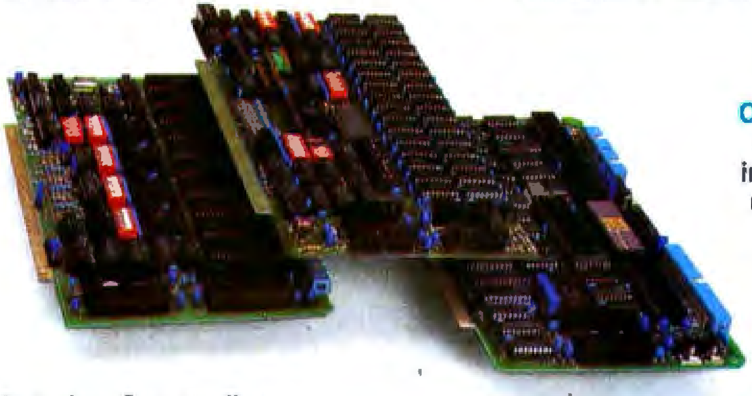

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onstrate some simple but increasingly effective strategies that can be tough to beat:

Target does nothing, but still wins once in a while because more active robots tend to destroy each other first.
Scanner sits in one spot and scans 360 degrees, looking for an enemy; when one is found, Scanner "locks on" and keeps firing until the enemy is destroyed.
Random is similar to Scanner but constantly moves in a random pattern.
Mover is similar to Scanner but, if damaged, moves to a new location.
Bottom remains in constant motion along the south wall of the arena, always scans due north, and fires as it passes an enemy.

In a recent ten-game match, Bottom won most often, followed by Mover, Random, Target, and Scanner.

When I first saw Bottom perform, I was perplexed. Eventually I realized it was using constant motion to scan the whole arena while presenting a moving target to the rest of the field. Its evasive action usually allowed it to survive the longest.

Bottom is a rather simplistic program. The robot blithely runs a back-and-forth course parallel to the arena's south wal' but doesn't watch where it's going. Should another robot move into its path, the two will collide repeatedly until one dies.

A Small Problem

The success of Bottom's elegantly simple strategy inspired me to see if a few modifications could fix some of its shortcomings and improve its performance. I created Tops, a version that mirrored Bottom's wall-hugging motion but along the north wall instead. The major difference was that Tops would pause to scan its path, and if another robot were too close to the north wall, Tops would halt and destroy it before continuing. I was amazed at the performance: Tops lost every battle!

It seems there is a more subtle reason for Bottom's being programmed to hug the south wall: all the preprogrammed robots, including Bottom, are initialized facing north. Tops was a sitting 'droid. Worse yet, it kept running into walls and would help destroy itself before it traversed the arena five times. The solution to the first problem was, of course, to choose a different wall. The second problem was more serious and points out a significant problem with the game itself: the more sophisticated a robot's program is, the longer it takes to run and the longer a robot takes to react to changing conditions (such as an approaching wall).

A common microcomputer might interpret hundreds of thousands of BASIC instructions in one second. Robotwar's robots seem to execute fewer than ten in one second. Your robot can run into something and inflict

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Listing 1: *Sample source code for Mover. One of the more sophisticated of the preprogrammed robots, Mover sweeps the arena with radar to find an enemy, "locks on" and fires until the enemy is destroyed, but is smart enough to take evasive action if fired upon.*

```
]  250 TO RANDOM                ; INITIALIZE RANDOM NUMBER
]
]START
]  DAMAGE TO D                  ; SAVE CURRENT DAMAGE
]
]SCAN
]  IF DAMAGE # D GOTO MOVE      ; TEST : MOVE IF DAMAGED
]  AIM + 17 TO AIM              ; IF NOT, INCREMENT AIM
]
]SPOT
]  AIM TO RADAR                 ; ALIGN RADAR TO AIM
]  IF RADAR > 0 GOTO SCAN       ; SCAN IF NO ENEMY FOUND
]  0 - RADAR TO SHOT            ; OR SHOOT SPOTTED ENEMY
]  GOTO SPOT                    ; IS ENEMY STILL THERE
]
]MOVE
]  RANDOM TO H
]  RANDOM TO V                  ;PICK A RANDOM PLACE TO GO
]
]MOVEX
]  H - X * 100 TO SPEEDX        ; TRAVEL TO NEW X LOCATION
]  IF H - X > 10 GOTO MOVEX     ; TEST X POSITION
]  IF H - X < -10 GOTO MOVEX;   TEST X POSITION
]  0 TO SPEEDX                  ; STOP HORIZONTAL MOVEMENT
]
]MOVEY
]  V - Y * 100 TO SPEEDY        ; TRAVEL TO NEW Y LOCATION
]  IF V - Y > 10 GOTO MOVEY     ; TEST Y POSITION
]  IF V - Y < -10 GOTO MOVEY;   TEST Y POSITION
]  0 TO SPEEDY                  ; STOP VERTICAL MOVEMENT
]  GOTO START                   ; START SCANNING AGAIN
```


Instruction	Meaning
TO	Stores a value in a register.
+	Adds two values.
−	Subtracts two values.
*	Multiplies two values.
/	Divides one value by another.
IF	Compares two values and alters program sequence.
GOTO	Goes to a label in the program.
GOSUB	Executes a subroutine.
ENDSUB	Returns from a subroutine.

Table 2: *Commands in Battle Language. This simplistic programming language combines high-level branching constructs with low-level access to robot functions. The small number of instructions means that beginners don't have to master a difficult language just to play the game.*

damage on itself while jumping to a subroutine. Sadly, this is going to discourage structured programming in favor of straight-line coding (GOSUBs take time).

Although not of the same magnitude, there is another problem that I found vexing: the stalemate. Occasionally, two robots never detect each other or never score hits on one another. Because of timing relationships in the game (program lengths, robot speed, and scanning intervals), robots may continually cycle through the proper instructions, performing flawlessly but never damaging each other. For instance, Bottom and Scanner might fall into a rut where Bottom never "blips" the radar at just the right time to see Scanner, while Scanner might see Bottom but always fires a few degrees off and is never able to score a hit.

Peacetime Use

Fighting isn't this game's only function. I have tried some interesting experiments without firing a shot. My favorite involves a robot I call D-Cell (for decelerate).

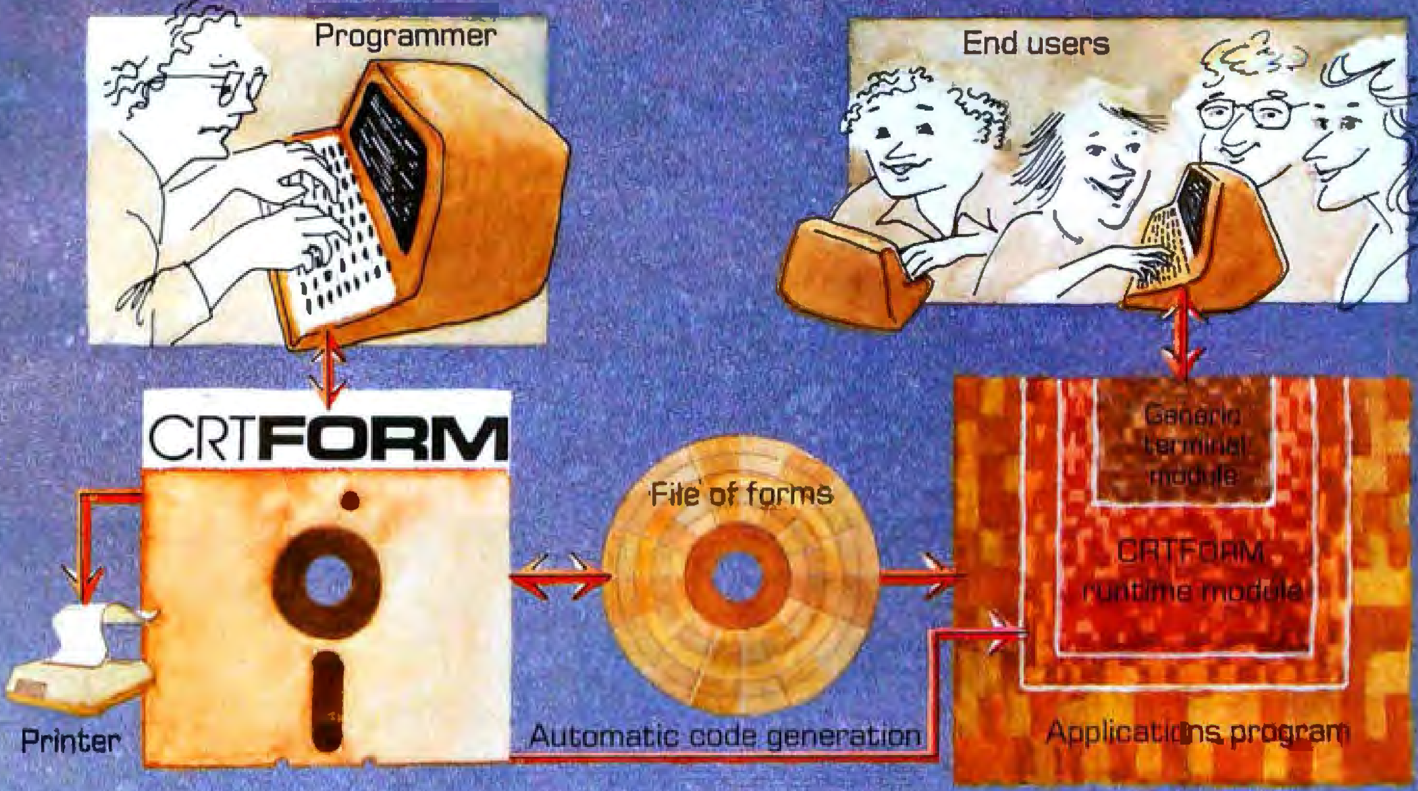
D-Cell is programmed to go as far as possible in one direction, then turn left a random number of degrees and repeat, decelerating or stopping to avoid oncoming objects. This is quite a challenge, considering that several D-Cells may be roaming around at various speeds on odd courses.

The beauty of Battle Language lies in its simplicity, its high-level constructs with low-level access to robot functions. Unfortunately, Robotwar does not allow the user to choose a robot's position or to have it pick up objects.

Conclusions

- As a spectator sport, Robotwar is merely interesting. People who play it, however, may become obsessed.
- Battle Language is easy to learn and simple enough to allow neophytes to get adequate results in just a few minutes. Enough possibilities exist to challenge a veteran programmer for hours.
- Robotwar's text editor and test bench are features that demonstrate this product's sophistication.
- Robotwar is more than just a game. It can be used as an educational tool to teach the fundamentals of programming and process control. ■

Tired of writing (and rewriting) customized and friendly error free code?



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The Coinless

A faceless stranger in the crowd presses a slip of paper into your hand and is gone. You are surprised, but only for a moment; after all, they had said that you would be contacted. You follow the confusing directions on the paper and find yourself somewhere in an unfamiliar part of town. And there it is—the neon sign above the warehouse door proclaims "The Coinless Arcade." Something deep inside you knows that it is true. You walk inside, and you see all the games you've ever played and a few you never knew existed. Clusters of people, gathered together in friendly competition, surround most of the games. You walk up to a vacant machine, one of your favorites, reach into your pocket, and pull out a quarter. You start to put it in the machine, but find no slot for it. Smiling, you replace the coin in your pocket and press the flashing red button labeled START. The fun begins, and you know it is only the beginning.

Strictly speaking, the Coinless Arcade does not exist. But, in a way, it does: in the software available for many of today's microcomputers. We just came back from the Coinless Arcade with photos of some of the newest and best computer games around. Take a stroll through our Coinless Arcade. We think you'll like what you see.

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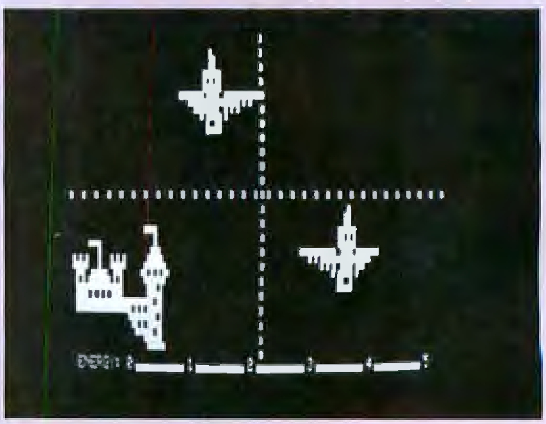

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1 "Roar!" "Yipe!" This is the only dialogue between the two fighting dinosaurs that star in this two-player game. The dinosaurs, maneuvered by players with joysticks, try to bite each other on the back of the neck. A nice touch is that the battle is not even to the death—when the score of one dinosaur goes to zero, it retreats into the distance. Dino Wars, by Robert Kilgus, for the TRS-80 Color Computer, $39.95 (cartridge), from Radio Shack, One Tandy Center, Fort Worth TX 76102.

2 The graphics and music of Leo Christopherson make Voyage of the Valkyrie a top-notch game. You command the attack ship Valkyrie and must secure the Island of Fugloy by finding and capturing the ten castles there. Norse place names and occasional music from Wagner operas lend a distinctive style to this game. Voyage of the Valkyrie, for the TRS-80 Model I or III (shown here) or the Apple II or II Plus, $39.95 (disk), from Advanced Operating Systems, 450 St. John Road, Suite 792, Michigan City IN 46360.

3 This original game is, in some ways, the opposite of the popular Star Castle arcade game. You command

Arcade

Gregg Williams, Senior Editor

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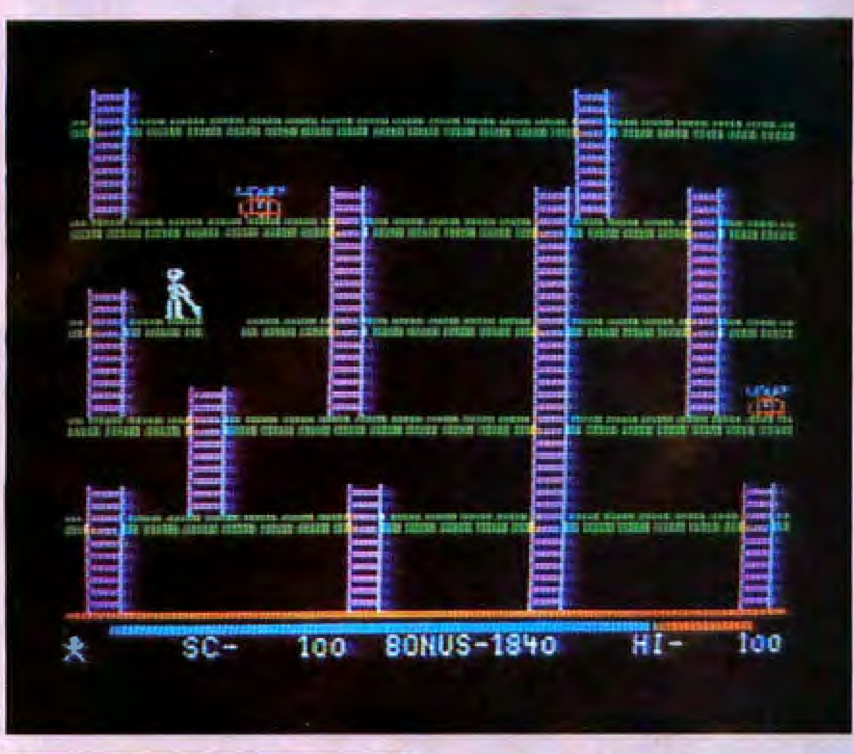

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the ship in the middle, and you try to last as long as possible against kamikaze ships that are battering your shields. You can shoot past your shields at the enemy ships, but they are very hard to hit. Space Warrior, by Marc Goodman, for the Apple II or II Plus, $24.95 (disk), from Broderbund Software, 2 Vista Wood Way, San Rafael, CA 94901.

4 Apple Panic is one of the most creative and novel games to be invented for a microcomputer. The small creatures after you are "apples," and you have only one way of stopping them. You must dig holes in the walkway you are on; when an "apple" falls into one and is temporarily stuck there, you must knock it through before it can get out of the hole and repair the walkway. Unlike so many arcade games that can often defeat you in less than a minute, this game is slow paced and easy to play (although it is still challenging). Apple Panic, by Ben Serki, for the Apple II or II Plus, $29.95 (disk), from Broderbund Software, 2 Vista Wood Way, San Rafael, CA 94901.

5 Kayos is an assault on the senses. While a field of asteroids distracts your eyes and two colored aircraft (middle) try to ram your ship (at bottom), your objective is to shoot the quickly moving red ship zooming across the top of the screen. Kayos, for any Atari 400/800, $34.95 (disk or cassette), from Computer Magic Ltd, 176 Main St, Port Washington NY 11050.

6 The classic game Galactic Empire has recently been translated for the Atari 400 and 800 computers. In this free-form game of military strategy, you command the flagship Orion and must use your limited resources to conquer and hold the twenty inhabited planets of the known galaxy. Galactic Empire, by Douglas Carlston (Atari translation by David Simmons), for the Atari 400/800, $19.95 (cassette), from Adventure International, POB 3435, Longwood FL 32750.

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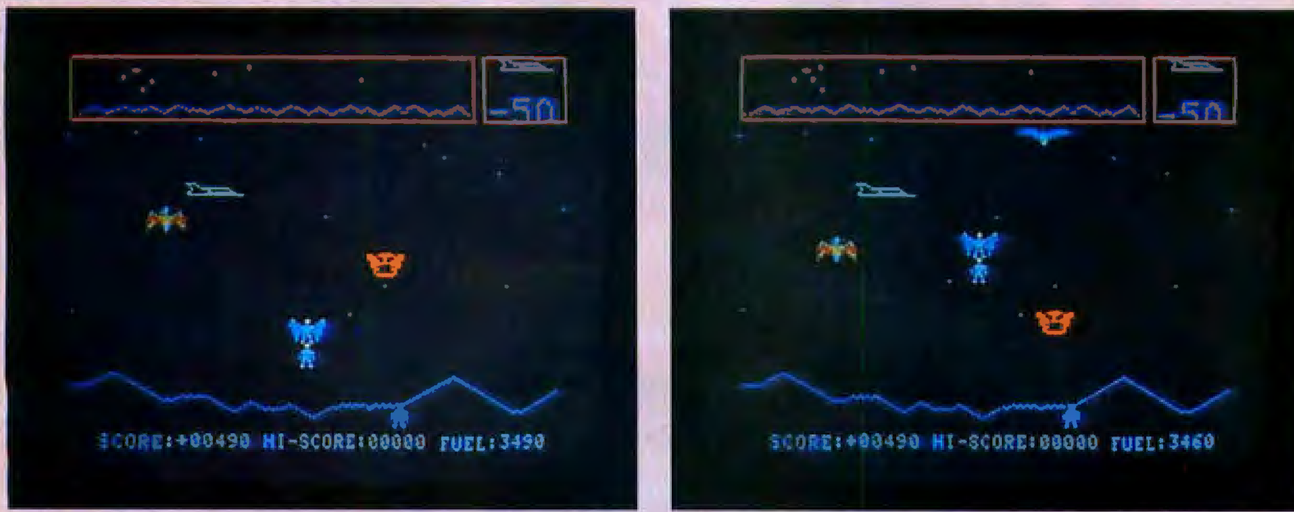
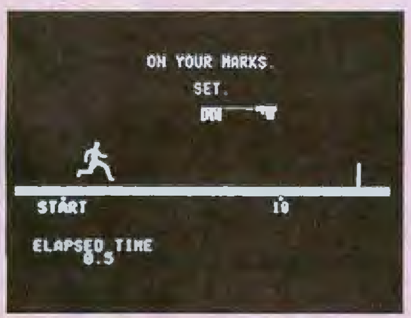


Games that Move!

1

1 Olympic Decathlon is the definitive game for the armchair athlete. Actually, Olympic Decathlon is a series of games that lets up to eight people compete in the ten events of the Decathlon. Timing and finger endurance are the qualities that guarantee success. In the 110-meter hurdle event (shown here), you have to press two paddle buttons in an exact sequence to make your player "run"; he jumps when you hold down a button for longer than an instant. Olympic Decathlon, by Timothy Smith, for the Apple II or II Plus, $29.95 (disk), or the Radio Shack TRS-80, $29.95 (disk or cassette), from Microsoft Consumer Products, 400 18th Ave NE, Suite 200, Bellevue WA 98004.

2 Earth is a battleground! You must patrol the skies, shoot down strange creatures that materialize from thin air, and rescue humans that are being abducted by a mysterious blue-winged creature. This game, loosely based on the Williams Defender coin-operated game, has the most breathtaking graphics I've seen to date! Gorgon, by Nasir Gebelli, for the Apple II or II Plus, $39.95 (disk), from Sirius Software, 2011 Arden Way #225A, Sacramento CA 95825.



3 Most microcomputer games that are versions of existing board or equipment games aren't worth the disks they're printed on, but Raster Blaster does not fall into that category! Ignore the totally realistic ball movement if you want to, but the robot arms that can hold a ball in play for later release are a feature that no

3

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existing pinball machine can match. Raster Blaster, by Bill Budge, for the Apple II or II Plus, $29.95 (disk), from BudgeCo, 428 Pala Avenue, Piedmont CA 94611.

4 Missile Command, one of the most popular coin-operated arcade games to date, is now available in a cartridge for the Atari 400 or 800 computers. The trackball of the coin-operated version has been replaced by an Atari joystick, and you have only one missile base (not three), but the sights, sounds, and behavior of the original game are still there. Missile Command, for the Atari 400/800 computer, $39.95 (cartridge), from Atari Inc, Consumer Division, 1195 Borregas Ave, Sunnyvale CA 94086.

5 This night-driving game features five Grand Prix-type racetracks, manual or automatic conditions, sound, varying road conditions, and several other options. The graphics and human engineering on this game are very good. International Grand Prix, by Richard Orban, for the Apple II or II Plus, $30.00 (disk), from Riverbank Software Inc, POB 128, Smith's Landing Road, Denton MD 21629.

More Arcade Fun

2

2 Computer-game enthusiasts have been "landing" spaceships on other planets for as long as computers have been around. Now you can try your skill on the Commodore VIC with the new Super Lander game. Of course, the most dangerous landing sites are the most rewarding. VIC Super Lander, for the Commodore VIC computer, $29.95 (cartridge), from Commodore Business Machines, 681 Moore Rd, King of Prussia, PA 19406.

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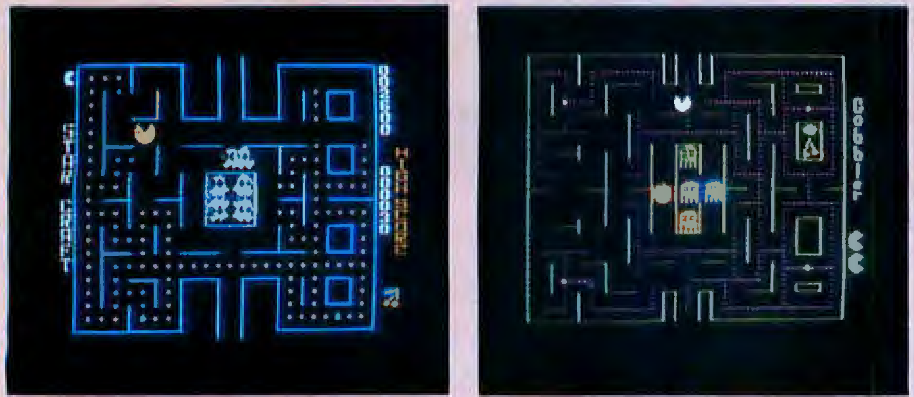

1 So you like the Pac-Man arcade game? Then your only decision is which microcomputer look-alike to buy—Snoggle (left) or Gobbler (right). Snoggle reproduces the play of the original game better, but Gobbler has smoother and more interesting graphics. Both are for the Apple II. Snoggle, by Jun Wada and Ken Iba, $32.95 (disk), from Broderbund Software, Box 3266, Eugene OR 97403. Gobbler, by Olaf Lubecke, $24.95 (disk), from On-Line Systems, 36575 Mudge Ranch Road, Coarsegold CA 93614.

3 Most arcade games give you three "lives." When you use them up, the games end. Not so with Star Thief; destroyed ships are recreated at the edge of the screen, and you keep playing until various enemy ships carry off all the "power-pods" in the center of the screen. The game, based loosely on the Ripoff coin-operated arcade game, can be played from either the keyboard or the game paddles and has a two-player cooperative version—both of you against the computer. Star Thief, by James Nitchals, for the Apple II or II Plus, $29.95 (disk), from Cavalier Computer, POB 2032, Del Mar CA 92014.

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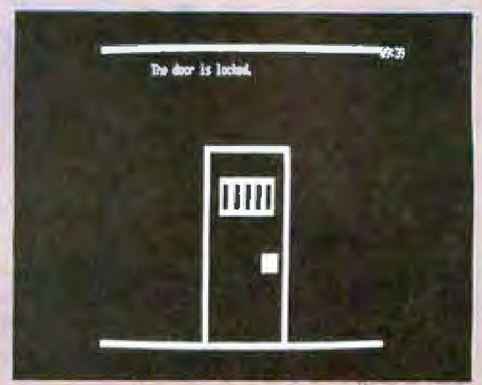


Games For Experts

4 Eastern Front (1941) is possibly the first fun war game for people who hate war games. The playing screen is several times larger than the video-display window—but you can see the entire map by smoothly scrolling the window across it! Also, the map changes with the seasons, the game has no charts or tables (the computer does all the calculations automatically), and there are no long waits for the computer to finish a move (it does its calculations while you are entering your moves). Eastern Front (1941), by Chris Crawford, for the Atari 400 or 800 computers, $26.95 (cassette) or $29.95 (disk) plus $2.50 shipping and handling, from the Atari Program Exchange, POB 427, 155 Moffett Park Dr, Sunnyvale CA 94086.

5 "From darkest dungeons to deepest space!" This extravagant claim is fulfilled by the game Ultima, a graphics-oriented role-playing game. The game takes place in several locations—outdoors (shown here) and in space, a three-dimensional dungeon, and a castle. Ultima, by Lord British, for the Apple II or II Plus, $39.95 (disk), from California Pacific Computer Co, 1623 Fifth St, Davis CA 95616.

6 Even though you're in the Asylum, they are trying to kill you, and you have until morning to get out! Asylum is an adventure game (that is, a puzzle to be solved) with graphics, full-sentence commands, and a real-time clock that gives you a deadline for getting out. Not only is it a devious game, it is a very good buy for the money. Asylum, by Frank Corr, Jr and William Denman, Jr, for the Radio Shack TRS-80 Models I and III, $14.95 (cassette), $19.95 (disk), from Med Systems Software, POB 2674, Chapel Hill NC 27514.

Build a Touch Tone Decoder for Remote Control

Steve Ciarcia
POB 582
Glastonbury CT 06033

I'm lucky. Every month I can chip away at my mental list of unfulfilled fantasies through my Circuit Cellar project for BYTE. The editorial staff thinks of these articles as "a selected mixture of electronic theory and hardware presented as a practical application for personal-computing enthusiasts." [*That's what Steve thinks we think. . . .*RSS] Up to now I have carefully avoided revealing my true motivations.

This month, however, my "selected mixture" turned into a long-term engineering project. Let me explain.

I have always wanted to be able to telephone the computerized home-control system in my house from anywhere in the country, to find out what the conditions are like in and around the house, be informed of problems or messages, and remotely control lights and thermostat settings.

This idea is neither new nor something found only in science fiction. Any computer presently equipped with an autoanswer modem could conduct such a dialogue with a remote user terminal, transmitting and receiving ASCII (American Standard Code for Information Interchange) characters.

But I really don't want to carry an ASCII terminal with me. For the simple functions I propose, even carrying a small pocket terminal is quite a bother. I don't need a full keyboard for a few simple coded inputs, and with a little innovative thinking I can eliminate the need for a message display at the remote end of the communication.

Innovative Thinking

The keypad on a Touch Tone telephone receiver is a readily available, convenient means of transmitting data. (Only telephone instruments from the Bell System are properly called Touch Tone; the generic term used by other telephone manufacturers is *dual-tone, multiple-frequency*, or DTMF, signaling.) Where only rotary-dial telephones are available, a battery-powered DTMF keypad can be carried much more easily than any full-function terminal. Decoding of DTMF signals by my home-control computer, therefore, became one cornerstone of my remote-command arrangement.

The other cornerstone was to be output in the form of audible responses: words spoken over the telephone line by a voice synthesizer driven by the computer. Those who have read my June and September 1981 articles know I have been experimenting with two voice-synthesis integrated circuits: the Digitalker from National Semiconductor and the Votrax SC-01 from the Votrax Division of Federal Screw Works. Using these components, I designed the Micromouth and Sweet Talker speech interfaces, respectively. Either of these, interfaced in an approved way to the telephone line, could give me the voice-response capability I envisioned.

My first step was to decode the DTMF tones. As the title of this article indicates, I didn't get much further.

Pitfalls for the Unwary

There are many decoding schemes. Most work only at room temperature when the tide is high and the moon is full. Even though they *might* work under ideal circumstances, the circumstances encountered in transcontinental communication are often far from ideal. Decoding DTMF tones reliably turned out to be a much more difficult task than I imagined.

Budgeting a couple of days to build the DTMF decoder and set up the telephone interface, I started by looking through other magazines for appropriate circuits. There were very few such circuits (this should have been a clue), and most of them used type-567 small-scale-integration phase-locked-loop tone-decoder chips.

In a classic me-too approach, I wired up seven LM567 tone decoders

---

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

Some figures accompanying this article were provided through the courtesy of the International Telephone & Telegraph Corporation and Mostek Corporation.

and tested a quick-and-dirty circuit. Unsatisfied with its reliability, I added a separate bandpass filter to the input of each LM567. This greatly improved the signal-to-noise ratio, but it used a hundred components. I put this circuit aside and tried using separate bandpass filters with an integrated DTMF tone-decoder chip. This reduced the component count by 25 percent, but it was hardly the "quick-build" Circuit Cellar project I wanted. I soon realized why I hadn't seen many articles on personal applications of DTMF decoding.

Telephoning my computer and having it respond with audible words will have to wait. We have to begin with the subtopic of DTMF encoding and decoding.

Principles of DTMF

The next time you pick up the handset of a Touch Tone or other DTMF-dialing telephone receiver, press one of the keys and listen. The sound you hear, aside from the dial tone, is not a single-frequency sine wave but a combination of two frequencies. The 12 keys are arranged in four rows and three columns, as shown in table 1 on page 45. All the keys in a given row or column have one tone in common. For example, pressing the digit "9" (row 3 and column 3) produces an 852 Hz and a 1477 Hz tone simultaneously. Similarly, pressing "4" (row 2 and column 1) produces 770 Hz and 1209 Hz tones simultaneously.

The full DTMF-encoding standard defines four rows and four columns for a total of 16 two-tone combinations. Standard telephones use only 12 of these combinations, but for the purposes of this discussion we shall consider all 16. Depending upon your application, these extra codes may be useful.

The eight frequencies associated with the rows and columns are separated into two groups. The low group, containing row information, has a range of 697 Hz to 941 Hz. The high group, containing column information, covers 1209 Hz to 1633 Hz.

Photo 1a: *A standard Touch Tone DTMF-encoding module used by the Bell System. It can encode tone pairs for four rows and three columns of the full DTMF matrix.*

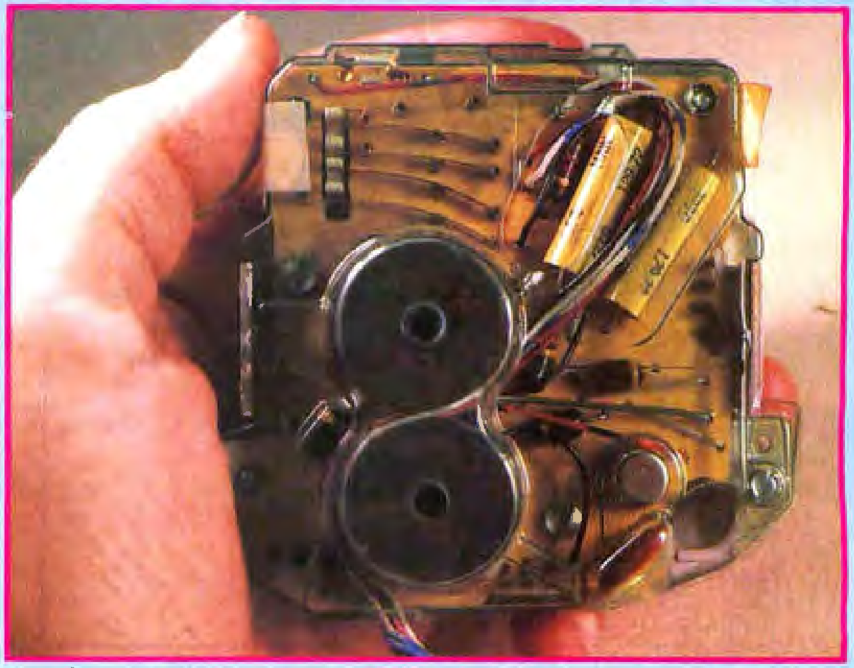


Photo 1b: *The back side of the Touch Tone module showing the transistorized inductance/capacitance oscillators and the mechanical levers and contacts.*

(1a)

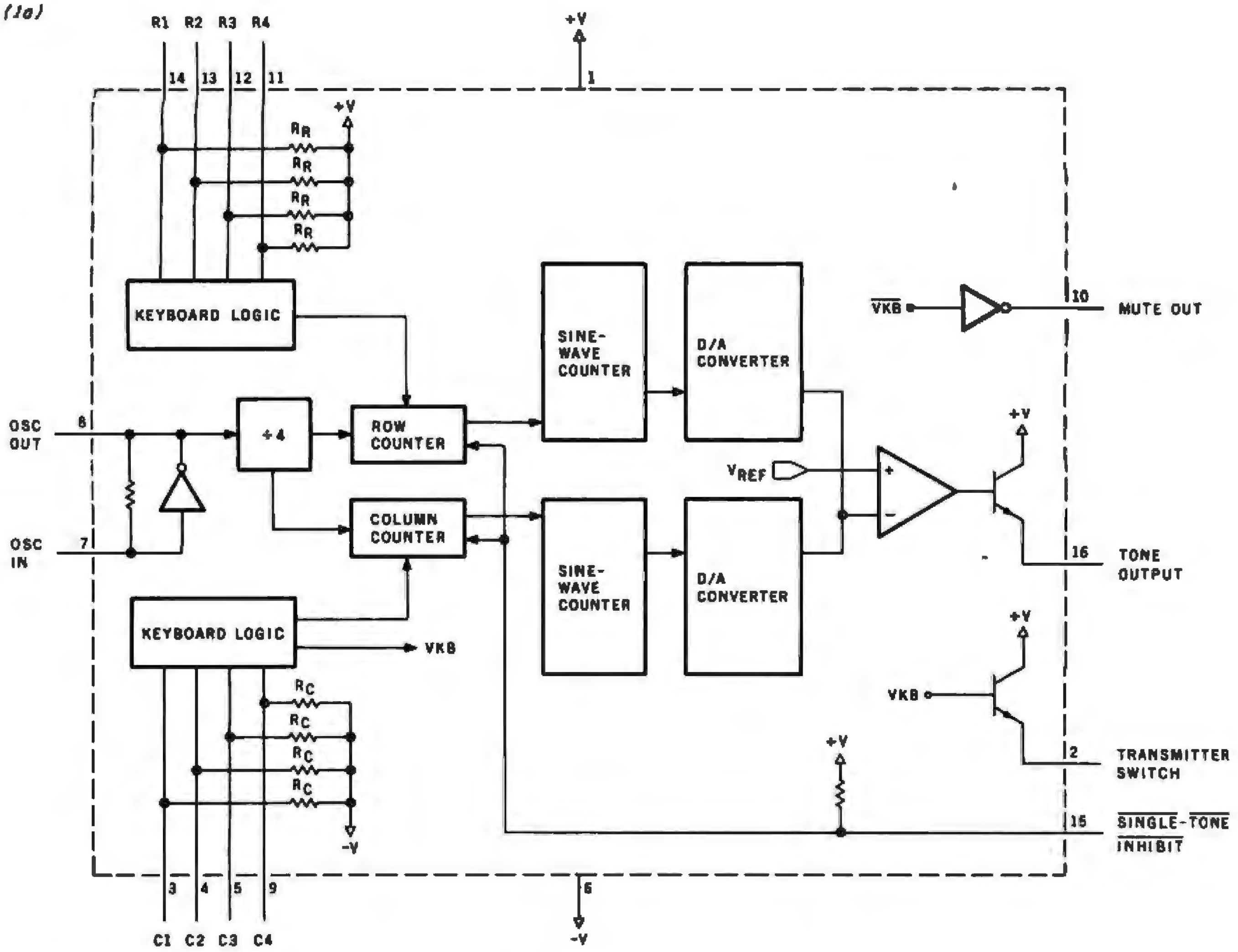


Figure 1a: *Block diagram of the Mostek MK5087 DTMF (dual-tone, multiple-frequency) signal encoder.*

(1b)

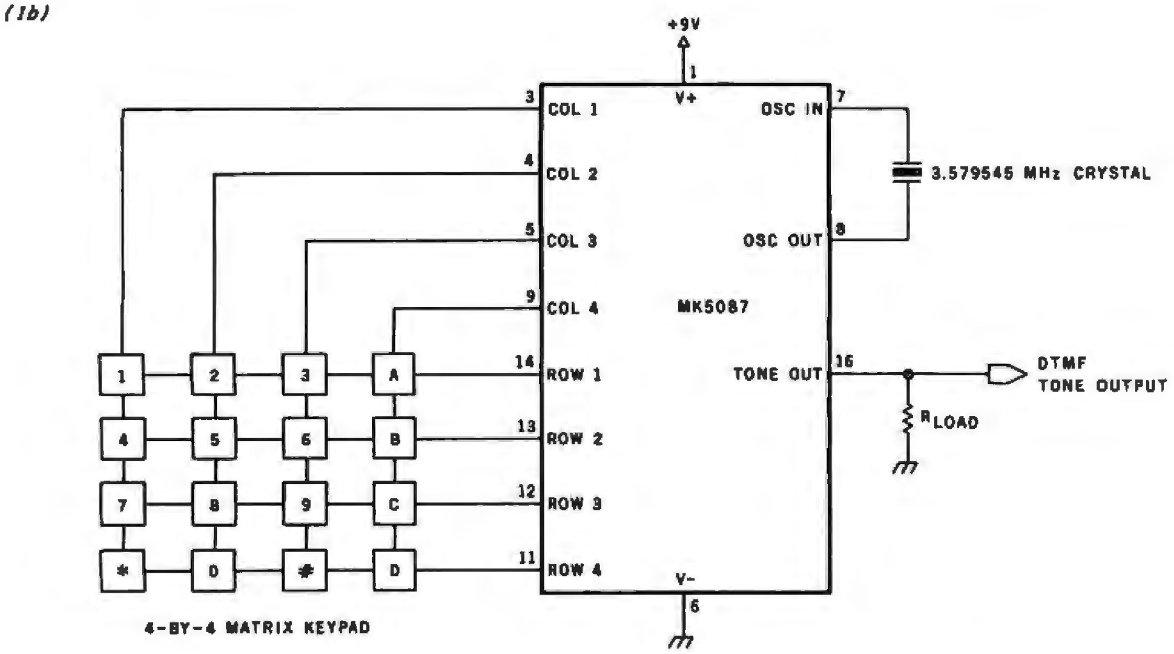


Figure 1b: *Schematic diagram of a DTMF-encoding circuit that employs the MK5087, a 4-by-4 matrix keypad, and a 3.579545 MHz color-burst crystal.*

As you can see from table 1, there is little bandwidth between frequencies.

A variety of methods are employed to generate and decode these tone combinations. Generally, the level of sophistication employed in these circuits is governed by the application. Telephone companies strive for reliability and aren't particularly concerned with the size and weight of the result. Apparently, the telephone-company engineers' primary concern is that the system should still work 20 years from now and withstand a nuclear attack. Thus, except in the very latest equipment, discrete LC- (inductance/capacitance) tuned circuits are usually found in telephone-company equipment.

Non-telephone-company commercial users of DTMF signaling take a different approach. Instead of LC-tuned circuits, they generally prefer crystal-controlled integrated-circuit-based systems. One system is not necessarily better than the other, but the large telephone companies have more facilities for winding inductors.

In computer-control applications, the approach I recommend is to follow in the footsteps of the commercial designers, using large-scale-integrated circuits where possible. In the case of encoding the row and column signals, this route is obvious and the cost is relatively low. DTMF decoding, on the other hand, is fairly complicated and relatively expensive. Before choosing one of the cheaper approaches, try to make a fair evaluation of the time involved in building and troubleshooting such a circuit and weigh that against a slightly more expensive integrated circuit with fewer potential problems.

DTMF Encoding

Telephone companies have traditionally used transistor LC oscillators to encode the DTMF tone pairs. The practical alternative for the rest of us is use of an integrated tone-encoder component, such as the MM53125 from National Semiconductor and the MK5087 from Mostek. Referred to as *integrated tone-dialer circuits,* these chips divide a 3.579545 MHz reference frequency into the eight DTMF frequencies. The frequency combinations are selected by a 12- or 16-key matrix keypad connected directly to the chip. The output is a stair-step D/A (digital-to-analog) approximation of the mixture of the high- and low-group tones. No frequency adjustment is necessary to meet standard DTMF specifications, and the average circuit configuration requires little more than the keypad, a crystal, and the integrated circuit. Figure 1 shows a block diagram of the MK5087 and a typical DTMF-encoder circuit.

If you don't want to assemble a DTMF encoder, Radio Shack sells an encoder complete with a 12-key keypad. Using an MM53125, the CEX-4000 tone-generating keypad module (catalog number 277-1010) presently costs $16.95. To use it, you also need a 3.579545 MHz crystal (number 272-1310), which costs $1.99. Simply add a power supply

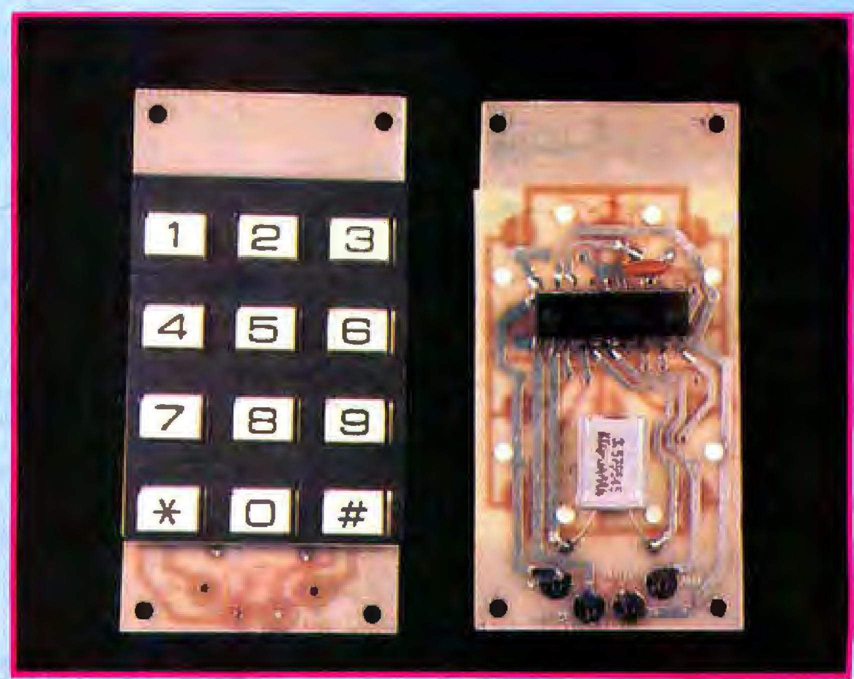
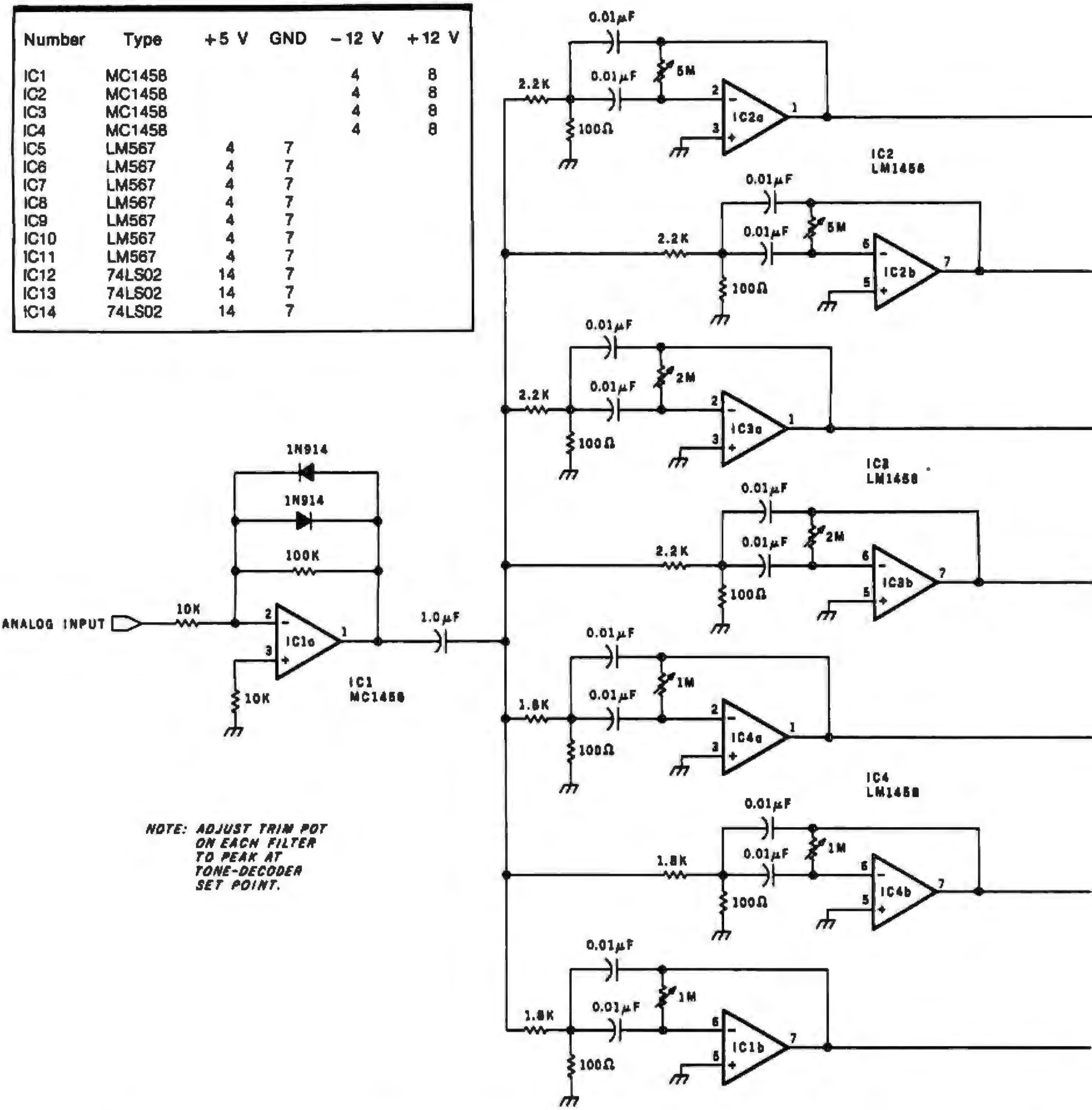


Photo 2: *The Radio Shack DTMF-encoding keypad module (catalog number 277-1010), which incorporates the National Semiconductor MM53125 tone-encoder chip.*

		High Group			
		Column 0 1209 Hz	Column 1 1336 Hz	Column 2 1477 Hz	Column 3 1633 Hz
Low Group	Row 0, 697 Hz	1	2	3	A
	Row 1, 770 Hz	4	5	6	B
	Row 2, 852 Hz	7	8	9	C
	Row 3, 941 Hz	•	0	#	D

Table 1: *The dialing matrix of the DTMF (dual-tone, multiple-frequency) signaling system. The two-dimensional matrix allows 16 different combinations of tones to represent 10 digits and 6 control signals. The low-group frequencies correspond to the matrix row; the high-group frequencies correspond to the column. Column 3 is not normally used in tone dialing, but it can be useful in remote-control applications.*

Number	Type	+5 V	GND	−12 V	+12 V
IC1	MC1458			4	8
IC2	MC1458			4	8
IC3	MC1458			4	8
IC4	MC1458			4	8
IC5	LM567	4	7		
IC6	LM567	4	7		
IC7	LM567	4	7		
IC8	LM567	4	7		
IC9	LM567	4	7		
IC10	LM567	4	7		
IC11	LM567	4	7		
IC12	74LS02	14	7		
IC13	74LS02	14	7		
IC14	74LS02	14	7		



and speaker to make it fully operational.

DTMF Decoding

DTMF decoding is considerably more complicated than DTMF encoding. Only recently has the advent of the single-chip decoder/receiver, such as the ITT MSD3210, made reliable DTMF decoding easy to achieve. In fact, I didn't find out about this hybrid component until after attempting to build a number of other circuits. If I had had this device initially, I could have devoted more time to the other parts of my remote home-control arrangement. However, since you might appreciate the MSD3210 and its kin more by seeing what you are missing, I will cover some of the other circuits I constructed.

The circuits range in complexity from approximately 100 components down to just two: a single integrated circuit and a crystal.

Discrete-Filter DTMF Decoder

Whatever the circuit, the purpose of a DTMF receiver is to decode tones that indicate which key was pressed on the transmitter. The output from the decoder can be a logic pulse on one of 12 output lines, a 4-bit binary code, or separate 2-bit row and 2-bit column outputs. The latter two

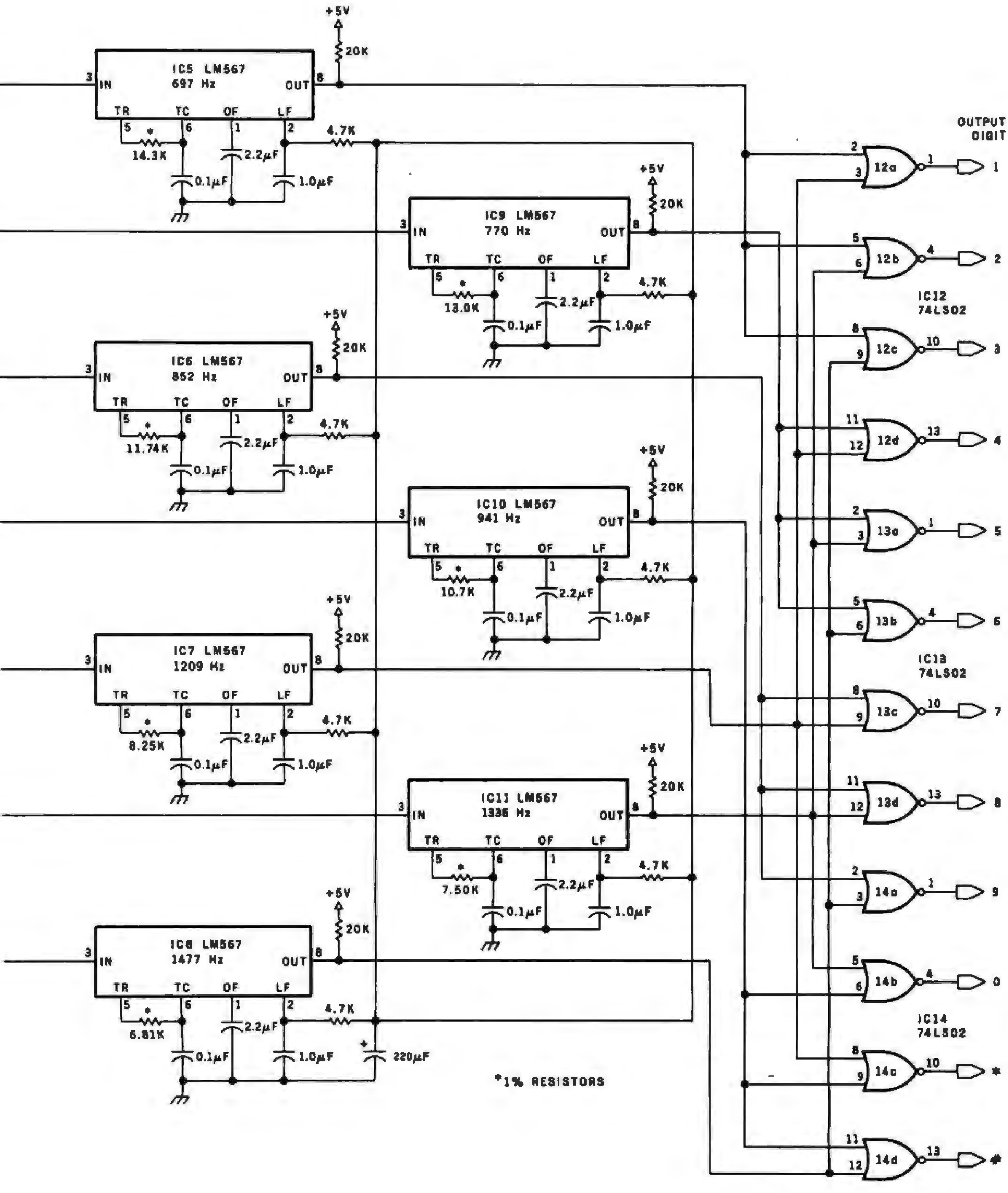


Figure 2: *Schematic diagram of a DTMF-decoding circuit that employs separate LM567 tone decoders with associated input filters for a total of approximately 100 components.*

methods combined with a "tone-detect" strobe signal are most frequently employed for connecting the DTMF receiver to a computer.

Most of the DTMF receiver circuits produced by hobbyists have incorporated seven type-567 tone-detector chips, one for each of the four low-group frequencies and for three of the four high-group frequencies (the fourth high-group frequency is not needed in many applications). The LM567 is a phase-locked-loop frequency detector that can be adjusted to detect the presence of a particular frequency even at very low signal-to-noise ratios. Detection errors are reduced with the addition of high-gain bandpass filters on each LM567 input.

Photo 3: *A Touch Tone DTMF receiver, used by the Bell System, consisting of tuned inductance/capacitance circuits and relays. This type of transistorized analog tone detector is quite accurate but very bulky.*

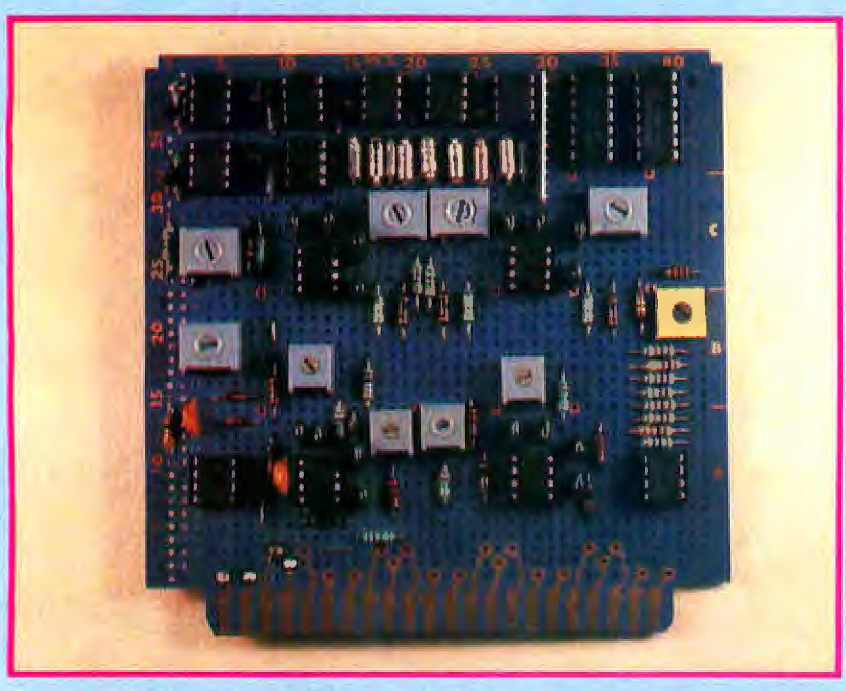


Photo 4: *The assembled prototype of the DTMF-decoding circuit shown in the schematic diagram of figure 2. This brute-force method requires about 100 components that take much patience to assemble and adjust.*

The usual technique is to connect the seven or eight LM567 analog frequency detectors in parallel. With one LM567 adjusted to each of the frequencies in table 1, DTMF decoding simply consists of determining which pair of LM567s is detecting tones. While this circuit works fine in the lab (or Circuit Cellar) under ideal conditions, experience has shown that the extraneous noise often present on telephone lines can cause considerable false detection.

Figure 2 illustrates a slightly better 12-key analog DTMF receiver that uses separate filters and LM567 tone decoders. Each filter and tone decoder combination is tuned for a specific frequency. Three 74LS02 quad two-input NOR gates, IC12 through IC14, present a 1-of-12-line output. Stable operation of this circuit requires the use of Mylar or polycarbonate capacitors in each filter section and 1-percent-precision resistors where noted.

Integrated Tone-Receiver Chips

The alternative approach to analog DTMF decoding is digital. The first DTMF receiver I built that I trusted used a CMOS (complementary metal-

DTMF Frequency (Hz)	Lower Detection Frequency Limit (Hz)	Upper Detection Frequency Limit (Hz)
697	683	711
770	755	786
852	834	869
941	922	960
1209	1184	1233
1336	1309	1363
1477	1447	1507
1633	1600	1666

Table 2: *The standard DTMF frequencies with the minimum and maximum values accepted within the 2-percent tolerance of digital tone-decoding devices such as the Mostek MK5102.*

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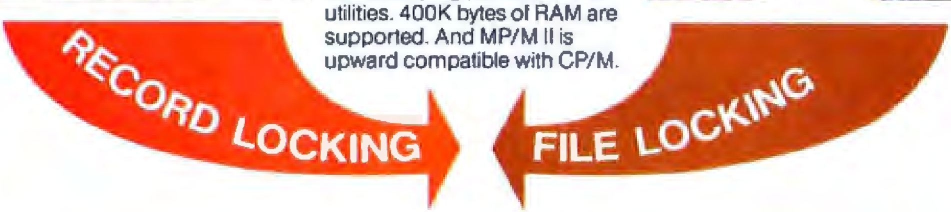

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Sorcim Corporation
SuperSoft Associates
Tarbell Electronics
Timin Engineering Co.

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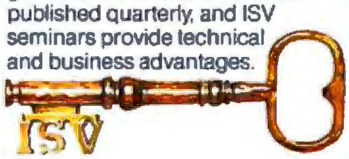

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Circle 126 on Inquiry card.

DIGITAL RESEARCH®

(3a)

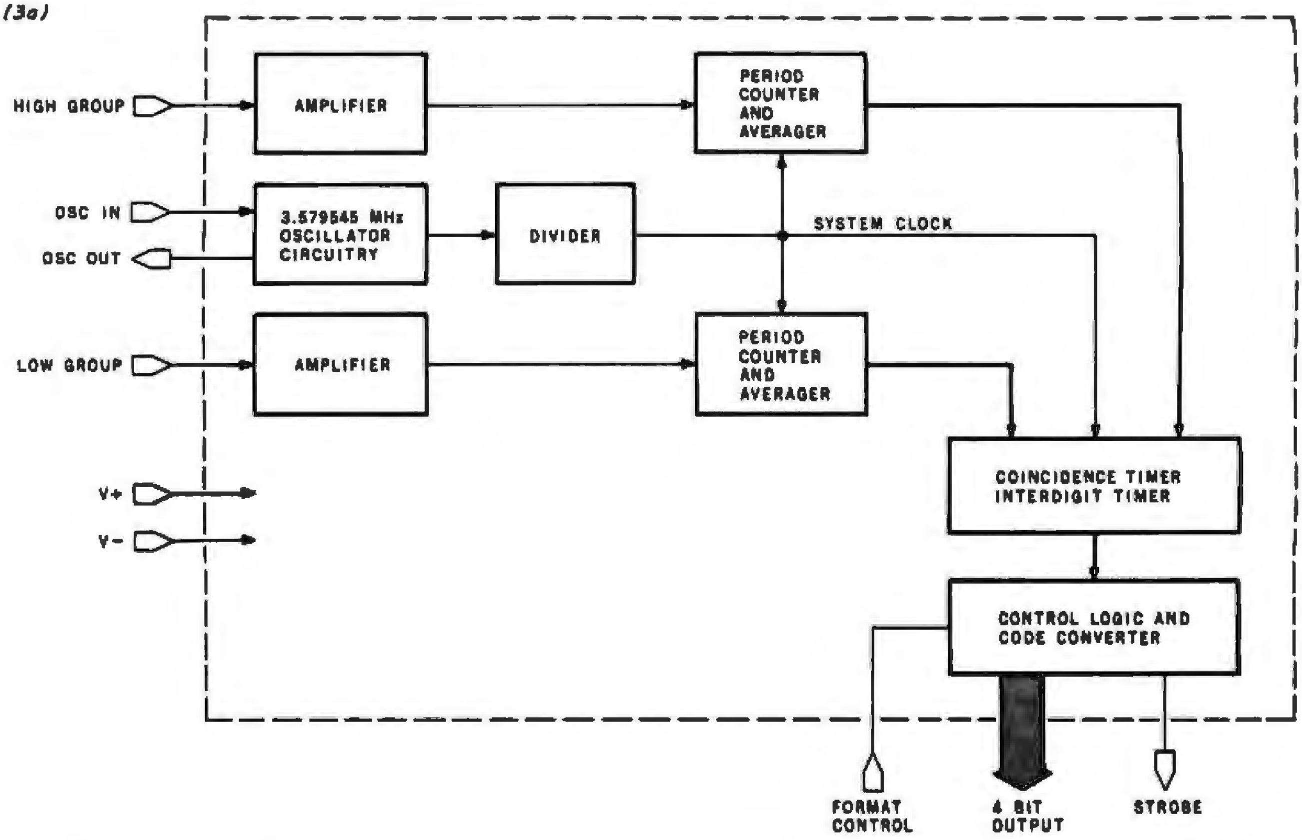

Figure 3a: *Block diagram of the Mostek MK5102 DTMF decoder/receiver. This device accepts DTMF signal inputs in two frequency bands, one each for the high group and low group of tones. A digital method is used to count the frequency of the signal being received.*

oxide semiconductor) integrated tone-receiver chip, the Mostek MK5102. The internal functions of this device are shown in figure 3a on page 52; its input-filter requirements are shown in figure 3b. Figure 3c shows a block diagram of a typical DTMF-receiver circuit using the MK5102. It consists of three basic components: group filters, limiters, and digital tone receiver.

In a digital DTMF-receiver circuit, the input is first separated through filters into the low-group frequencies and the high-group frequencies. The amplitude is then hard-limited to match the tone receiver's input circuitry. The MK5102 detects the DTMF tone through a digital counting method. The zero crossings of the incoming waveforms are counted for nine periods and the results averaged over a longer period. (For these counting-type integrated tone receivers to operate correctly, the input frequency must be exact within ±2 percent, as shown in table 2.) When a valid DTMF-digit tone pair has persisted for a minimum of 33 milliseconds, the data are latched onto the outputs, and the output strobe goes high. When the valid digit is no longer received, the output strobe goes low.

Many experimenters have been led down the garden path with regard to these integrated tone-receiver chips. At $20 they appear to be a bargain. But the difficult part of implementing this circuit is not decoding the tone pairs; the filters cause the problem.

(3b)

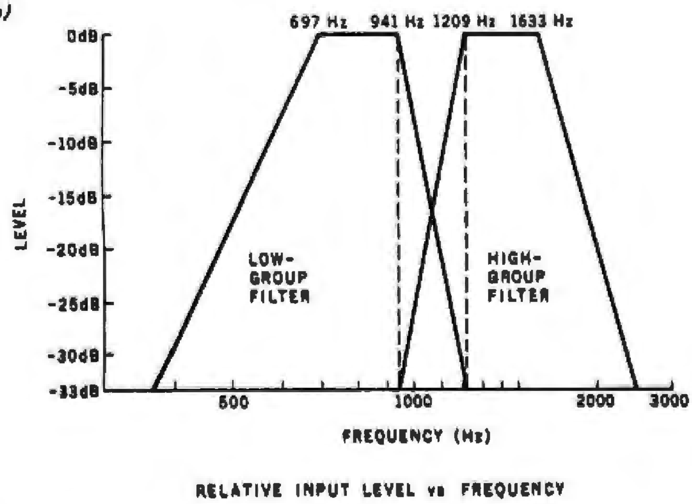

Figure 3b: *Input frequency-band requirements of the MK5102. As you can see, the required bandpass slopes are stringently steep.*

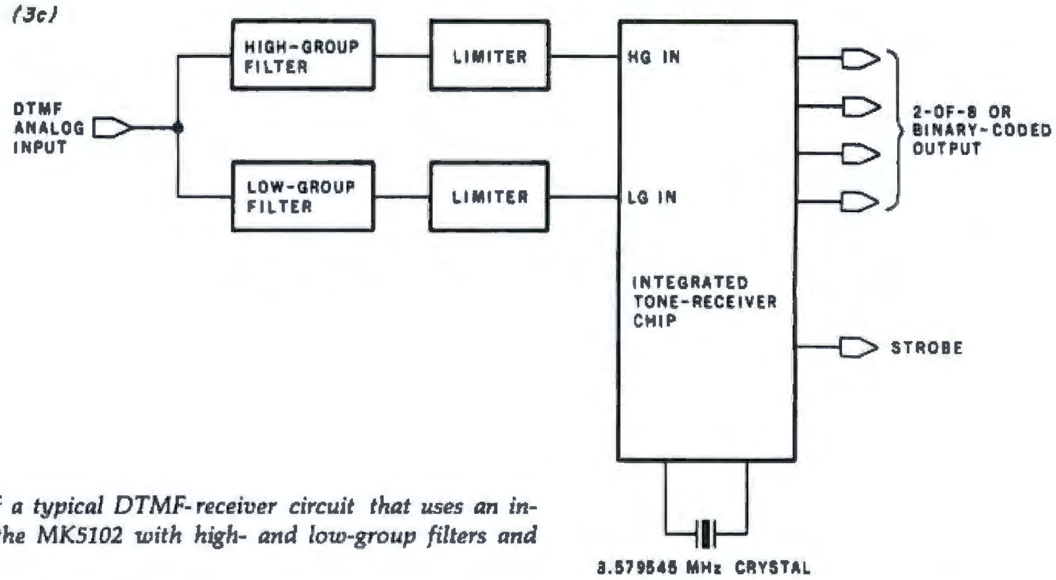

Figure 3c: *Block diagram of a typical DTMF-receiver circuit that uses an integrated tone receiver like the MK5102 with high- and low-group filters and limiters.*

As you can see in figure 3b, the bandpass requirements are exceptionally tight. Many people buy the tone-receiver chip only to realize they can't design filters.

Dusting off my disused filter-design talents, I decided to see if this method was feasible at all. Figure 4 on page 54 shows an outline of the bandpass-filter method I used. It consists of a fifth-order high-pass filter in series with a fifth-order low-pass filter. The circuit was duplicated and tuned separately to cover each of the two group ranges.

On the high-group side, for example, the high-pass section allows all frequencies above 1150 Hz to pass through. The output of this section in turn is fed to a low-pass filter with a cutoff beginning at 1650 Hz. Theoretically, the combined circuit should be a bandpass filter that passes only the frequencies between 1150 Hz and 1650 Hz. Similarly, on the low-group side, the bandpass was selected to be the range of 650 Hz to 1000 Hz. Figure 5 on pages 56 and 57 is a schematic diagram of a circuit that embodies the design in the block diagram of figure 4.

Wiring and testing this circuit gave me a much greater appreciation for LSI (large-scale integration) devices. While the circuit of figure 5 does work, the filters have a cutoff slope of only 30 dB per octave, which is marginal. The MK5102 generally requires a band separation of 33 dB, but it will receive correctly with separation as poor as 22 dB if there is no noise. Everything worked under Circuit Cellar conditions, but I won't guarantee anything on the telephone line without further experimentation.

A definite improvement could be obtained by using faster operational amplifiers, such as LM318s, instead of the LM741s and MC1458s used here. However, I merely wanted to see if building such a circuit was feasible, and I don't necessarily recommend its use, especially considering the DTMF receivers I am about to describe.

Hybrid Bandpass Filters

The answer to the previous problem is to buy an off-the-shelf filter with the exact requirements necessary for DTMF decoding. Of particular significance is a pair of hybrid bandpass filters from ITT (International Telephone & Telegraph Corporation) North, Microsystems Division, called

Text continued on page 58

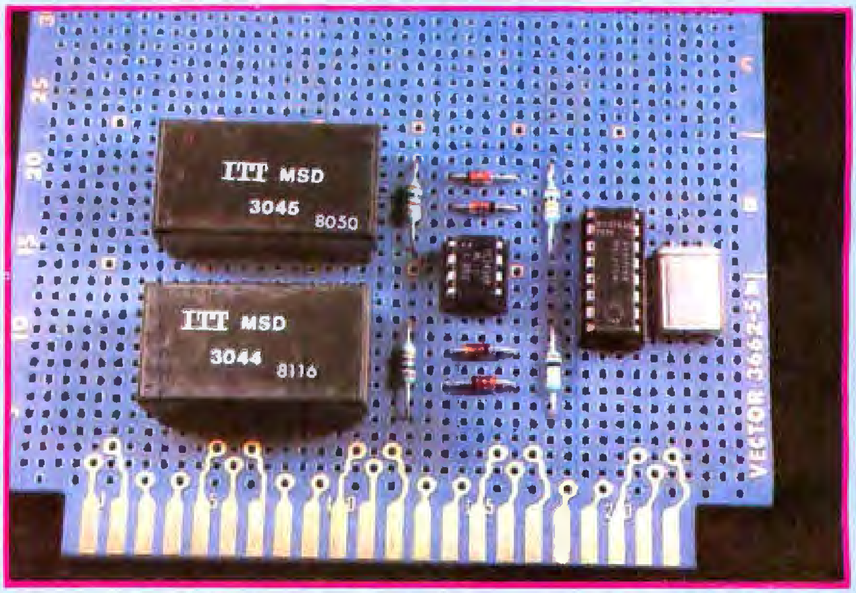

Photo 5: *Prototype of the DTMF-decoding circuit of figure 7. This much more compact approach to DTMF decoding uses two ITT 8-pole hybrid bandpass filters (for group separation) and the Mostek MK5102 DTMF decoder/receiver. The total cost of the parts is about $85.*

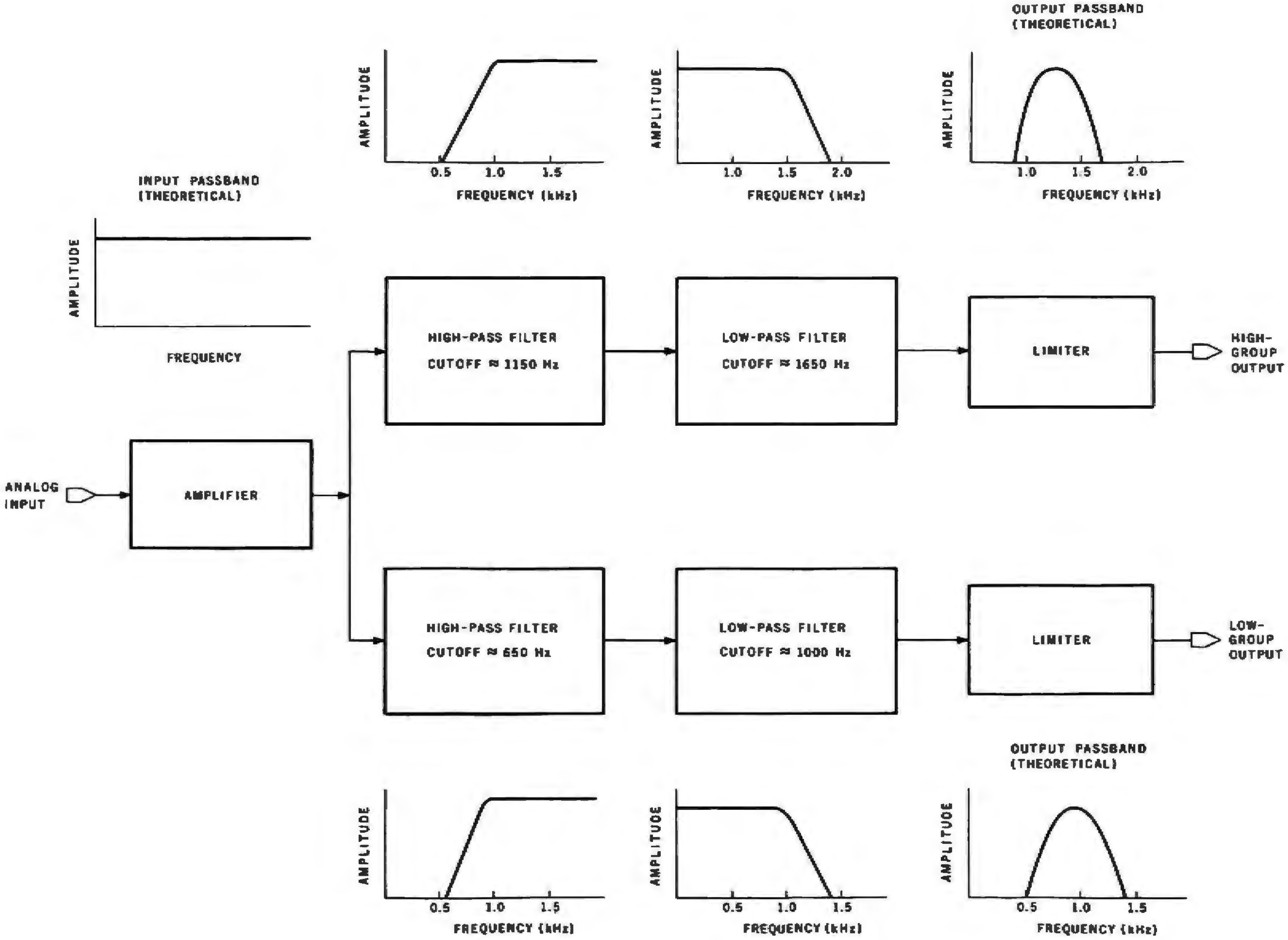

Figure 4: *Block diagram of a set of bandpass filters that use separate low-pass and high-pass filters in series.*

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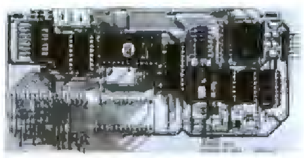

The original Keyboard and Display Enhancer is still available for Revision 0-6 Apples (on which the new Enhancer][will not fit). These Apples have memory select sockets at chip locations D1, E1 & F1. The Keyboard and Display Enhancer allows entry and display of upper & lower case letters with fully functional shift keys. It does NOT have user definable keys nor a type ahead buffer. The price is $129.00

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- Font Editor
- Pascal Mid-Res Graphics
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- Inverse
- German
- Katakana (Japanese)
- Line Drawing Graphics (Expanded)
- Spanish
- French
- Math & Greek Symbols
- Super & Subscript

Dvorak EPROM (Enhancer) $29.00

Lower Case Chip $29.00

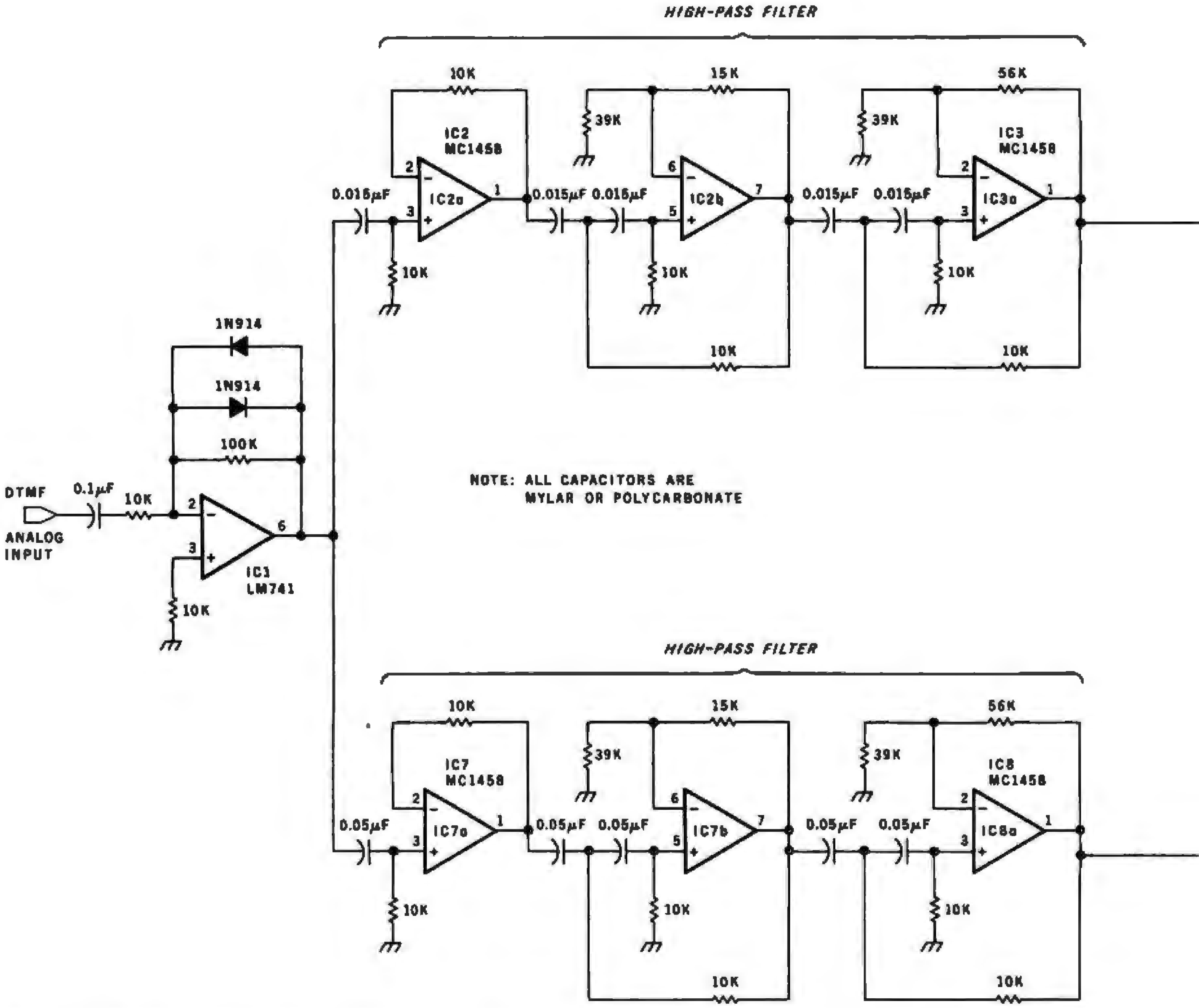
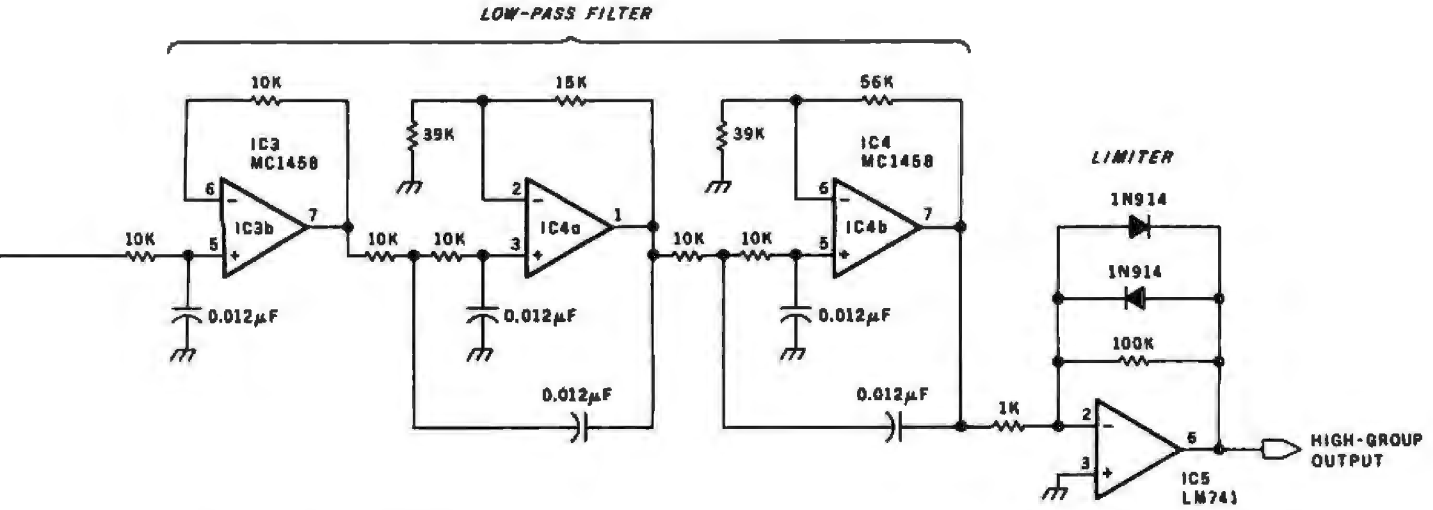
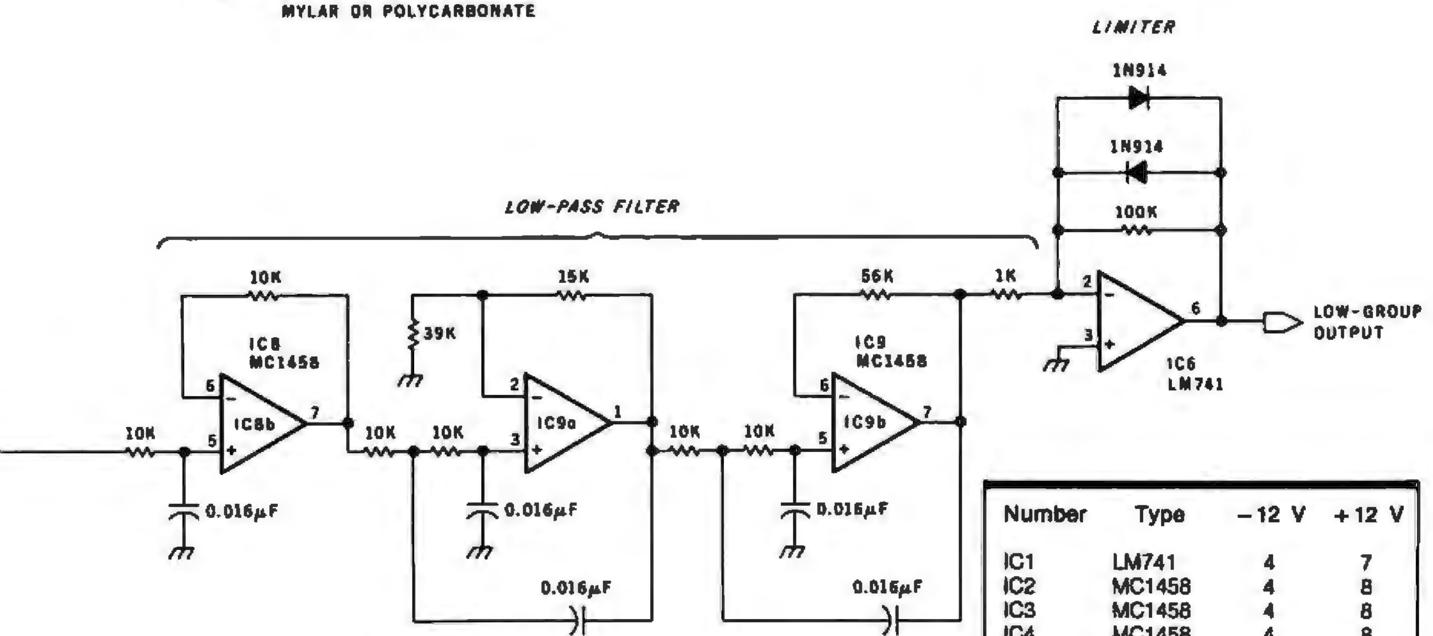


Figure 5: *A filter circuit built from separate high-pass and low-pass stages for the high and low tone groups. While this circuit can be used with the MK5102, hybrid bandpass filters such as the ITT 3044 and 3045 exhibit superior performance.*



NOTE: ALL CAPACITORS ARE
MYLAR OR POLYCARBONATE



Number	Type	−12 V	+12 V
IC1	LM741	4	7
IC2	MC1458	4	8
IC3	MC1458	4	8
IC4	MC1458	4	8
IC5	LM741	4	7
IC6	LM741	4	7
IC7	MC1458	4	8
IC8	MC1458	4	8
IC9	MC1458	4	8

Text continued from page 53:
the 3044/3045 DTMF group filters. Each filter is contained in a 24-pin dual-inline package and plugs into a standard integrated-circuit socket. Internally, each is an 8-pole bandpass filter with specifications far exceeding the minimum requirements of the MK5102. (A performance curve of the model 3044/3045 filters is shown in figure 6 on page 58.)

Using these filters, the entire DTMF receiver can be constructed with only 16 components, as shown in figure 7 on page 62, a vast improvement over the complex circuits of figures 2 and 5.

The Ultimate Goal

I thought 16 components was the ultimate until I discovered two new

Text continued on page 63

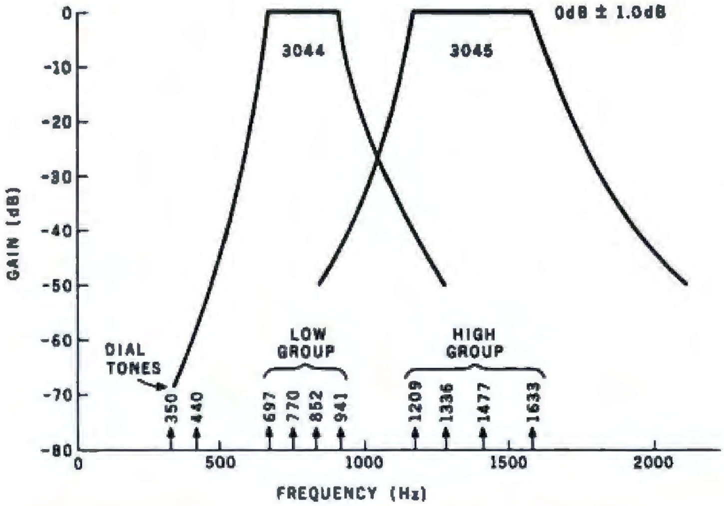


Figure 6: *Passband curves of the ITT 3044 and 3045 hybrid bandpass filters, designed specially for DTMF applications.*

	4-bit binary				Dual 2-bit row/column: column		Dual 2-bit row/column: row	
Digit	D8	D4	D2	D1	D8	D4	D2	D1
1	0	0	0	1	0	0	0	0
2	0	0	1	0	0	0	0	1
3	0	0	1	1	0	0	1	0
4	0	1	0	0	0	1	0	0
5	0	1	0	1	0	1	0	1
6	0	1	1	0	0	1	1	0
7	0	1	1	1	1	0	0	0
8	1	0	0	0	1	0	0	1
9	1	0	0	1	1	0	1	0
0	1	0	1	0	1	1	0	1
*	1	0	1	1	1	1	0	0
#	1	1	0	0	1	1	1	0
A	1	1	0	1	0	0	1	1
B	1	1	1	0	0	1	1	1
C	1	1	1	1	1	0	1	1
D	0	0	0	0	1	1	1	1

Table 3: *The two output formats of integrated DTMF receivers showing digit correspondences. Either a 4-bit binary or a split 2-bit row/column output format may be chosen. On the Mostek chips, the format is controlled through the FORMAT CONTROL input pin; on the ITT devices, the pin having the same function is labeled H/B28.*

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Circle 109 on inquiry card.

Pin	Name	Description
1	MON OUT	Provides signal that is one-tenth differential input
2	TP	Internal Test Point
3	V_P	Positive Supply Voltage
4	GI	Gain Adjust I
5	GII	Gain Adjust II, resistor from GI to GII increases sensitivity (see table 4b)
6	GIII	Gain Adjust III, resistor from GII to GIII decreases sensitivity (see table 4b)
7	V_N	Negative Supply Voltage (ground)
8	NC	
9	XOUT	Crystal Out, 3.579 MHz crystal connected from pin 9 to pin 10
10	XIN	Crystal In (Tie to V_P if external oscillator is used)
11	XEN	Enable Internal Oscillator. Tie to V_P if crystal is used, tie to V_N if external oscillator is used.
12	ATB	Alternate Time Base. If XEN is high, ATB is clock output. If XEN is low, ATB is clock input from other 3210.
13	DV	Data Valid. Indicates tone burst has been detected by going to high logic level. Will remain high until tone is removed or CLRDV is pulsed high.
14	CLRDV	Clear Data Valid. Pulsing this pin to a high logic level will reset DV.
15 16 17 18	D8 D4 D2 D1	Digital outputs. These outputs provide a coded representation of the signal received when DV is high. The code is selected by H/B28 (pin 19).
19	H/B28	Code Select. When tied to V_P, the output on lines D8 through D1 is hexadecimal; when tied to V_N, the output is binary-coded 2 of 8.
20	EN	Output Enable. When this pin is a logic high, the output codes on lines D8 through D1 are enabled. When this pin is a logic low, outputs D8 through D1 assume a high-impedance state.
21	IN1633	Inhibit 1633 Hz. When this pin is at a logic high, the 3210 will detect only digits 0 through 9, #, and *. When at a logic low, the 3210 will detect all 16 tone-pair combinations.
22	NC	
23	RING	More negative of the two analog inputs
24	TIP	More positive of the two analog inputs

Table 4a: *Description of the pin functions of the ITT MSD3210 integrated tone decoder/receiver.*

Gain Increase	Resistance GI-GII	Gain Decrease	Resistance GII-GIII
3.0 dB	100k	3.5 dB	1 megohm
5.3	50k	6.3	470k
7.1	33k	8.0	330k
9.3	22k	10.3	220k
11.6	15k	12.7	150k
14.3	10k	15.6	100k

Table 4b: *Varying amounts of signal gain may be obtained from the adjustable-gain stage of the ITT MSD3210 by connecting different values of resistance, shown here, to the three gain-adjust input pins.*

FORTH

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An absolute must for the serious FORTH programmer...

Current tab over value and CP location displayed at all times.

Deupdate command included along with other utilities.

Works very well with memory mapped video.

Maintains its own 64 byte buffer that never changes location. Any text transferred to it via CTRL-T will remain until system shut-down or another CTRL-T transfer.

Message displayed when iNsert mode is toggled on via CTRL-N.

A special formatted list routine included for printer output.

CP is never allowed outside of the FORTH screen boundary.

Less than two lines of code need to be changed to work on most any terminal. (Clear screen code and the XY cursor addressing.)

Screen format for the standard CRT version.

List of commands: These commands are for the TeleVideo 912, but are very easily modified to match the character set or special functions keys on any terminal.

DEL	Delete — Delete character to left and move CP left one position.
CTRL-L	Right arrow ⟶ — CP advances one position to right.
CTRL-H	Left arrow ⟵ — CP advances one position to left.
CTRL-G	Get character — Character at CP location is erased when all text on line to right is moved left one position. The end of line character location is blanked out.
CTRL-I	Tab over to next tab location — The tab over count is stored as a variable and can be changed to any number between 0 and 63. CP will advance to next location each time command is given.
CTRL-J	Down arrow — CP moves down one line and maintains same column position.
CTRL-K	Up arrow — CP moves up one line and maintains same column position.
CTRL-E	Erase line — Line occupied by CP will be completely erased.
CTRL-S	Spread open — All lines below and including CP line move down one line. . .last line is lost.
CTRL-T	Transfer — Transfer the CP line to the editor buffer. . .the editor buffer contents will be overwritten.
CTRL-R	Read — Read a copy of the editor buffer into the line occupied by CP. . .editor buffer contents remain unchanged.
CTRL-D	Delete and close — All lines below CP move up one line and last line is erased to all spaces. . .original line is overwritten.
CTRL-C	Clear — All lines below and including line occupied by CP are erased to all spaces. . .total screen is erased if CP is on first line.
CTRL-B	Beginning of line — CP moves to leftmost position on line.
HOME	Home — CP moves to top leftmost position of Forth screen.
RETURN	Return key — Do a carriage return line feed.
CTRL-Z	Zap to end of line — All text from CP to end of line is erased.
CTRL-F	Find — Search screen starting at CP position for a string that matches the contents of the editor buffer. (This routine is purchased separately.)
CTRL-N	iNsert mode is toggled on or off — Character input at CP location will push text on current line to right one position. . .last character on line will be lost. . .delete, valid character entry, control-G and control-N are the only commands recognized while in iNsert mode . . .control-G works the same. . .delete not only deletes the character to the left, but also moves text from CP to end of line left one position. . .control-N will toggle iNsert mode off.
CTRL-Q	Quit editing and return to Forth.

Three listings included. The first listing is for use with a standard CRT terminal. The second and third listings are for use with a Memory Mapped Video (16x64 and 24x80).

The above example reflects a transfer of line 3 to the editor buffer via control-T. The editor buffer contents can be read into any line occupied by Character-Pointer via control-R. This buffer never changes location and its contents are displayed at all times. It is very handy for relocating lines or moving lines from one screen to another.

Please note the "NSERT/ON" message displayed at the upper right to indicate that the iNsert mode has been toggled on via CTRL-N. This message is erased when iNsert mode is toggled off.

The TAB over count is stored as a variable so it can be changed at any time. The current value is always displayed to the right of 'TAB='.

CP location is maintained within the boundaries of the Forth screen at all times. Its value is always displayed to the right of 'CP='.

Memory requirements are well under 2K.

All code conforms to the Forth-79 Standard. Each line of code is fully explained and flow-charted (Forth style) for easy modification.

Bomb proof. . .all unused control codes are trapped.

Must be used with a CRT that has cursor addressing or with a Memory Mapped Video.

The FINDWD package is sold separately but space has been reserved in the EDitor for future insertion. It will prove to be an invaluable tool for finding a word or words in a screen or searching a wide range of screens. It is fully documented and flow-charted. We spent a tremendous amount of time on this routine and have cut the search time down to under a second per screen (for a screen that is already in memory).

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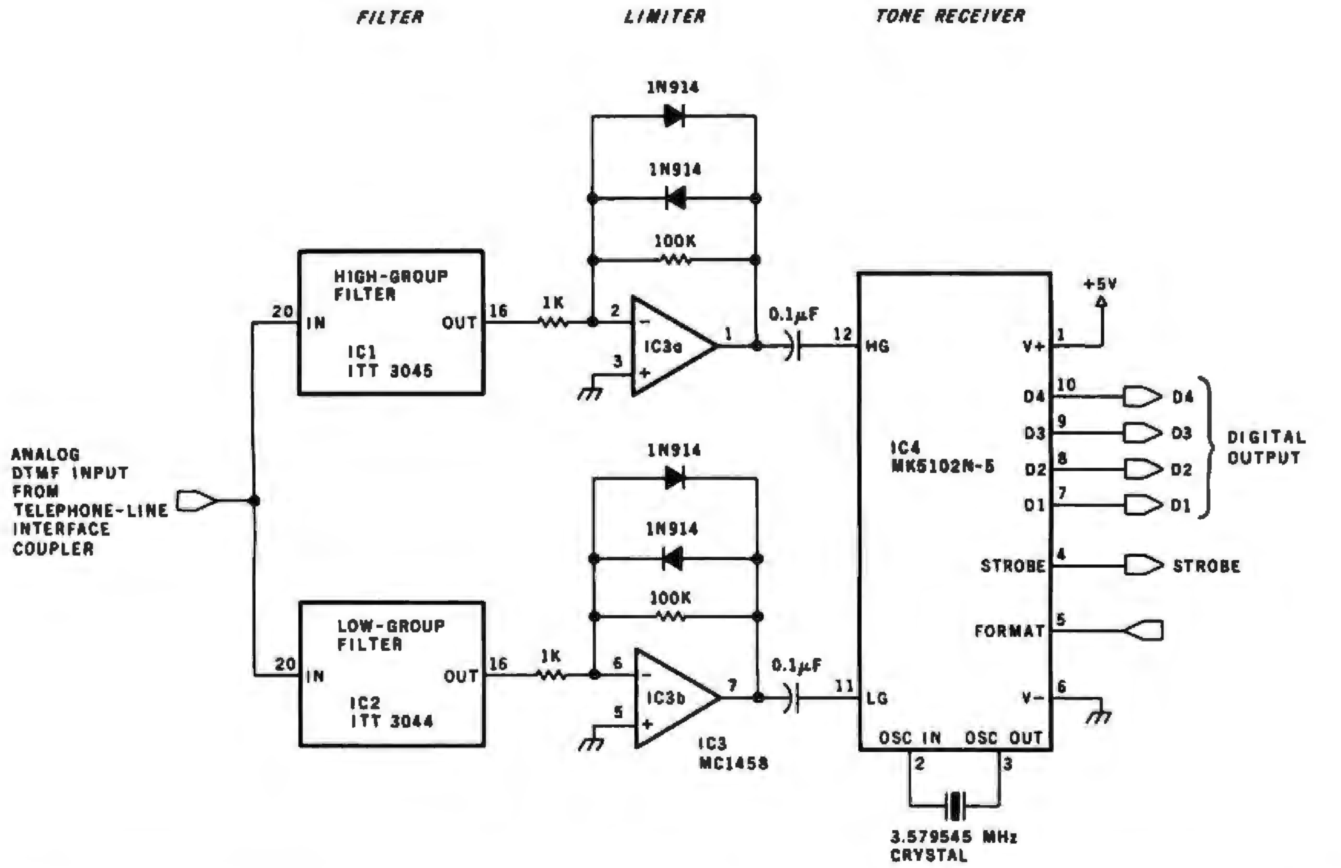


Figure 7: *Schematic diagram of a DTMF-receiver circuit that employs the ITT 3044 and 3045 hybrid bandpass filters and the MK5102 decoder.*

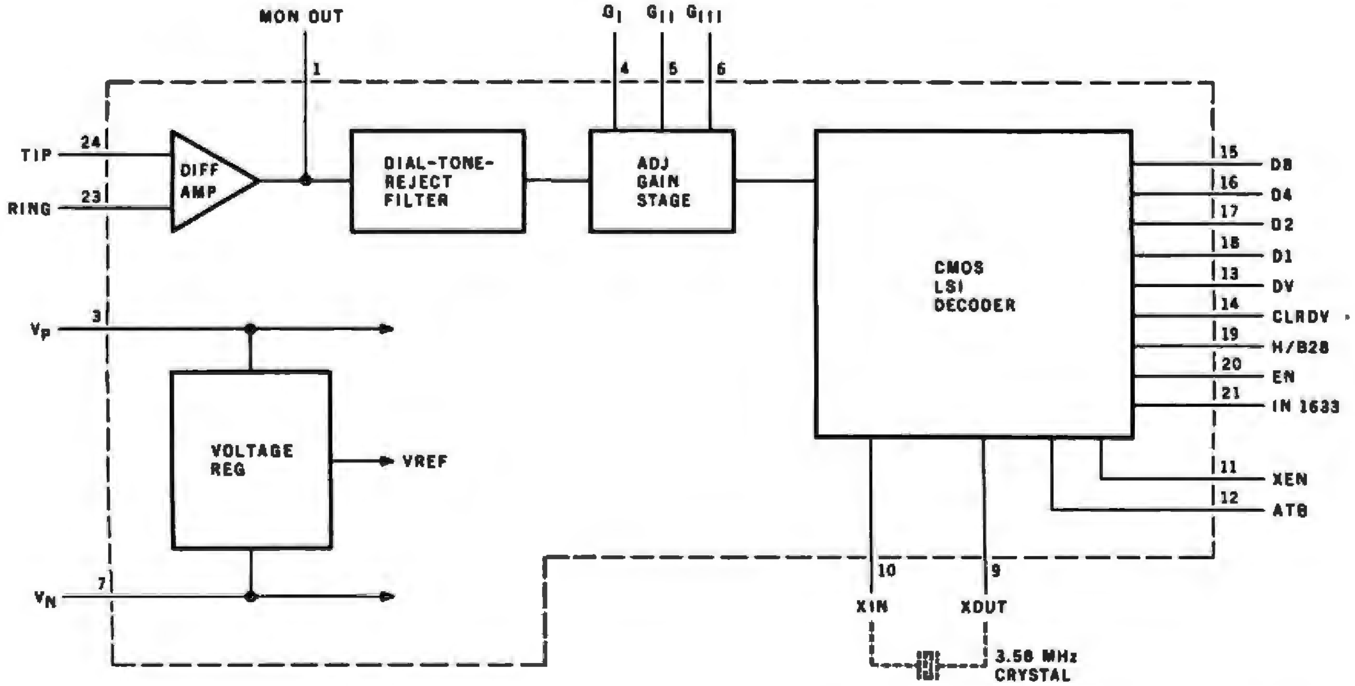


Figure 8: *Block diagram of the ITT MSD3210 hybrid thick-film-technology DTMF decoder/receiver shown in photo 6 on page 68.*

Number	Type	+5 V	GND	−12 V	+12 V
IC1	ITT3045		18	13	5
IC2	ITT3044		18	13	5
IC3	MC1458			4	8
IC4	MK5102N-5	1	6		

Power connections for circuits shown in figure 7.

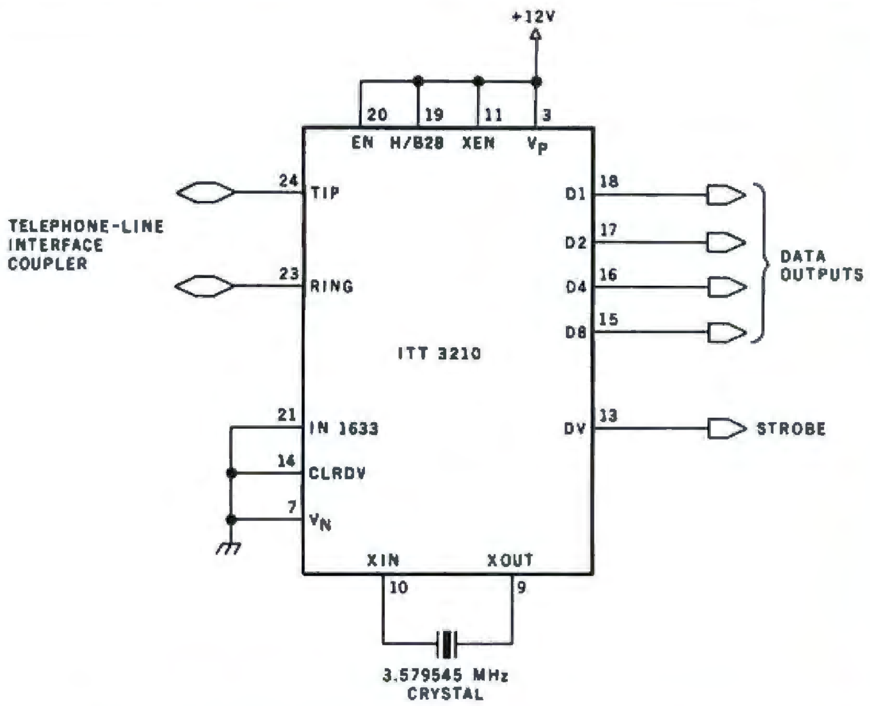


Figure 9: *Schematic diagram of connections to the MSD3210 for use as a DTMF receiver.*

Text continued from page 58:

integrated circuits from ITT, the MSD3210 and MSD3201. The MSD3210 is a hybrid DTMF tone receiver that uses thick-film CMOS/LSI technology. The output is a 4-bit code directly compatible with standard CMOS logic. As shown in the block diagram of figure 8 on page 62, the input signal is received on the telephone-line-compatible inputs called, for historical reasons, "tip" and "ring." (This compatibility does not, however, necessarily mean that you can connect it directly to a telephone line and still be in compliance with telephone-company tariffs.) Each line is protected for a voltage range from −200 to +200 volts, and the two provide a balanced differential input impedance of 600 k ohms.

The output of this first stage is passed through a high-pass and dial-tone-reject filter into an adjustable gain and attenuation stage. Next, the CMOS LSI decoder circuit provides bandsplitting, tone detection (by the digital zero-crossing method), and timing functions. The output code is selected by the H/B28 (hexadecimal or binary-coded 2-of-8 select) line. The code relationships are shown in table 3. When the DV (output strobe) line goes high, a tone pair is present on the input lines and the output data levels are valid. Table 4 on page 60 describes the functions of all the MSD3210's pins. A complete DTMF-receiver circuit, as shown in figure 9 on page 63, requires only two components.

While my personal choice for a DTMF receiver right now is the MSD3210, ITT also makes a true single-chip CMOS DTMF receiver (as opposed to a hybrid package)

Text continued on page 68

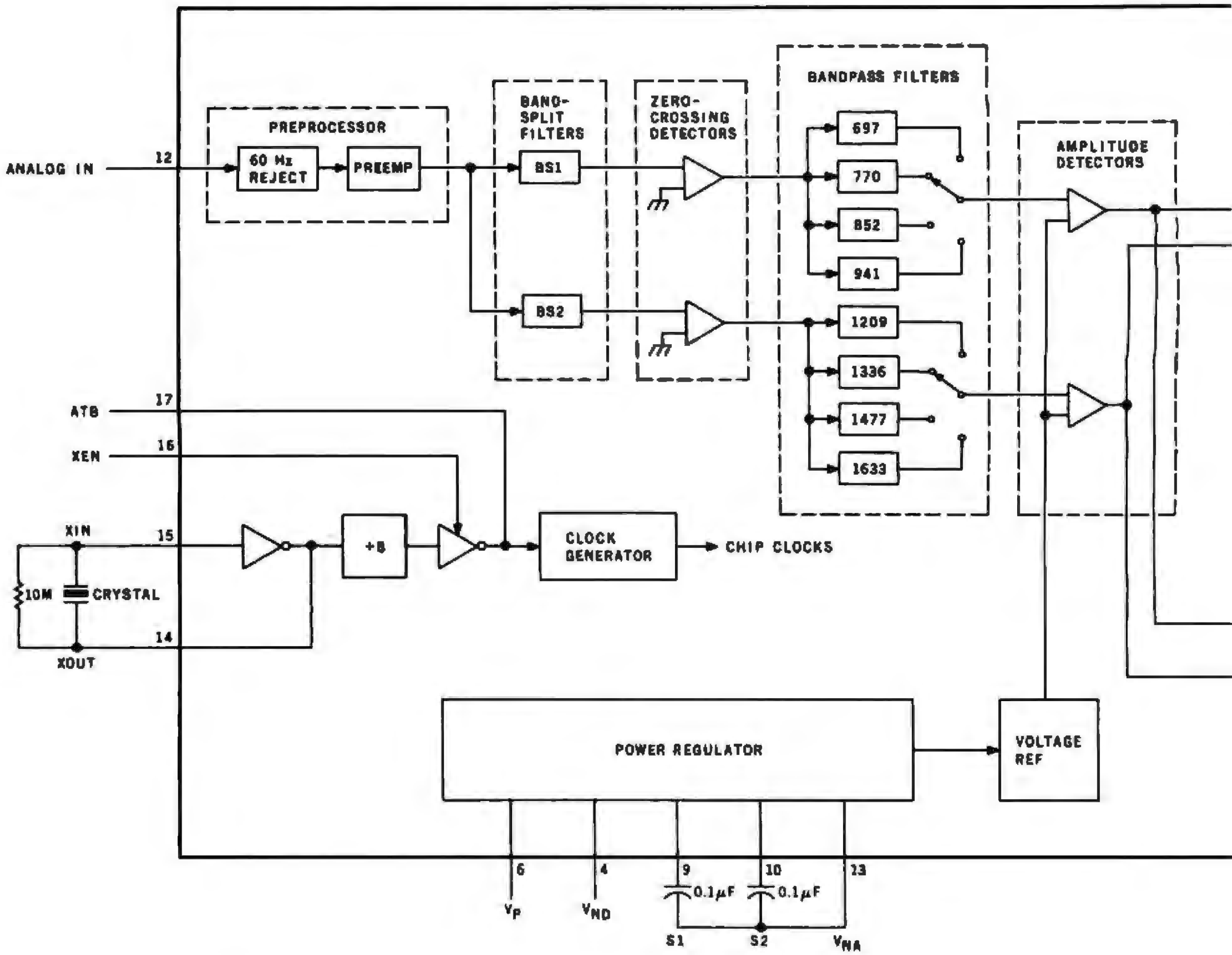
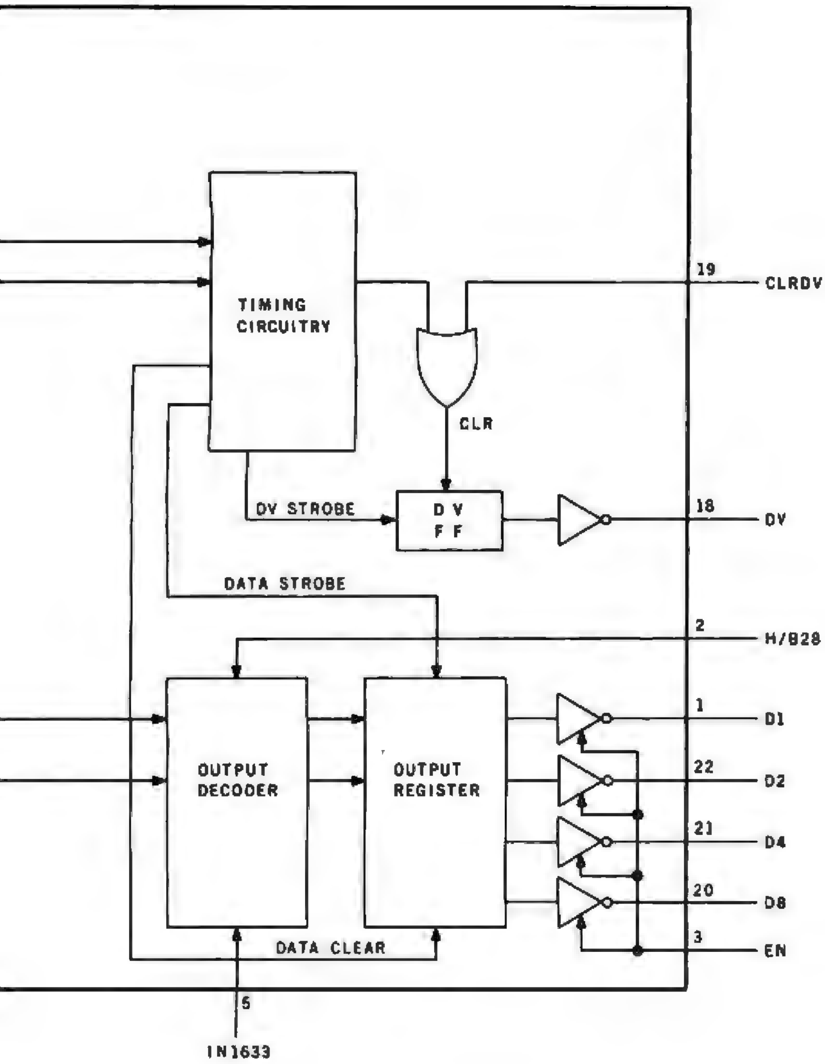
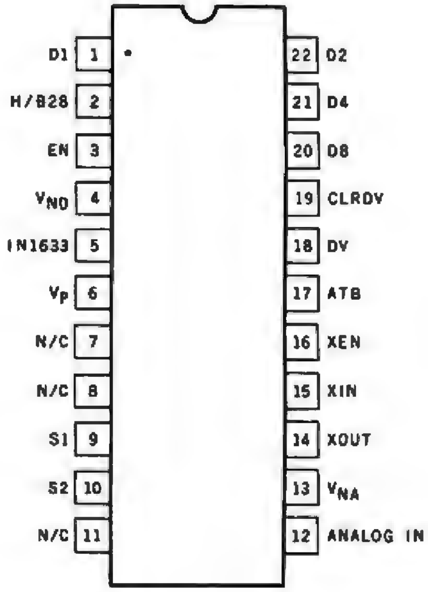


Figure 10: *Block diagram and pinout specifications of the ITT MSD3201 CMOS DTMF-decoder/receiver chip shown in photo 7. Because of the inherent ease of manufacture of CMOS components, the price of the 3201 may be expected to fall.*


TIMING CIRCUITRY
CLR
19
CLRDV
DV STROBE
D V F F
18
DV
DATA STROBE
2
H/B28
OUTPUT DECODER
OUTPUT REGISTER
1
D1
22
D2
21
D4
20
D8
3
EN
DATA CLEAR
5
IN1633


D1 1
H/B28 2
EN 3
VND 4
IN1633 5
VP 6
N/C 7
N/C 8
S1 9
S2 10
N/C 11
22 D2
21 D4
20 D8
19 CLRDV
18 DV
17 ATB
16 XEN
15 XIN
14 XOUT
13 VNA
12 ANALOG IN

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You get the features you need, like searching, a scratchpad buffer for moving and rearranging sections of text, complete file handling on multiple drives and iteration macros. For ease of use VEDIT has features you won't find elsewhere, like automatic indenting for use with structured languages such as Pascal and PL/I. You are less likely to make a mistake with VEDIT, but if you do, one key will 'Undo' the changes you made to a screen line. And if you run out of disk space with VEDIT, you can easily recover by deleting old files or even inserting another diskette. Take a hint from our customers who have other editors and word processors. They find VEDIT the fastest and most comfortable to use.

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Text continued from page 63:
designated the MSD3201, the internal structure of which is shown in the block diagram of figure 10 on pages 64 and 65. It uses a slightly different technique to process the DTMF signal. After the usual 60-Hz-reject and bandsplitting filters, the 3201 uses eight bandpass filters to detect the tones by analog means (remember the seven LM567s?), rather than the digital method employed in the 3210. Other than that, its operation is similar to the 3210's.

The MSD3201 is aimed at high-volume users. In common with any integrated circuit of this type, its price will drop in volume production.

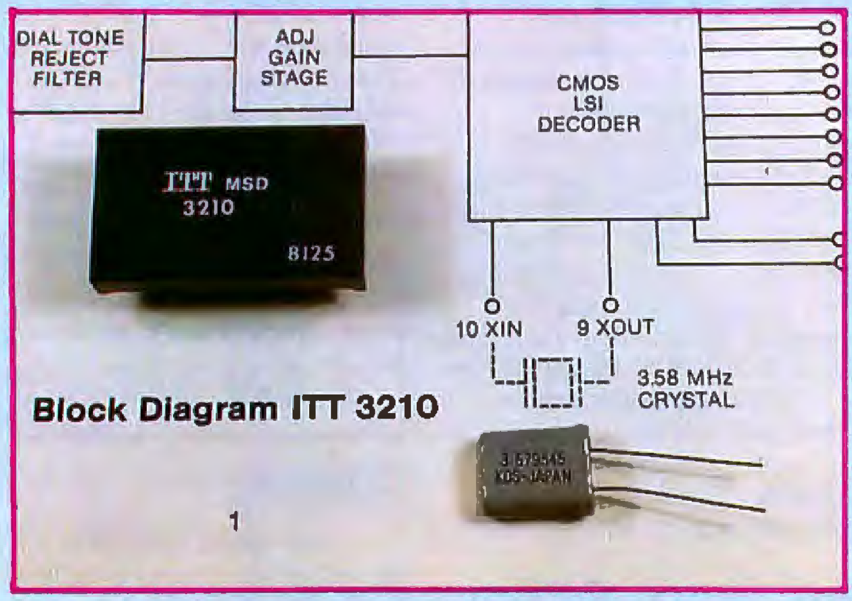

Photo 6: *An even more compact DTMF receiver can be made using the ITT MSD3210 hybrid thick-film-technology DTMF decoder/receiver chip. A single dual-inline package and a crystal form the complete receiver, at a cost of about $70.*

Photo 7: *Most future high-volume designs will use advanced devices such as this ITT MSD3201 single-chip CMOS DTMF decoder/receiver.*

Making the Connection

Before you decide to build one of these circuits, be aware of the restrictions in attaching it to the telephone line. Like a direct-connect modem or automatic telephone-answering device, any of these circuits must be connected through an FCC- (Federal Communications Commission) approved line-protection transformer or coupler. This line-interface device is installed to protect the telephone system from half-asleep experimenters who might short 115 volts AC onto the telephone lines. The coupler generally consists of a 600-ohm matching transformer and some overvoltage-protection components. If you plan on experimenting with the telephone lines, the telephone company will install a coupler for a low monthly charge.

It is not absolutely necessary to directly connect to the telephone lines. In his book *Telephone Accessories You Can Build* (reference 2), Jules H. Gilder describes the construction of an automatic answering device using an acoustic-coupling method. A small microphone hears the telephone ringing and triggers a solenoid that lifts the handset off the cradle. A speaker and microphone fastened over the mouthpiece and earpiece of the handset provide a link to the user's answering device. For casual use, this sort of kluge can be effective.

Other Possible Approaches

I hope you can see the benefits of using the MSD3210 and 3201 DTMF receivers because of the effort required to construct your own separate-component filters. Of course, I have a tendency to lean toward hardware solutions to any problem and avoid strenuous programming. If, however, you hold a black belt in machine-language programming, you might try an all-software approach. Conceivably, you could write an FFT (fast-Fourier-transform) routine to detect the DTMF frequencies. Personally, I'd rather do something else between ar-

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ticles than wrack my brain while staring at a video display. I'll just buy a few more chips.

One place software might work well is the DTMF-encoding function. I haven't tried that because I've always envisioned myself stepping into a phone booth in Butte, Montana, and "talking" to my computer through either the built-in Touch Tone keypad or a small handheld DTMF encoder. Software-generated tones might not be very portable. If your application is less mobile, you might try synthesizing the DTMF waveforms with software timing loops or through a simple D/A conversion. An informative article by John Renbarger entitled "A Telephone-Dialing Microcomputer" that deals with D/A-conversion signaling on a KIM-1 system was published in the June 1980 BYTE (page 140).

In Conclusion

Through a series of circuits ranging from a hundred components down to two, I have attempted to demonstrate both hobbyist and commercial decoding techniques. The choice of which one to build is generally a compromise between assembly time and component cost. If you have a lot of spare time and an ample junk box, you might try building the 100-component circuit. Designers working on commercial applications, on the other hand, would definitely opt for the latter. In my own case, wiring all those resistors and capacitors together once was enough. I will stay with the ITT MSD3210 and gladly pay the difference.

Inasmuch as it may be a while before I have an intelligent conversation with my computer, and technology moves very fast, perhaps by the time I am ready to fully implement remote interaction with my computer I will discard DTMF signaling in favor of voice recognition.

Next Month:

In case you're interested in trying to generate DTMF waveforms by D/A conversion, we'll look at the basic principles of digital-to-analog and analog-to-digital conversion. Oh yes, you may find it interesting for other applications, too. ■

References

1. Berlin, Howard M. *Design of Phase-Locked Loop Circuits, with Experiments.* Indianapolis: Howard W. Sams, 1978.
2. Gilder, Jules H. *Telephone Accessories You Can Build.* Rochelle Park NJ: Hayden, 1976.
3. Hilburn, John L. and David E. Johnson. *Manual of Active Filter Design.* New York: McGraw-Hill, 1973.
4. Lancaster, Don. *Active Filter Cookbook.* Indianapolis: Howard W. Sams, 1978.
5. Renbarger, John. "A Telephone-Dialing Microcomputer." BYTE, June 1980, page 140.

Editor's Note: *Steve often refers to previous Circuit Cellar articles as reference material for the articles he presents each month. These articles are available in reprint books from BYTE Books, 70 Main St, Peterborough NH 03458.* Ciarcia's Circuit Cellar *covers articles appearing in BYTE from September 1977 through November 1978.* Ciarcia's Circuit Cellar, Volume II *presents articles from December 1978 through June 1980.*

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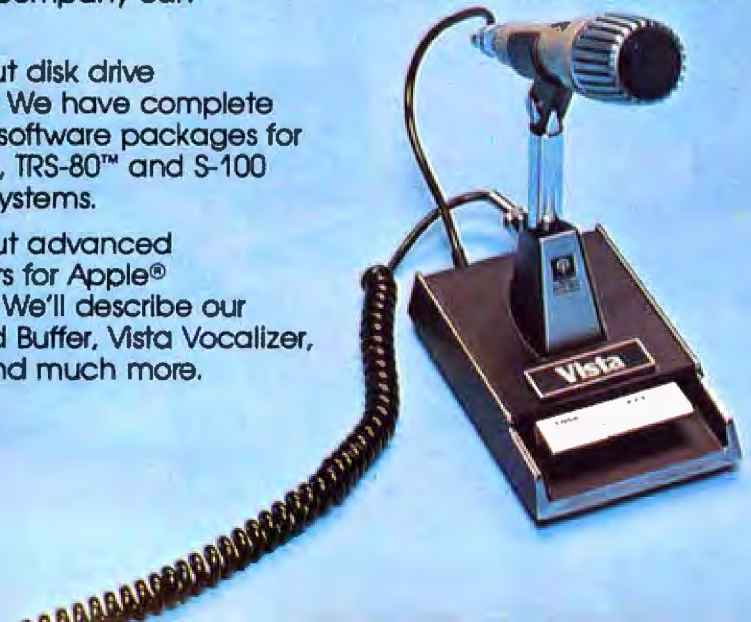

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Game of the Year

When I first heard of this program, it sounded fairly bland. With its dull name, I just knew it couldn't compare to "Super-Intergalactic-Cosmos-Blasters."

Luckily, I happened to witness the presentation of the Creative Computing Game of the Year award at the West Coast Computer Faire. Guess which program took the honors for 1980? That's right: Olympic Decathlon, by Tim Smith. At the presentation Tim gave us a firsthand demonstration of his ingenious creation. When the presentation ended, I bought a copy and raced home to try it on my computer. I wasn't disappointed; the program exceeds its promise.

Photo 1: *The javelin throw (TRS-80 Model I version).*

Photo 2: *The javelin throw (Apple II version).*

Olympic Decathlon is a remarkable simulation of the two-day event at the Olympic Games. It includes the 100-meter dash, long jump, shot put, high jump, and 400-meter dash on the first day. The second day features the 110-meter hurdles, discus throw, pole vault, javelin throw, and 1500-meter run. The winner of this combined event is considered the world's best athlete. After you participate in the computer version of the decathlon, you'll understand why.

Each event is displayed in superb animated graphics that you control via the keyboard. The appropriate keys necessary for each event are displayed on the screen before each trial. These instructions are sufficient to explore each event, but you may wish to consult the manual for ways to approach some of the more difficult ones.

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Name ______________________

Title ______________________

Company Name ______________________

Address ______________________

City __________ State __________ Zip __________

At a Glance

Name
Olympic Decathlon

Type
Game/simulation

Manufacturer
Microsoft Consumer Products
400 108th Ave NE, Suite 200
Bellevue WA 98004
(206) 454-1315

Price
$24.95

Author
Timothy W Smith

Format
5¼-inch floppy disk or cassette (TRS-80 only)

Language
Z80 machine code (TRS-80);
6502 machine code (Apple)

Computer needed
16 K TRS-80 Model I, Level I or II—tape version; 32 K TRS-80 Model I, one disk drive (two needed to do backup); 48 K Apple II or Apple II Plus, one disk drive (two needed to do backup), and two game controller paddles

Documentation
48 pages for TRS-80;
39 pages for Apple

Audience
Armchair athletes of all nations

The events require fast reflexes, good coordination, timing, and *lots* of practice. There is a practice mode for each event so that you can polish your technique before the start.

Competition

Olympic Decathlon may be played alone or with others. When you are ready to begin, the computer asks for the number of competitors. Up to eight athletes may compete in the TRS-80 version; as many as six in the Apple version. Playing alone, you will strive to better your previous performances. When several people participate, the game develops an entirely different character. Scores take on new meaning as the competitors jockey for position in the standings. Head-to-head confrontations in the running events add to the drama.

The Simulation

Smith has captured the flavor of the Olympic Games on magnetic media. With a bit of imagination, you may relive those days on your hometown track, where you

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can still hear the crowd buzzing about the last race. Now it's your turn. Suddenly you are aware only of the starter's voice as you toe the starting line.

ON YOUR MARK
SET
GO!

As you frantically tap the keyboard, your animated counterpart streaks across the screen. As you near the finish line, your fingers scream for relief, but you can't give up now; your brother-in-law is gaining. With a final burst of energy, you cross the finish line and collapse into your chair, savoring a narrow victory.

The simulation of the actual events is uncanny. Each is unique and requires its own combination of timing, technique, endurance, coordination, and speed. For example, the pole vault demands a healthy dose of all these qualities. You begin with a running approach. As the graphic figure nears the pit, the pole must be planted in the vaulting box. Miss the box, and the vault is aborted.

If the pole plant is successful, and your flying fingers have generated enough momentum, the figure will ride the pole toward the crossbar—where he must pull up into a handstand, just before hitting the bar. Finally, the pole must be released before it follows through the crossbar. Proper timing is rewarded with SUCCESSFUL VAULT!

Authenticity

The rules in Olympic Decathlon are virtually identical to the real event. For example, in the vaulting events you may "pass" on the lower heights and save your energy for the tougher ones. If you miss on three consecutive attempts, you are eliminated from that event.

The rules are enforced by an eagle-eye official. If he determines that you "purposely" knocked down the hurdles, you will be disqualified. He also keeps a watchful eye on the fault line in the javelin throw and long jump. And, of course, jumping the gun in a race is forbidden.

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Program Reliability

The program has exceptionally good error handling. User response is strictly controlled to eliminate the acceptance of unreasonable input. The TRS-80 version appears to be crash-proof. Try as I might, I couldn't cause the program to crash or even become flustered. Apple II users can avoid missing any turns by disabling the RESET key.

I found one minor logic error in the TRS-80 version. When several pairs of people are competing serially, the "false starts" are charged by lane rather than by individual. By the time this review is published, Microsoft will have corrected this problem. Otherwise, the program appears flawless.

Documentation

The program is accompanied by an instruction booklet containing background information about the program, the author, and Microsoft. The instructions cover running the program, cassette-loading problems, backing up the disk (you are allowed one backup), and tape or disk replacement. Each event is discussed in detail, and hints on technique and strategy are included.

Hardware Requirements

Olympic Decathlon is available for the TRS-80 Model I and Apple II computers. Each version took about 10 months to complete.

The TRS-80 version is available on either cassette or disk. The disk version requires 32 K bytes and one disk drive. This version is an impressive example of the creative animation attainable with low-resolution graphics (see photo 1).

The Apple version is available on disk only. It requires 48 K bytes, one disk drive, and game paddles. The high-resolution color graphics are quite impressive (see photo 2). The Apple version also plays the Olympic Anthem during the opening and awards ceremonies.

Software Support

Microsoft is not playing games when it comes to support after the sale. Tapes and disks are guaranteed to work. If the program fails to load properly, return it to the dealer or to Microsoft for a free replacement. If it becomes damaged during normal use, Microsoft will replace it for $7.50. The disk version allows a single backup (requires two drives) to facilitate play while you await your replacement disk.

Conclusions

Olympic Decathlon is a superior graphics game. A well-written simulation that captures much of the flavor of the Olympic Games, it is challenging and entertaining.

While many game programs quickly find their way to the "All Played Out" file, the interactive graphics, multiplayer capability, and unique features of Olympic Decathlon will keep it in your active program library for a long time.■

Missile Defense vs ABM

Robert Moskowitz
22200 Tioga Place
Canoga Park CA 91304

All is quiet—perhaps too quiet. Then, without warning, comes the attack! At first, a single incoming missile streaks across the sky. Another follows. Then dozens upon dozens, in a crazy-quilt pattern of bomb trajectories and defensive streaks, darting and exploding in rapid fire. Killer warheads of every description veer relentlessly for your cities: ordinary bombs, MIRVs that retarget themselves and multiply without warning, and even "smart" bombs that can dodge your most accurate firing. With increasing speed, they rain down in waves, until your defenses are taxed to the limit—or more likely overtaxed—and your brain circuits sizzle like the cities just fried by nuclear fireballs.

But wait. Nobody is dead. This is fiction. The scenario takes place thousands of times every day, at arcades across the country and now in thousands of homes equipped with Apple computers and color TVs. At the arcade, it is Atari's Missile Command—one of the most popular games around. At home, you can have two versions of the game: Missile Defense(by On-Line Systems) and ABM (by Muse Software). All three play a tough, fast game with plenty of thrills, sound effects, and graphics. This review hopes to differentiate the subtleties, the slight distinctions, and the all-important "feel" that make for a really rousing atomic war!

Two notes on these reviews: First, I relied on a panel of

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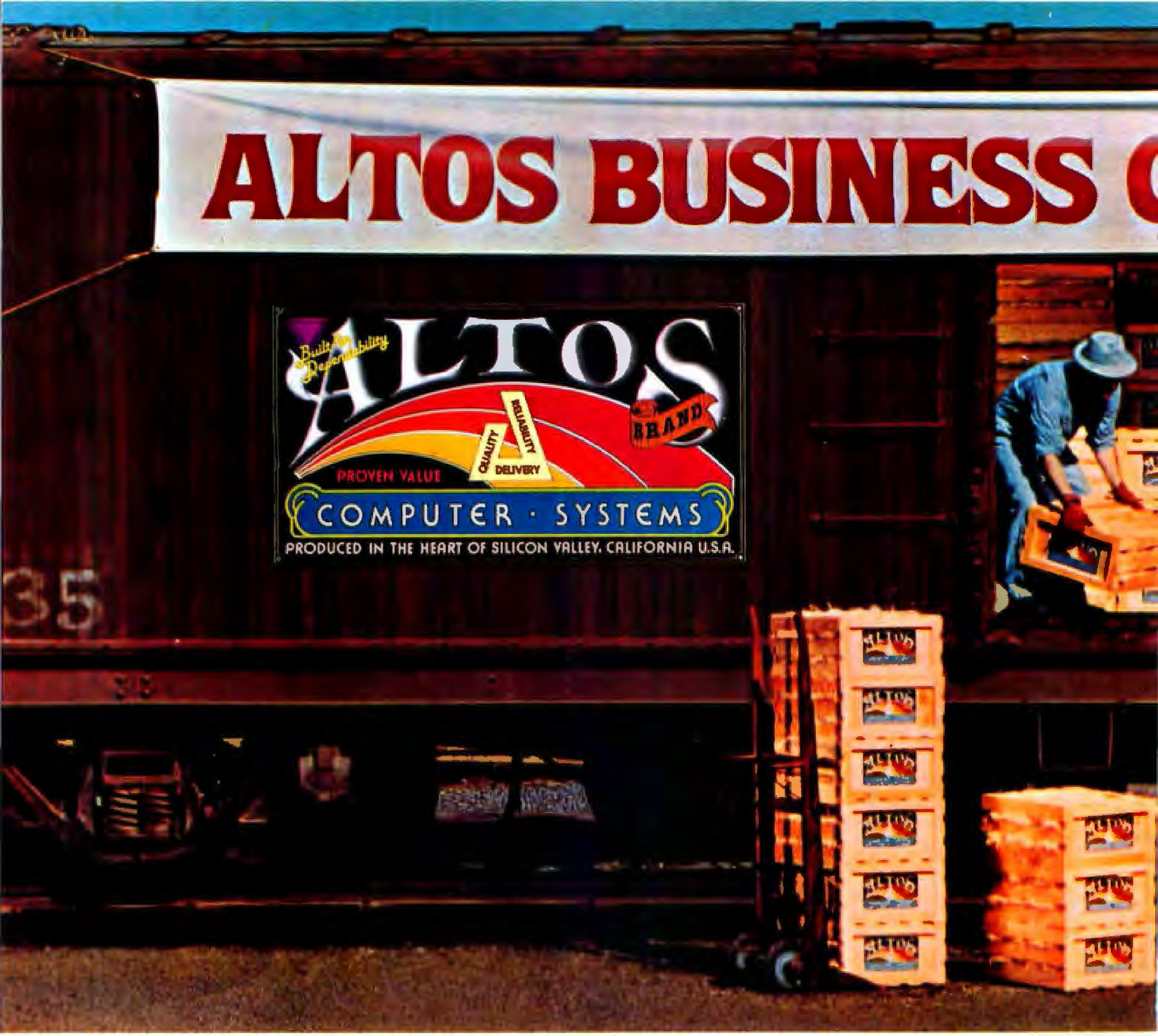

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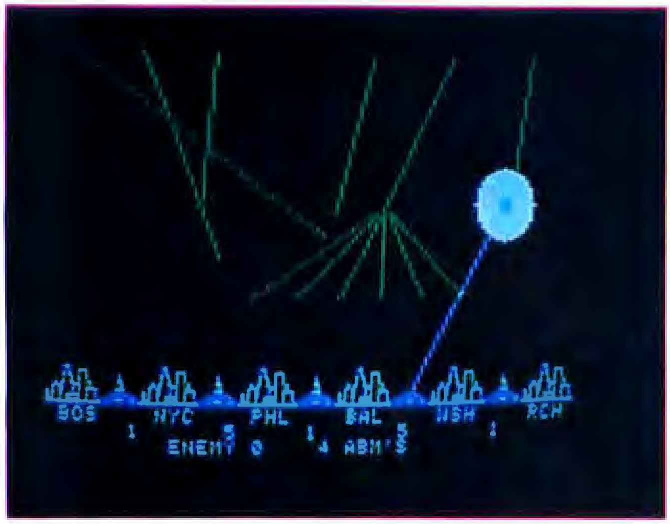

Photo 1: *Muse's ABM game is progress.*

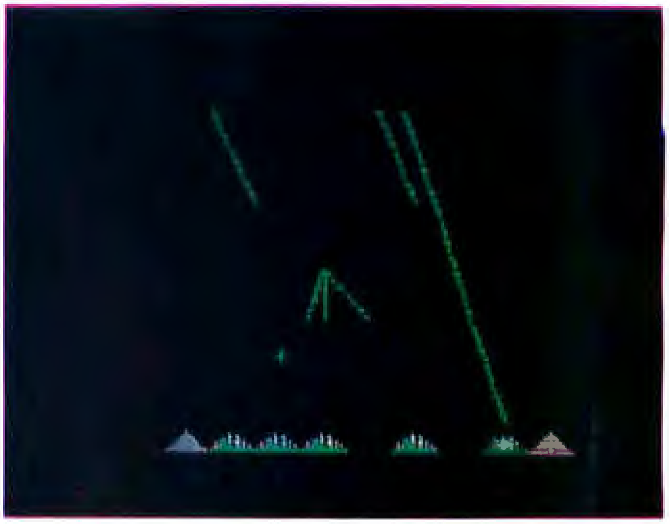

Photo 2: *On-Line Systems' Missile Defense game in progress.*

judges, ages five to 19, to play the games extensively and give me their opinions. Second, I took Missile Command—the original arcade version of the game—as the basis for comparison. For better or worse, our judges had much more time on that game than either of the home-computer versions up for review. So it was natural to see which of the home-brew war games compares best with the original.

The Scenario

All three games offer you a chance to control a missile defense system during a savage enemy attack on your cities. The game continues until all your cities have been destroyed.

Missile Defense copies the original theme in great detail, giving you six nameless cities defended by three missile bases. Incoming objects include single bombs, MIRV bombs that split and separately retarget themselves, and "smart bombs" that move upward and horizontally to avoid your defensive missiles. You must be *very* accurate to destroy a smart bomb and very fast to counter a MIRV attack.

The attacks tend to come in waves, initially slow, then faster, splitting and swerving across the screen in a cacophony of screeches, sizzles, and howling sound effects. If a bomb penetrates and hits a city, the target is cleanly destroyed. Should a bomb hit a missile base, you lose it and any missile firepower that may have remained there.

When the waves end, the computer tabulates your score, awards bonus cities for every increment of 10,000 points, and then restores your three fully loaded missile bases for the next round. While the scores achieved with this game are lower than those of the arcade version, the scoring system and pattern were judged to be similar, and our panel generally felt comfortable at the controls.

If you run out of missiles, the enemy becomes merciless and usually decimates what is left of your cities. Our judges disliked this tendency and claimed that the original Atari version generally has enough built-in mercy to leave at least one of your cities when it finds you totally defenseless. Several times, the intelligence behind Missile Defense stunted the spirit of a good game by mercilessly obliterating three or more cities after we depleted our missile supply in the third or fourth round.

ABM has a slightly different scenario. Here you defend the Eastern Seaboard, with its six familiar cities: Boston, New York, Philadelphia, Baltimore, Washington, and Richmond. You have both high- and low-yield defensive missiles, fired from five separate bases between the cities. You can choose to fire high- or low-yield, but the computer decides which base actually launches the missile. You have an unlimited number of defensive missiles to fire. Enemy weaponry includes single bombs and MIRVs, but no smart bombs.

The attacks come continuously, at progressively faster and overwhelming rates. ABM gives a continuous readout of your total shots and hits, but the final score only appears after all your cities have been eliminated. Scoring is low, with a record high of 7120. No matter how well you do, the computer never restores a single city during the game. There is no pause and no restoration of armament until the game concludes. Judges preferred the arcade system, which pauses, scores, and restores cities before resuming the game.

Circle 249 on inquiry card. →

If a bomb penetrates your defenses in ABM, it fireballs on or near the ground, destroying everything within the fireball. This lends a swiss-cheese effect to your cities and allows you to lose half of Richmond or nine-tenths of Boston, for example—an impossible occurrence in the original version. If a missile base is bombed, you lose that firepower, although one active base is as effective as five.

ABM has a special demonstration mode. If you boot the game disk and do nothing, it pauses, then begins playing itself. This is a fun introduction to the game, but has little relevance to the quality of play and was probably included as a marketing device. Touch any key and ABM goes into normal play.

Both games keep your eyes, ears, and hands busy. But overall, our judges like the arcade version the best; more on this a little later. For now, let us examine the action piece by piece.

Mobility

Mobility is the prime factor in a high-scoring defensive system. The faster you can move your cross hairs to retarget your missiles, the better chance you have to repel the enemy attack and the more missiles you can fire if your first shots miss.

The original game offers a special "rolling ball" (track ball) control to provide exceptionally fast mobility, which neither home game can match. Our test Apple is equipped with the standard paddle controls and, after some practice, our panel of experts was able to move the cross hairs about the playing screen with speed and accuracy. The paddle controls, however, require a large range of motion to go from, say, upper left to lower right on the screen. Even the ABM adjustment program (more on this later) could not reduce the *range* of motion enough to increase overall mobility. This paddle problem affected the play in both versions of the game. Almost all the judges guessed that joystick controls on the Apple would make both versions of the game even better.

ABM provides a blinking set of cross hairs that disappear for a short time immediately after you fire a missile. The launched missile heads for the spot your cross hairs occupied when you hit the firing button, but the cross hairs turn invisible. You can still move them, but you do not know where they are. This limits your ability to launch a rapid-fire counterattack. Even worse, it actually confused some of our panel. Habitués of the game invariably want to fire and retarget in almost the same motion. In that second or two of invisibility, the players lost track of the cross hairs and lost more time looking for them when they reappeared. With a joystick, there would have been better feedback from the fingers to help retain a sense of screen location. But the eyes have it in this game, and cross hairs that disappear are a serious liability—particularly when the pace accelerates. In addition, the judges felt the blinking cross hairs were harder to see than the steady ones you get in the original version.

Missile Defense offers a very stable cross-hair pattern, which remains visible throughout the game. Our judges found it simple to fire and instantly retarget for the next incoming object with this version. As with ABM, the missile streaks toward the point where your cross hairs were

At a Glance

Name
ABM

Type
Arcade-style game

Manufacturer
Muse Software
330 N Charles St
Baltimore MD 21201
(301) 659-7212

Price
$24.95

Author
Silas Warner

Format
5¼-inch floppy disk

Language
Applesoft and 6502 machine language

Computer
Apple II or Apple II Plus, with Applesoft in ROM or Language Card, 32 K bytes of memory, and one disk drive

Documentation
Printed leaflet

Audience
Anyone who likes fast-action arcade games, especially Atari's Missile Command

At a Glance

Name
Missile Defense

Type
Arcade-style game

Manufacturer
On-Line Systems
36575 Mudge Ranch Rd
Coarsegold CA 93614
(209) 683-6858

Price
$29.95

Author
Dave Clark

Format
5¼-inch floppy disk

Language
6502 machine language

Computer
Apple II or Apple II Plus, with 48 K bytes of memory and one disk drive

Documentation
2-page leaflet

Audience
Anyone who likes fast-action arcade games, especially Atari's Missile Command

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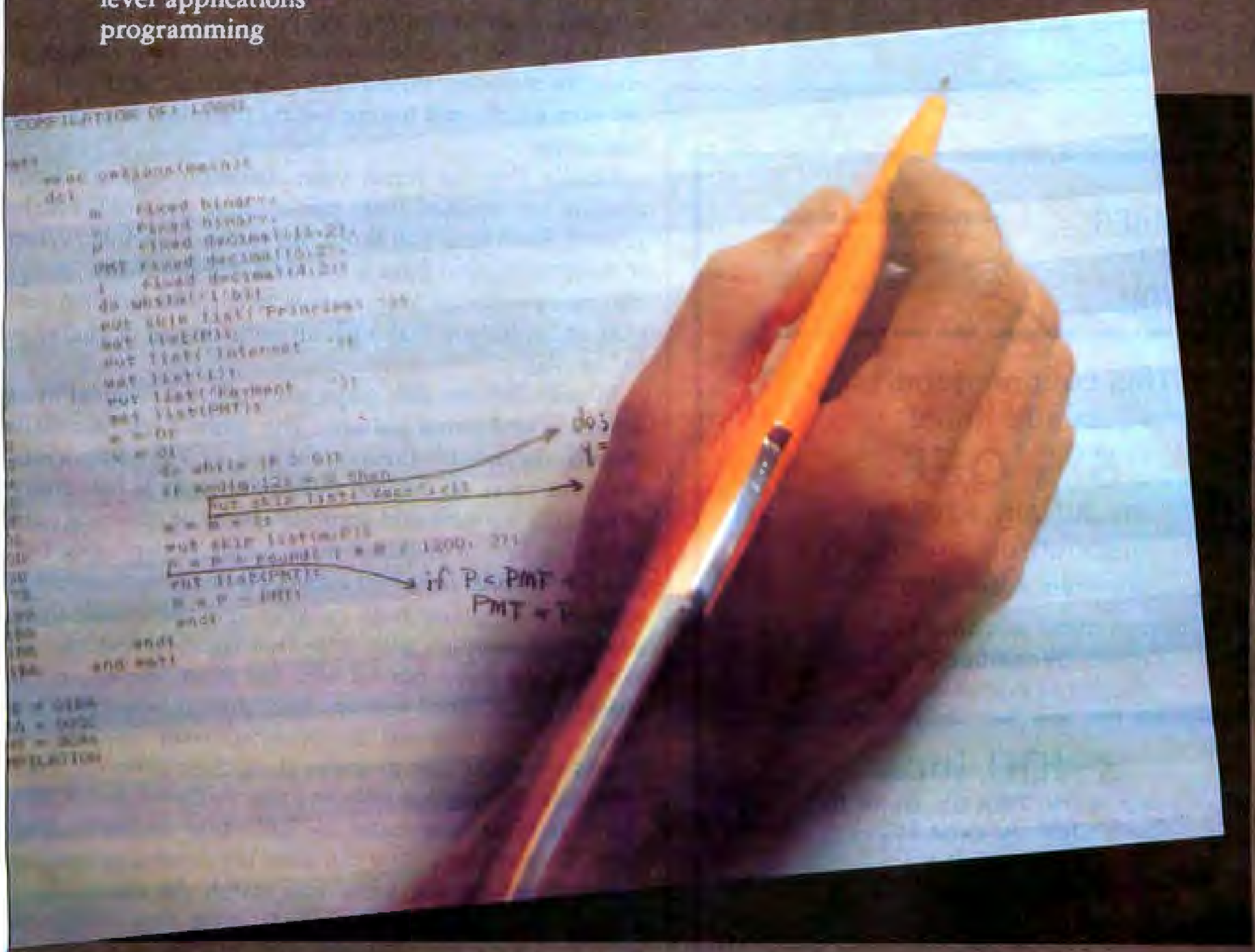

Circle 127 on inquiry card.

when you fired. Meanwhile, you can be halfway across the sky, preparing for the next defensive shot.

ABM offers a unique adjustment program so you can set up the paddles (or joystick) to suit your muscular instincts. Our judges applauded this ingenious feature and used it to make each paddle control react as *they* wished. This way, you can change the way the cross hairs respond to a given paddle movement if it seems wrong.

Missile Defense offers the option of controlling the cross hairs from the paddles or from the keyboard. The U-I-O-L-.-,-M-J pattern of keys triggers movement in eight directions, providing a kind of "keyboard joystick." The more often you hit one of these keys, the faster the cross hairs move in the specified direction. A touch of the K key immediately stops the cross hairs. Some of our judges preferred this arrangement to the paddle controls, claiming it offers a closer simulation to the original track ball and that it facilitates one-hand operation of the cross hairs—a definite advantage in Missile Defense, as we shall discuss.

Defensive Missiles

ABM provides an unlimited defensive arsenal. You can fire for an eternity, and ABM will remain poised to pump out more missiles on your command. (The original version strictly limits your firepower.) In ABM, you fire the missiles with the two paddle control buttons. One button fires missiles from the two bases equipped with 5-kiloton warheads; the other button fires missiles from three other bases, which are equipped with relatively tame 1-kiloton warheads. The adjustment program lets you decide which finger will deal each blow. The larger warheads create larger fireballs than their smaller cousins and, therefore, have the potential to engulf more incoming objects.

Despite the impressive fireballs, the need for accuracy is far greater with ABM than with the original. Some incoming missiles seem to outrun the expanding fireballs, while others survive what looks like a solid hit. In the original, you can detonate your missile in the track of the oncoming enemy. The explosion lingers long enough to erase the intruder. With ABM, you cannot "lead" the target very much, and hitting behind the attacker is usually ineffective.

Missile Defense limits your defensive arsenal. Your missiles are released from one of three pyramids on the ground. Each time you shoot, the pyramid shrinks. When it disappears, that base is without missiles. Most of our players saw this as more comparable to the original version and a feature that adds an extra degree of challenge to the play.

Missile Defense also plays more like the original in its accuracy and firing pattern. This game fires its missile from the keyboard. Pressing the 1, 2, or 3 key fires a missile from bases on the left, middle, or right of the screen. While this is a sure and accurate means of directing your defensive fire, it requires three hands (when using two paddle controls) for rapid action. None of our judges was able to manipulate both paddles and the missile-firing keys conveniently with only two hands. However, all felt that the game played with the missile-firing keys is close to the original version. And, it must be admitted, a joystick—which could be operated with one hand—would eliminate any problem along these lines.

Missile Defense has only one size warhead. But, again, this closely approximates the kill range of the original version's warheads. You can also "lay down a pattern" of explosions with this game and watch the enemy drive into it. The explosive dust clouds linger long enough to trap an oncoming projectile and take it out. This is another factor that helps Missile Defense play very much like the original.


ACI-1
ACI-2

Sound Effects

Both games have some interesting sound effects. ABM provides a juicy sizzle when a missile or a bomb detonates. Missile Defense emits a tinkling sound when a missile or a bomb discharges. You also receive introductory effects, a long, falling whistle when you lose, and finally, a flashing red screen (duplicating the ending of the original Atari game).

Neither game produces the shooting sounds you get when you loose your own missiles in the original, and aficionados of the game claimed to miss the extra sound. I found both games noisy, active, and more than enough to occupy the senses.

Graphics

ABM provides an interesting display of the six East Coast cities. The colorful missile tracks break up and jump as they cross resolution lines on the TV screen, and the fireballs are expanding white circles that engulf and eliminate everything in range.

Missile Defense has a nameless row of cities, also seemingly identical. The missiles come in smoothly, with very little break-up of their tracks on the screen. Smart bombs are shown as small plus signs. Explosions are detailed clouds of colored dots that grow, freeze, and evaporate within a few seconds.

Both games play in the Apple high-resolution graphics mode, with exciting opening sequences. Neither game matches the original, however, which uses different color combinations as the action gets more intense. All things considered, they play almost identically in terms of quality, action, and color.

You may be interested in our judges' ratings. On a scale of 0 to 100—with the original Missile Command as 100—Missile Defense rated 85 and ABM rated 75. The relevance of these numbers is unclear, but remember you heard it here first.

Conclusions

Both games are exciting, demanding, frustrating, challenging, and great fun. The preference seems to depend on your playing history. If you have spent a lot of time on the arcade original, you will probably prefer Missile Defense. It looks, sounds, scores, and plays much more like the original than ABM. It is like bringing the arcade game into your own home.

If, like me, you have no experience on the arcade original, you may appreciate ABM's subtle differences: the unlimited shooting, the identification of the cities, the high- and low-yield weaponry, the continuous performance readouts, and the paddle adjustment program.■

Gorgon

Peter V Callamaras
25 C Scott Circle
Bedford MA 01730

"Blue Three to Blue Leader—We have them in sight."

"Blue Leader to Blue Three—Watch out for Space Mines."

"Blue Three to Blue Leader—We got them! But there's more on the wa..."

"Blue Two to Blue Leader—They got Blue Three. They're all over the place! They grabbed one of our people and are carrying him off—I'm starting my attack run and..."

"Blue Leader to Blue Base—we lost two ships. I'm the only one left. I'm breaking off and will commence the attack from the opposite direction."

Suddenly there is a blinding flash of piercing white light and a voice breaks in:

"Honey—do you realize it's almost three in the morning?"

Time passes quickly when you're playing Gorgon, a new arcade-style space game from Sirius Software. This is one of the typical high-quality, highly graphic games we have come to expect from the Sirius/Nasir team. Rest assured that you Nasir Gebelli fans will not be disappointed by this one!

The premise behind Gorgon is fairly simple—the earth has entered a time warp, and strange creatures called Gorgons appear at random to abduct helpless earthlings. You are a fighter pilot trying to blast the Gorgons with your laser cannon before the kidnappings occur.

If you are too late, you can still shoot the Gorgon who is carrying off one of your people. But you must then catch the falling human and lower him safely to the earth's surface. Hitting the earthling with your cannon fire or allowing him to hit the ground costs you 50 points; saving a captured earthling gains you 100 points.

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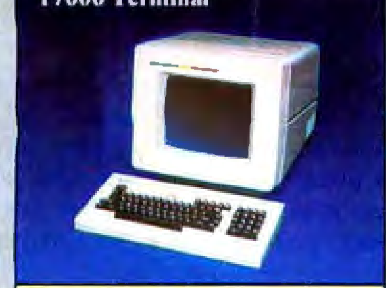

- *ANSI X3.64 Terminal*
- *80 x 25 rows on a 12" diagonal screen*
- *Optional touch panel*
- *Blink, blank, reverse video, half-intensity and underline*

System 100

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- *Up to 14MB of main memory*
- *Supports up to 96 intelligent terminals*

System 150-IT

- *68000 Processor*
- *Up to 1.5MB main memory*
- *Single-user intelligent terminal*

System 150-FS

- *68000 Processor*
- *Up to 1.5MB main memory*
- *2, 5¼" floppy disk drives (1.92 MB or 320KB)*

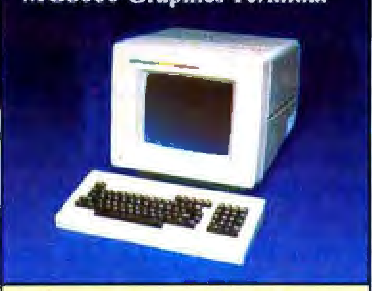
System 100-DT

- *68000 Processor*
- *2, 8" dual-sided, double-density floppy disks (2.4MB)*
- *Up to 3MB of main memory*
- *Supports 4 dumb terminals*

System 150-WS

- *68000 Processor*
- *10MB hard disk—5¼" floppy disk for back-up*
- *Up to 1.5MB main memory*
- *Single-user or multi-user operating system (multi-user version supports 4 terminals)*

MG8000 Graphics Terminal



- *Same features as T7000 Terminal*
- *Monochrome graphics—400 x 300 pixel resolution*
- *Simultaneous support of text and graphics features (2 independent graphics planes for animation)*
- *Optional touch panel*

System 110-DT

- *68000 Processor*
- *1, 8" dual-sided, double-density floppy disk (1.2MB)*
- *Up to 1.5MB of main memory*
- *Ideal single-user workstation for video-disc and simulation*

Photo 1: *The game Gorgon in progress.*

Your Gorgon opponents come in four different forms, each worth different point totals. Only one type grabs people, but the others release space mines that destroy your fighter on contact. You get three fighters during a game.

The display for Gorgon seems complex at first, but you soon become accustomed to it (see photo 1). The bottom four-fifths of the screen shows a side view of the earth's surface, which features undulating terrain and an occasional human. Above this is a situational sensor view showing your position relative to any Gorgons. Thus, you can leave the immediate battle area and do a bit of reconnaissance. Later, you can reenter the battle zone from a more advantageous direction. Next to the sensor screen is a display of your remaining ships (upper right corner). Below the terrestrial view is information on remaining fuel, present score, and high score.

You don't expect this game to be too easy, and it isn't. The Gorgons materialize at random locations in the battle area, and hesitation at shooting them presents several problems:

- The Gorgons destroy your fighter if they make contact with your craft before you can blast them.
- The different creatures release two kinds of space mines which destroy your ship on contact; you can't easily shoot them down, but they temporarily disappear if you outrun them for a certain distance.
- The more time you take to destroy the Gorgons or mines, the more Gorgons appear—and you are rapidly overwhelmed and destroyed.

Fuel depletion can be remedied by the option that allows you to refuel from an orbiting space station. You must maneuver past your sensor satellites, and your lasers are deactivated. (The rationale is that you can't destroy the satellites because they give you information on the Gorgons in the other half of the game.) If you should collide with one of your sensor satellites, your ship is destroyed. This feature actually gives you a game within a game.

Action is controlled from the keyboard. The game can be played without paddles if none are available. The game requires coordinated use of both hands to pilot the fighter and fire the laser.

For a change, the choice of keys and their locations doesn't lead to the fatigue and finger cramps experienced in some other games—notably, those programmed in Japan. The A and Z keys control the vertical fighter direction and velocity, while the left and right arrow keys control the horizontal direction and speed (hit a key and the ship points in that direction; hit the same key and the ship's speed increases). It takes time to become accustomed to using the keys continually to change direction

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and speed. But it isn't distracting. The space bar fires the laser, so it doesn't matter if you are left- or right-handed. This key arrangement is very comfortable and gives you a place to rest your hands.

At a Glance

Name of software
Gorgon

Type
Arcade-style game

Manufacturer
Sirius Software Inc
2011 Arden Way #225A
Sacramento CA 95825

Price
$39.95

Author
Nasir Gebelli

Format
5-inch floppy disk

Language
6502 machine language

Computer
Apple II or Apple II Plus; with one disk drive (13- or 16-sector) and 48 K bytes of memory

Documentation
One-page instruction sheet

During play, there are options allowing you to pause during the action, restart the game, or decide whether you want the sound effects on or off. (If you find yourself still battling Gorgons late at night, the silence option will *really* be appreciated!)

Although Gorgon seems difficult at first, there's a compulsion to keep going (not the least of which is your gradually increasing score). The psychological factors that separate a good game from a mediocre one have been successfully incorporated in Gorgon. This isn't an easy game, but it's not difficult to start attaining better scores. The more you play it, the better you like it. You find yourself trying different strategies and discovering the intricacy of such games. You can simply wait and shoot the Gorgons as they appear, but then they get behind you—so you keep moving. Then you try running from the mines which suddenly surround you. Before you know it, another fighter bites the cosmic dust! I leave devising the "best" strategy—if there is one—to you.

The graphics match what we expect from the Sirius/Nasir team. The exploding fighters and laser fire are fantastic. When you finally get past the sensors and dock for fuel, you are rewarded with one of the best high-resolution graphics displays in the game! All movement in the game is smooth, and the playing pace never slows. Although the game is quite playable with either a black-and-white or color television set, color is the better choice.

After your three ships have been destroyed, the game automatically reloads from disk (an unusual and frustrating feature for an Apple game). Since the game retains your highest score, you always have a new goal to exceed. You can still play the game in the demonstration mode, albeit with only one fighter.

If you are inclined to visit the local arcade to compare Gorgon and its counterpart (Williams' coin-operated "Defender" game), I think you'll agree Gorgon is more easily assimilated. Your scores climb faster, and the game is just more fun to play. This is a welcome change from home computer games that come close to the arcade version, only to leave you tossing away quarters to play "the real thing."

Conclusions

At first, I expected to find Gorgon just another arcade game converted for the Apple. But it's well programmed and much more enjoyable than the arcade version. The initial difficulty of getting used to the keyboard action vanishes very quickly. (All too often, I find a good game that requires too much time to get comfortable with the action or to get a reasonable score. I soon lose interest and regret having bought the game in the first place. You won't have that problem with Gorgon.)

The Gorgons come faster as your score rises, until destruction is imminent. If you play Gorgon long enough, however, you may discover a little quirk in the program which allows you to take over control of the game and defeat the Gorgons. (I'll let you find that yourself.)

Refueling takes you into the second portion of the game, which is perhaps as challenging as trying to shoot Gorgons. Though you quickly ascertain how to maneuver past the sensor satellites, you find yourself getting fancy and, after losing several fighters, you revert to *zapping* the Gorgons.

Sirius was correct in making Gorgon a keyboard-controlled game. You aren't faced with the necessity of a joystick or controllers, but can begin play at once. This game may even help develop hand-eye coordination in youngsters or physically handicapped players.

Although Sirius uses only premium disks, you can get a replacement for a flat $10 fee. This should relieve those worried about wearing out the disk through the constant reloading of the game.

The documentation is adequate and the overall quality of the game is very high, in programming and playability. Since Sirius doesn't sell its products directly, you may have to get in line at your favorite dealer or send off an early mail order. A good model for you future game programmers to follow, Gorgon should provide many hours of enjoyment.■

Commbat: A Tele-Game for Two

George Stewart
Technical Editor

Most computer games are solitary activities. Whether you're hunting Klingons, exploring an imaginary world, or racing down an endless loop, it's you versus the computer. That relationship can become a little dry; after all, what does a computer know about the thrill of victory or the agony of defeat?

Commbat, a war game from Adventure International, offers a novel and exciting alternative to one-player games. It's a "tele-game " which you and a friend play using two computers linked by phone lines. The contest is one of strategy, tactics, and reflexes. Most important, your opponent is a human, not a computer; the computers serve merely to create an imaginary battlefield and to function as combat consoles.

The Scenario

You and your opponent have been commissioned to engage in single combat; the outcome will resolve a dispute over mining rights to uranium deposits on a planet in the Deneb galaxy. (It could just as well have been oil in the Middle East, but that wouldn't have offered as much escapist fantasy.) The battle area is vast—4096 square kilometers. Each of you has a base station and a military arsenal of eight tanks, four reconnaissance drones, three decoy bases, 200 mines, 250 shells, 255 laser units, 200 rockets, and one ICBM.

To win Commbat, you must destroy your opponent's base, and that's no easy task. When the game begins, you select your base's position and your opponent selects his. Neither of you has any idea where the other's base is. Using tanks and reconnaissance drones, you've got to pinpoint the enemy base. The problem is that you can't easily distinguish decoys from the real thing; it takes careful observation and deductive reasoning to make the determination. The only practical way to destroy the enemy base is with your single ICBM. If you waste the missile on a decoy, your game prospects are grim.

While you're out searching for the enemy base, your opponent is doing likewise. This means you must take defensive measures, too—like laying mines, setting up decoys, and positioning tanks at strategic points throughout the battle area. All of these objectives become immediate goals; destroying the opponent's base becomes a distant, ultimate goal. As in real war, there are many minor victories and losses in the field as your tanks destroy and are destroyed. A game may last anywhere from 30 minutes to four hours.

How Good Is It?

The key to an enjoyable, interactive strategy game is having "tools" that work convincingly in the imaginary world. The more complex the tools and the more intricate the natural laws of the imaginary world, the better. By this criterion, Commbat is a great success. Although it takes a while to use them proficiently, the tools

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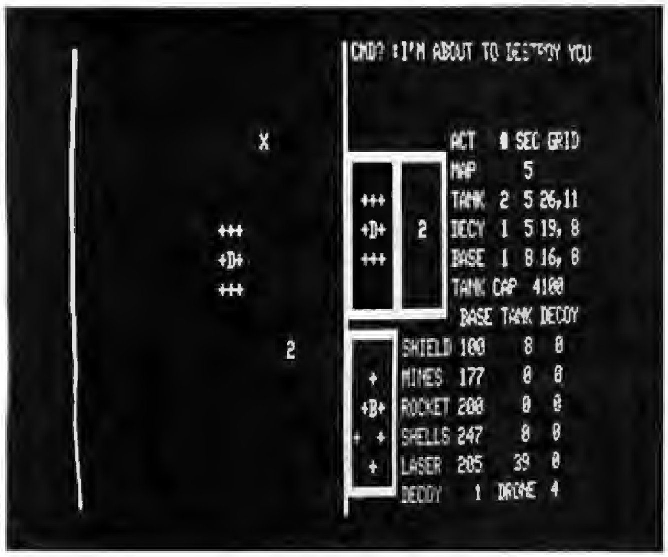


Photo 1: *The Commbat console display in the heat of battle. The left side of the screen is a map of sector 5, according to the base computer's latest information. The "X" represents an exploded tank; "2" is your own tank; "D" is your own decoy; and the "+"s are your mines. In the upper right portion of the screen is a message you are about to send to your opponent. The three rectangles in the center of the screen are windows on your decoy, tank, and base.*

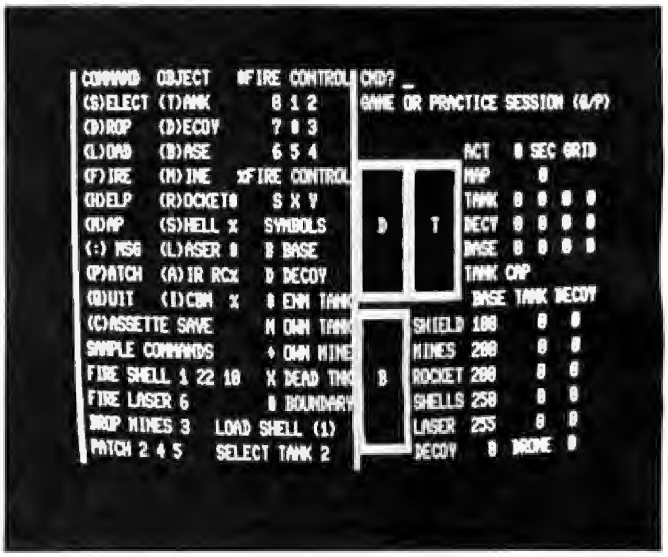


Photo 2: *The Commbat console, showing the command and function summary available through the "help" command.*

(weapons, in this case) are impressive from the start. And although the terrain is too vast to display on the screen at once, it doesn't take long for you to form a mental map and to begin thinking of a real space somewhere beyond the confines of the combat console. In short, the game is credible.

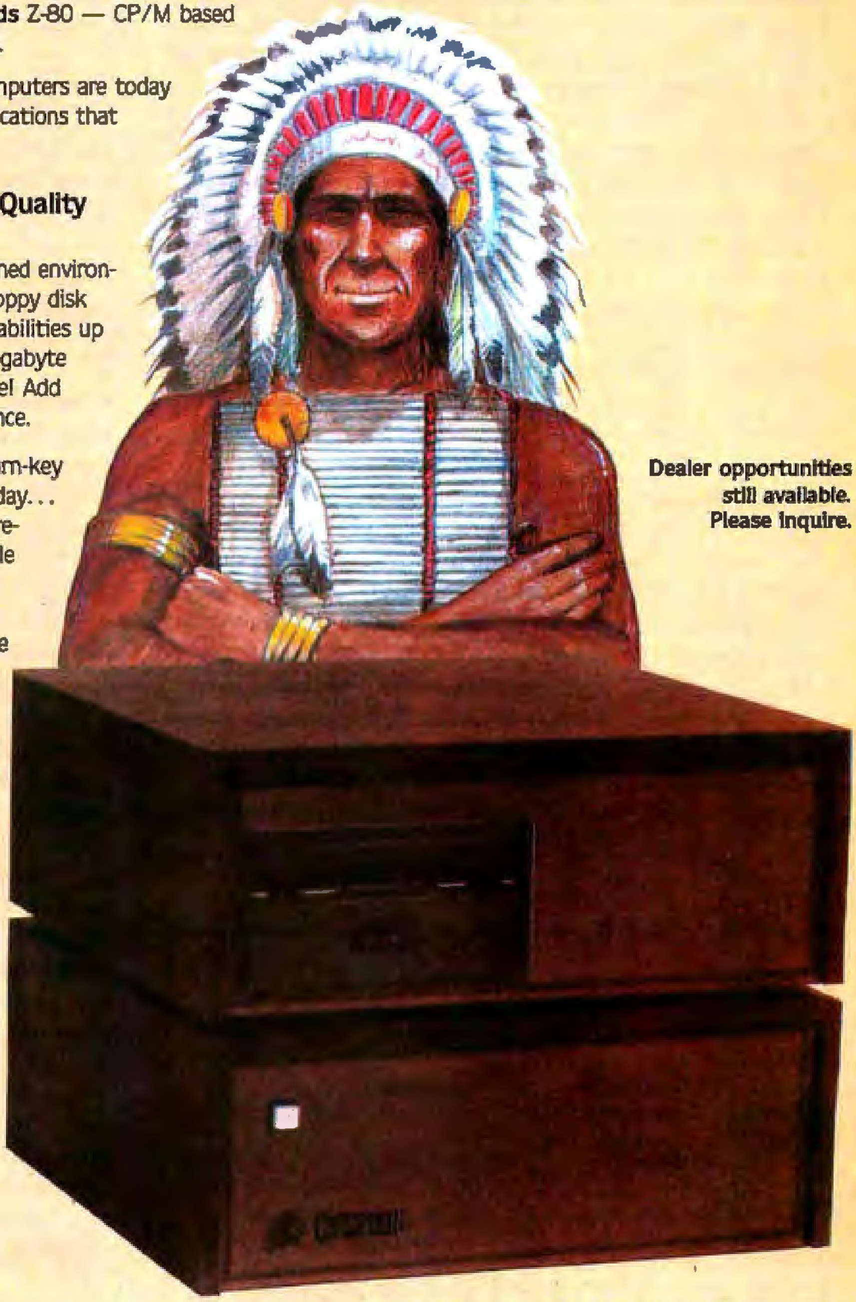
Take the console display for example (see photo 1). It has six components:

- a map display showing the latest information about any of the 16 by 32 kilometer sectors (as sensed by one of your tanks or drones)
- three windows displaying the immediate areas around your base, one of your decoys, and one of your tanks
- status indicators reporting on the location and condition of your base station and all tanks and decoys
- a command line, where your typed commands are displayed, along with urgent reports from the field and messages from your opponent.

Suppose you have a tank and a decoy in the same 7 by 7 kilometer area. Looking out the tank window, you see the tank (designated by a "T") in the center and a decoy ("D") off to the left. But looking out the decoy window gives the opposite picture, with the decoy in the center and the tank to the right. Move the tank one space to the left. In the tank window, the tank remains stationary—since it is the reference point—and the decoy appears to move toward the tank. But in the decoy window, the opposite takes place: the decoy remains in the center and the tank moves toward it. *Motion is relative to the observation point.* It takes some getting used to on your part, but this consistent modeling is what makes Commbat so intriguing.

Using Commbat is definitely a learning experience. When you first start playing, you'll probably employ just the simplest tools. As you progress, you'll begin to appreciate the advanced capabilities. For example, using the "patch" command, you can advance two or more of your tanks and fire weapons in unison—creating a massive onslaught on your enemy's defense lines.

Another essential game element is its interactiveness. You and your opponent can move, fire weapons, and select different tanks and decoys at any time. This makes the game infinitely more challenging than the typical, wait-your-turn war game played on a board. Suppose, for example, that while you're typing in a command, you notice some enemy action through one of your three windows. You can cancel the command and make an immediate response to your opponent. You can even send him a message at any time ("Let's quit for a while," "Aha!" or some distracting thought).



Playing the Game

A typical game session goes like this. You telephone a friend who also has the Commbat program. The two of you agree on what RS-232C characteristics you'll use and set up your Model I or III TRS-80s accordingly: word length, parity, number of stop bits, and bits per second (this last is set whenever you start the program).

Each of you starts the Commbat program, maintaining voice contact over the phone lines. Commbat will ask you for some start-up information, including what transmission rate you want to use. With most modems, you'll be limited to 300 bits per second. Finally, the computer will tell you to press the Enter key to check the communications link. Both of you must do this at approximately the same time and immediately put the two computers on line. When the computers are synchronized, you will be asked to select your base location. Then the actual combat begins.

Special Features

Commbat has several important convenience features. For example, there's a practice mode to get you accustomed to moving your tanks around, deploying mines and decoys, and even firing weapons (if you don't mind destroying your own resources). You don't have to be on line with another computer to use the practice mode.

Another important feature is the ability to save games on tape or disk for later retrieval. You'll invest a lot of time and thought in some Commbat games; the ability to save a game precludes the need to throw it away if the session is interrupted. To save a game, both combatants must enter secret passwords. For either to load the saved game, both of them must enter their passwords. This prevents either player from cheating by improving his position in the other's absence.

At a Glance

Name
Commbat

Type
Two-player strategy game using telecommunications

Manufacturer
Adventure International, a Division of Scott Adams Inc
POB 3435
Longwood FL 32750
(800) 327-7172 (phone orders only)

Price
Cassette version, $19.95
Mini-disk version, $20.95

Author
Bob Schilling

Format
Cassette "system" file
Mini-disk "command" file

Language
Z80 machine code

Computer
Radio Shack Model I or III, with at least 16 K bytes (cassette version), or at least 32 K bytes and one disk drive (disk version); RS-232C interface and modem

Documentation
12-page leaflet, plus command and function summary available in program

Documentation

Commbat's manual is adequate. Most useful is a one-page reference sheet. In addition, the program offers a "help" command, which displays a command and function summary at any time (see photo 2).

Suggestions for Improvement

I found Commbat's main fault not in the game itself, but in the procedure required for starting it. Both players must start the "check-commlink" sequence almost simultaneously; otherwise, the program will "hang up," and you'll both have to reset your computers. This procedure can be a little tricky if you're using a single telephone and an acoustic modem. Ideally, it wouldn't matter when you started the check-commlink sequence—the first computer would simply wait until the second computer came on line. A programmer at Adventure International acknowledged that the present method is a little awkward, but said that the program's author has yet to find a good solution.

Another complaint is that the keyboard response occasionally seems sluggish: you'll type in a command and press Enter, only to realize that one or more of your keystrokes were missed. Of course, this always seems to happen at the worst times, as when you're engaged in battle with an enemy tank. The Adventure International programmer pointed out that this keyboard-response slowdown is an unavoidable limitation of the system due to the great amount of data being sent back and forth across the phone lines. (Both computers must keep complete data on both players, even though each player gets a much more one-sided view of things.)

The keyboard sluggishness isn't all that serious. For one thing, it's experienced by both players and won't give either an advantage. As well, it's not hard to accept; after a while, you begin imagining that your weaponry is becoming rusty or intermittent due to the stress of battle. Carry on!

Conclusions

Commbat opens an exciting new realm of multiplayer computer games in which the players may be anywhere that phones are available. Shedding their role as impassive opponents, the computers become active tools for competition between humans.

The imaginary world of Commbat is interesting and intricate, and it really does test one's strategy, tactics, and reflexes. ■

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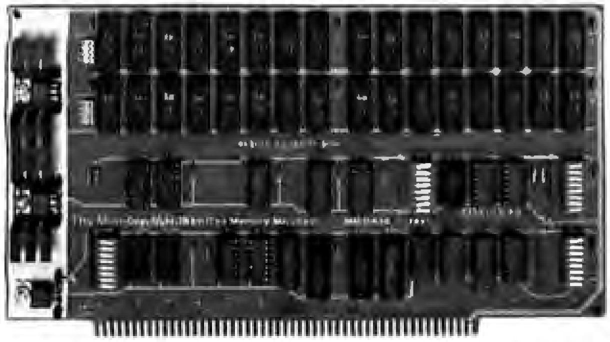

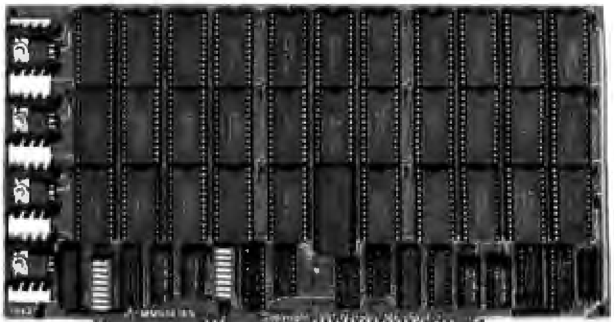

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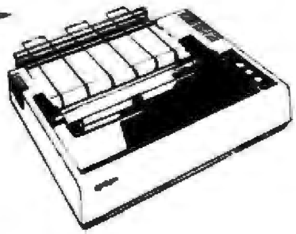

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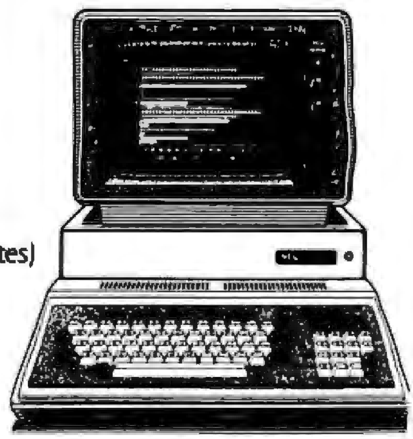

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alphaSyntauri Music Synthesizer

Steve Levine and Bill Mauchly
c/o Audio Data Consultants
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Music and computers seem to go together naturally. Indeed, there appears to be some metaphysical link between them. Musical minds take readily to programming concepts, and it's hard to find a coven of computer programmers without at least one musician in its ranks. The idea of making music with computers is almost as old as the computer itself.

But the human interface is always a problem. How do you translate the idea of making music into a computer program?

A musical score is much like a program; it's a list of instructions with various branches and repeats. So the obvious solution is to give the musician a *language* to describe the music. This may then be fed into the computer for the result. Until recently, using slow, batch-mode processing could mean waiting a day or more for the sound to reach your ears. Even worse, the computer needed to know exactly what was desired. But how was the poor musician to know in advance what he wanted to hear? He's heard violins before, but what does a computer sound like?

The dawn of the microcomputer promised a new era in computer music. Suddenly, the machine was yours alone and when you said RUN, it ran. But both the hardware and software of the first microcomputer music systems ignored the need for real-time feedback. Maybe the software allowed the score to be typed into a screen editor rather than with a keypunch, but it still made you wait until the computer was ready to play the music.

The Syntauri Corporation has changed all that. A five-octave music keyboard and a disk of software form the heart of the alphaSyntauri synthesizer. The software allows control of the sophisticated Mountain Computer MusicSystem digital synthesizer hardware from the keyboard, via an Apple II computer. (See "Mountain Computer's MusicSystem," July 1981 BYTE, page 60.) The alphaSyntauri system allows music to be played directly or to be recorded and played back. It allows the changing, storing, and recalling of waveforms, envelopes, and tunings. Most important, because it is based on the Apple II computer, it is possible to change or add to the system software.

User interaction, which is the primary advantage of microcomputer systems, has been extended to play—not just write—music. Immediate feedback links the creation to the sensation of music. For the first time, the personal computer is an instrument, not a glorified music box.

This article reviews the capabilities of the alphaSyntauri synthesizer as a musical instrument and discusses the hardware and software details of interest to both musicians and computerists.

The Syntauri Philosophy

The alphaSyntauri music synthesizer is a software-based system and the brainchild of Charlie Kellner. Aside from the Mountain Computer synthesizer boards, the system uses an interface card and a professional music keyboard. But the system is more than just an Apple peripheral; it is a musical instrument in its own right. Its price and performance clearly place it beside commercial synthesizers made by Moog, Oberheim, Arp, Yamaha, and Sequential Circuits. Its modular design with software flexibility makes it comparable to such digital synthesizers in the $20,000-$30,000 bracket as the Synclavier II and the Fairlight Computer Music Instrument. Obviously, these more expensive synthesizers can produce sounds with higher quality than the alphaSyntauri music

About the Authors

Steve Levine is a microprocessor engineer whose interest in computer music has run the gamut from controlling pipe organs to digital signal processing. He has coproduced the unique Computer Music Festivals in Philadelphia for four years. Bill Mauchly is a recording engineer and musician. Son of the father-of-the-computer, John W Mauchly, his knowledge of computers is genetic. Levine and Mauchly formed Audio Data Consultants in 1980 to collaborate on ideas in digital synthesis and signal processing. Research with the Fairlight CMI, coupled with the production of the Symposium of Small Computers in the Arts this November, has brought them in close communication with many computer musicians.

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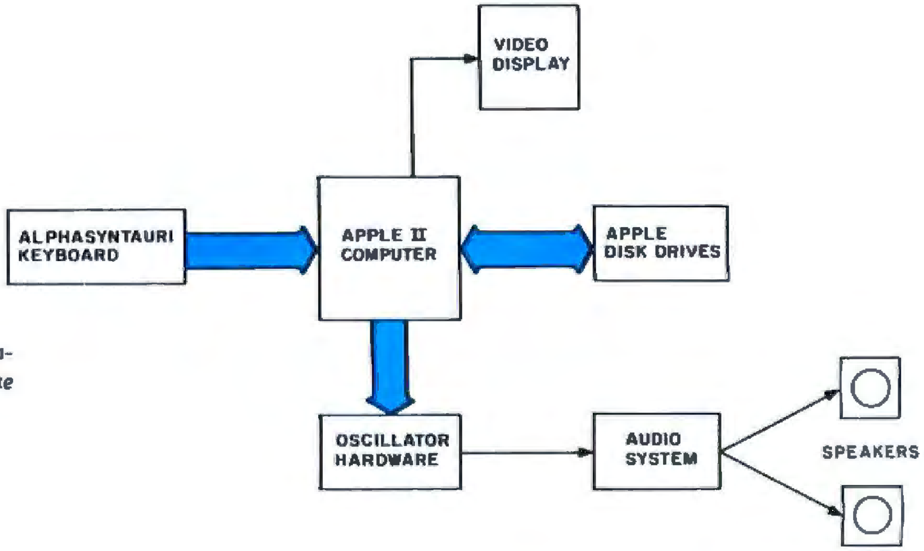

Figure 1: *This shows the hardware configuration and the interaction of the various system parts.*

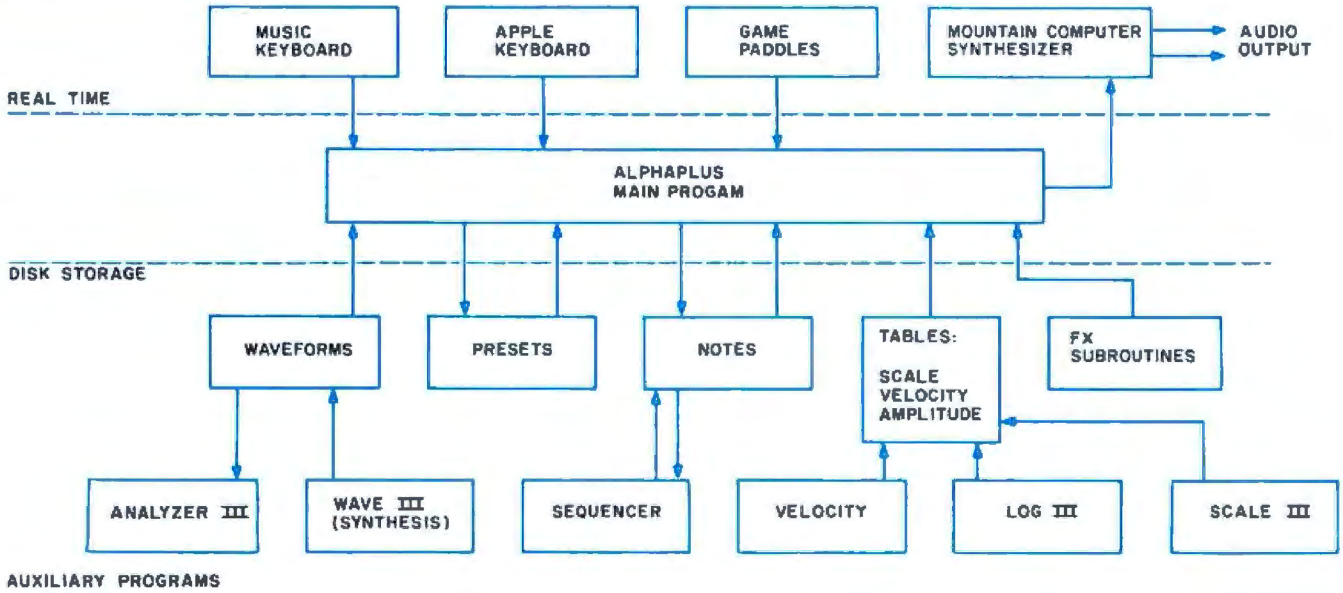

Figure 2: *The ALPHAPLUS program is the main program, with auxiliary programs providing or modifying data for ALPHAPLUS.*

synthesizer. But even these "super-synthesizers" do not allow prying into the operating system. Unique in a world of black boxes, the alphaSyntauri synthesizer is a music system that a user may customize.

The advantage of software functions over hard-wired features is that they are so easily changed. First, the manufacturer can provide updates as new features are developed; planned obsolescence is replaced with upward expandability. Second, the infernal musician, notorious for making his tools do things "they weren't meant to do," has a truly programmable instrument. The alphaSyntauri synthesizer is ideally suited to those stubborn types who aren't always satisfied with the 12-tone scale, who insist on using the Dow-Jones average as a waveform, or who would like to jam against a sequence of notes resembling the Maine coastline played in three-quarter time. Programmability is the single most important advantage of the alphaSyntauri system over all other keyboard synthesizers.

Turn It On

The alphaSyntauri disk boots itself up, asks you if everything is plugged in the same as it was yesterday, and brings the synthesizer up with a group of 10 preset sounds. Presets on the alphaSyntauri synthesizer are preprogrammed instruments or sounds, similar in concept to organ presets. Only one is active at a time, and pressing the number keys (0-9) on the Apple allows selection of different presets.

The preset's name is shown on the screen, along with the envelope parameters which describe its dynamics. The music keyboard is then instantly alive with the sound of vibes, clavinet, clarinet, B3 organ, pickle, bump, or whatever you have selected. Push another number, and

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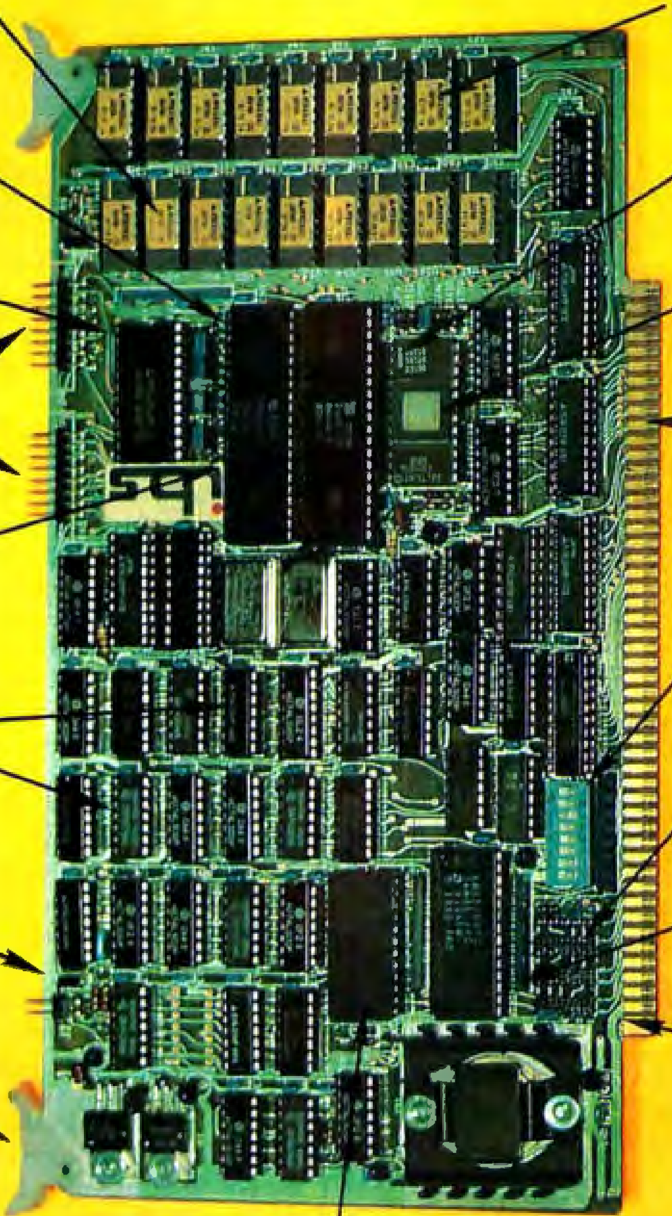

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Photo 1: *The Envelope Control Screen is shown with a color display of a C major chord. PD0 and PD1 are live paddle displays of the vibrato and FX controls.*

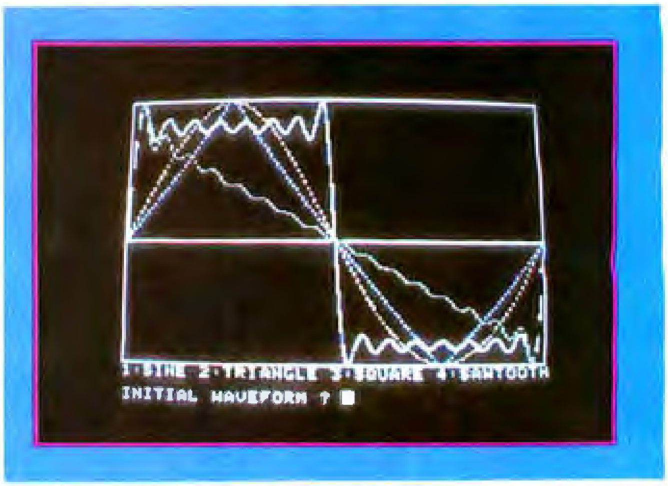

Photo 2: *WAVE III Additive Synthesis Wave Creation Program. When the program first comes up, it displays each of the stock waveforms available and, as they are plotted, the corresponding sound is heard from the amplifier.*

you get another sound. Simplicity and speed make the system easy to learn and elegant to use. For added wonderment, a 12-color graphics display dances across the video screen, following the notes of the keyboard.

Software

The alphaSyntauri software has one main program that provides the personality of the keyboard instrument—plus a library of programs for configuring, analyzing, and generating control parameters which can be used by the program (see figure 2). The system we evaluated (a prerelease version of AlphaPlus) will have been released as an enhancement to Alpha III (the first software revision) by the time this article is printed.

The main program becomes the synthesizer's "control panel," with screen displays for parameters entered with the Apple's alphanumeric keys. Pressing an "A", for example, makes the cursor jump to a field at the bottom of the screen, where AR = 210 might be displayed. This is the Attack Rate, or the speed at which one of the envelopes will rise to its maximum value every time a key is depressed. The value may then be altered, either stepwise using the left or right arrow keys, or by typing a number and hitting return. The result is similar to adjusting an array of knobs; it's a little slow, but more accurate. From this control panel, all of the real-time functions—including music recording, playback, presets loading, and editing—may be accomplished with a few keypresses.

The alphaSyntauri software controls the 16 oscillators of the Mountain Computer hardware by pairing two oscillators per voice to provide an eight-voice synthesizer. If all eight are already playing, then the first voice used is reassigned to the new note. Since all eight sound identical, it is impossible (and irrelevant) to tell which oscillator is assigned to which note.

Both of the two oscillators per voice are available as separate outputs. Although this allows stereo effects, the correct use for most sound involves mixing together monophonically. The two oscillators use different waveforms and different envelopes, but are activated simultaneously (see figure 3). This is essentially similar to two separate eight-voice synthesizers hooked to the same keyboard.

One of the oscillators is designated the Primary, while the other is called the Percussive. These names are actual-

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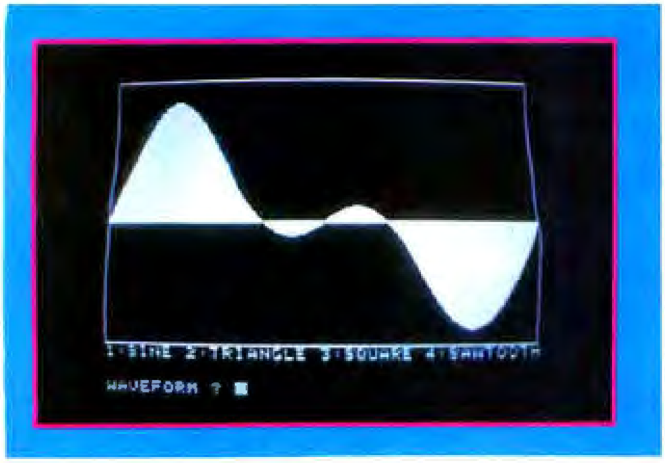

Photo 3: *This is the result of using the WAVE III program. This waveform shows the addition of the first, second, third, and fourth harmonic, with the respective amplitudes of 50, 40, 30, and 20 percent.*

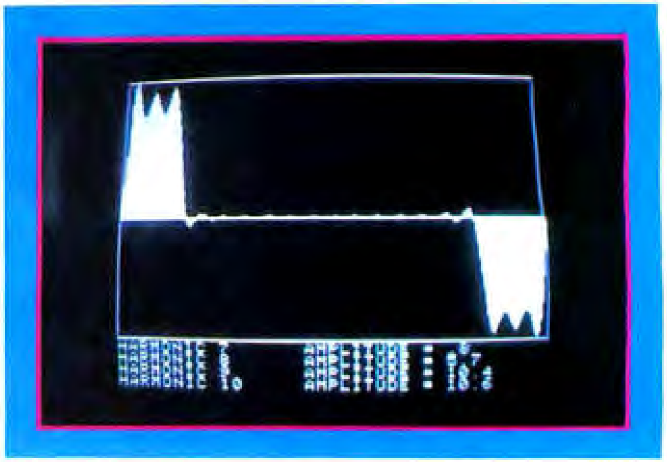

Photo 4: *The ANALYZER III graphic display shows a rich pulse wave which was synthesized with another program, AUTO-PULSE, written by Steve Leonard. ANALYZER III is shown performing an analysis on the wave, with a numerical output for each of the harmonics and their respective amplitudes.*

ly arbitrary, for it is certainly possible to put a very percussive envelope on the primary oscillator. At any rate, the parameters describing the two currently active envelopes are displayed at the bottom of the screen, while a simple Control-W allows you to view the names of the waveforms loaded into the primary and percussive oscillators. Pressing the ? gives a catalog of the disk so that you can see what waveforms are available.

A number of useful waveforms come on the system disk. They include sine, triangle, square, and that old standby, sawtooth. Also, any arbitrary waveform may be created through additive synthesis, to be discussed later.

The primary and percussive waves are offset in frequency by a user-defined amount of 16 semitones per note (ie: 16 possible steps from C to C#). Selection of a great enough offset produces the effect of two notes per one keypress. A more practical use, however, is to slightly offset the two oscillator frequencies to add a *fullness* or *fatter* sound. This works especially well for synthesized piano or organ sounds.

Envelopes

The envelope controls (determining the rise, duration, and fall of each note) are straightforward and easy to use (see figure 4). They are laid out logically, and one or two keypresses will move the cursor to any parameter you wish to change. The letters A, D, and R, for example, select the Attack Rate, Decay Rate, and the Release Rate, respectively, for the primary wave. The letters P and F select Percussion Rate and Fall Rate, which are simply different names for the attack and release of the percussive envelope. One more key press will drop you down to the second line, where the levels are displayed. If you press P, for example, you select Percussion Rate; whether or not you change it, pressing Return will drop you to Percussion Volume.

A few other parameters at the bottom line affect special envelope controls. The percussion channel of the instrument can be turned off, leaving just the primary. This same parameter controls the velocity-sensitive envelope. When on, the velocity with which a key is struck will modulate the attack rate and volume (for the primary wave). The quicker the key goes down, the faster the attack rate. A very nice, expressive quality results once you get comfortable with this control.

Another special feature in the envelope section lets you loop the primary wave envelope so that it is constantly executing its attack and release curves. The result is similar to tremolo; the amplitude is fluctuating periodically. The effect is useful for certain sounds, like putting the *vibe* in Vibraphone.

The frequency control (FC) simply tunes both waveforms by quartertones in relation to some arbitrary zero point.

Vibrato

A last major control panel parameter is vibrato, which is a controlled modulation of the frequency. The Apple II game paddles are used to control the amount or "depth" of vibrato (PD1) and the speed of change or *rate* (PD0). The vibrato is extremely effective in giving a more realistic and dynamic sound to most instrument settings.

Presets

All of the parameters shown on the screen, together describing one preset, may be saved or recalled from disk. Although only one preset is active at any moment, 10 different sounds are loaded in memory and ready to be selected. The entire configuration of 10 different presets may also be stored on disk as a Preset Master. A preset master has the advantage of storing the waveforms that were loaded into each preset. This creates a Waveform Master on the disk. (Ideally, individual instruments should also have an automatic waveform recall; but not in this version of the software.

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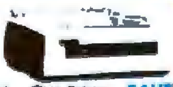

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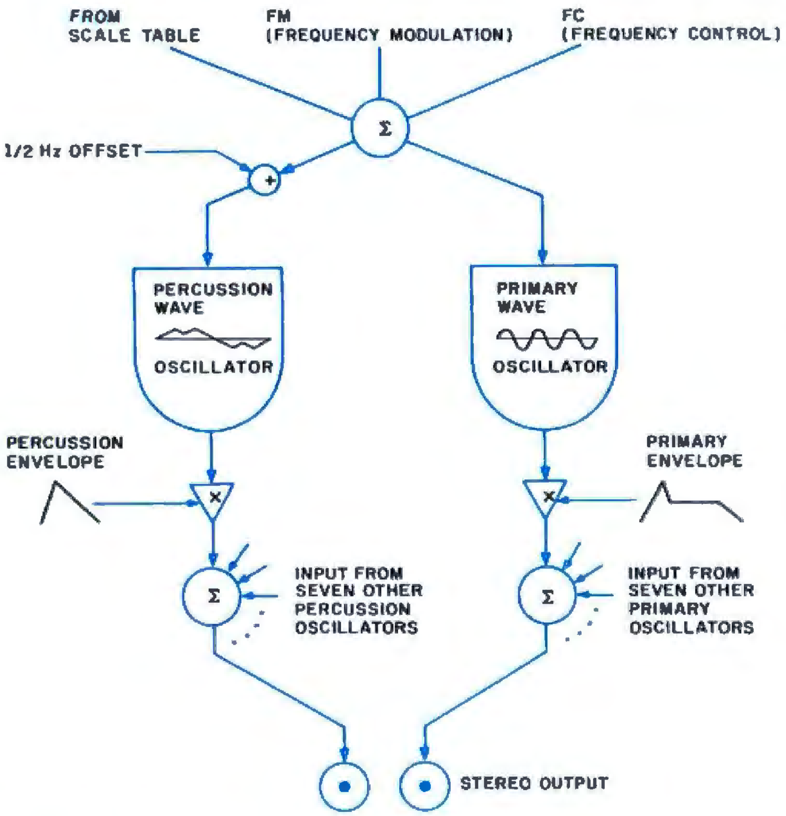

Figure 3: *The flow diagram is a model of the synthesis process for the development of computer-generated music.*

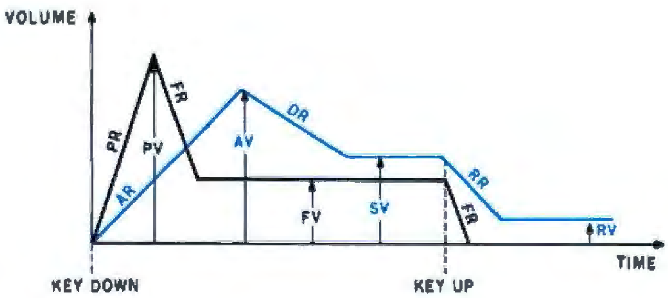

Figure 4: *This example shows the various parameters and their relationships, which determine the sound of a preset. The dual envelopes, produced when a key is pressed, control the amplitudes of the two oscillators. The parameters for the selected preset are displayed as integers from 0 to 255 (255 being the fastest or loudest). When key velocity is fast, AR and AV are increased. When the sustain pedal is depressed, DR replaces RR.*

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mance situation, where a particular song may call for five different sounds in quick succession. A preset master for that song might contain the required presets in numerical order. All the performer must worry about then is 1, 2, 3, not preset #42, #13, or tibia 16'. Incidentally, when a composition is recalled from disk (as will be described in the next section), it selects the numbered preset that was active when it was made.

Recording Performances

Like any good computer music system, the alphaSyntauri synthesizer simplifies recording key closures and their associated timing information. This is not unlike an analog synthesizer sequencer, except the music programming is accomplished by playing on the keyboard. Key velocity, pitch, and duration are saved in a memory buffer. Then, with the SAVE command, they are written to a disk file with the prefix Notes. With 48 K bytes of memory, you will be able to store up to 3285 note events.

The sequence of keystrokes to initiate recording is very simple. From the main menu, just press the space bar R for record (the remaining number of notes will be displayed on the screen) and then hit Return. This will return you to the main menu, where the instrument name will be in reverse video to indicate you are in the record mode. The program will wait for your first keystroke before starting to save the notes in memory.

Once you finish the sequence, hit the space bar and then S (Save). You will then be asked to provide a file name for your performance. Hit Return for a saved performance.

An interesting recording sequence feature is Echo. This allows instant, continuous playback of the last recorded sequence. Many musicians find this useful for accompaniment purposes, though a perfectly spliced sequence is difficult to create. When you finish playing the segment, hit the space bar and the sequence will play back with a rest inserted between the last and first notes played. This rest will equal the time between the last note played and the point at which you hit the space bar. For a good splice, it is necessary to hit the space bar just ahead of the next note's downbeat.

The Mountain Computer synthesizer generates an interrupt every eight milliseconds. Syntauri's alphaPlus operating system uses every other interrupt for a watchdog timer. This makes it easy to synchronize the keyboard playback with another timebase for playing along with prerecorded music. Previous releases of the software did not use this timebase and suffered severe slowdown when the keyboard was used during playback. The interrupt system virtually eliminates the problem. In summation, the sequencing ability of the alphaSyntauri synthesizer is a deluxe feature.

Programmability

To now, we have examined the way the system behaves as a conventional synthesizer, with functions that all operate in real time. If we drop out of the main program, however, we may run programs which can create, modify, or analyze data used by the system. This data is in binary disk files which contain tables or lists. These tables are used by the main program and include waveforms, notes, tunings, and functions for mapping velocity and amplitude values. The programs provided, and those created by the user to manipulate that data, provide the programmability that sets the alphaSyntauri system apart from all other synthesizers. Although detailed documentation on the architecture of the programs and a usage map of the Apple II memory aren't distributed with the system, Syntauri is reasonably helpful in assisting the knowledgeable user with customization. (The assembly-language source code is offered for a nominal fee.)

Wave III

This is a slow, flexible Applesoft program which graphically displays the process of building waveforms via additive synthesis. The procedure is simple: you are queried for "Which waveform?" and then "Which har-

At a Glance

Name
alphaSyntauri Music Synthesizer

Type
Sound development system for performing and recording

Manufacturer
Syntauri Corporation
3506 Waverley St
Palo Alto CA 94306
(415) 494-1017

Price
$1500

Hardware
An interface card occupies a slot in the Apple II. The professional music keyboard and foot pedals connect to the card

Software
An operating system is supplied on disk. Several programs allow sounds and music to be developed, changed and recorded

Language
The programs are written in 6502 assembly language, Applesoft BASIC, and Integer BASIC. An assembly language listing is available from Syntauri Corp

Software Format
The disk supplied requires Apple's DOS 3.3

Computer
Apple II or Apple II+ with 48 K bytes of programmable memory, at least one disk drive, and Apple's DOS 3.3. Both Applesoft and Integer BASIC are required

Documentation
Documentation includes a tutorial manual, two quick reference guides, and a technical manual

Hardware Required
Mountain Computer (formerly Mountain Hardware) MusicSystem music synthesizer boards, a stereo amplifier, and speakers are required. (The operating system originally supplied with the Mountain Computer hardware is not used)

Comments
The alphaSyntauri system can also be configured for use with the ALF Music Synthesizer from ALF Products Inc

Audience
Apple II owners who want to compose music, create sounds, or do live performances

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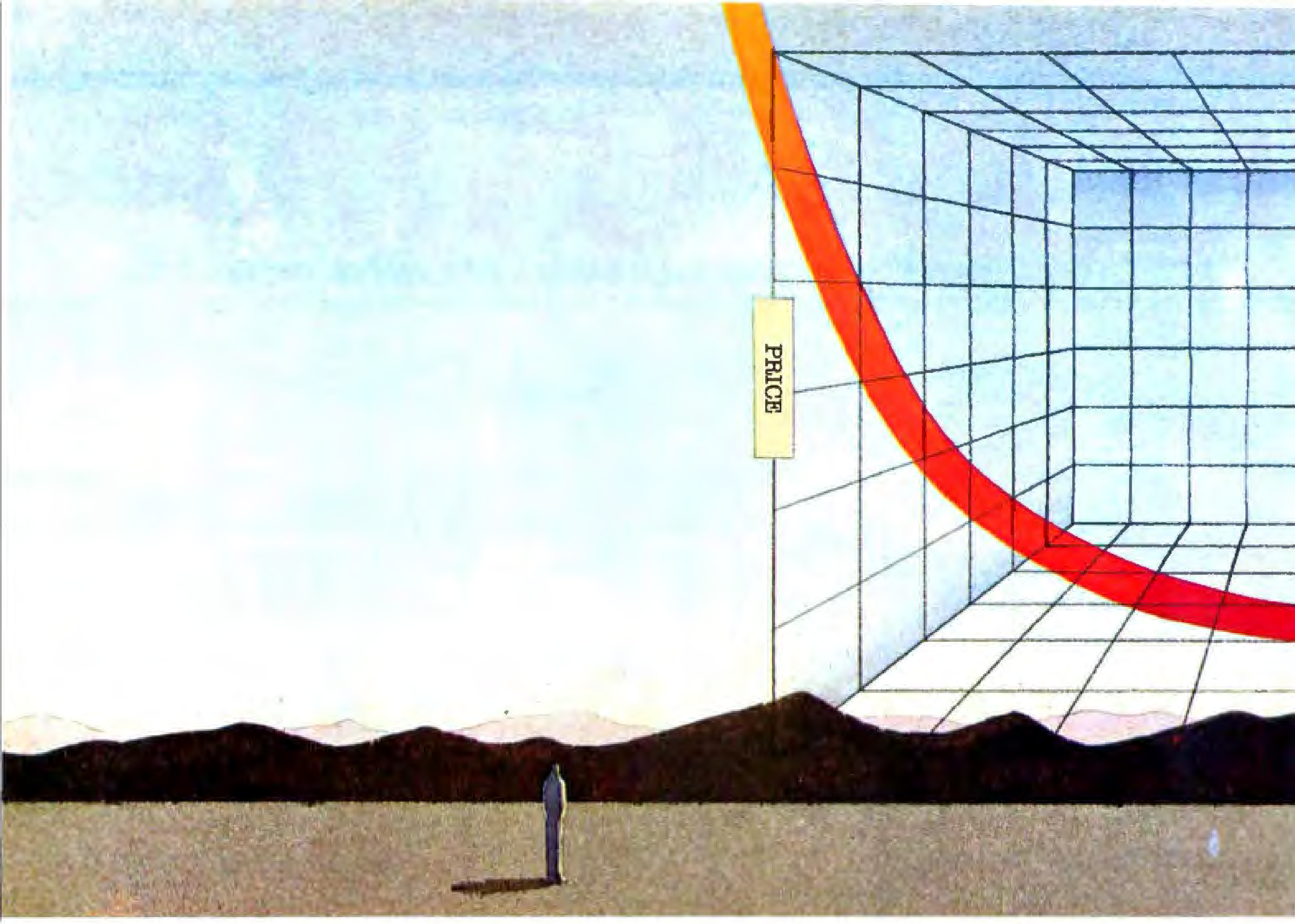

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Relative Performance

	Intel 8088 (5 MHz)	*Zilog Z80B (6 MHz)*	*Motorola MC6809 (2MHz)*
Computer Graphics	*1.0*	*0.1*	*0.05*
16-bit Multiply	*1.0*	*0.17*	*0.5*
Block Move	*1.0*	*0.75*	*0.49*

Full details of these benchmarks available in the iAPX 88 Book.

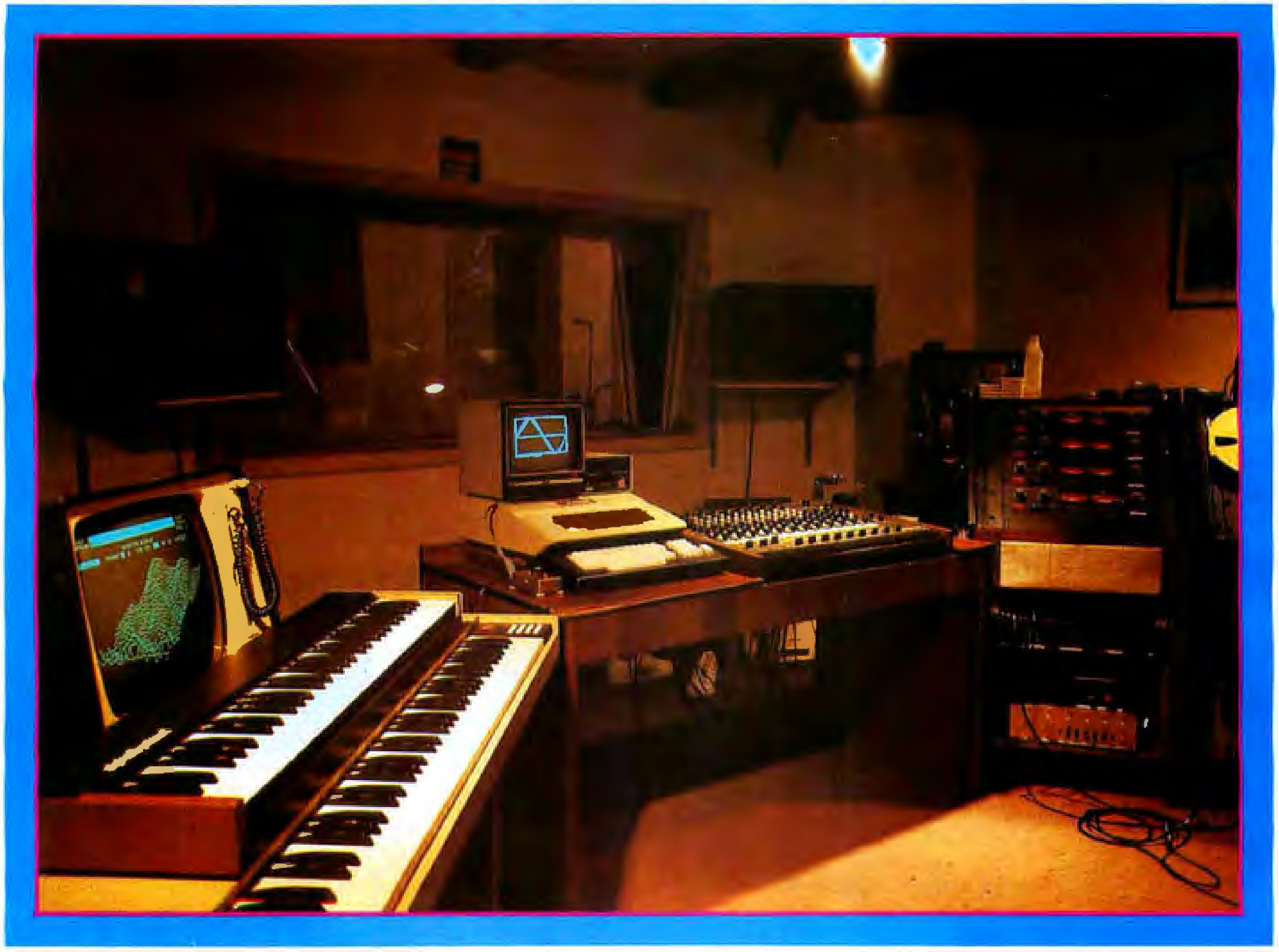

Photo 5: *Bill Mauchly's eight-track Linden Studio in Ambler, Pennsylvania. In the foreground is the Fairlight Computer Music Instrument, the alphaSyntauri keyboard on top of the CMI, the monitor, an Apple II with Mountain Computer music synthesizer boards, the Fairlight ASCII keyboard, The Sound Workshop 12-channel mixing console, an Otari eight-track recorder, and various outboard equipment in the rack at lower right. The studio is a 100-year-old barn, and the research lab is located a short distance away. (Photo by Irene Mohler)*

monic?" until you decide you're done. On each iteration, the resultant wave is played back at a constant pitch for evaluation. The waveforms available for addition and subtraction are band-limited versions of the common analog wavetypes: sine, triangle, square, sawtooth, or any user-specified complex waveform. This program is the most common and useful way of generating wavetables. If Syntauri would rewrite Wave III in assembly language, it would be capable of instant display and, therefore, be a more intuitive feedback loop between the creation of waveforms and envelopes.

Analyzer III

Fourier analysis of a waveform is the reciprocal to additive synthesis of sine waves. The program takes as its input any wave and supplies the harmonic content up to any specified harmonic.

The most creative use for this program that we've heard is by Cretones keyboardist Steve Leonard, who needed to simulate a Vox portable organ. He used an oscilloscope to get a picture of the waveform he wanted, then wrote a BASIC program to draw a line segment approximation of the wave and write it to a binary file. Next, he analyzed the wave with Analyzer III. Using the resultant harmonic specification, he resynthesized the wave with Wave III.

Why didn't he just use the line-segment version of the waveform? Steve knew, as the analysis confirmed, that some very high harmonics were present in his line-segment waveform. When a digital oscillator—like that used in Mountain Computer hardware—tries to create frequencies above half its sampling rate (above 16,000 Hz, in this case), the frequencies fold over and show up as lower, incorrect frequencies within the audio spectrum. This phenomenon is known as "aliasing." (A good explanation of aliasing is given in the *Computer Music Journal*, volume 2, #2 in "Introduction to the Mathematics of Signal Processing," by F R Moore.) These stray aliases usually have little to do with the intended sound and are objectionable. To reduce their presence, care must be taken to limit the strengths of high harmonics in a wavetable.

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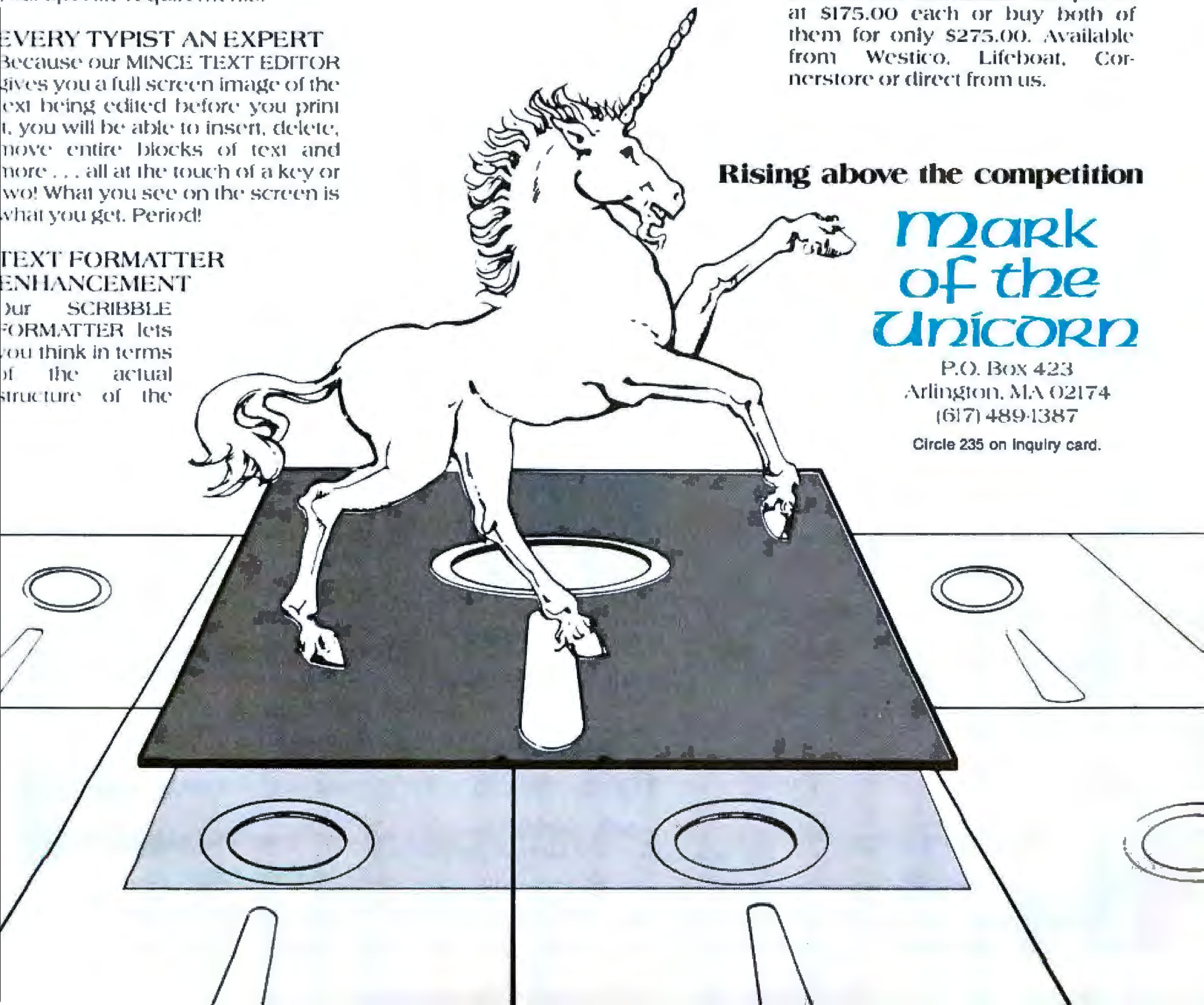

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The other consideration is the fundamental frequency at which the note will be played. A waveform for a bass instrument can get away with richer, higher harmonics. Practically speaking, aliasing can be a useful effect in the simulation of noise and complex nonharmonic tones.

Keyboard Architecture

The alphaSyntauri synthesizer keyboard is a standard, two-bus, 61-note, Pratt-Reed organ keyboard. This keyboard assembly is found in many commercial musical instruments, such as Moog, Arp, and Crumar synthesizers. Syntauri has added CMOS circuitry, which allows the Apple to scan each key's two vertically positioned contacts (lower and upper) approximately once every 10 milliseconds for make or break conditions.

After the entire keyboard is scanned, this information is compared with a memory map of the last scan and is updated if different. A timer, maintained in the computer's memory, counts the number of scans between changes, including the time between closing of the lower and upper contacts of each key. This number (in the counter when the key is fully down) is used as an index in a velocity table, which is in turn applied to the attack rate and the final attack volume. The table contains 32 entries and allows the production of up to 32 different perceived velocities. By altering a value specified in the velocity setup program, the inverse relationship of key velocity to loudness can be made more or less linear on a scale of 0 to 7.99. In effect, this varies the keyboard response to velocity from linear to logarithmic.

The keyboard's tuning is organized by a scale table, which is set up by the Scale program. *Just*, *well-tempered*, *international*, or any scale from 1 to 32 intervals/octave may be chosen. The standard scale is *well-tempered* and is 12 intervals/octave. (A very concise discussion of the alphaSyntauri keyboard can be found in a paper presented by Charlie Kellner, Ellen Lapham, and Laurie Spiegel at the 67th convention of the Audio Engineering Society, New York City, November 1, 1980. Reprints are available from Syntauri Corp.)

One other setup program is Log III, which creates a log table for producing attack, decay, and release envelopes. Two envelope log table types are available: linear and exponential. Linear is best for nonpercussive sounds with slower attacks, such as strings and brass. Exponential works well for percussive sounds, like pianos and bells.

The FX Controls

What would a synthesizer be without some kind of performance effects? Syntauri and Laurie Spiegel devised some neat ways to modify the sound while playing; these are dubbed FX. Hitting the space bar and the letter "F", you are asked which effect file is desired. The files are text type and are prefixed with MOD.nnnnnn. (You don't have to type Mod.) Hit Return and you have the newly selected effect. The available FX are Timbre Scan, Pitch Sweep, and Pitch Bend.

The effects like vibrato use the game paddles for con-

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SSS RATFOR is supplied with *source code* in FORTRAN and RATFOR
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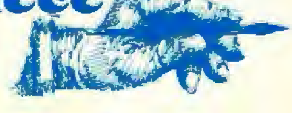

CP/M REGISTERED TRADEMARK DIGITAL RESEARCH trol. Timbre Scan actually scans through all the waveforms in the preset master, in a sequence whose rate and pitch are controlled by the paddles. Pitch Sweep modulates the frequency upward into aliasing at a depth controlled by one of the paddles. Pitch Bend allows for dynamic frequency changes through the movement of a paddle with one hand, while the other plays the keyboard. All effects can also be used with vibrato.

Graphics

One of the most captivating features of the alphaSyntauri system is the "Close-Encounters" graphics that accompany the music. A corresponding bar on the screen lights up for each key that is down. A captivating and entertaining effect results, especially when the sequencer is playing back some piece. At a trade show, a spectator was overhead saying to her friend, "I've never seen music before!" While this is not a feature we would spend hundreds of dollars to obtain, it is a great extra as a byproduct of performance. When the question "What good does that do?" arises, we mumble something about the ability to visually inspect playing technique. (By watching the blocks, it is quite easy to gauge the amount of rollover between adjacent keys. Speaking candidly, though, the graphics are just attractive.)

The Manual

The alphaSyntauri manual is very much in the spirit of the Applesoft tutorial manual—friendly and jovial, though a little confusing. It works quite well as a tutorial; you can sit down with the instrument, read through the manual, and apply things that you learn. The explanations of synthesis theory are well illustrated. We found the "Quick Reference Guide" more useful when we had a general knowledge of the system. Neither document has an index.

Applications

We tried to put the alphaSyntauri through its paces and discover what other people were doing with it. Steve *Leonard, mentioned* earlier, uses his onstage with a rock band and has developed a set of presets to replace a lot of heavier, traditional professional keyboards. We put his instruments into action when the rock group Sister Sledge was working at Linden Studio. No analog synthesizers were available, so keyboard player Steve Gould received a mini-lesson in using the alphaSyntauri synthesizer. Within five minutes, he was playing independently. The Close Encounters theme was heard many times that night.

On the academic side, Stanford University has a computer-assisted instruction project in the works. The curriculum, developed on its PDP-10 by Dr. Wolfgang Kuhn, is being adapted to the alphaSyntauri system to teach basic music theory. This should be very interesting, and I am sure many other universities will implement it.

Laurie Spiegel, a composer who uses the alphaSyntauri system in her work, has too extensive a background in computer music composition and programming to cite here. But we feel that one of her contributions to the alphaSyntauri system is worth mentioning. Laurie has one of the earliest Syntauri keyboard prototypes. Even before there was really a developed product, she was writing her own 6502 programs on her Apple (which is also a prototype), to process and interact with the keyboard in interesting ways.

In a concert series, "Computer in Performance"—presented in New York City during 1980—Laurie used a keyboard program she wrote in Pascal. An effective PEEK and POKE permutation algorithm, it used the keyboard to specify transposition. Melodic and harmonic materials were specified by software. There were several processes running which specified sets of pitches to be played. Laurie selected which sets the program would be permuting, while the alphaSyntauri synthesizer specified the base pitch. The paddles were used to modify the timbre and effects, and the result was musical and interesting.

A more recent program is a composition which she patched into the alphaSyntauri system software. Going to the recorder menu and typing "C" (for compose), she can build lines of music based on written algorithms which are then patched into the main alphaSyntauri BASIC program. For example, a small FOR-NEXT loop is used to build an arpeggio. Her program asks for the number and spacing of the events in the sequence, along with a number of simultaneous notes. It will fill a notes table with a sequence based on the information supplied and the little algorithm which was preprogrammed. This is simply one user's own experiment, not an official release by Syntauri. (This little composing program is just the tip of the iceberg for algorithmic composition.)

Complaints

Game paddles are a drag. They are imprecise, don't stay where you put them, and waste processor time. I really wish the system had a couple of slide potentiometers and a cheap analog-to-digital converter.

The manual has no index! (Syntauri says it's preparing one.) The system takes too long to boot up. (Syntauri's working on that, too.) Depending on your audio quality requirements, the Mountain Computer synthesizer hardware can be a bit noisy (8-bit digital-to-analog converters). But it is the best choice when you compare price to performance.

Conclusions

- The software allows for system expansion. Innovative musical ideas or new methods of analysis can be easily incorporated into the operating system.
- The alphaSyntauri system uses a modular approach for the hardware, allowing for future improvements and upgrading of the system. This means the system can grow, not be outgrown.
- The software—while some may argue the advantages of straight assembly language—is fast when it needs to be and slow and accessible where necessary.
- The real-time interaction with the composer is an important improvement. This changes the synthesizer into a true musical instrument.
- The price is obviously more than the average Apple II owner can afford. For the serious musician, however, the alphaSyntauri's combination of quality sound, good performance, and price make it well worth the money. ■

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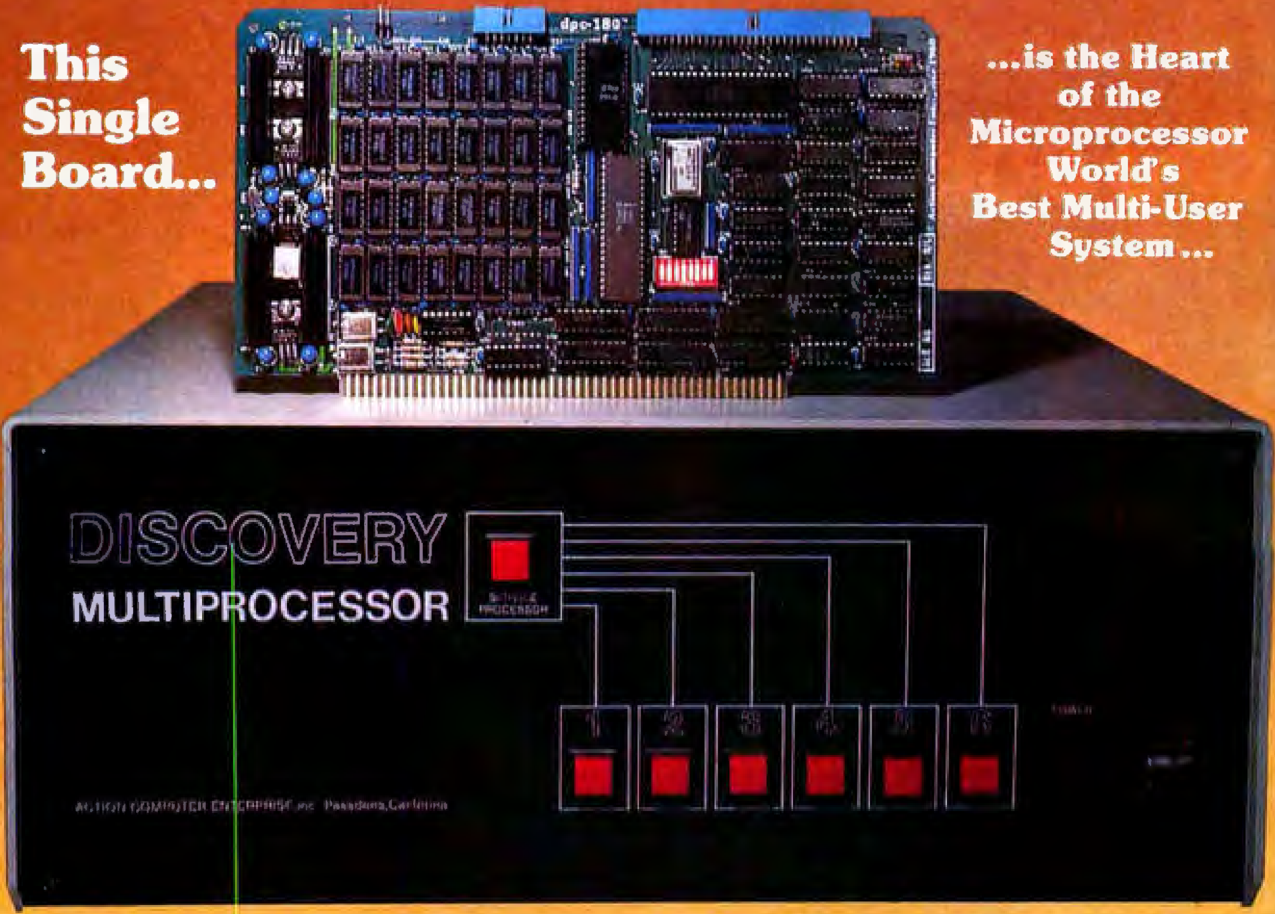

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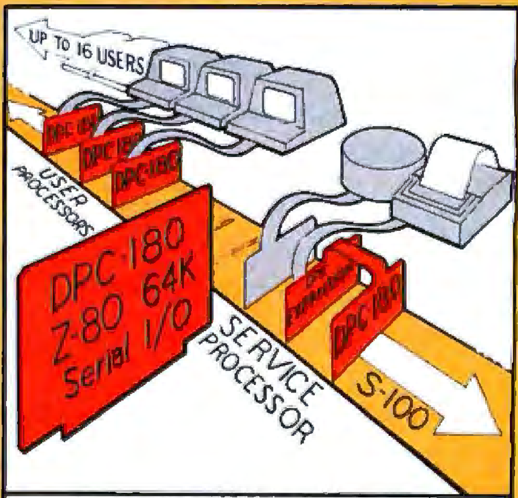

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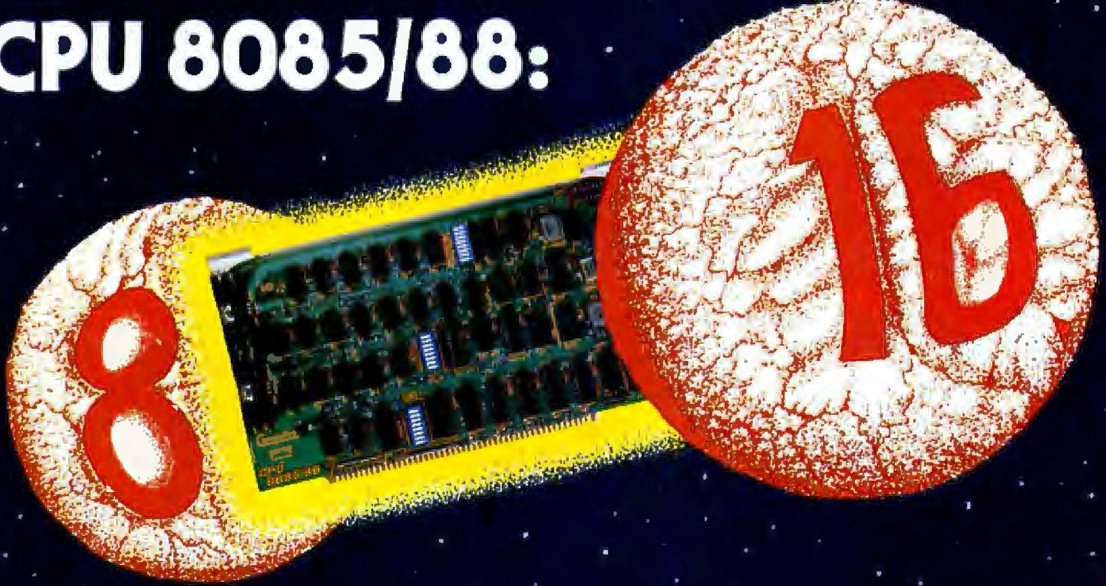

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Book Reviews

AIM 65 Laboratory Manual and Study Guide

Leo J Scanlon
John Wiley and Sons Inc
Somerset NJ, 1981
179 pages, softcover
$7.95

Reviewed by
Bob Katz
248 E 90 St #3B
New York NY 10028

The AIM 65 Laboratory Manual and Study Guide is designed to provide an inexpensive but effective means for high schools, vocational schools, and colleges to implement a microprocessor computer lab. It is a good introduction to machine-language software techniques.

The manual is designed only for use with the Rockwell AIM 65 computer; the monitor commands will not work with other computers. However, students who master this manual should be able to program fluently in 6502 machine language and in a dialect of a popular 6502 assembly language.

A vocational school that trains computer service technicians would be especially interested in the AIM 65 course. People who repair hardware must also understand software on the machine-language level. For example, they should be able to read and write bytes to and from a suspect output port and make checks with a logic analyzer to see if the hardware is at fault.

In my experience, half of all hardware problems are due to bad connections. After eliminating these, only 20 percent or so are related to bad components. I believe, however, that more than 90 percent of all service problems are actually software problems. Remember GIGO (garbage in, garbage out)? Practice work with the AIM 65 should educate students in the complexities—and the pitfalls—of software writing. They will certainly have more sympathy for future clients who call for repairs, only to discover that the problem lies in the software.

Most computer-repair schools have a digital logic course or lab in transistor-transistor logic and complementary metal-oxide semiconductor devices, a Boolean algebra course, and a basic electronics course. Ultimately, a microprocessor computer lab would complete the program.

The AIM 65 is a single-board computer built by Rockwell International and is a refinement and extension of the popular KIM computer, which was developed by MOS Technology (now Commodore). But the AIM has some "big-gun" features that successfully emulate those of larger systems to give computer students a taste of the "real world."

The AIM 65 includes an on-board, 20-column thermal printer, a companion 20-character light-emitting-diode display, a full-size typewriter keyboard, a very-interactive monitor and text editor, 20 input/output ports, and up to 4 K bytes of RAM on board. BASIC and the two-pass assembler are also ROM options. A number of cottage industries have sprouted to provide peripheral support for the ubiquitous single-board computer; therefore, a school could easily expand one or more laboratory stations to include an RS-232 interface, 64 K bytes (or more) of memory, DOS (disk operating system), and more.

Leo J Scanlon is documentation manager for Rockwell International. Scanlon's writing style is always clear, yet pleasantly conversational in tone. In *6502 Software Design*, Scanlon wrote in an analytical manner for the serious reader who can handle large amounts of abstract material. I did manage to learn the 6502 language and concepts from *Software Design* before purchasing or even using my first computer. Most people, however, are uncomfortable with learning in such an abstract manner.

AIM 65 takes another approach. It was written for those who need the feedback that comes from the tactile process of experimenting with a computer while also learning about it. It is an effective, modularized, step-by-step educational approach to using and programming a 6502-based microcomputer. Students are encouraged to write their own programs and learn debugging techniques. Each experiment is well-organized, beginning with "object" and "pre-lab preparation" (reading) and ending with "discussion" and "procedure."

Chapter headings include: Getting to Know the AIM 65; Addition Operations; Subtraction and Logical Operations; Program Sequencing; Debugging Programs; Multiplication Operations, with Shift and Rotate; Division Operations; Subroutines and the Stack; Unordered Lists; Sorting Unordered Data; Code Conversion from Input; Code Conversion for Output; Input/Output; A More Powerful I/O Device, the R6522 VIA; Interrupts; A Timing Program with Decimal Output; The Aim 65 Assembler.

I've performed several of the experiments described by Scanlon and can verify that this lab manual works quite well as a self-study method. I recommend it to any purchaser of the AIM 65 computer, and I feel it is the best learning tool available for the novice machine-language programmer.■

BYTE's Bits

Conference Proceedings

In January 1981, the College of Education at Arizona State University hosted a microcomputer conference that was designed to introduce educators and administrators to the applications of microcomputers in the classroom. The conference proceedings are now available in a 340-page book that includes more than 30 articles. Among the titles are "Instructional Techniques for Teaching BASIC Programming to Elementary Children," "Using Computers with the Blind and Deaf Children," "Managing Instruction with a Micro," "The Challenge of the 1980's: Computer Literacy," and "Microcomputers in High School Physics."

The proceedings are available for $10 from Dr Gary Bitter, Arizona State University, Payne B203, Tempe AZ 85287.■

Color Computer from A to D

Make Your Color Computer "See" and "Feel" Better

First in a series

William Barden Jr
28122 Orsola
Mission Viejo CA 92692

The Radio Shack Color Computer has an amazing amount of circuitry built into it for the price. One of its most interesting features is the joystick interface, which allows you to control the screen cursor position by the use of two joysticks. Actually, this use of the joystick is one of the most mundane applications of the built-in analog-to-digital (A/D) circuitry. How would you like to use the joystick inputs for reading in temperature, intensity of light in a room, or other real-world physical quantities? And do it with only a few additional inexpensive components? How would you like to have four channels of data coming into the Color Computer, making it a data-acquisition system for storing and processing real-world data?

In this article I'll show you how to accomplish all of these things. The Color Computer hardware that handles the joystick inputs, the software that drives the input electronics, and the implementation of real-world inputs will all be investigated. *[For background information on the Color Computer's circuitry, see Tim Ahrens et al., "What's Inside Radio Shack's Color Computer?" March 1981 BYTE, p. 90.]*

This is the first article of a series devoted to Radio Shack computers: TRS-80 Model I, Model III, and the newest member of the Tandy family, the Color Computer. The emphasis will be on using the Radio Shack systems to interface to the real world. In some cases, special-purpose hardware that connects to the computer input/output ports will be used; in other cases, no special hardware will be required, because the computer systems provide everything necessary.

In general, a systems approach to the problem of interfacing will be used. Too often the advocates of hardware and software are separated by a wide gulf. We've all seen implementations in a computer system where an applications problem is solved by interfacing a custom-designed device that uses 315 integrated circuits; in this case, one suspects the designer has a strong hardware background. Conversely, there's the implementation where everything is "software-driven" in a 2000-instruction, hand-coded, machine-language program using a single computer input/output line; the designer here is obviously from the software clan. I'll attempt to take a middle road. After all, the important point is that a computer system can be used to accomplish some pretty spectacular real-world things; I'll show how to do this in the most efficient fashion possible, using a balance of hardware and software techniques.

Joystick Circuitry

First, a look at the hardware. Figure 1 shows a block diagram of the Color Computer joystick circuitry. Two joysticks, each having an X and a Y channel, connect to a data selector that selects one of the four channels. The output of the selected channel goes to a comparator.

The second input to the comparator is a software-controlled *reference voltage*. This voltage comes from a digital-to-analog converter (DAC) driven by six programmable data lines. (Yes, that's "digital-to-analog," even though the subject of this article is analog-to-digital. I'll explain why the DAC is needed later on.) The data lines come from a peripheral interface adapter (PIA).

The output from the comparator goes to one input line of a second PIA. A more detailed diagram of the electronics is shown in figure 2. Parts placement on this diagram corresponds to the functional blocks of figure 1. I'll refer to figure 2 in the fol-

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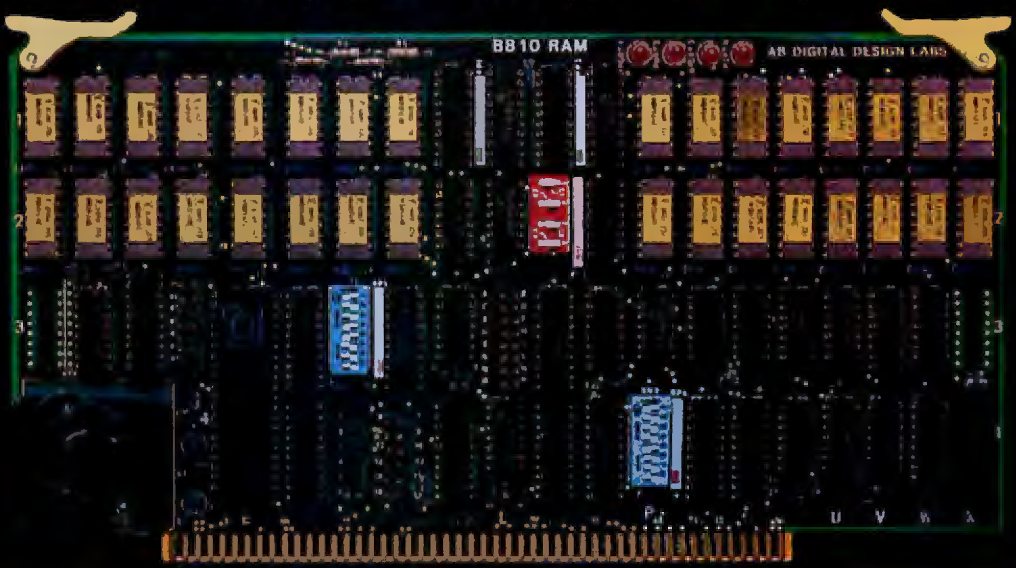

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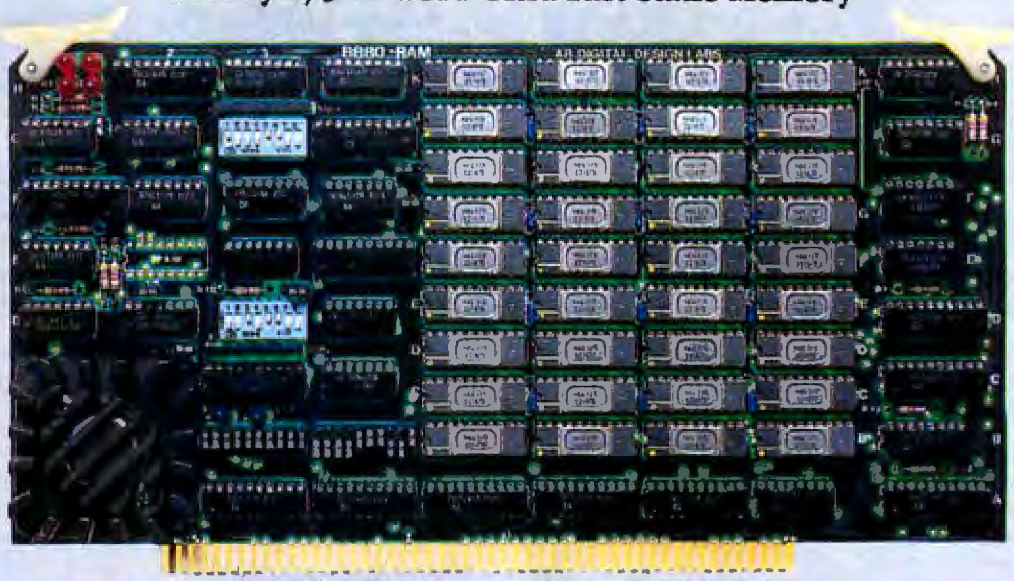

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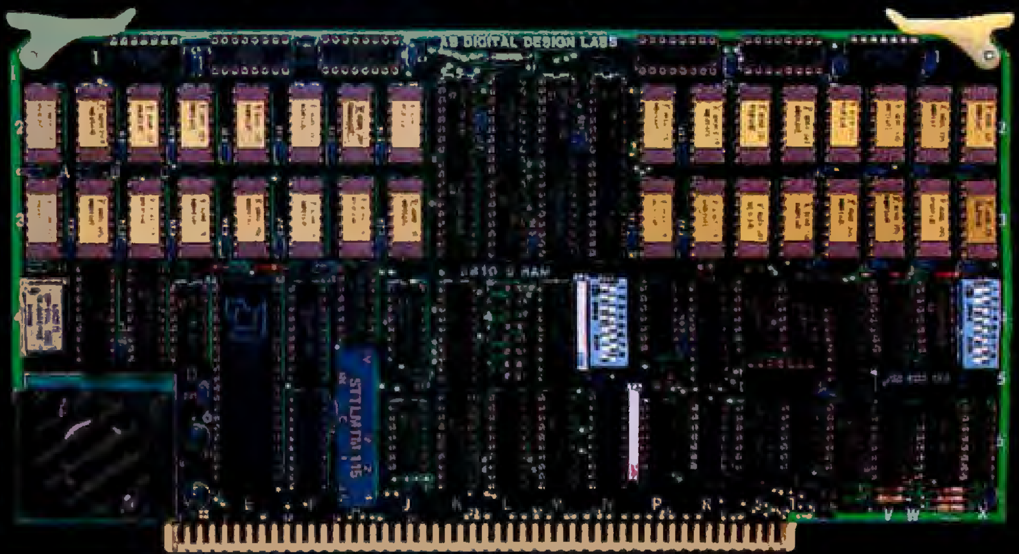

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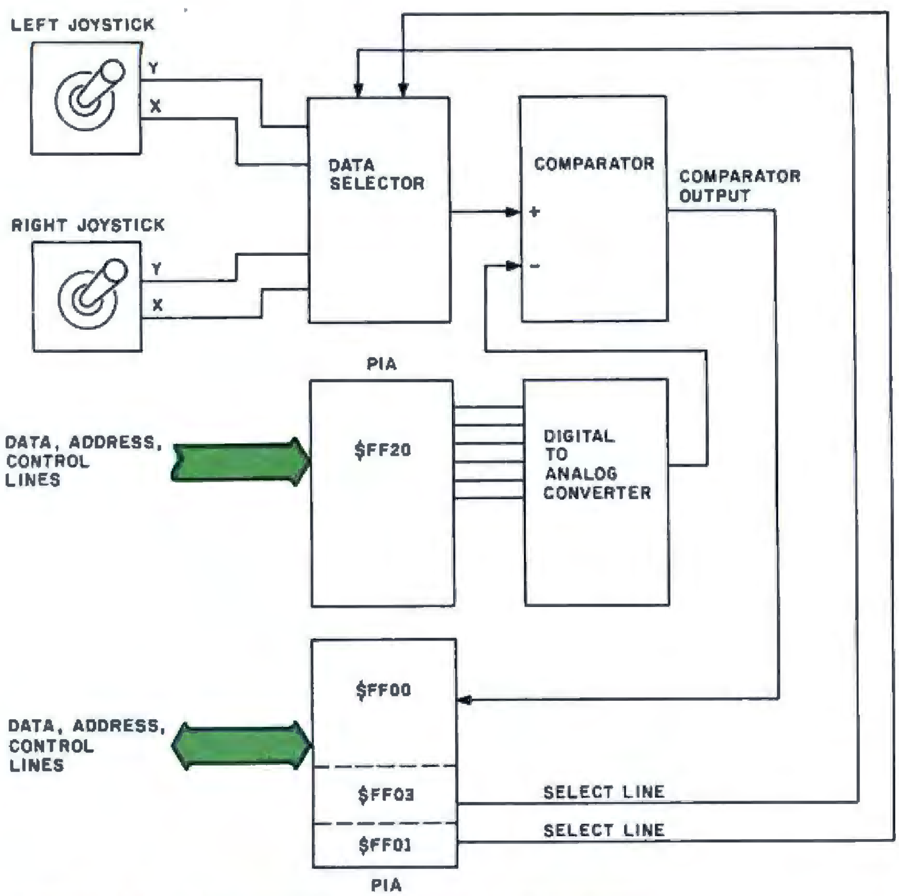

Figure 1: *Color Computer joystick circuitry, block diagram.*

lowing discussion and explain some of the parts for you software types.

Joysticks. The joysticks are simply variable resistors, or *potentiometers*, as shown in figure 3. Move the joystick control in the up-down direction only, and the Y potentiometer *wiper* moves across the potentiometer, varying the resistance from 0 to 100,000 ohms (Ω). Move the joystick control in the right-left direction only, and the X potentiometer wiper varies the resistance from 0 to 100,000 Ω. Every position of the joystick can be translated into X and Y coordinates, with resulting X and Y positions and corresponding resistance values.

Because both potentiometers are connected between +5 volts (V)—from the Color Computer—and ground, the voltage output to the X and Y channels varies between approximately 0 V (up or left position) and +5 V (down or right position). A switch on each joystick connects another input pin (pin 4) to ground when it is pressed.

Data Selector. The MC14529 is an analog switch. This device selects one of four input channels and routes it to the output W. The signal is not otherwise processed as it passes to the LM339 comparator, so the voltage input from one of the channels is fed unchanged to the LM339 positive (+ or noninverting) input.

The selection of the channel is determined by two *select* lines, SEL1 and SEL2. These lines are outputs from the second 6821 PIA. I'll discuss the PIAs in a moment, but for now, simply note that you can select one of the four channels easily by changing SEL1/SEL2 to 00, 01, 10, or 11.

The Comparator. The LM339 is a common device that compares two voltage inputs. The inputs are two DC levels which can vary from 0 V to some positive voltage. The output is either on or off. In this case, the two inputs will vary from 0 to +5 V (approximately), and the output will be either 0 V (+ input greater than − input) or +5 V (+ input less than − input). The output, then, represents a binary 0 or 1 and reflects the comparison of a joystick voltage and a second input called CASSOUT.

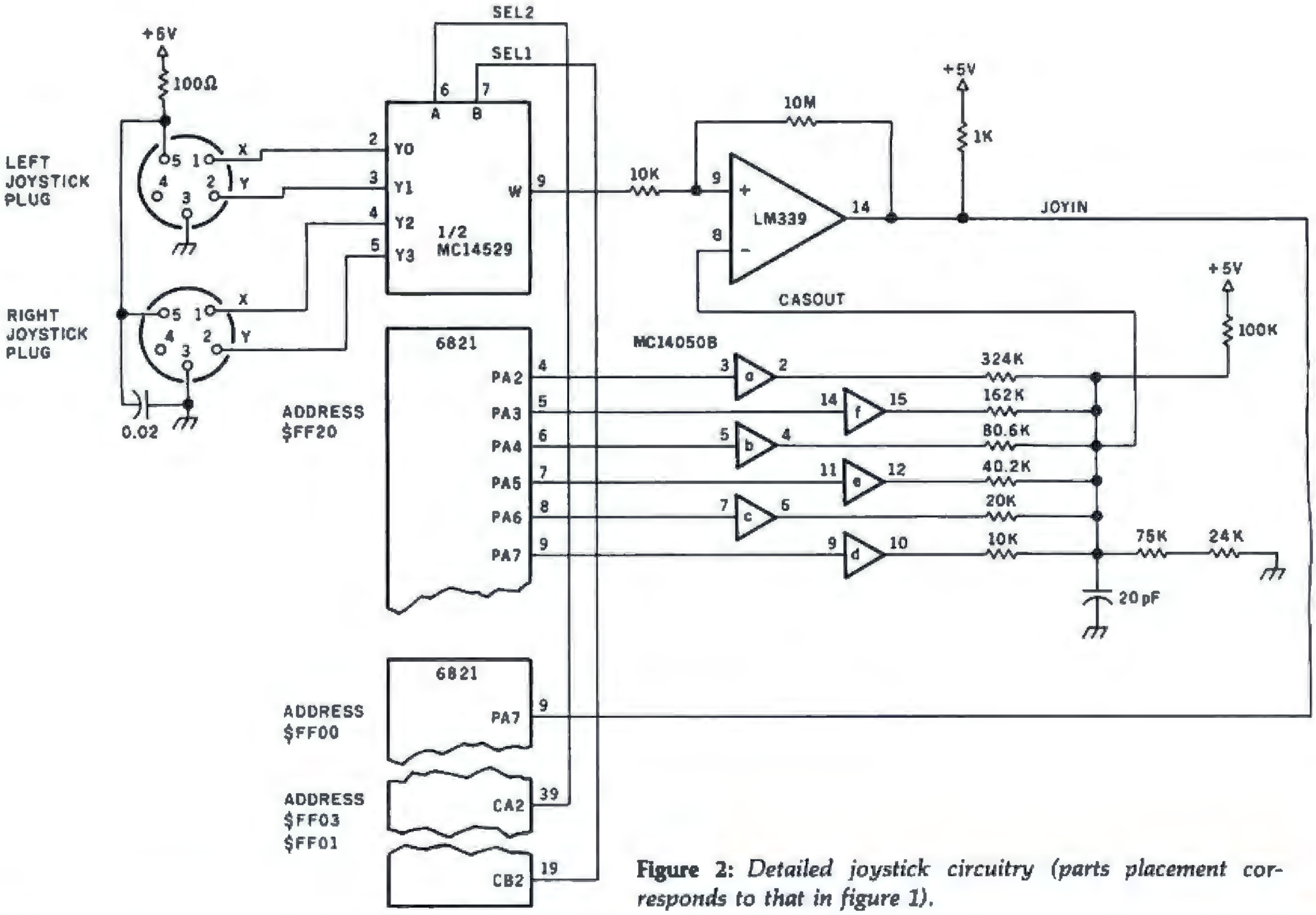

Figure 2: *Detailed joystick circuitry (parts placement corresponds to that in figure 1).*

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Digital-to-Analog Converter. Now for the seemingly out-of-place DAC. In short, it provides a mechanism for "guessing" the value of the currently selected joystick channel. You might think of it as a guess-my-number affair.

The six buffers of the MC14050B and the resistor network make up the DAC. The DAC takes the six lines labeled PA7 through PA2 and converts the binary values of 000000 through 111111 into corresponding voltages of 0 to +5 V DC. Because 64 separate values are represented over this range (111111 is 63), the voltages represented will be in steps of $^{5}/_{64}$ V (approximately)—0 V, $^{5}/_{64}$ V, $^{10}/_{64}$ V, $^{15}/_{64}$ V, . . . up to $^{320}/_{64}$ V (5 V).

The method used for this conversion is a *voltage-divider* resistor network, where each resistor produces a weighted voltage. The output of each MC14050B buffer is either 0 or +5 V (approximately). If the buffer output is 0 V, the resistor associated with the buffer can be considered to be at ground; if the output is +5 V, the resistor can be considered to be at +5 V. The resulting resistor network for a typical configuration is shown in figure 4. The output voltage is the total voltage from ground to the output point. Table 1 shows approximate output voltages for the range of input values.

The PIA. The PIA is Motorola's peripheral interface adapter, basically a 20-line device in which most lines can be programmed as inputs or outputs. In the standard Color Computer configuration, PIA lines feeding the DAC are assigned hexadecimal address $FF20; PIA lines selecting the channel of the data selector are assigned hexadecimal address $FF01; and the PIA line for JOYIN is assigned hexadecimal address $FF00. [**Editor's note:** *Following 6809 conventions, all hexadecimal values are prefixed with "$".*] Other lines are involved with the PIAs—lines to read the keyboard, lines to handle RS-232 communication, and so forth—but the lines pertaining to the joystick inputs are the only ones shown in figure 5.

Each set of lines is *memory-mapped* in the Color Computer; using BASIC's tools, a PEEK at 65280 can be used to read the JOYIN bit, while a POKE to 65312 will output a value to the DAC.

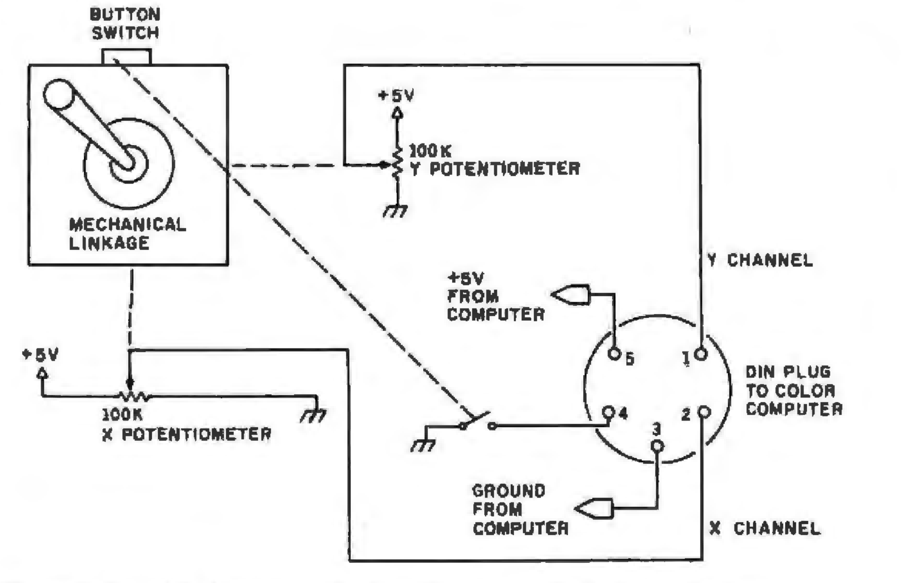

Figure 3: *Joystick electronics; the joysticks are relatively simple devices.*

Joystick Software

From here on, the problem is "simply a matter of programming." The first task is to find the X/Y position of either joystick. The algorithm for doing this is fairly simple:

1. Select the joystick and X/Y channel by sending data to the SEL1/SEL2 lines. To select the right joystick and X, for example, a 0 must be sent to bit 3 of decimal address 65283 and a 1 output to bit 3 of decimal address 65281.

2. The input from the joystick is now at the + input of the comparator. Assuming you aren't playing a hot game of Space Invaders, that input should remain relatively constant for some period of time, although in normal use it could be fluctuating from 0 to +5 V in ¼ second or less.

3. Send a value of binary 100000

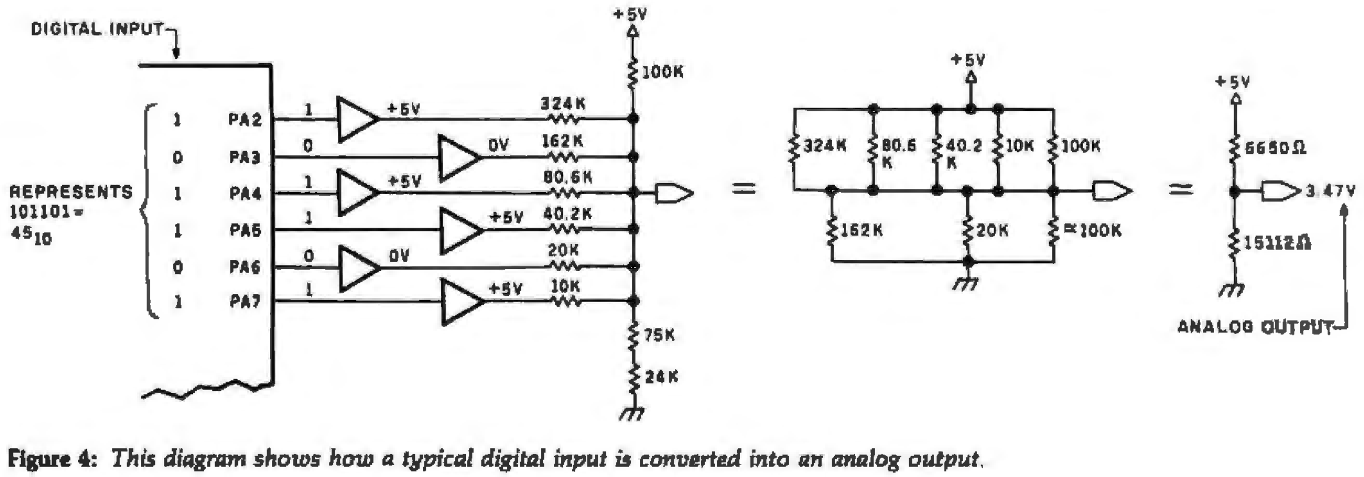

Figure 4: *This diagram shows how a typical digital input is converted into an analog output.*

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(decimal 32, or about +2.5 V) to the DAC by using a POKE 65312,128.

4. Look at the output of the comparator by doing a PEEK (65280) and testing bit 7 by performing a logical AND with 128. If the output is a 0, the channel value is less than the output from the DAC. In this case, take half of the remaining range (binary 010000, decimal 16, or about 1.38 V) and try again. If the output is a 1, the channel value is greater than the output from the DAC. In this case, take half of the remaining range (binary 110000, decimal 48, or 3.69 V) and try again.

5. Repeat this process six times. Each time, take one-half the remaining range and try again. At the end of the six tries, take the value most recently output; it will be within $5/64$ of the actual voltage produced by the joystick.

Savvy readers will recognize this algorithm as our old friend the binary search. In this case, a binary search has been used to converge on the X or Y input voltage by *successive approximation*. To prove that this method *does* work, run the BASIC program shown in listing 1. This program zeroes in on the X channel of the right joystick. Move the joystick and the program will report back the new X position for each iteration.

BASIC Joystick Commands. The JOYSTK command in Color BASIC accomplishes the same function as the program in listing 1. The format of the command is

JOYSTK (j)

where *j* is 0 for the right joystick X; 1 for the right joystick Y; 2 for the left joystick X; and 3 for the left joystick Y. JOYSTK(0) must be executed before JOYSTK(1), (2), or (3) can be returned.

As with other BASIC operations, there is a limit to how fast JOYSTK can be performed. Assuming you want to read the X/Y coordinates of one joystick (see listing 2), the speed of operation is about 23 X/Y readings per second. This is not too bad but doesn't allow such things as smooth plotting of points on the screen during rapid joystick movement, as in listing 3.

Machine Language. The answer to a faster reading of the joysticks, as you might suspect, is in 6809 machine language. Two driver subroutines in Color BASIC are associated with the joysticks: one to select the joystick channel and one to read all four channels into four page-zero locations. The Select-Joystick subroutine in Color BASIC is at location $A9A2; the Read-Joystick is at $A9E0. Listings 4 and 5 show the disassembled code; I've added program commentary in a separate text box (see page 160).

Other Uses for A/D Inputs

As the foregoing discussion has demonstrated, a built-in set of four A/D channels resides in the Color Computer—channels in which the input voltage may range from 0 to

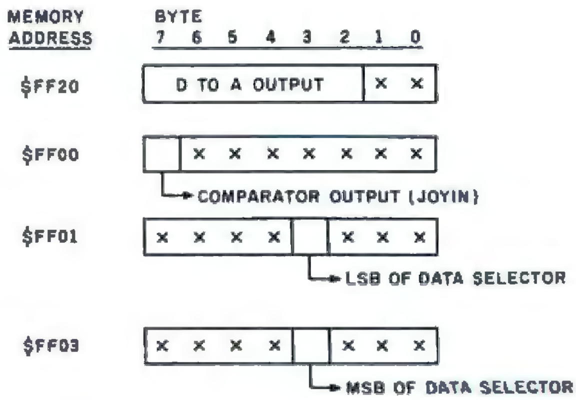

Figure 5: *The Color Computer's PIAs are memory-mapped. A single memory-mapped byte has several functions on the bit level.*

+5 V DC and in which data can be sampled at rates of up to 2500 samples per second for a single channel. There are many other uses for these channels.

Electrical Analogs. Many physical quantities can be represented by an electrical analog of voltage, resistance, or current. A *thermistor*, for example, changes its resistance in accordance with temperature. Certain types of crystals generate a voltage when stressed; thus, crystal microphones can produce an output voltage in step with sound input. Photoresistors change their resistance values when subjected to varying light intensities.

One problem with many types of *transducers* like these is that they are not linear. Equal changes in the physical quantity do not produce equal changes in the electrical property over a wide range. Manufacturers strive to maintain linearity in the devices, and, as a result, the transducers become expensive. Using the Color Computer A/D inputs, you can completely bypass linearity problems because you can easily convert input values to the corresponding physical values by use of a conversion table. As a result, you can use many "garden variety" devices for transducers.

Another powerful aspect of the Color Computer is that you can do more than just read instantaneous input values. You can use the Color Computer as a data-acquisition device. Inputs can be sampled many times a second and then stored in memory, on cassette, or on disk. You can retrieve the input data as often as required and process them in any way you wish.

Following are illustrations of two types of real-world inputs that use the A/D inputs of the Color Computer, a light detector and a thermometer. You may be amazed at how simple this can be.

Standard Plug. As a first step, make a standard plug for the A/D inputs. The standard joystick plug is a 5-pin DIN male plug, which Radio Shack sells in most stores. Be certain to get a "thin-walled" type; the thicker plastic type will not fit in the jack. Use any four-conductor wire, or four single wires, to connect to the DIN pins as shown in figure 6. If you'd like, you can add a fifth wire for the pushbutton switch, although its use is not detailed in this article.

Listing 1: *A BASIC program that accomplishes an A/D conversion on the right joystick's X-coordinate. The program reads the hardware directly for the sake of illustration; the BASIC language offers a single command (JOYSTK) to do the same thing, as shown in listing 2.*

```
 90 REM SELECT RIGHT, X
100 A = PEEK(65283)
110 A = A AND 247
120 POKE 65283,A
130 A = PEEK(65281)
140 A = A AND 247 OR 4
150 POKE 65281,A
160 REM SETUP VALUE, DELTA
170 V = 128: D = 64
175 REM BINARY SEARCH HERE
180 POKE 65312,V
190 A = PEEK(65280)
200 A = A AND 128
210 IF A = 0 THEN V = V - D ELSE
    V = V + D
220 D = D/2
230 IF D<>1 THEN GOTO 180
235 REM NOW GET 6 LS BITS
240 V = V AND 252
250 V = V/4
260 PRINT V
270 GOTO 100
```

Listing 2: *A typical use of BASIC commands to read the X- and Y-coordinates of the right joystick. Line 130 keeps track of how many times the joystick has been read; this program obtains 23 X/Y readings per second.*

```
100 REM TYPICAL JOYSTK PROGRAM
110 A = JOYSTK(0)
120 PRINT JOYSTK(0),JOYSTK(1)
130 I = I + 1
140 GOTO 120
```

Listing 3: *This BASIC program shows that the JOYSTK command is too slow to keep up with rapid joystick movements; you can't get a smooth plot on the screen unless you move the stick very slowly.*

```
100 REM PROGRAM TO PLOT POINTS
    FROM JOYSTICK
110 PMODE 4,1: PCLS: SCREEN 1,0
120 PSET(JOYSTK(0)*4,JOYSTK(1)*3)
130 GOTO 120
```

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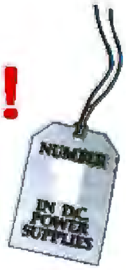

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Input Value	Output	Input Value	Output
0	0.230	32	2.53
1	0.302	33	2.61
2	0.373	34	2.68
3	0.444	35	2.75
4	0.517	36	2.82
5	0.588	37	2.89
6	0.659	38	2.96
7	0.731	39	3.04
8	0.805	40	3.11
9	0.876	41	3.18
10	0.947	42	3.25
11	1.01	43	3.32
12	1.09	44	3.40
13	1.16	45	3.47
14	1.23	46	3.54
15	1.30	47	3.61
16	1.38	48	3.69
17	1.45	49	3.76
18	1.52	50	3.83
19	1.59	51	3.90
20	1.67	52	3.98
21	1.74	53	4.05
22	1.81	54	4.12
23	1.88	55	4.19
24	1.95	56	4.26
25	2.03	57	4.34
26	2.10	58	4.41
27	2.17	59	4.48
28	2.24	60	4.55
29	2.31	61	4.62
30	2.38	62	4.69
31	2.46	63	4.76

Table 1: *The Color Computer's D/A circuit converts values from 0 to 63 into voltages from 0.230 to 4.76 V. The resultant voltage can then be compared with the voltage level from one of the joystick input channels. By a method of successive approximation, software can "measure" the voltage accurate to within 1/64 V.*

A Light Detector

The light-detector application uses just two components attached to the right joystick X channel as shown in figure 7. The primary component is a cadmium sulfide (CdS) photocell, which currently costs $1.29 in Radio Shack stores. Its resistance is dependent upon the amount of light striking it and varies from about 5 megohms (MΩ) (5 million ohms) in complete darkness (where it was hard to read the ohmmeter) to about 20 Ω in direct sunlight. Some other readings are shown in table 2.

Obviously, this is quite a wide range. For this example, the normal house interior settings, out of direct sunlight, were chosen for a program that would determine when the room was adequately lighted—a range of about 500 to 5000 Ω. The input voltage V to the 0 channel is given by:

$$V = R1/(R1 + R_{cr}) \times 5$$

where R_{cr} is the resistance of the photocell and R1 is the resistance of the second component (a ¼- or ⅛-watt (W) carbon resistor, which costs about $.25 or less). For a midpoint R_{cr} of 2750 Ω, R1 should be 2750 Ω. The closest standard resistance value of 2200 Ω was used in the example. Vary the resistance as required for the light conditions you are testing.

A potentiometer with the center and one outer pin tied together (actually a rheostat) could be substituted for the fixed resistor to allow this circuit to be used for a variety of applications. (Both the fixed resistor and the potentiometer are available from Radio Shack and other electronics parts stores.)

You read channel 0 using the

Condition	Reading (ohms)
Facing sun	20
Sunlit outdoors	30
Overcast outdoors	50
Shaded outdoors	100
Inside house, facing window	180
Inside house, facing interior	830
Artificially lighted (bright) room	2200
Interior of closet, swathed in old racoon coat	5 M

Table 2: *Readings taken with the light detector. The unit is more light sensitive than the human eye, detecting differences where the human eye sees none.*

BASIC JOYSTK(0) command or by calling the joystick assembly-language subroutine.

This light-detector circuit could be used for a number of things: an electronic exposure meter for a darkroom, a light-level detector for artificial lighting, the aiming of solar panels (with an output to control panel positioning), or burglar alarms (a detectable drop in output occurs as a person walks past the sensor). In my tests, the CdS photocell was sensitive enough to detect differences in clothing color and the whiteness of various types of paper. Many of the differences were not discernible by the human eye.

A Thermometer

The thermometer application also uses two components (shown in figure 8). One is a *thermistor*. A thermistor's resistance varies with ambient temperature. A rather gross type of thermistor, a replacement television thermistor, was used for this application. It has a resistance of about 120 Ω at 25 degrees Celsius (°C) and about 1.8 Ω at 65°C. A thermistor of this type has a slow response to temperature changes but is inexpensive ($2.20). Better-quality thermistors, over a wide range of resistance values, are available from manufacturers' representatives and are priced from $6 to $10. Choose one with a resistance in the 10-kilohm (kΩ) range to reduce the effect of the 100-Ω resistor in series with the +5 V pin.

A plot of the values obtained by reading JOYSTK(0) is shown in figure 9. Even with this unsophisticated thermistor, a temperature resolution of 3 to 4 degrees at lower temperatures was achieved. (The effect of 100 Ω resistance was less pronounced.) This particular thermistor took several seconds to respond to changes in temperature, though. It's easy to see that many interesting temperature applications could be implemented with this simple circuit: measurement of liquid temperature, fire detection, flow gauges (*moving fluid* cools the thermistor), a weather station, and the like.

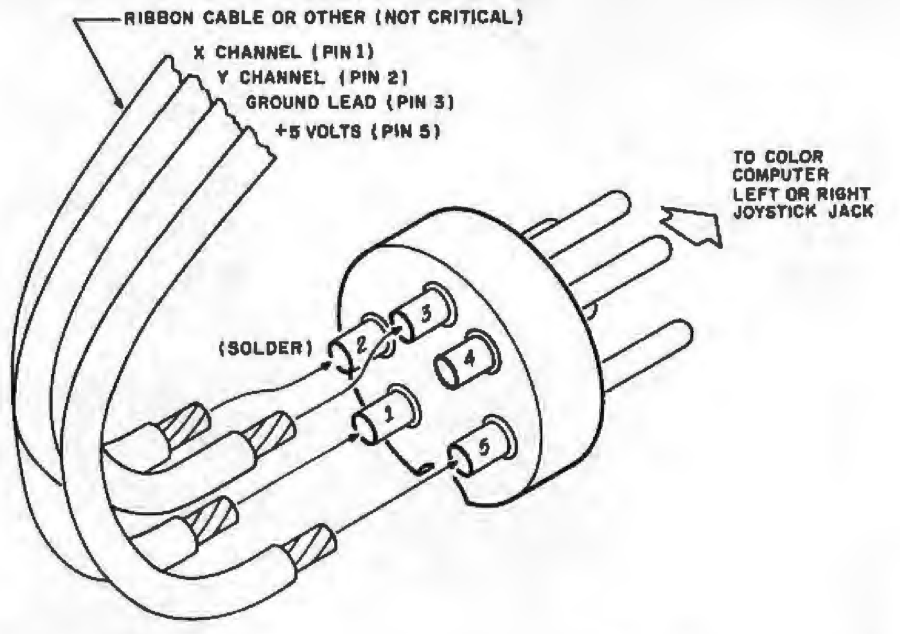

Figure 6: *A five-pin "standard" plug, DIN-type, for connecting external devices to the Color Computer's joystick input jack.*

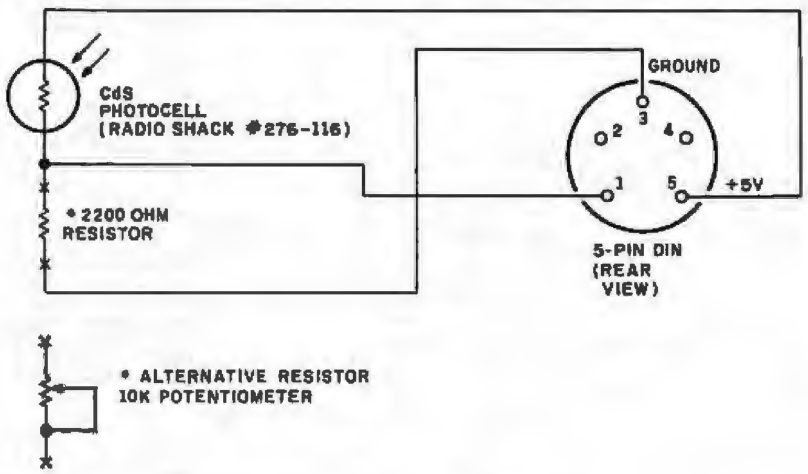

Figure 7: *The light detector components and connections.*

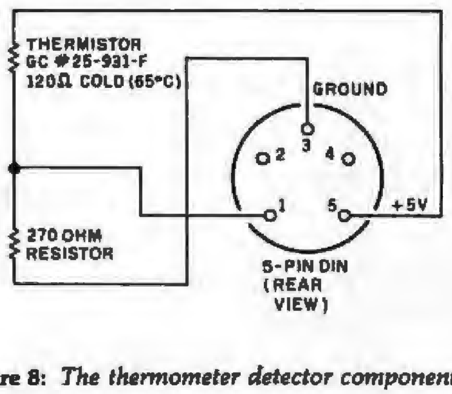

Figure 8: *The thermometer detector components and connections.*

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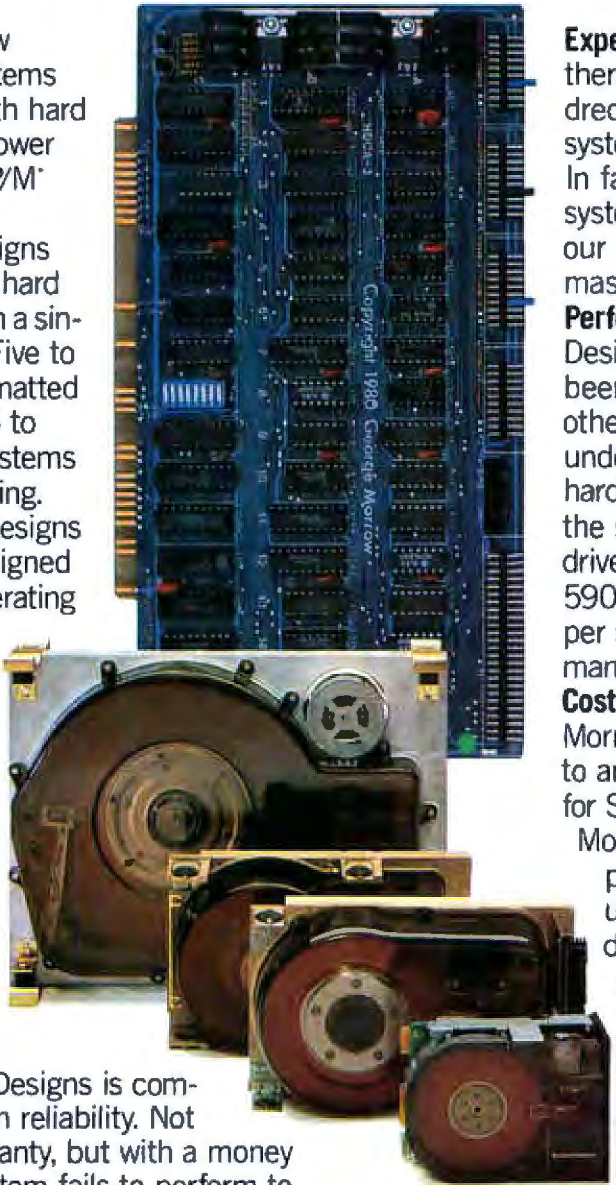

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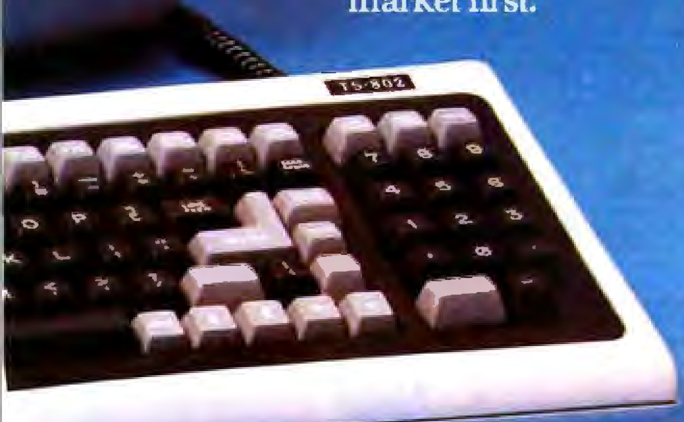

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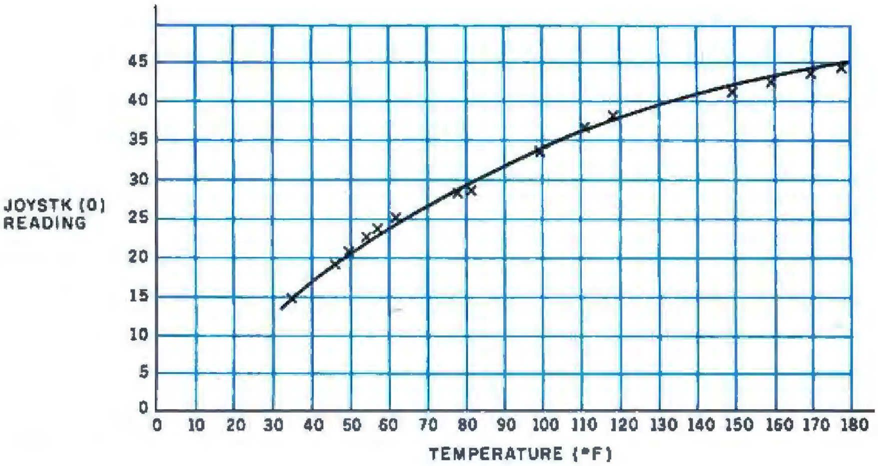

Figure 9: *Readings taken with the thermometer; notice that the device is almost linear in the 80-180°F range.*

Other Applications

Don't hesitate to try other transducers with the joystick inputs. Anything that can resolve physical quantities into resistance or voltage can be measured by the Color Computer joystick inputs:

- A small DC motor, for example, might be used in reverse as a generator. Driven by anemometer-type wind cups, the motor would generate a voltage proportional to wind speed which could be applied directly across pin 3 (ground) and pin 1 (X input). (Some amplification by a single transistor might be necessary.)
- A solar cell can be used in a similar fashion. Tie its output directly to pins 1 and 3 to read voltage generated by sunlight striking the cell.
- Used with a microphone and small amplifier, the Color Computer could also act as a sound detector for


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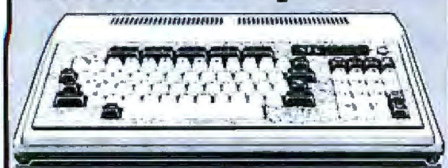

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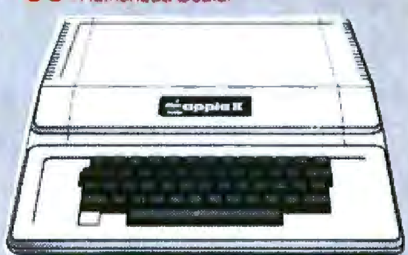

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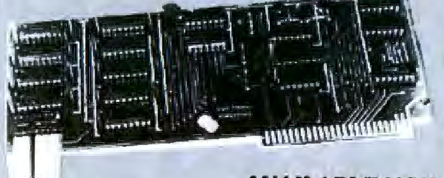

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Listing 4: *A disassembly of Color BASIC's select-joystick subroutine in 6809 machine language.*

```
Address  Object Code  Source Code          Comments

A9A2     CE  FF01     LDU    #FF01         $FF01 TO U
A9A5     8D  00       BSR    A9A7          DO $A9A7 TWICE
A9A7     A6  C4       LDA    0,U           READ $FF01 PIA
A9A9     84  F7       ANDA   #F7           RESET SELECT BIT
A9AB     57           ASRB                 SHIFT OUT BIT TO C
A9AC     24  02       BCC    A9B0    ONCE  GO IF SELECT BIT = 0
A9AE     8A  08       ORA    #08           SELECT BIT = 1
A9B0     A7  C1       STA    U++           STORE IN $FF01 PIA, BUMP TO $FF03
A9B2     39           RTS                  RETURN
```

Listing 5: *A disassembly of Color BASIC's subroutine to read all four joystick channels in 6809 machine language.*

```
Address  Object Code  Source Code                               Comments

A9E0     8E  015E     LDX    #015E                              POINT TO STORAGE + 1
A9E3     C6  03       LDB    #03                                LOOP COUNT-3 TO 0
A9E5     86  0A       LDA    #0A                                # OF RETRIES
A9E7     ED  E3       STD    --S                                 SAVE # TIMES, RETRIES
A9E9     8D  B7       BSR    A9A2                                SELECT JOYSTICK 3-0
A9EB     CC  4080     LDD    #4080                                $40-A,$80-B=DELTA, START
A9EE     A7  E2       STA    -S                                     SAVE
A9F0     CA  02       ORB    #02                                    ??RS-232 OUT
A9F2     F7  FF20     STB    FF20                                   CURRENT TRY TO D/A
A9F5     C8  02       EORB   #02                                    FLIP BIT?
A9F7     B6  FF00     LDA    FF00                                   GET JOYIN
A9FA     2B  03       BMI    A9FF                                   GO IF 1
A9FC     E0  E4       SUBB   0,S               INNER LOOP #2        SUBTRACT DELTA
A9FE     8C  EBE4     CMPX   #EBE4                                  BYTES 2,3=ADDB 0,S
AA01     A6  E0       LDA    S+                                     GET DELTA
AA03     44           LSRA                                          FIND NEXT DELTA
AA04     81  01       CMPA   #01                                    TEST FOR END
AA06     26  E6       BNE    A9EE                                   GO IF NOT DELTA OF 1
AA08     54           LSRB             INNER LOOP #1              ALIGN FINAL VALUE TO 00XXXXXX
AA09     54           LSRB
AA0A     E1  1F       CMPB   -01,X                                GET LAST VALUE
AA0C     27  04       BEQ    AA12                                 GO IF EQUAL
AA0E     6A  E4       DEC    0,S       OUTER LOOP                 NOT EQUAL—RETRY
AA10     26  D9       BNE    A9EB                                 TRY 10 TIMES
AA12     E7  82       STB    -X                                  STORE VALUE IN STORAGE
AA14     EC  E1       LDD    S++                                 GET COUNT
AA16     5A           DECB                                       DECREMENT COUNT(#)
AA17     2A  CC       BPL    A9E5                                GO IF NOT 4 JOYSTICKS
AA19     39           RTS                                       RETURN
>>
```

security systems.

- A spring-loaded, sliding potentiometer (which costs a few dollars) could be used with a second resistor to provide an output for a scale to weigh anything from elephants to letters.
- The same device can be used to convert linear movement into a form readable by the Color Computer. With two multi-turn potentiometers (under $10 each), a little bit of cord, and a few pulleys, it's not difficult to construct an X/Y plotter to enable manual digitization of two-dimensional drawings or patterns.
- With a photocell, a simple lens (for example, a partial microscope assembly), and some transistor amplification, it's possible to construct an automatic digitizer that will convert shades of gray into digital form for screen display.
- Remove the stops from a linear-taper potentiometer (not hard to do) and you have a resistor whose resistance value is an analog of compass heading or rotational position. Use this with a second resistor as in the voltage-divider circuit discussed above (figures 7 and 8).

Well, I hope you're impressed with the possible uses of the Color Computer's A/D circuitry. It's not that difficult to devise real-world "sensors," and it's fun to write the software that drives them. Once you have started, you'll find that the possibilities are endless. Just think what Rube Goldberg could have done with a Color Computer!■

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Commentary on the Machine- Language Subroutines

Select-Joystick. On entry to the select-joystick subroutine, load the B register with the joystick channel number 0-3. The user stack pointer register U is first loaded with $FF01. A following BSR $A9A7 performs the subroutine code twice. A is first loaded with the current configuration of the PIA bits at address $FF01. An AND with $F7 resets the select bits. The ASRB shifts the least-significant bit of the B register into the carry flag. If this bit is a 1, an OR with 8 sets the select bit. The STA U++ stores SEL2 and increments the user stack pointer by two so that it holds $FF03. The RTS returns to $A9A7, where the same operation is repeated for the second select bit in the PIA at address $FF03.

Read-Joystick. The main code for the joysticks is at $A9E0 (see listing 5). This code is entered without parameters and stores the values of channels 0 through 3 into page-zero locations $15A, $15B, $15C, and $15D.

The X index register initially points to the address following the joystick variable storage location. B is loaded with a loop count of 3. The code from $A9E5 through $AA17 is the outer loop. For each of four passes, a channel value is found and put into a joystick variable.

Outer loop: A is loaded with $0A (decimal 10). This is the number of retries for the joystick value. If the same value is not found a second time, up to 10 tries are made to find a matching value. The number of times in B and the number of retries is stored in the stack by the STD instruction. A call is then made to $A9A2 to select the current joystick channel. This corresponds to the loop count of 3 to 0 in B. The code from $A9EB through $AA10 is inner loop 1. It finds the value of the channel. At the end of this loop ($AA12), the value is stored in the variable storage area by STB − X. This auto-decrement causes X to point to the next lower value *before the store* occurs. Next, the count in B and the number of retries in A are retrieved by the LDD, the count is decremented, and a BPL causes a loop back to $A9E5 if the count is not equal to −1.

Inner loop 1: The code from $A9EB through $AA10 is the inner loop that finds the value for the current channel. Within this code is inner loop 2, from $A9EE through $AA06, which actually does the binary search. The value $40 is loaded into A and the value $80 into B to start the search. Value $80 is binary 100000*xx* for the initial value of 32, while value $40 contains binary 010000*xx* for the "delta," the size of the remaining range.

At the end of the binary search at $AA08, the final PIA-format value is in B. This value is aligned to the right by the two LSRBs to represent a binary value of 0 through 63. It is then compared with the previous value. If these are the same, a branch is made to $AA12 to store the value in the outer loop. If the value is different, the number of retries is decremented, and, if the count is not equal to 0, another binary search is done by a branch to $A9EB.

Inner loop 2: The code from $A9EE through $AA06 is the binary search to find the channel value. A (the delta) is saved in the stack. The current value in B is then output to the DAC by STB $FF20. The output of the comparator is read by the LDA $FF00. If this value is equal to 1, the delta is added to the current value; if it is equal to 0, the delta is subtracted from the current value. The next value is then found by retrieving the delta from the stack and shifting it right one bit position. If the result is 1, the smallest delta has been processed, and B holds the final value. If the next delta is not 1, a branch back to $A9EE goes to the next iteration in the search.

This subroutine can be used for high-speed processing of the joystick position from other assembly-language programs. Results are obtained quickest when the joystick position is fixed and only one retry is necessary for comparison. A test program from BASIC indicates that it takes about 1.5 milliseconds for each set of four values. To find only the X channel of joystick 0, call location $A9E5 with B = 0 and X pointing to $15A. In this case, the time should be about 400 microseconds, although I haven't verified this.

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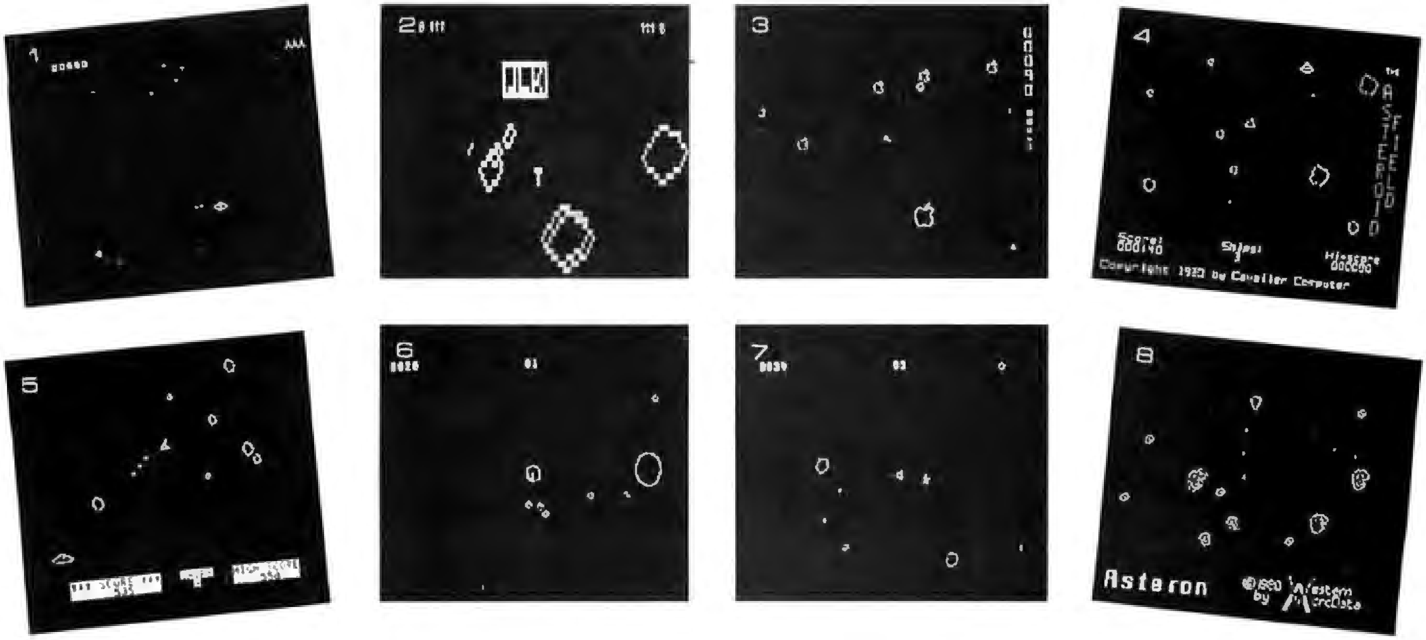
Battle of the Asteroids

Gregg Williams, Senior Editor



1: Planetoids, from Adventure International; 2: Super Nova, from Big Five Software; 3: Apple-oids, from California Pacific Computer Co; 4: The Asteroid Field, from Cavalier Computer; 5: Meteoroids in Space, from Quality Software; 6: Bubbles, from Softape; 7: Planetoids, from Softape; 8: Asteron, from Western MicroData Enterprises, Ltd.

If imitation is the sincerest form of flattery, then the people who designed Atari's coin-operated video game Asteroids have a lot to be proud of. Asteroids is one of the most successful commercial games around (equaled or surpassed only by Midway's Space Invaders and a newer Atari game, Missile Command) and has its own sequel (Asteroids Deluxe, also by Atari). Its popularity has inspired numerous imitations for use with personal computers. With so many versions around, the only dilemma is which one to buy.

I gathered every Asteroids-like game I could find (all but one were for the Apple II) and created a chart that shows you which version does what. Some notes to keep in mind: all Apple disk versions boot on either DOS 3.2 *or* 3.3 systems; unless noted in the table, versions with sound have no way of turning it off (important when playing late at night); all the games (except Apple-oids) give a black-and-white-only display; all of the versions are, in their own way, entertaining and well done; and none of the games (except possibly The Asteroid *Field)* looks or works *exactly* like the arcade original. Also keep in mind that two of these Asteroids-like games (Apple-oids and Bubbles/Planetoids) give you an extra game in the package price; this certainly influences how much game you get for your money. ■

See pages 164-165 for the comparison chart.

Asteroids is a trademark of Atari, Inc. The game is available in two coin-operated versions and cartridges for the Atari Video Computer System (game-cartridge system) and the Atari Personal Computer System (the Atari 400 and 800 microcomputers).

Product Name	Manufacturer	Price	Computer Used	Levels of Play	Ships per Game	Method of Firing
Planetoids	Adventure International POB 3435 Longwood FL 32750	$19.95 (disk), $14.95 (cassette that loads to disk)	Apple II or II Plus with 32 K bytes of memory and one disk drive	three: easy (asteroids explode each other), regular, hard (asteroids attracted to ship)	four	any key
Super Nova	Big Five Software POB 9078-185 Van Nuys CA 91409	$17.95 (Model I disk version), $15.95 (Model I/III cassette version)	Radio Shack TRS-80 Model I or III (disk and 32 K bytes of memory for disk version, 16 K bytes of memory for cassette version)	one	three	P key
Apple-oids (part of Apple-oids game package)	California Pacific Computer Co 1623 Fifth St Davis CA 95616	$29.95	Apple II or II Plus with 32 K bytes of memory and one disk drive	one	three	0 through 9 keys (identical in function)
The Asteroid Field	Cavalier Computer POB 2032 Del Mar CA 92014	$24.95	Apple II or II Plus with 32 K bytes of memory and one disk drive	two	Five (easy level of play) or three (expert level)	several: forward arrow, paddle button 0 or 1; see notes
Meteoroids in Space	Quality Software 6660 Reseda Blvd Suite 105 Reseda CA 91335	$19.95	Apple II or II Plus with 32 K bytes of memory and one disk drive	one (but many variations influence difficulty)	five	autofire (bursts of fire come automatically from ship) or space bar for manual firing
Bubbles (part of Baker's Trilogy)	Softape 10432 Burbank Blvd North Hollywood CA 91601	$29.95 for a disk containing Bubbles, Planetoids, and a racing game called Burnout	Apple II or II Plus with 32 K bytes of memory and one disk drive	one	three	paddle button 0
Planetoids (part of Baker's Trilogy)	Softape 10432 Burbank Blvd North Hollywood CA 91601	$29.95 for a disk containing Bubbles, Planetoids, and a racing game called Burnout	Apple II or II Plus with 32 K bytes of memory and one disk drive	one	three	ship fires automatically during game (no player control over firing
Asteron	Western MicroData Enterprises Ltd. POB G33 Postal Station G Calgary, Alberta T3A 2G1 Canada	$29.95	Apple II or II Plus with 48 K bytes of memory and one disk drive	one	three	space bar

Method of Turning Ship	Method of Moving Ship	Hyper-space Avail-able?	Sound Effects?	Number and Kind of Enemy Ships	Notes	Overall Impression
paddle 0	paddle button 0 causes movement until button released	no	yes	two kinds of enemy ships that shoot back	•See May 1981 BYTE, page 116, for a full review. •Hard level of play is too hard—ships get destroyed as soon as they appear.	•An interesting Asteroids-like game.
T and R keys, to rotate ship one-eighth turn clock-wise and counter-clockwise, respectively	O key causes movement until key released	yes (space bar)	no	five kinds of enemy ships that shoot back (with varying degrees of intelli-gence)	•See May 1981 BYTE, page 108, for a full review.	•The best TRS-80 Asteroids-like game I've seen.
paddle 1	paddle button 1 causes movement until button released	yes (any key ex-cept 0 through 9)	yes	two kinds of enemy ships that shoot back (enemy ships are colored yellow)	•A nice feature is that your ship rotates three com-plete turns for the full paddle move-ment; this prevents rotation problems when you are near the end of the pad-dle rotation.	•A good version of Asteroids (but the asteroids are shaped like apples—strange!) •Includes a Break-out-like game that is also very good. •A nice set of games for the price.
several: D and F keys, paddle 0; see notes	several: back arrow, paddle button 1; see notes	yes (space bar); screen flashes to denote hyper-space jump—a nice touch	yes (in-cluding an acceler-ating "thump-thump" sound as found in Space In-vaders)	two kinds of enemy ships that shoot back (size and shape same as in coin-operated game)	•Game gives four options for ship con-trol: one keyboard-only option and three that use key-board and/or paddles. •Sound effects cannot be turned off. •Control-C inverts playfield to black on white.	•Many options make this game very easy to play. •Display is flicker-free. •Game play is closest to coin-operated version of all versions listed here. •Easily the best Apple Asteroids-like game I've seen.
P, RETURN keys (manual turn), arrow keys (auto-matic turn), or paddle 0	Z key or pad-dle button 0; ship can use "auto brake" (moving ship does not coast indefi-nitely) or not	yes (asterisk key)	yes (in-cluding an acceler-ating "thock-thock" sound as found in Space In-vaders)	one kind of ship that shoots back (and is very ac-curate)	•An updated ver-sion of Asteroids in Space (reviewed on page 116 of the May 1981 BYTE). •Good placement of keys for key-board version.	•A very good Asteroids-like game (although it is not exactly like the original). •Game has five sets of options; dif-ferent combinations give several levels of difficulty.
paddle 0	none; hexa-gonal ship is fixed in center of screen	no	yes	no enemy ships	•Bubbles bounce back from the top and bottom edges of the screen. •Smallest bubbles are very small but still dangerous.	•An interesting variation of Asteroids.
paddle 0	paddle button 0 causes movement that con-tinues until an opposite thrust is applied	yes (any key)	yes	no enemy ships	•Planetoids are pentagons that come in four sizes. •Game gives extra points for "docking" (running over) with "stars" that decrease in size and vanish.	•An interesting variation of Asteroids.
paddle 0 or Q,U,W,I,E,O, R,P keys	button on paddle 0 (or C and M keys) causes move-ment that continues un-til an oppo-site thrust is applied	yes (hit any num-ber key)	yes; may be turned on and off with con-trol-Q	one kind of enemy ship that shoots back	•All figures on the screen flicker slightly. •Player must hit S key with each new ship to start (or re-start) game.	•A mediocre im-plementation; it is awkward to use and has no interesting features to com-pensate.

The Atari Tutorial

Part 4: Display-List Interrupts

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The display-list interrupt is one of the most powerful features built into the Atari personal computer system. It is also one of the least accessible features of the system, requiring of the programmer a firm understanding of assembly language as well as all of the other characteristics of the machine. Used alone, display-list interrupts provide no additional capabilities; they must be used in conjunction with the other features of the system, such as player-missile graphics, character-set indirection, or color-register indirection. With display-list interrupts, the full power of these features can be realized.

Display-list interrupts take advantage of the sequential nature of the raster-scan television display. The television draws the screen image in a time sequence, from the top of the screen to the bottom. This drawing process takes about 13,000 microseconds and looks instantaneous to the human eye. But that is a long time in comparison to the time scale the computer works in. The computer has plenty of time to change the parameters of the screen display while it is being drawn. Of course, the computer must make each change each time the screen is drawn, which happens 60 times per second. Also (and this is the tricky part), it must change the parameter in question at exactly the same moment each time the screen is drawn. That is, the cycle of changing screen parameters must be synchronized to the screen-drawing cycle. One way to do this might be to lock the 6502 microprocessor into a tight timing loop with an execution frequency of exactly 60 hertz. This would make it very difficult for the computer to do anything other than the screen-display computations. It would also be a tedious job. A much better way is to interrupt the 6502 just before the time has come to change the screen parameters. The 6502 responds to the interrupt, changes the screen parameters, and returns to its normal business. The interrupt to do this must be precisely timed to occur at exactly the same point during the screen-drawing process. This specially timed interrupt is provided by the ANTIC integrated circuit within the Atari 400/800; it is called a *display-list interrupt* (DLI).

With display-list interrupts, many key Atari registers can be changed during the drawing of a single screen-display frame.

The timing and execution of any interrupt process can be intricate; therefore, I shall first describe the sequence of events in a properly working display-list interrupt. The process begins when the ANTIC chip encounters a display-list instruction having its interrupt bit (bit D7) set. ANTIC waits until the last scan line of the mode line it is currently displaying. ANTIC then refers to its NMIEN (nonmaskable interrupt enable) register (hexadecimal location D40E) to see if display-list interrupts have been enabled. If the enable bit (bit D7) is cleared (to a logic 0), ANTIC ignores the interrupt and continues its regular tasks. If the enable bit is set (to a logic 1), ANTIC "pulls down" the NMI (nonmaskable interrupt) line on the 6502, signaling an interrupt. ANTIC then goes back to its normal display activities. The 6502 starts executing an interrupt-service routine pointed to by the NMI vector in the operating system. This routine first determines the cause of the inter-

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rupt. If the interrupt is indeed a display-list interrupt, control is transferred indirectly by means of the 16-bit address contained in hexadecimal locations 0200 and 0201 (low byte first) to a DLI-service routine. The DLI routine changes one or more of the graphics registers controlling the display. The 6502 then returns from the interrupt routine to resume its mainline program.

Creating a Display-List Interrupt

A number of steps are involved in setting up a display-list interrupt. The first thing you must do is write the DLI routine itself. The routine must start by pushing any 6502 registers that will be altered onto the stack, because the operating system interrupt-poll routine itself saves no registers. (The 6502 status register is automatically pushed onto the stack.) The routine should be short and fast; it should change only those registers related to the display; and it should end by restoring any 6502 registers pushed onto the stack.

Next, you must place the DLI-service routine somewhere in memory. Page six (hexadecimal addresses 600 to 6FF) is an ideal place. Set the vector at hexadecimal locations 0200 and 0201 to point to your routine. Determine the vertical point on the screen where you want the DLI to occur, and then go to the corresponding display-list instruction and set bit D7 of the *previous* instruction. Finally, enable the DLI by setting bit D7 of the NMIEN register at hexadecimal location D40E. The DLI will begin executing immediately.

As with any interrupt-service routine, timing considerations can be critical. ANTIC does not send the interrupt to the 6502 immediately upon encountering an interrupt instruction; it delays doing this until the last scan line of the interrupting mode line. The 6502 and the interrupt-service routine in the operating system together consume 33 machine cycles. Thus, the first instruction of your DLI-service routine will not be reached until 33 machine cycles have elapsed in the last scan line of the interrupting mode line. Thirty-three machine cycles corresponds to 66 color clocks on the screen. Thus, your DLI-service routine will begin executing while the electron beam is partway across the screen in the last scan line of the interrupting mode line. For example, if such a DLI routine changes a color register, the old color will be displayed on the left half of the scan line and the new color will show up on the right half of the same scan line. Because of uncertain timing in the response of the 6502 to an interrupt, the border between the colors will not be sharp, but will jiggle back and forth irritatingly.

The solution to this problem is provided in the form of the WSYNC (wait for horizontal sync) register (hexadecimal address D40A). Whenever this register is addressed in any way, the ANTIC chip pulls down the RDY line on the 6502. This effectively halts the 6502 until the WSYNC register is reset by the next horizontal synch pulse. The result is that the 6502 freezes until the electron beam returns to the left edge of the screen. If you insert a STA WSYNC instruction just before an instruction that stores a value into a color register, the color being displayed will change

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Listing 1: *A simple Atari BASIC program to demonstrate display-list interrupts. This program changes the screen color from blue to pink and darkens the character set halfway down the video display. The complete BASIC program in listing 1a contains the assembly-language routine given in listing 1b.*

1a

```
10 DLIST=PEEK(560)+256*PEEK(561):REM   find display list
20 POKE DLIST+15,130:REM               insert interrupt instruction
30 FOR I=0 TO 19:REM                   loop for poking DLI service routine
40 READ A:POKE 1536+I,A:NEXT I
50 DATA 72,138,72,169,80,162,88
60 DATA 141,10,212,141,23,208
70 DATA 141,24,208,104,170,104,64
80 POKE 512,0:POKE 513,6:REM           poke in interrupt vector
90 POKE 54286,192:REM                  enable DLI
```

1b

```
PHA          save accumulator
TXA
PHA          save X-register
LDA #$50     dark color for characters
LDX #$58     pink
STA WSYNC    wait
STA COLPF1   store color
STX COLPF2   store color
PLA
TAX
PLA          restore registers
RTI          done
```

while the beam is off the left edge of the screen. The color transition will occur one scan line lower, but it will be neat and clean.

The proper way to use a display-list interrupt, then, is to set the DLI bit on the mode line *before* the mode line for which you want the action to occur. The DLI-service routine should first save the 6502 registers onto the stack and then load the 6502 registers with the new graphics values to be used. It should execute a STA WSYNC immediately before storing the new values into the appropriate ANTIC or CTIA registers. Finally, it should restore the 6502 registers and return from the interrupt. This procedure will guarantee that the graphics registers are changed while the electronic beam is off the screen and that the new display parameters take effect at the beginning of the desired line.

The program in listing 1 is a very simple DLI-service routine. It changes the background color from blue to pink. It also changes the color of the characters so that they show up as dark against the pink background. The upper half of the screen remains

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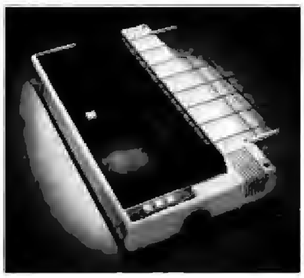

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blue even though the DLI routine keeps stuffing pink into the color register. This is because the operating system's vertical-blank-interrupt routine keeps stuffing blue into the color register during the vertical-blank period. The blue color comes from the operating system's shadow register for that color register. Every hardware color register is shadowed out to a RAM (random-access read/write memory) location. You may already know about these shadow registers at decimal locations 708 through 712. For most purposes, you can change colors by poking values into the shadow registers (see last month's article for an explanation of shadow registers). If you poke directly into the hardware registers, the operating system shadow process will wipe out your poked color within $\frac{1}{60}$ second (ie: at the top of a new screen display). For DLIs, however, you must store your new color values directly into the hardware registers. You cannot use a DLI to set the color of the first displayed line of the screen. The operating system takes care of that line for you (and the first line is off the top of the screen, anyway). Use DLIs to change colors of lines below the first line.

By stuffing colors directly into the hardware registers, you create a new problem: you defeat the automatic attract mode. Attract mode is a feature provided by the operating system. After nine minutes without a keypress, the colors on the screen begin to cycle through random hues at lowered luminances. This insures that a computer left unattended for several hours does not burn an image into the television screen.

It is easy to build attract mode into a DLI routine by inserting only two lines of assembly code, as shown in listing 2.

Listing 2: *Restoring the Atari attract mode to a display driven by display-list interrupts. Only two 6502 assembly-language instructions have to be added to the DLI routine. DRKMSK and COLRSH are page zero locations (hexadecimal 4E and 4F) set up and updated by the operating system during the vertical blank interrupt. When the attract mode is not in force, COLRSH takes a value of 00 and DRKMSK takes a value of hexadecimal FF. When attract mode is in force, COLRSH is given a new random value every four seconds and DRKMSK holds a value of hexadecimal F6. Thus, COLRSH scrambles the color and DRKMSK lops off the high-order luminance bit.*

```
LDA NEWCOL      LDA NEWCOL
STA WSYNC       EOR COLRSH
STA COLPF2      AND DRKMSK
                STA WSYNC
                STA COLPF2
```

The implementation of attract mode in display-list interrupts exacerbates an already difficult problem: the shortage of execution time during a DLI. A description of DLI timing will make the problem more obvious.

DLI Timing

DLI execution is broken into three phases. Phase 1 covers the period from the beginning of the DLI to the STA WSYNC instruction. During phase 1, the electron beam is drawing the last scan line of the interrupting mode line. Phase 2 covers the period from the STA WSYNC instruction to the appearance of the beam on the television screen. Phase 2 corresponds to the horizontal blank; all graphics changes should be made during this phase. Phase 3 covers the period from the appearance of the beam on the screen to the end of the DLI-service routine. The timing of phase 3 is not critical.

One horizontal scan line takes 114 clock cycles of real time. A DLI reaches the 6502 on or around cycle number 15. The 6502 takes about 7 cycles to respond to the interrupt. The operating-system routine to service the interrupt and turn control over to the DLI-service routine takes 11 machine cycles. Thus, the DLI-service routine does not gain control until about 33 clock cycles have elapsed. Furthermore, the STA WSYNC instruction must begin by cycle number 103; this reduces the time available in phase 1 by 11 cycles. Finally, ANTIC's DMA (direct memory access) will steal some of the

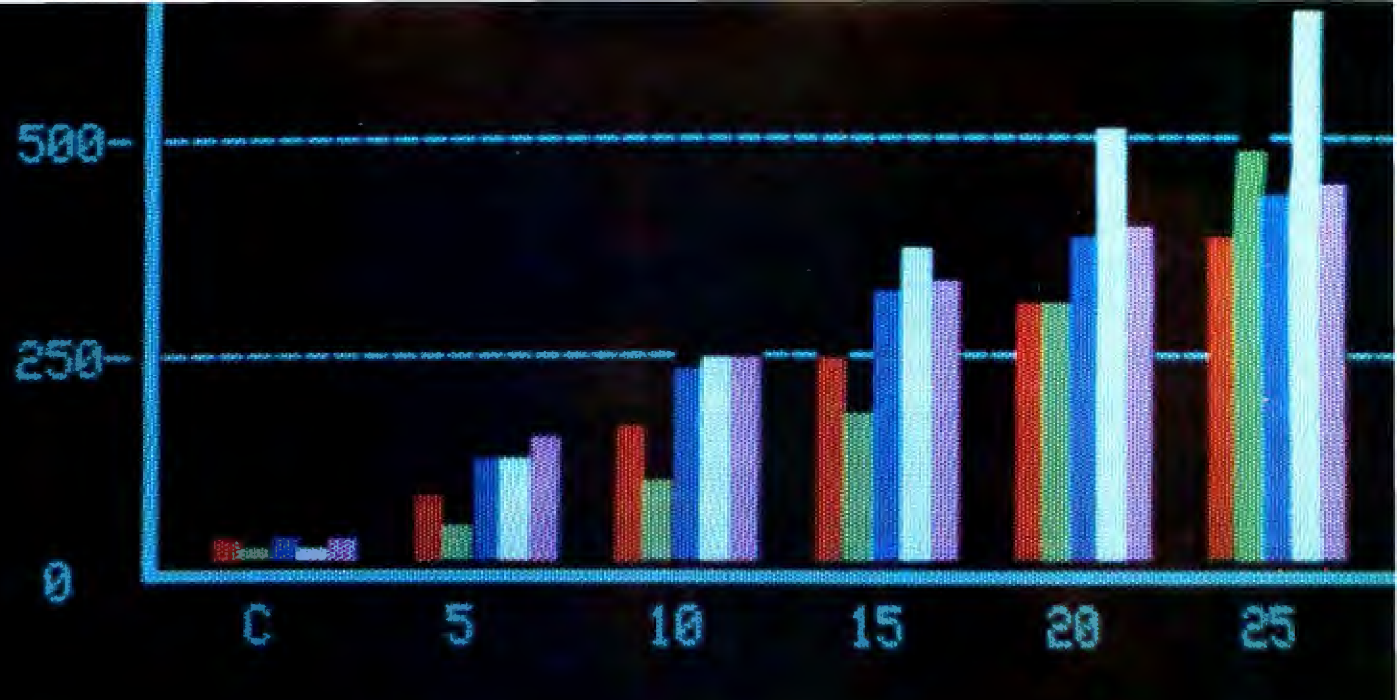
remaining clock cycles from the 6502. Nine cycles will be lost to memory-refresh DMA. This leaves an absolute maximum of 61 cycles available for phase 1. This maximum is achieved only with blank-line mode lines. Character and map mode instructions will result in the loss of one cycle for each byte of display data. The worst case arises with BASIC modes 0, 7, and 8, which require 40 bytes per line. Only 21 machine cycles are available to phase 1 in these modes. Thus, a phase 1 routine will have from 21 to 61 machine cycles of execution time available to it.

Phase 2, the critical phase, extends over 24 clock cycles of real time. As with phase 1, some of these cycles are lost to cycle-stealing DMA. Player-missile graphics will cost 5 cycles if they are used. The display instruction will cost 1 cycle. Two more cycles will be stolen if the Load Memory Scan option in the display list is used. Finally, 1 or 2 cycles may be lost to memory refresh or display-data retrieval. Thus, from 14 to 23 usable machine cycles are available to phase 2.

The problems of DLI timing now become obvious. To load, attract, and store a single color will consume 14 cycles. Saving the 6502 A, X, and Y registers onto the stack and then loading, attracting, and saving three colors into A, X, and Y registers will cost 47 cycles: most, if not all, of phase 1. Obviously, the programmer who wishes to use DLIs for extensive graphics changes will expend much effort on the timing of the DLI. *Fortunately, the beginning programmer need not concern himself with extensive timing calculations.* If only single-color changes or simple graphics operations are to be performed, cycle counting and speed optimization are unnecessary. These considerations are only important for high-performance situations.

No simple options are available to the programmer who needs to change more than three color registers in a single DLI. It might be possible to load, attract, and store a fourth color early in phase 3, if that color is not displayed on the left edge of the screen. Similarly, a color not showing up on the right side of the screen could be changed during phase 1. Another approach is to break one overactive DLI into two less ambitious DLIs, each doing half the work of the original. The second DLI could be provided by inserting a single-scan-line blank instruction (with the DLI bit set) into the display list just below the main interrupting mode line. This will, of course, consume some screen space.

Another partial solution is to perform the attract chores during vertical-blank periods. To do this, two tables of colors must be kept in memory. The first table contains color values intended to be displayed by the DLI routines. The second table contains the attracted values of these colors. During vertical blank, a user-supplied interrupt-service routine fetches each color from the first table, attracts it, and stores the attracted color in the second table. The DLI



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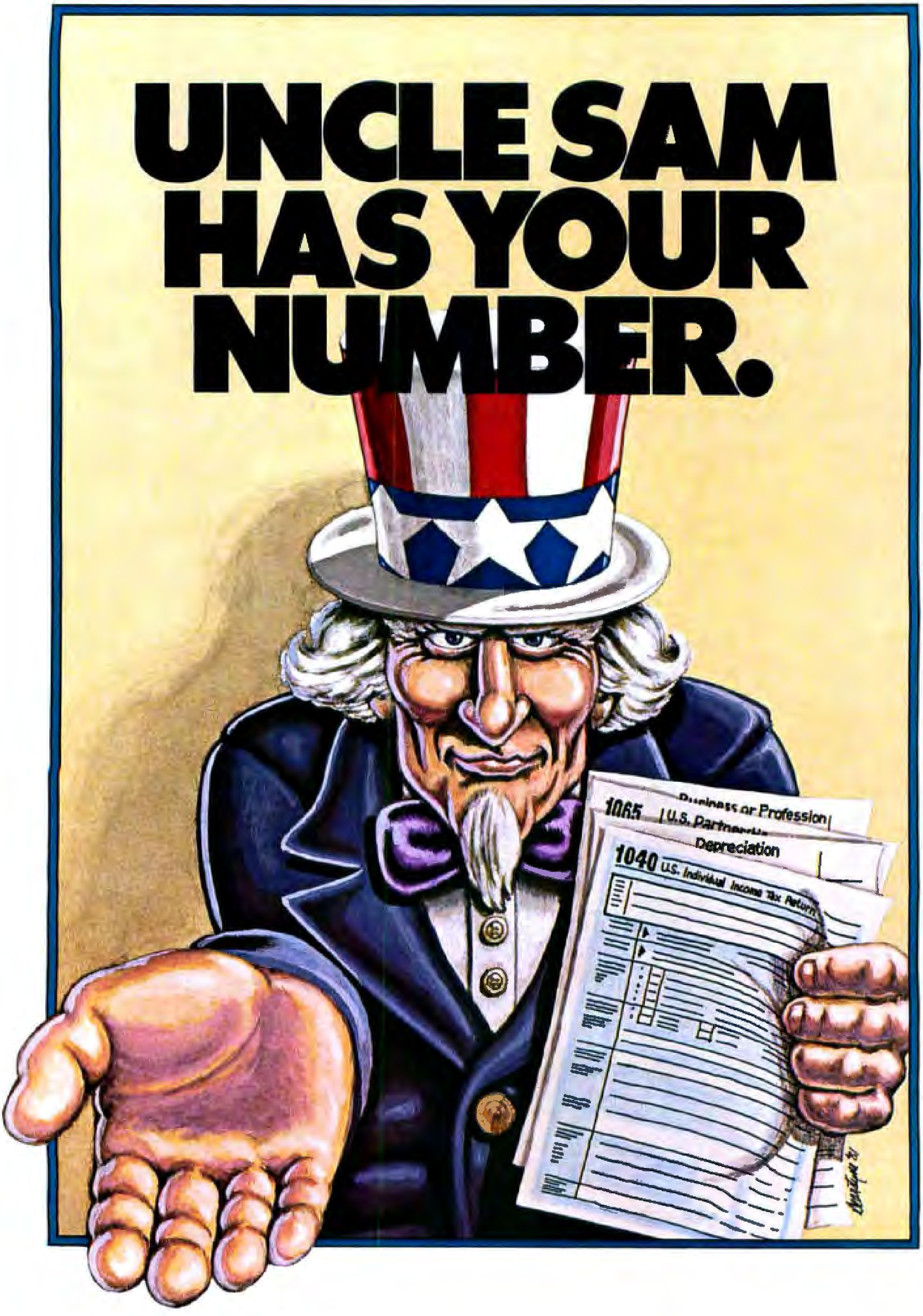
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7 DISPLAY TRIAL RETURN                 17 EXIT TO PARTNERSHIP TAX SYSTEM
8 PRINT RETURN                         18 LOAD SALES TAX TABLE
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```

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Listing 3a: *An assembly-language routine which is included in the multiple display-list-interrupt program shown in listing 3b.*

```
        PHA
        TXA
        PHA
        INC COUNTR
        LDX COUNTR
        LDA COLTAB,X   use page $F0 for color table
        STA WSYNC      wait
        STA COLBAK
        CPX #$4F       last line?
        BNE ENDDLI     no, exit
        LDA #$00       yes, reset counter
        STA COUNTR
ENDDLI  PLA
        TAX
        PLA            restore accumulator
        RTI
```

routine then retrieves values directly from the second table without paying the time penalty for attract.

Multiple Display-List Interrupts

It is often desirable to have a number of DLIs occurring at several vertical positions on the screen. This is an important way to add color to a display. Unfortunately, there is only one DLI vector; if multiple DLIs are to be used, then the vectoring to the appropriate DLI must be implemented in the DLI routine itself. There are several ways to do this. If the DLI routine does the same process with different values, then it can be table-driven. On each pass through the DLI routine, a counter is incremented and used as an index to a table of values. A sample DLI routine for doing this is given in listing 3.

Another way to implement multiple display-list interrupts is to use a DLI counter as a test for branching through the DLI-service routines to the proper DLI-service routine. This slows down the response of all the DLIs, particularly the ones at the end of the test sequence. A third method is to have each DLI-service routine write the address of the next routine into the DLI vector at hexadecimal locations 200 and 201. This should be done during phase 3. It is the most general solution to the problem of multiple DLIs and has the additional advantage that vectoring logic is per-

Listing 3b: *A simple Atari BASIC program to demonstrate multiple display-list interrupts. This program puts 80 different colors on the video display. The complete BASIC program shown here contains the assembly-language routine given in listing 3a.*

```
10 GRAPHICS 7
20 DLIST=PEEK(560)+256*PEEK(561):REM   find display list
30 FOR J=6 TO 84:REM                   give every mode line a DLI
40 POKE DLIST+J,141:REM                BASIC mode 7 with DLI bit set
50 NEXT J
60 FOR J=0 TO 30
70 READ A:POKE 1536+J,A:NEXTJ:REM      poke in DLI service routine
80 DATA 72,138,72,238,32,6,175,32,6
90 DATA 169,0,240,141,10,212,141,26,208
100 DATA 224,79,208,5,169,0
110 DATA 141,32,6,104,170,104,64
120 POKE 512,0:POKE 513,6:REM          vector to DLI service routine
130 POKE 54286,192:REM                 enable DLI
```

formed after the time-critical portion of the DLI, not before.

Keyboard-Click Routine

The operating system keyboard-click routine interferes with the function of the DLI. Whenever a key is pressed and acknowledged, the on-board speaker is clicked. The timing for this click is provided by several STA WSYNC instructions. This can throw off the timing of a DLI routine and cause the screen colors to jump downward by one scan line for a fraction of a second. There is no easy solution to this problem. One possible remedy involves the VCOUNT register (hexadecimal location D40B), a read-only register in ANTIC that tells what scan line ANTIC is displaying. A DLI routine could examine this register to decide when to change a color. Another solution is to disable the operating system keyboard-service routine (a tedious job) and provide your own keyboard routine. A third alternative is to accept no inputs from the keyboard. If keypresses are not acknowledged, the screen jiggle does not occur.

Kernels

The display-list interrupt was designed to replace a more primitive software/hardware technique called a kernel. A kernel is a 6502 program loop that is precisely timed to the display cycle of a television set. By monitoring the VCOUNT register and consulting a table of screen changes catalogued as a function of VCOUNT values, the 6502 can arbitrarily control all graphics values for the entire screen. A high price is paid for this power: the 6502 is not available for computations during the screen-display period, which is about 75 percent of the time. Furthermore, no computation may consume more than the 4000 or so machine cycles available during vertical-blank and overscan periods. This restriction means that kernels can only be used with programs requiring little computation, such as certain skill and action games. For example, the Basketball program for the Atari 400/800 uses a kernel; the program requires little computation but much color. The multicolored players in this game could not be done *with* display-list interrupts because DLIs are keyed to playfield vertical positions, not player positions.

It is possible to extend the kernel idea right into a single scan line and change graphics registers on the fly. In this way, a single color register can present several colors on a single scan line. The horizontal position of the color change is determined by the amount of time that elapses before the change goes in. Thus, by carefully counting machine cycles you can get more graphics onto the screen. Unfortunately, this is extremely difficult to achieve in practice. With ANTIC performing DMA on the 6502, it is very difficult to know exactly how many cycles have really elapsed; a simple count of 6502 cycles is not adequate.

If ANTIC's DMA is turned off, the 6502 can assume full control of the display, but it must then perform all the work that ANTIC normally does. For these reasons, horizontal kernels are seldom worth the effort. If the two images to be displayed in different colors are widely separated, however, say by 20 color clocks or more, the separation should cover up the timing uncertainties and render this technique feasible.

Using Display-List Interrupts

The tremendous value of graphics indirection and all those modifiable registers in the hardware now becomes obvious. With display-list interrupts, every one of those registers can be changed dynamically. You can put lots of color, graphics, and special effects onto the screen. The most obvious application of DLIs is to put more color onto the screen. Each color register can be changed as many times as you have DLIs. This applies to both playfield color registers and player color registers. Thus, you have up to nine color registers, each of which can display up to 128 different colors. Of course, a normal program could not effectively use all of those colors. Too many DLIs start slowing down the whole program, and sometimes the screen layout cannot accommodate all of them. In practice, displaying a dozen colors is easy, two dozen requires careful planning, and more than that requires a contrived situation.

But DLIs can give more than color. They can also be used to extend the power of player-missile graphics by changing the horizontal position of a player. In this way, a player can be repositioned partway down the screen. A single player can then have several incarnations on the screen. If you imagine a player as a vertical column with images drawn on it, a DLI becomes a pair of scissors with which you can snip the column and reposition sections of it on the screen. Of course, no two sections of the player can be on the same horizontal line, and so two incarnations of the player cannot be on the same horizontal line. If your display needs allow graphics objects that will never be on

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the same horizontal line, a single player can do the job.

Another way DLIs can be used in conjunction with players is to change their width or priority. This would most often be used along with the priority-masking trick described in part 3 of this series last month.

DLIs can also be used to change character sets partway down the screen. This allows a program to use character graphics in a large window and regular text in a text window. Multiple character-set changes are possible. A program might use one graphics character set at the top of the screen, another graphics character set in the middle of the screen, and a regular text character set at the bottom. A "Rosetta Stone" program would also be possible, showing different text fonts on the same screen. The vertical reflect bit can be changed with a DLI routine, allowing some text to be right side up and other text to be upside down.

The proper use of the DLI requires careful layout of the screen display. Designers must give close consideration to the vertical architecture of their displays. The raster-scan television system is not two-dimensionally symmetric; it has far more vertical structure than horizontal structure. This is because the pace for horizontal screen drawing is about 200 times faster than the pace for vertical screen drawing. The Atari 400/800 display system was designed specifically for raster-scan television, and it mirrors the anisotropy of the raster-scan system. The Atari 400/800 display is not a flat, blank sheet of paper on which you draw; it is a stack of thin strips, each of which can take different parameters. The programmer who insists on designing an isotropic display wastes many opportunities. You will achieve optimal results when you organize the information you wish to display in a strong vertical structure. This allows the display-list interrupt to be used to its greatest potential. ■

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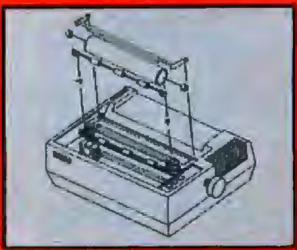

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How to Build a Maze

David Matuszek
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Mazes are fun to solve. With a little imagination, mazes can be incorporated into many different computer games. If you know how, it's a simple matter to use the computer to generate random mazes.

A traditional maze has one starting point and one finishing point. In addition, all locations inside the maze are reachable from the start, and there is one and only one path from start to finish. While it is easy to place doorways and barriers randomly inside a maze, it is more difficult to satisfy the two latter constraints. This article describes a fairly simple method that efficiently produces a random traditional maze.

The General Approach

We begin with a rectangular array. Each cell of the array is initially completely "walled in," isolated from its neighbors (see figure 1).

Secondly, we judiciously erase walls inside the array until we arrive at a structure with the following property: for *any* two cells of the array, there is only one path between them. Thus, any cell can be reached from any cell, but only by a single unique path (see figure 2). Computer-science jargon refers to such a structure as a *spanning tree*, and it is the creation of this spanning tree that is the tricky part of building a maze.

Finally, the border of the maze is broken in two places to provide a start and a finish position. Since there is a unique path between *any* two cells of the maze, there will be a unique path from start to finish. Hence, start and finish can be chosen in any convenient manner, say, at random locations on opposite sides of the maze (see figure 3).

Building the Spanning Tree

Starting with a fully "walled-up" array (see figure 1), pick a single cell in the array and call this cell the

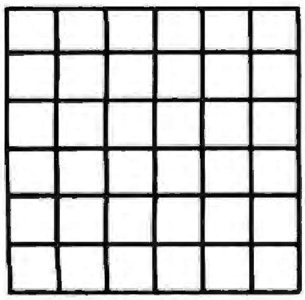

Figure 1: *The initial array from which the maze will be constructed.*

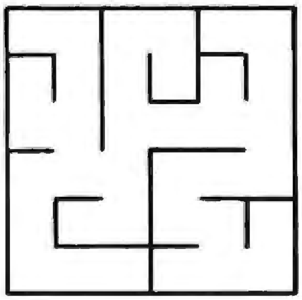

Figure 2: *One possible spanning tree for the array in figure 1.*

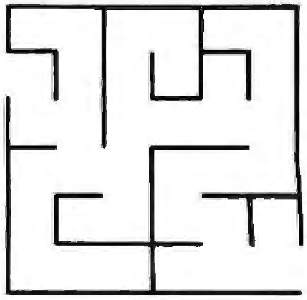

Figure 3: *The spanning tree from figure 2 with possible entry and exit points added.*

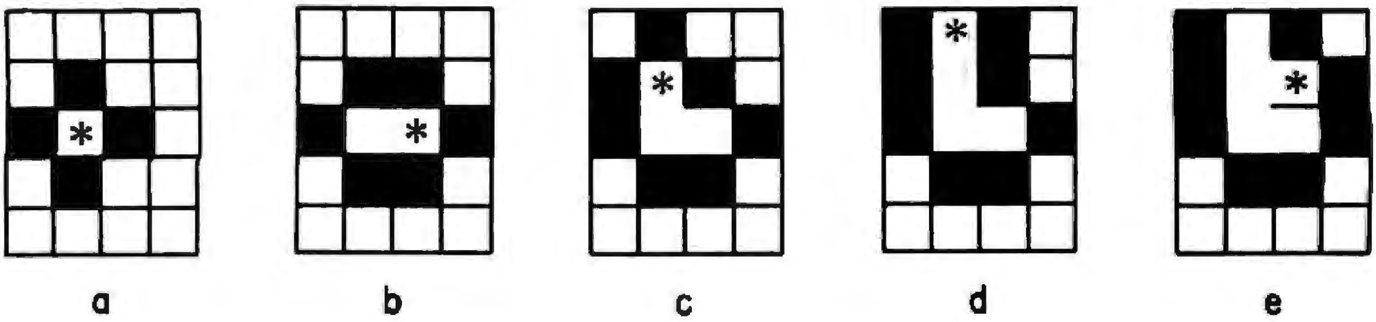

Figure 4: *Initial steps involved in building a maze. The cell added at each step is marked with an asterisk. The next cell to be added to the maze will be selected from the shaded frontier cells.*

spanning tree. Then adds cells one at a time to the spanning tree until it fills the entire array.

At any point during this procedure, there will be three types of cells in the array:

- those that are already in the spanning tree
- those that are not in the spanning tree, but are immediately adjacent (horizontally or vertically) to some cell in the spanning tree (we call these cells *frontier cells*)
- all the other cells

The algorithm follows:

1. Choose any cell of the array and call it the spanning tree. The four cells immediately adjacent to it (fewer if it is on an edge or in a corner) thus become frontier cells.
2. Randomly choose a frontier cell and connect it to *one* cell of the current spanning tree by erasing *one* barrier. If it is adjacent to more than one cell of the spanning tree (and it could be adjacent to as many as four!), randomly choose one of them to connect it to, and erase the appropriate barrier.
3. Check the cells adjacent to the cell just added to the spanning tree. Any such cells that are not part of the spanning tree and have not previously been marked as frontier cells must now be marked as frontier cells.
4. If any frontier cells remain, go back to step 2.
5. Choose start and finish cells.

Figure 4 shows the first few steps in building a maze. In each case the array is shown as it would be just before execution of step 2 of the algorithm. Note that the newly added cell (marked by an asterisk) in figure 4e was adjacent to *two* cells in the spanning tree, yet it was connected to only one of these (the one to its left) by randomly choosing and erasing *one* barrier.

If you're mathematically inclined, it is easy to show by induction that this process results in a spanning tree. When the tree consists of a single cell, there is (vacuously) only one path between any pair of cells. As each new cell is added, it forms no new paths between cells already on the tree (since the tree is a dead end), and there is exactly one path from the new cell to any other cell (you can get out via only one cell, and from that cell there is only one path). Finally, the process ends when there are no more frontier cells (cells adjacent to the spanning tree but not in it), and this can happen only when all cells have been absorbed into the spanning tree.

Implementation Details

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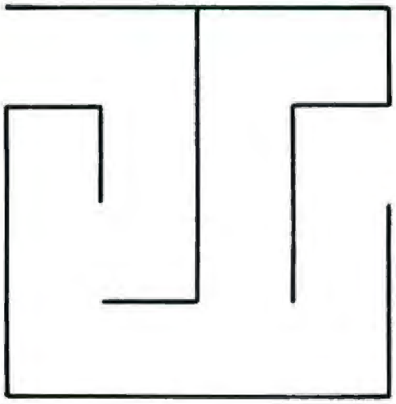
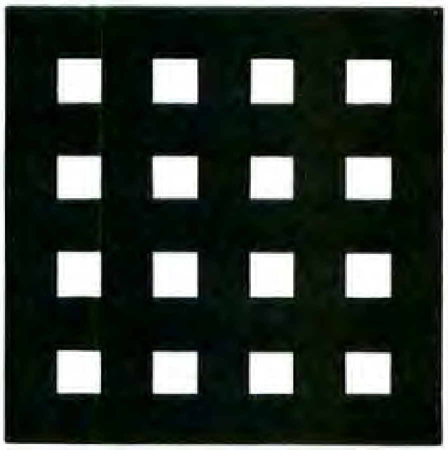


5a



5b

5c

Figure 5: *For an* m *by* n *maze to be displayed on a computer graphics system, a resolution of at least* $2m+1$ *by* $2n+1$ *must be available. The 4- by 4-maze array of figure 5a requires a graphics array of 9 by 9. The initial cells of the 4 by 4 array are shown displayed using the 9 by 9 resolution in figure 5b. The finished maze, with openings between the cells where paths exist, is shown in figure 5c.*

array a number indicating: 1. whether it is in the spanning tree, in the frontier, or in neither; and 2. if it is in the spanning tree, which of the cell's barriers have been erased. One possibility is to use—1 for frontier cells, positive numbers for cells, positive numbers for cells in the spanning tree, and 0 for all other cells.

any cell of the spanning tree is open to at least one other cell, I suggest the following encoding: start with 0 in each cell, add 1 if the barrier on the right is erased; add 2 if the barrier below is erased; add 4 if the barrier on the left is erased, and add 8 if the barrier above is erased. The result will be a number from 1 to 15 that specifies exactly which combination of barriers has been erased. (Decoding this number shouldn't be too hard if you work with binary numbers.) Note that when you erase a barrier between two cells you will have to add the appropriate numbers to each of them.

The minor exception mentioned above is the initial cell of the spanning tree, immediately after step 1 of the algorithm (see figure 4a). Since it is the first, it is not yet open to any other cell. Give it the value 16 (or 100, or 1984, if you prefer) so that it will be positive, and subtract this number out again in step 5.

Now that the array representation has been settled, let's discuss efficient implementation of the algorithm. In step 2 a frontier cell was randomly chosen. To prevent bumbling around in the array, you must keep a list of those cells. This can be simply accomplished by storing the indices of the n cells of the frontier (each of which is specified by a row number and a column number) in the first n locations of two arrays, R (row numbers) and C (column numbers). A frontier cell can be quickly chosen by randomly choosing a k less than or equal to n, and using the cell whose indices are given by $R(k)$, $C(k)$.

Since the order of the n frontier cell locations in arrays R and C is not important, the following code suffices to remove the chosen cell k:

$R(k) = R(n)$
$C(k) = C(n)$
$n = n-1$

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Figure 6: *The maze of figure 5 as it might appear as printed output, with each maze-array element represented by space characters or X characters. One space or X is used in 6a; two spaces or Xs are used in 6b.*

When this frontier cell is added to the spanning tree, some of the cells adjacent to it (those having a zero value) become new frontier cells, and their locations must be inserted into the R and C arrays. Adjacent cells with value -1 are already frontier cells and already have their locations recorded in the R and C arrays; they must not be inserted again.

Finally, how large should arrays R and C be? For an m by n array, analysis shows that in the worst case $(2/3)\ mn$ locations will be required, but practical experience shows that $3(m+n)$ is almost always enough. However, if you use the latter figure there is a slight probability that the program will fail.

Concluding Remarks

While we have discussed building a maze, nothing has been said regarding how to display it. That depends entirely on your particular hardware and software; the answers are different for the display screen of a Commodore PET than for that of an Apple II, and different again for a character printer.

To display a maze on a screen with graphics capabilities, the following scheme is appropriate. For an m by n maze, you need to be able to display at least $2m+1$ points vertically and $2n+1$ points horizontally—the "cells" will be those points at the intersection of even-numbered rows with even-numbered columns (see figures 5a through 5c). Maze building on the screen proceeds exactly as in figures 1 through 3, except that the walls are necessarily thicker.

To print a maze out, the same general scheme is used with, say, "X" characters for walls and blanks for paths (see figure 6). Of course, you can't erase an X once it is printed, so it will be necessary to build the entire maze internally before printing it. Then you can decipher and print the maze one row at a time.

As a final note, if you are an aficionado of hexagonal grids, the maze algorithm is easily modified for other than rectangular grids. Implementation may be a bit messy—but then, implementation is always messy. ■

Toward a Structured 6809 Assembly Language

Part 2: Implementing a Structured Assembler

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3501 Ed Bluestein Blvd
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Assembly-language programmers can have their cake and eat it too. They need not be shut out of the world of structured programming in order to make the most efficient use of a particular computer. Part 1 of this article showed a set of structured control statements that can be added to the 6809 assembly language. Now the magician will pull back the curtain to show how it was all done: I will present the actual code for the MC6809 structured macros and explain their operation.

However, I will not stop there. As several areas of programming-language design and implementation come together to produce a structured assembly language, it is tempting to look beyond the present and try to visualize where these techniques might lead. This article will conclude with some speculation on just how "high-level" an assembly language might become.

It is not necessary to buy a new assembler in order to use these structured contol statements. Any assembler that allows user-defined macroinstructions will allow the implementation of structured control statements. Before going into a detailed presentation of the Motorola MC 6809 macroassembler, I would like to discuss macros in general for those readers who may not be familiar with them.

Listing and figure caption numbers continued from Part 1.

What Is a Macro?

Macros, like subroutines, are a way of assigning a single name to a complex sequence of operations. While subroutines are found in virtually all programming languages, macros are much less widely used. Macros and subroutines have many similarities and one major difference. First we will look at the similarities.

In assembly language, macros and subroutines are similar in appearance and in the way they are used. Each must be defined before it is used (ie: its name must be associated with the sequence of instructions that perform its operation). Then, whenever that sequence of operations is needed in a program, the subroutine or macro is *called*.

With a subroutine, the instructions that define its operation exist only once, and a "call" instruction transfers control to that subroutine from every place its operation is needed. A macro is different in that the instructions that define its operation are inserted directly into a program wherever they are needed. Thus, an obvious difference between a subroutine and a macro is that a subroutine reduces program size because its instructions exist in memory only once, while a macro takes more memory because its instructions are stored once for each time the macro is used. A macro is also faster because the subroutine CALL and RETURN instructions are not needed.

The above difference is technically correct, but it misses the truly significant difference between subroutines and macros: a macro is expanded *at translation time*, while a subroutine is expanded *at execution time*. By "expanded," I mean the operation of replacing a single name with the complex sequence of instructions that defines its operation. An example should clarify this distinction.

Suppose I want to be able to shift any of the microprocessor's three index registers to the right. Using subroutines, I will need three separate subroutines, one for each register. These subroutines are given in listing 10. Here each subroutine has an implicit parameter—the register to be shifted right. Having written these subroutines, I can now use them by inserting a call instruction into the program by using the form:

```
        LBSR    SHRTX
```

or:

```
        LBSR    SHRTY
```

At translation time, each subroutine will be translated from assembly instructions into the equivalent machine instructions and placed at a particular location in memory. Similarly, the LBSR SHRTX will be translated to the machine instruction that branches to the location where SHRTX starts in memory. In essence,

Text continued on page 204

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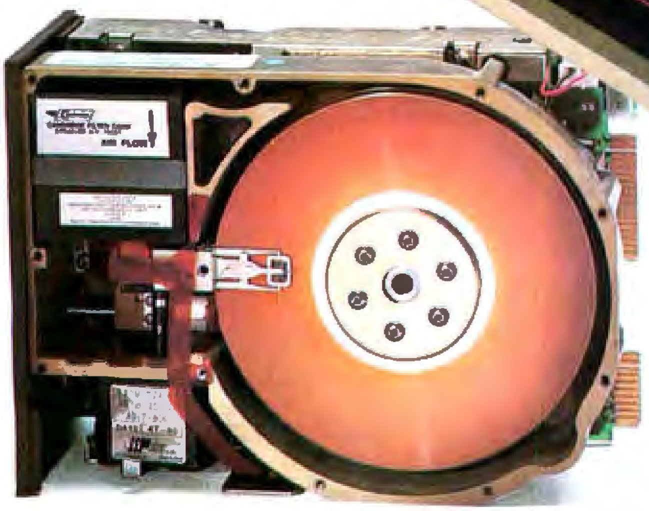

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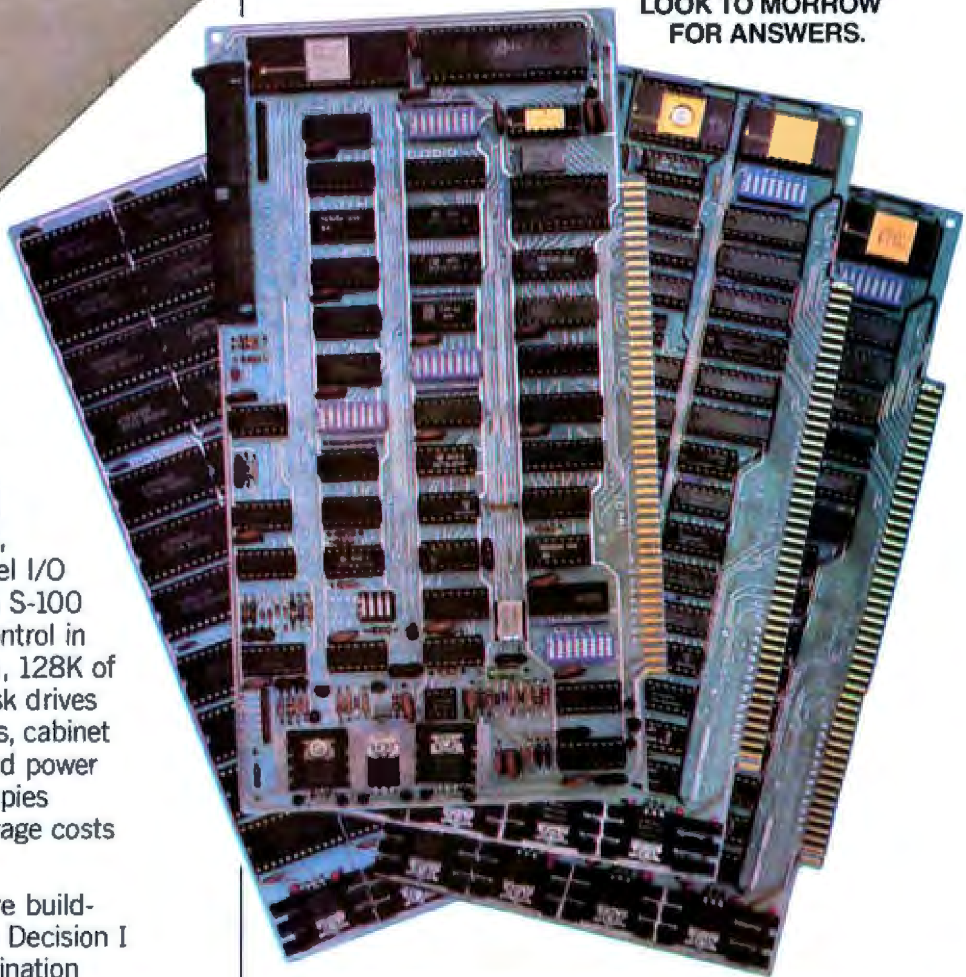

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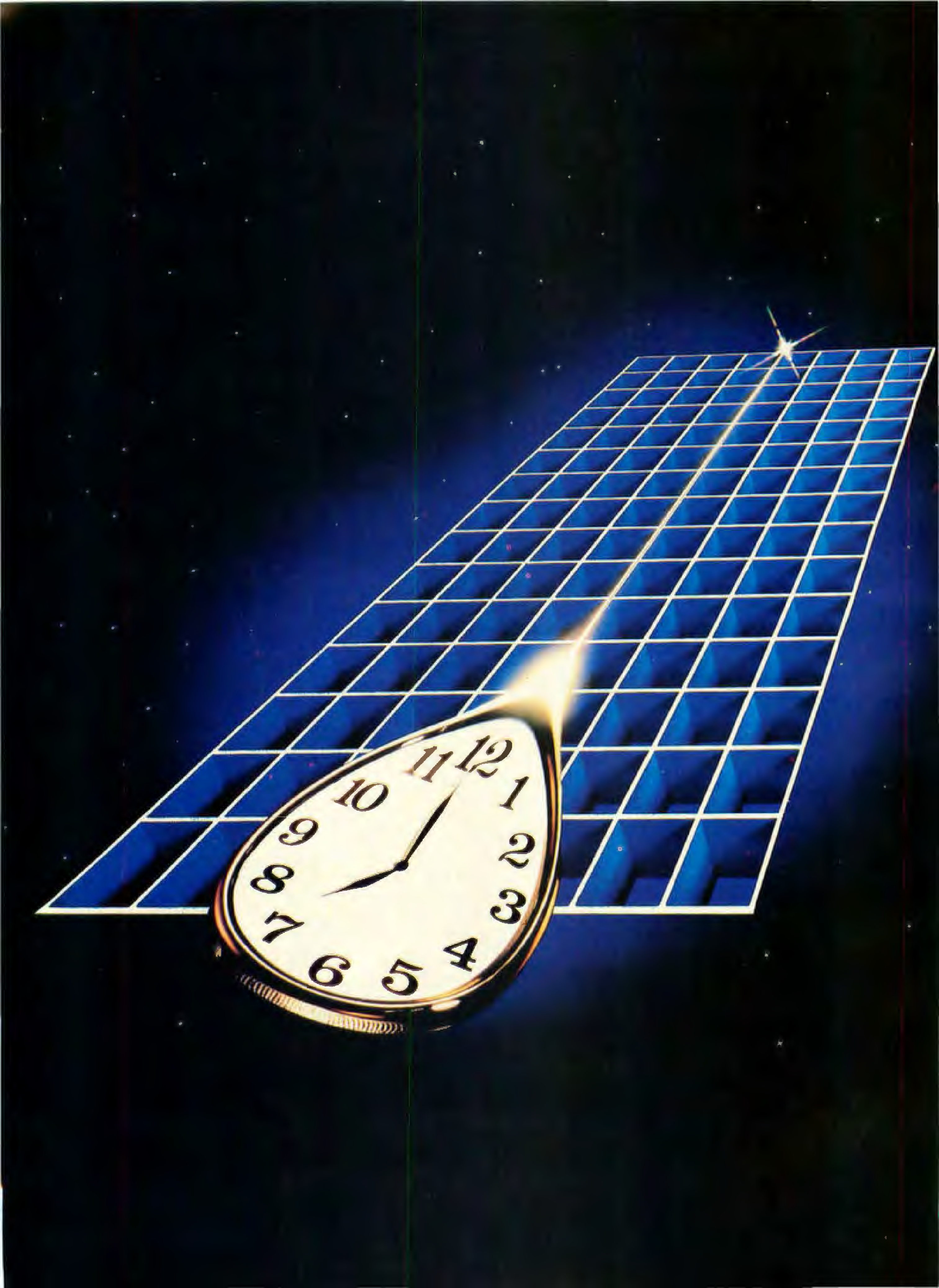

Listing 10: *Subroutines for 16-bit right-shift operation.*

```
*
*        SHIFT X-REGISTER RIGHT ONE BIT
*
SHRTX    EXG      X,D
         LSRA
         RORB
         EXG      D,X
         RTS
*
*        SHIFT Y-REGISTER RIGHT ONE BIT
*
SHRTY    EXG      Y,D
         LSRA
         RORB
         EXG      D,Y
         RTS
*
*        SHIFT U-REGISTER RIGHT ONE BIT
*
SHRTU    EXG      U,D
         LSRA
         RORB
         EXG      D,U
         RTS
```

Listing 11: *Assembly-language macro to shift a 16-bit register value one bit to the right.*

```
*
*        Shift a 16-bit register right one bit
*
SHRT     MACR
         EXG      \0,D
         LSRA
         RORB
         EXG      D,\0
         ENDM
```

Text continued from page 198:
there has been no expansion yet, because the subroutine call still refers to the subroutine by a single name (ie: its starting location).

During execution, the computer will step through the program, performing each instruction in turn. When it comes to the machine code for LBSR SHRTX, control will transfer to the beginning of the SHRTX subroutine, and the computer will perform the instructions that define SHRTX. At the end of the subroutine, execution will return to the instructions following the subroutine call.

This explanation will seem like old hat to anyone who has written a subroutine, but the details are necessary in order to show that the subroutine has been expanded at execution time. Only when the subroutine call is executed does the call, in effect, expand into the operations that define it.

With the subroutine case firmly in mind, you may have already guessed how macros are expanded at translation time. Listing 11 shows the shift-right operation written as a macro for the MC6809. In this case, one macro suffices to provide the shift-right operation for all three registers.

The \0 in listing 11 represents a macro parameter that is replaced with a register name when the macro is expanded. The \0 refers to the first parameter in the macro call line; wherever the \0 appears in the macro, the first parameter will be substituted in its place. (The substitution is purely a text manipulation. The characters that make up the first parameter in the macro call are substituted for the \0 characters in the macro body.) A macro call is written by simply placing the macro name as an assembly operation with the parameters in the operand field of the same line. Listing 12 shows examples of calls to the SHRT macro and the actual instructions generated by the macro expansion.

The instructions that define the macro are inserted into the program wherever there is a macro call. Admittedly they take up more memory than a single branch-to-subroutine instruction, but that property is far less important than the power you gain by being able to substitute specific values for the macro parameters during translation. In this case, we have defined a similar operation on three

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	— Actual —			Growth		Total	—Projected—		
	1978	1979	1980	Rate	Average	(000's)	1981	1982 *	1985
Item A	**42,323**	**51,891**	**65,123**	24.04	53,112	159.34	80,782	100,206	191,262
Item B	**45,671**	**46,128**	**49,088**	3.67	46,962	140.89	50,891	52,761	58,791
Total	87,994	98,019	114,211	13.93	100,075	300.22	131,673	152,966	250,053
% Item	48.10	52.94	57.02	8.88	52.69	158.1	61.35	65.51	76.49
% Item	51.90	47.06	42.98	-9.00	47.31	141.9	38.65	34.49	23.51
Total	100.00	100.00	100.00	—	100.00	300.0	100.00	100.00	100.00

*Two intervening years not shown.

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Listing 12: *Expansion of macroinstructions.*

```
Call                          Expansion

LDX     CAT                   LDX     CAT
SHRT    X                     EXQ     X,D
STX     CAT                   LSRA
                              RORB
                              EXG     D,X
                              STX     CAT

LDY     DOG                   LDY     DOG
SHRT    Y                     EXQ     Y,D
STY     DOG                   LSRA
                              RORB
                              EXG     D,Y
                              STY     DOG
```

Listing 13: *Format for Motorola MC6809 macroassembler directives.*

```
  1) Conditional assembly based on character string comparison

        IFC     <character string>,<character string>
            (Statements generated if character strings
                are the same, else skip to ENDC.)

        ENDC

  2) Conditional assembly based on comparison of a numeric expression
     with zero.

        IFEQ    <numeric expression>
             (Statements generated if expression is equal
                to zero, else skip to ENDC.)
        ENDC

  3) Assign a new value to a label.

<label> SET     <value>
```

different registers by writing only one macro—one-third as much programming as was required by the subroutine approach.

In addition to parameter substitution, many macroassemblers provide the ability to perform *conditional assembly* (similar to branching around instructions with a conditional branch instruction, except that conditional assembly occurs during translation of the program). A test is made at translation time, and two different sequences of instructions are produced, depending on the outcome of the test.

Assemblers also use labels to associate a name with a particular value. Labels are usually used to assign a written name to a particular memory location. In a more general sense, though, they can also be used as translation-time variables for storing numeric values. Listing 13 shows the capabilities of the Motorola MC6809 macroassembler used in the structured macros.

Implementation Details

Listing 14 shows the macro definitions that add structured statements to the 6809 assembly language. The first seven macros, PUSH, POP, BACK1, RELOP, RELTST, RELCC, and REGTST, provide primitive operations that are used by the structured macros.

PUSH, POP, and BACK1 implement a translation-time stack, which is needed if the structures are to be nested one inside another. Two parallel stacks, each ten levels deep, are set up using the labels S1 through S10 and L1 through L10. The symbols S1 through S10 store the locations of branch instructions that are generated by the structures. For each branch instruction, the corresponding L1 through L10 symbol will store a value of 1 or 0, 1 indicating a long branch and 0 indicating a short branch.

The label STKTOP contains a value from 0 to 10 that indicates which pair of S and L labels is at the top of the stack. The PUSH macro puts a pair of values on the top of the stack by incrementing the value of STKTOP. It then stores the values to be pushed into the labels that STKTOP references.

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Listing 14: *Structured macro definitions.*

```
 PAGE
*******************************************************************
*
*       STRUCTURED MACROS FOR ASSEMBLY LANGUAGE PROGRAMMING THE MC6809
*
*       COPYRIGHT (C) 1980 BY GREGORY WALKER FOR MOTOROLA, INC
*
*
EXBUG EQU $F000         DEFAULT 16-BIT ADDRESS
STKTOP SET 0            STACK INITIALLY EMPTY
ISLONG SET 0            BRANCHES DEFAULT TO SHORT OFFSET

*******************************************************************
*
*       PUSH --
*               THIS MACRO SIMULATES A 10-LEVEL STACK USING TEN SYMBOLS
*       WHOSE VALUES ARE REDEFINED TO BE THE VALUES ON THE STACK.  THE
*       SYMBOL "STKTOP" CONTAINS A NUMBER FROM 0 TO 10 WHICH INDICATES
*       THE SYMBOL (S1 TO S10) THAT CONTAINS THE VALUE ON THE TOP OF THE
*       STACK.  A VALUE OF ZERO FOR STKTOP INDICATES THAT THE STACK IS
*       EMPTY
*
PUSH MACR
STKTOP SET STKTOP+1
 IFEQ STKTOP-1
S1 SET \0
L1 SET ISLONG
 ENDC
 IFEQ   STKTOP-2
S2 SET    \0
L2 SET ISLONG
 ENDC
 IFEQ  STKTOP-3
S3 SET \0
L3 SET ISLONG
 ENDC
 IFEQ STKTOP-4
S4 SET \0
L4 SET ISLONG
 ENDC
 IFEQ STKTOP-5
S5 SET \0
L5 SET ISLONG
 ENDC
 IFEQ STKTOP-6
S6 SET \0
L6 SET ISLONG
 ENDC
 IFEQ STKTOP-7
S7 SET \0
L7 SET ISLONG
 ENDC
 IFEQ STKTOP-8
S8 SET \0
L8 SET ISLONG
 ENDC
 IFEQ STKTOP-9
S9 SET \0
L9 SET ISLONG
 ENDC
 IFEQ STKTOP-10
S10 SET \0
L10 SET ISLONG
 ENDC
 IFGT STKTOP-10
 FAIL ** SYMBOL STACK OVERFLOW **
 ENDC
 ENDM

*******************************************************************
*
*       POP --
*               THE POP MACRO REMOVES THE TOPMOST ELEMENT FROM THE
*       SIMULATED STACK.
*
POP MACR
 IFLE STKTOP                        IF STACK IS EMPTY, THEN ERROR
 FAIL ** SYMBOL STACK UNDERFLOW **
 ENDC
 IFGT STKTOP                        IF STACK NOT EMPTY, DECREASE
STKTOP SET STKTOP-1                     STACK POINTER BY ONE.
 ENDC
 ENDM

*******************************************************************
*
*       BACK1   --
*               THIS MACRO SETS THE ASSEMBLER'S LOCATION COUNTER TO
```

Listing 14 continued on page 210

The BACK1 macro resolves forward references within a matched pair of structured macros. It uses the value on the top of the stack as the address of an unresolved branch instruction. The L value from the stack is given to the symbol ISLONG to indicate whether the branch to be generated is long or short. In addition, the ORG (origin) statement causes the branch offset to be generated at the proper location. BACK1 does not change the stack.

The three macros RELOP, RELTST, and RELCC process the relational operators for the IF, IFTST, and IFCC macros, respectively. The RELOP macro is also used by the WHILE and UNTIL macros. RELOP, RELTST, and RELCC operate similarly: they generate a conditional branch instruction that corresponds to the particular relational operator used in the macro. If the branch is a backward reference, the branch is made to the value on the top of the stack. If the branch is a forward reference, a dummy branch is generated. The location and size (long or short) of this dummy branch instruction are pushed onto the stack for later resolution.

The REGTST macro is used by all of the structures to test for valid MC6809 registers. As with the other macros, if an error is detected, an error message is printed out using the FAIL directive.

Given the above primitive operations, the structured macros themselves can be written by examining the equivalent machine code that each macro must generate. These structured macros are general in form and should move easily to assemblers for other computers. The primitive operations will have to be redefined, depending on the macro facilities available on a particular assembler, and the calculation of branch offsets must be changed to the use of absolute addresses if the target computer does not provide relative branch instructions.

In summary, only three capabilities such as the following are needed in an assembler to allow the creation of a set of structured macros:

Text continued on page 224

Listing 14 continued:

```
*       THE VALUE ON THE TOP OF THE STACK.  A FORWARD REFERENCE IS
*       RESOLVED BY FILLING IN THE BRANCH OFFSET AT THE STACKED
*       LOCATION.  THE SYMBOL "BACKLNG" IS SET TO INDICATE WHETHER A
*       LONG OR SHORT OFFSET IS TO BE GENERATED.
*               THE CONTENTS OF THE STACK ARE NOT CHANGED BY THIS
*       MACRO.
*
BACK1 MACR
 IFEQ STKTOP-1
 ORG S1
BCKLNG SET L1
 ENDC
 IFEQ STKTOP-2
 ORG S2
BCKLNG SET L2
 ENDC
 IFEQ STKTOP-3
 ORG S3
BCKLNG SET L3
 ENDC
 IFEQ STKTOP-4
 ORG S4
BCKLNG SET L4
 ENDC
 IFEQ STKTOP-5
 ORG S5
BCKLNG SET L5
 ENDC
 IFEQ STKTOP-6
 ORG S6
BCKLNG SET L6
 ENDC
 IFEQ STKTOP-7
 ORG S7
BCKLNG SET L7
 ENDC
 IFEQ STKTOP-8
 ORG S8
BCKLNG SET L8
 ENDC
 IFEQ STKTOP-9
 ORG S9
BCKLNG SET L9
 ENDC
 IFEQ STKTOP-10
 ORG S10
BCKLNG SET S10
 ENDC
 IFLE STKTOP
 FAIL ** REFERENCE WAS MADE TO EMPTY SYMBOL STACK **
 ENDC
 IFGT STKTOP-7
 FAIL ** STACK TOP POINTER EXCEEDS STACK **
 ENDC
 ENDM
******************************************************************
*
*       RELOP --
*               THIS MACRO CREATES A RELATIVE BRANCH INSTRUCTION
*       FOR THE 'IF', 'WHILE', AND 'UNTIL' MACROS BASED ON THE
*       RELATIONAL OPERATOR PASSED TO IT AS ITS FIRST ARGUMENT.
*       THE SYMBOL "ISLONG" DETERMINES WHETHER A LONG OR SHORT BRANCH
*       IS GENERATED.  A SHORT BRANCH IS GENERATED IF "ISLONG" EQUALS
*       ZERO, ELSE A LONG BRANCH IS GENERATED.
*
RELOP MACR
 IFC \0,EQ
  IFEQ ISLONG
  BNE *
  ENDC
  IFEQ ISLONG-1
  LBNE EXBUG
  ENDC
 ENDC
 IFC \0,NE
  IFEQ ISLONG
  BEQ *
  ENDC
  IFEQ ISLONG-1
 LBEQ EXBUG
 ENDC
ENDC
IFC \0,LE
 IFEQ ISLONG
 BGT *
 ENDC
 IFEQ ISLONG-1
 LBGT EXBUG
 ENDC
```

Listing 14 continued on page 212

Listing 14 continued:

```
 ENDC
 IFC \O,LT
  IFEQ ISLONG
  BGE *
  ENDC
  IFEQ ISLONG-1
  LBGE EXBUG
  ENDC
 ENDC
 IFC \O,GE
  IFEQ ISLONG
  BLT *
  ENDC
  IFEQ ISLONG-1
  LBLT EXBUG
  ENDC
 ENDC
 IFC \O,GT
  IFEQ ISLONG
  BLE *
  ENDC
  IFEQ ISLONG-1
  LBLE EXBUG
  ENDC
 ENDC
 IFNC \O,EQ
  IFNC \O,NE
   IFNC \O,LT
    IFNC \O,LE
     IFNC \O,GE
      IFNC \O,GT
      FAIL ** INVALID RELATIONAL OPERATOR -- \O **
      ENDC
     ENDC
    ENDC
   ENDC
  ENDC
 ENDC
 ENDM
*****************************************************************
*
*      RELTST --
*            THE 'RELTST' MACRO TESTS THE VALIDITY OF THE
*      RELATIONAL OPERATOR USED WITH AN 'IFTST' MACRO AND
*      GENERATES THE PROPER RELATIVE BRANCH INSTRUCTION
*
RELTST MACR
 IFC \O,EQ
  IFEQ ISLONG
  BNE *
  ENDC
  IFEQ ISLONG-1
  LBNE EXBUG
  ENDC
 ENDC
 IFC \O,NE
  IFEQ ISLONG
  BEQ *
  ENDC
  IFEQ ISLONG-1
  LBEQ EXBUG
  ENDC
 ENDC
 IFC \O,GE
  IFEQ ISLONG
  BLT *
  ENDC
  IFEQ ISLONG-1
  LBLT EXBUG
  ENDC
 ENDC
 IFC \O,LT
  IFEQ ISLONG
  BGE *
  ENDC
  IFEQ ISLONG-1
  LBGE EXBUG
  ENDC
 ENDC
 IFNC \O,EQ
  IFNC \O,NE
   IFNC \O,GE
    IFNC \O,LT
    FAIL ** \O IS AN INVALID RELATIONAL OPERATOR FOR 'IFTST' **
    ENDC
   ENDC
  ENDC
 ENDC
 ENDM
```

Listing 14 continued on page 214

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Listing 14 continued:

```
**************************************************************************
*
*       RELCC --
*             THE 'RELCC' MACRO TESTS THE VALIDITY OF THE RELATIONAL
*       OPERATOR FOR AN 'IFCC' MACRO AND GENERATES THE PROPER RELATIVE
*       BRANCH INSTRUCTION.
*
RELCC MACR
RELERR SET 0
 IFC \0,EQ
  IFEQ ISLONG
  BNE *
  ENDC
  IFEQ ISLONG-1
  LBNE EXBUG
  ENDC
 ENDC
 IFC \0,NE
  IFEQ ISLONG
  BEQ *
  ENDC
  IFEQ ISLONG-1
  LBEQ EXBUG
  ENDC
 ENDC
 IFC \0,LE
  IFEQ ISLONG
  BGT *
  ENDC
  IFEQ ISLONG-1
  LBGT EXBUG
  ENDC
 ENDC
 IFC \0,LT
  IFEQ ISLONG
  BGE *
  ENDC
  IFEQ ISLONG-1
  LBGE EXBUG
  ENDC
 ENDC
 IFC \0,GE
  IFEQ ISLONG
  BLT *
  ENDC
  IFEQ ISLONG-1
  LBLT EXBUG
  ENDC
 ENDC
 IFC \0,GT
  IFEQ ISLONG
  BLE *
  ENDC
  IFEQ ISLONG-1
  LBLE EXBUG
  ENDC
 ENDC
 IFC \0,CC
  IFEQ ISLONG
  BCS *
  ENDC
  IFEQ ISLONG-1
  LBCS EXBUG
  ENDC
 ENDC
 IFC \0,CS
  IFEQ ISLONG
  BCC *
  ENDC
  IFEQ ISLONG-1
  LBCC EXBUG
  ENDC
 ENDC
 IFC \0,VC
  IFEQ ISLONG
  BVS *
  ENDC
  IFEQ ISLONG-1
  LBVS EXBUG
  ENDC
 ENDC
 IFC \0,VS
  IFEQ ISLONG
  BVC *
  ENDC
  IFEQ ISLONG-1
  LBVC EXBUG
  ENDC
 ENDC
 IFNC \0,EQ
```

Listing 14 continued on page 218

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The SpeedProgramming Package is an integrated set of tools which allows you to create Pascal/MT+® programs, check them for correct syntax and undefined identifiers, format them to display flow of control, and do this all within the editing environment before you ever invoke the compiler. Programmers like SpeedProgramming because it frees them from the time consuming chore of repeated compilations to correct simple syntactic and typing errors. Managers find that SpeedProgramming improves productivity, thereby reducing development costs. SpeedProgramming combined with our field tested Pascal/MT+® package gives you a comfortable, powerful, interactive programming environment in which to create your professional quality software. Your products demand production quality tools. Order Pascal/MT+® with SpeedProgramming today!

Screen Editor:
User configurable • Standard random cursor movement, file access, search and replace, insert, delete, exchange, etc. • Structured language editing features such as automatic indent, line adjustment, reading from and writing to a file, block text insertion and duplication. • Requires: 24 x 80 CRT (or larger), ASCII Keyboard (7 bit data), random cursor addressing.

Interactive Syntax Scanner:
Finds syntax errors in text being edited • Enters SPEED, puts cursor at error, prints error text.

Variable Checker:
Catches undefined and mis-spelled variables before the compiler is invoked.

On-Line Reformatter:
Beautify programs in seconds • Clearly shows structure and program flow.

Source Code Management Tools:
Automatic Modification Log and Backup utility program.

PRICING: *Read carefully, some systems do not include the SpeedProgramming Package but do include the compiler, linker, disassembler, debugger and other utilities.

AVAILABLE NOW!

*8080/8085/Z80 without SpeedProgramming . . . . Price $350.00
56K or larger CP/M-80 or Heath/Zenith HDOS
8080/8085/Z80 complete including SpeedProgramming . . . . Price $475.00
56K or larger CP/M-80 (not available for HDOS)
8080/8085/Z80 for special MP/M environments . . . . Contact Factory

---

*8086/8088 without SpeedProgramming . . . . Price $600.00
CP/M-86 or MP/M-86, requires 116K program area
8086/8088 complete including SpeedProgramming . . . . Price $800.00
*8086/8088 without SpeedProgramming for RMX-86 . . . . Price $1500.00

All 8086/8088 packages include 9511 and 8087 support and program to convert MT object files into Intel .OBJ 8086 files.

COMING SOON:

68000 Cross Compiler System . . . . Price (to be announced)
68000 Resident System with and without SpeedProgramming . . . . Price (to be announced)

Available on 8" (3740) Single Density Disks. Contact Distributors For Other Formats.
CPM/, MP/M are trademarks of Digital Research, Inc.
Heath, Zenith and HDOS are trademarks of Zenith Data Systems.

FOR: 8080/8085/Z80/8086/68000

Payment Terms:
Cash, Check, UPS, C.O.D., Mastercard, VISA,

MT Micro SYSTEMS

1562 Kings Cross Drive
Cardiff, California 92007 (714) 755-1366*
*We're moving to bigger quarters. Call this number and you'll be told our new telephone number.

Pricing:
8080/Z80 — $475.00
Others Call

Circle 293 on inquiry card.

Listing 14 continued:

```
   IFNC \0,NE
    IFNC \0,LT
     IFNC \0,LE
      IFNC \0,GE
       IFNC \0,GT
RELERR SET 1   ERROR FLAG FOR NEXT SET OF TESTS
       ENDC
      ENDC
     ENDC
    ENDC
   ENDC
  ENDC
  IFNE RELERR
RELERR SET 0
   IFNC \0,CC
    IFNC \0,VC
     IFNC \0,CS
      IFNC \0,VS
      FAIL ** INVALID RELATIONAL OPERATOR -- \0 **
      ENDC
     ENDC
    ENDC
   ENDC
  ENDC
  ENDM
*********************************************************************
*
*       REGTST --
*               THIS MACRO TESTS THE VALIDITY OF THE REGISTER
*       NAME PASSED AS ITS FIRST ARGUMENT. IF THE NAME WAS NOT
*       A VALID REGISTER, 'REGTST' WILL FAIL WITH AN ERROR MESSAGE.
*
REGTST MACR
 IFNC \0,A
 IFNC \0,B
 IFNC \0,D
 IFNC \0,X
 IFNC \0,Y
 IFNC \0,U
 IFNC \0,S
 FAIL ** \0 IS NOT A 6809 REGISTER **
 ENDC
 ENDC
 ENDC
 ENDC
 ENDC
 ENDC
 ENDC
 ENDM
*********************************************************************
*
*       IF --
*               THE 'IF' MACRO WILL CAUSE THE STATEMENTS FOLLOWING
*       IT TO BE EXECUTED UP TO THE FIRST 'ELSE' OR 'ENDIF' IF THE
*       CONDITIONAL EXPRESSION IS TRUE. ITS SYNTAX IS:
*
*       IF     <REGISTER NAME>,<RELATIONAL OPERATOR>,<ADDRESS EXPRESSION>
*
*       THE VALID RELATIONAL OPERATORS ARE: 'EQ', 'NE', 'LE', 'LT',
*       'GE', AND 'GT'
*
IF MACR
 IFNE NARG-3             TEST FOR VALID MACRO CALL
  IFNC \3,L
  FAIL ** 'IF' MACRO REQUIRES 3 ARGUMENTS **
  ENDC
 ENDC
 IFC \3,L
ISLONG SET 1
 ENDC
 REGTST \0               TEST FOR A VALID REGISTER
 CMP\0 \2                GENERATE CMP INSTRUCTION
 RELOP \1                GENERATE RELATIVE BRANCH ON CONDITION
 PUSH *-1-ISLONG         PUSH LOCATION OF FORWARD REFERENCE OFFSET
ISLONG SET 0                 ONTO STACK
 ENDM
*********************************************************************
*
*       ELSE --
*               THE 'ELSE' MACRO BEGINS THE STATEMENTS THAT WILL
*       BE EXECUTED IF THE CONDITIONAL EXPRESSION OF THE PRECEDING
*       'IF' MACRO WAS NOT TRUE
*
ELSE MACR
 IFC \0,L
ISLONG SET 1
 ENDC                    GENERATE BRANCH AROUND STATEMENTS FOLLOWING
 IFEQ ISLONG                 THE "ELSE"
 BRA *                       GENERATE A SHORT BRANCH
```

Listing 14 continued on page 220

FUTRA COMPANY
P.O. BOX 4380 — DEPT. B-12
Torrance, CA 90501

213) 328-8951 TWX 910 349-6211

oll Free Order Line Outside of Calif.—Please read
of press time we were in the process of obtaining a toll free 0 number and TWX line. To obtain our latest prices please dial 0 421-5006. If you have any trouble reaching us dial 800 rectory assistance at 800 555-1212 and ask for FUTRA OMPANY. Western Union informed us that there may be a ange in our TWX number.

HEWLETT PACKARD

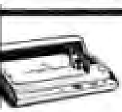
ALL FOR PRICING

HP-83 HP-85 HP-125
NOW AVAILABLE

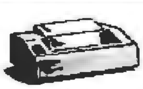
2903A HP+85/83 16K Memory Module $255.00

Firmware Enhancements:			Interfaces:		
82936A					
82936A	ROM Draw	$ 42	82937A	HP-IB	$339
15001	Mass Stor.	135	82939A	Serial (female)	$339
15002	Plotter/Print	$135	82939	opt 001 (male)	$339
15003	In/Output	$274	Same 002	(crmt 1p)	$339
15004	Matrix	$135	82940A	GPIO	$421
15005	Adv.Prog.	$126	82941A	BCD	$420
15007	Assembly	$127.50	82949A	Printer Int.	$269

HP APPLICATION PACKS . . . . . . $ CALL



7225
aphics Plotter
$2089.95



HP 2631B
Matrix Printer
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HP 82902M
Disk Drive
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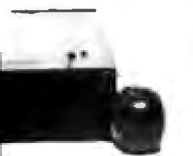
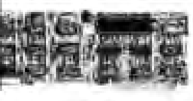
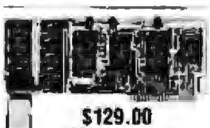
KONAN



Stop the floppy shuffle!
New Konan 5" Winchester Hard Disk Drive
Low Introductory Pricing



$289.00
Z-80 Soft Card with CP/M



$129.00
16K Ram Card
Limited Stock

en your Apple II computer to a larger world. With the Z-80 Soft-rd and 16K RAM Card you can now run CP/M compatible software, pand your memory for specific application, act as a firmware card d much more. If you add any boards to your Apple this year these the ones.

VIDEX 80 x 24 VIDEOTERM AND KEYBOARD ENHANCER

$ CALL
Videoterm

$ CALL
Keyboard Enhancer

ALS "Smarterm" 80 column card $295.00

aintain optimum software compatibility industry wide. By adding the deoterm 80 x 24 videoboard and keyboard enhancer your Apple acts milar to CRT Terminals on larger systems. Combine this with the icrosoft Softcard and you've got some system.

COMPUTER SUPPLIES:

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744-16 5" SS/SD 16 sect.	$28	•743-0 8" DS/DD	$44
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ISC.

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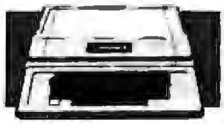
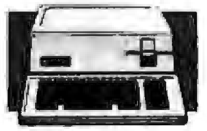
APPLE COMPUTERS





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16K
48K CALL

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128K **$3255.00**

What can we say except that they're super systems and the prices are a steal.

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- Disk II 2nd CALL
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- Integer firmware $149
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- Hand Controllers $ 27
- Vinyl Carrier $ 33
- Joystick II $ 45
- Graphics Tablet $665
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Apple III
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- Disk II for AIII $495
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- Arithmetic Proc/Disk $325
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Mountain Computer Inc.
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- Romwriter $152
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- ABT Soft Key $145
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- Visiterm $125
- Visiplot $147
- Visidex $159
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Microsoft: (requires Z80 SoftCard & CP/M)
- Basic Compiler $296
- Assembly Language $84
- COBAL Language $562.50
- Fortran Language $149.80

Peachtree/40: (requires Z-80 SoftCard & 16K RAM Card)
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- Payroll $195
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Misc: (48K AII or AII+)
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- BPI General Ledger $315
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- BPI Payroll $315
- BPI Job Cost Sys. $315
- Software Publishing Corp. "PFS" $ 87.50
- "PFS: Report" $ 87.50
- MicroFocus "COBOL" $743.00
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CPM Software Packages — 8" Diskettes
- Peachtree CPM
- MicroPro
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The CCS 2210 is a low cost S100, Z80 computer system with 64K of memory, disk controller, parallel/serial I/O and CPM operating system.

$ CALL

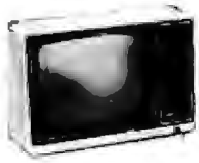
Separate Components
- 2200A Mainframe
- 2810A CPU
- 2065 64K RAM

CALL FOR PRICE

- 24221 Disk Cntrlr.
- 2718 Par/Ser I/O

CALL FOR PRICE

ZENITH MONITOR

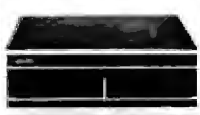


12" GREEN DATA MONITOR $119.00

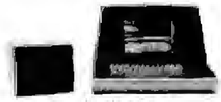
Reduce eyestrain with the monitor from the people who say "The quality goes in before the name goes on." Excellent for Apple II, Apple III and others.

COMPUTER SYSTEMS

Call for Lowest Price Possible

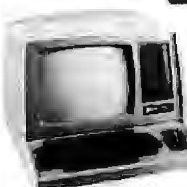


ALTOS

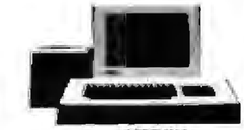


VECTOR

NEC



ZENITH



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- 12" Green Monitor
- 12" B&W Monitor
- 13" Color Monitor
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AMDEK:
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CALL FOR PRICE

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- 12" Color Monitor

VIDEO TERMINALS:
- ADDS Viewpoint CRT
- Soroc 130
- Televideo

CALL FOR PRICE

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Your price **$759.00**

Probably the best buy in a printer this year. Compare features with any other and compare price (especially ours). 4 character sizes all may be placed into letter quality enhanced mode. Friction and removable tractor, 9 by 9 to 18 by 18 dot Matrix, logic seeking, and much more. Not to mention DOT PLOTTING?GRAFTRAX option built right in. **WOW! What a printer!**

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- MX 80 Printer CALL
- MX 70 Printer CALL
- MX 80 Ribbons $14
- MX Ser.Interface Opt $65
- Epson Apple Par.Int. $69
- Epson Par.Cable $20
- MX-80 or 80/ft Graftrax ROM $78

ADDITIONAL PRINTERS

NEC
PC 8023
3510

DIABLO
630

XEROX
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9501
9600
9001

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Listing 14 continued:

```
 ENDC
 IFEQ ISLONG-1
 LBRA EXBUG                GENERATE A LONG BRANCH
 ENDC
MCRTMP SET *
 BACK1                  FILL IN FORWARD REF. OFFSET IN THE BRANCH
 IFEQ BCKLNG               GENERATED BY AN "IF", "IFTST", OR "IFCC"
 IFGT (MCRTMP-*-1)-128
 FAIL ** LONG 'IF' IS REQUIRED **
 ENDC
 FCB MCRTMP-*-1            GENERATE A SHORT OFFSET
 ENDC
 IFEQ BCKLNG-1
 FDB MCRTMP-*-2            GENERATE A LONG OFFSET
 ENDC
 ORG MCRTMP
 POP                    REMOVE POINTER TO "IF" OFFSET FROM STACK
 PUSH *-1-ISLONG        PUSH LOCATION OF FORWARD REF. OFFSET
ISLONG SET 0                      FORMED BY THIS MACRO.
 ENDM
*************************************************************************
*
*       ENDIF --
*               THE 'ENDIF' MACRO IS THE TERMINATING STATEMENT FOR THE
*       STATEMENTS CONTROLLED BY THE PRECEDING 'IF' OR 'ELSE' MACRO
*
ENDIF MACR
MCRTMP SET *
 BACK1                  FILL IN FORWARD REF. OFFSET FROM AN "IF" OR "ELSE"
 IFEQ BCKLNG
 IFGT (MCRTMP-*-1)-128
 FAIL ** LONG 'ELSE' REQUIRED **
 ENDC
 FCB MCRTMP-*-1             GENERATE A SHORT OFFSET
 ENDC
 IFEQ BCKLNG-1
 FDB MCRTMP-*-2             GENERATE A LONG OFFSET
 ENDC
 ORG MCRTMP
 POP                    REMOVE POINTER TO FORWARD REFERENCE FROM STACK
 ENDM
*************************************************************************
*
*       IFTST --
*               THE 'IFTST' MACRO OPERATES LIKE AN 'IF' MACRO EXCEPT
*       THAT IT GENERATES A 'TST' INSTRUCTION INSTEAD OF A 'CMP'
*       THE SYNTAX IS:
*
*       IFTST   <REGISTER OR ADDRESS EXPRESSION>,<RELATIONAL OP>,0
*
*       THE VALID RELATIONAL OPERATORS FOR USE WITH 'IFTST' ARE  'EQ',
*       'NE', 'LT', AND 'GE'
*
IFTST MACR
 IFC \3,L
ISLONG SET 1
 ENDC
 IFC \2,L
ISLONG SET 1
 ENDC
 IFC \0,A
 TSTA                   GENERATE "TST" OF ACC. A
 ENDC
 IFC \0,B
 TSTB                   GENERATE "TST" OF ACC  B
 ENDC
 IFNC \0,A
  IFNC \0,B
  TST \0                GENERATE "TST" OF A MEMORY BYTE
  ENDC
 ENDC
 RELTST \1              GENERATE RELATIVE BRANCH (FORWARD REF.)
 PUSH *-1-ISLONG        PUSH LOCATION OF FORWARD REFERENCE
ISLONG SET 0
 ENDM
*************************************************************************
*
*       IFCC --
*               THE 'IFCC' MACRO FUNCTIONS LIKE AN 'IF' MACRO, EXCEPT
*       IT ONLY GENERATES A 'BRANCH ON CONDITION' INSTRUCTION DIRECTLY.
*       THIS IS USEFUL BECAUSE IT ALLOWS THE ASSEMBLER TO GENERATE THE
*       LABEL FOR THE BRANCH INSTEAD OF FORCING THAT BURDEN ON THE
*       OVER-WORKED PROGRAMMER. THE SYNTAX IS:
*
*       IFCC    <RELATIONAL OPERATOR>
*
*       THE VALID REALTIONAL OPERATORS ARE: 'EQ', 'NE', 'GE', 'GT',
*       'LE', AND 'LT'
*
```

Listing 14 continued on page 222

★★

4MHZ, DOUBLE DENSITY, COLOR & B/W GRAPHICS . . THE LNW80 COMPUTER

When you've compared the features of an LNW80 Computer, you'll quickly understand why the LNW80 is the ultimate TRS80 software compatible system. LNW RESEARCH offers the most complete microcomputer system at an outstanding low price.
We back up our product with an unconventional 6 month warranty and a 10 days full refund policy, less shipping charges.

LNW80 Computer $1,450.00
LNW80 Computer w/B&W Monitor & one 5" Drive $1,915.00
All orders must be prepaid, CA residents please include 6% sales tax.
Contact us for shipping charges

* TRS80 Product of Tandy Corporation.
** PMC Product of Personal Microcomputer, Inc.

COMPARE THE FEATURES AND PERFORMANCE

FEATURES	LNW80	PMC-80**	TRS-80* MODEL III
PROCESSOR	4.0 MHZ	1.8 MHZ	2.0 MHZ
LEVEL II BASIC INTERP.	YES	YES	LEVEL III BASIC
TRS80 MODEL 1 LEVEL II COMPATIBLE	YES	YES	NO
48K BYTES RAM	YES	YES	YES
CASSETTE BAUD RATE	500/1000	500	500/1500
FLOPPY DISK CONTROLLER	SINGLE/ DOUBLE	SINGLE	SINGLE/ DOUBLE
SERIAL RS232 PORT	YES	YES	YES
PRINTER PORT	YES	YES	YES
REAL TIME CLOCK	YES	YES	YES
24 X 80 CHARACTERS	YES	NO	NO
VIDEO MONITOR	YES	YES	YES
UPPER AND LOWER CASE	YES	OPTIONAL	YES
REVERSE VIDEO	YES	NO	NO
KEYBOARD	63 KEY	53 KEY	53 KEY
NUMERIC KEY PAD	YES	NO	YES
B/W GRAPHICS, 128 X 48	YES	YES	YES
HI-RESOLUTION B/W GRAPHICS, 480 X 192	YES	NO	NO
HI-RESOLUTION COLOR GRAPHICS (NTSC), 128 X 192 IN 8 COLORS	YES	NO	NO
HI-RESOLUTION COLOR GRAPHICS (RGB), 384 X 192 IN 8 COLORS	OPTIONAL	NO	NO
WARRANTY	6 MONTHS	90 DAYS	90 DAYS
TOTAL SYSTEM PRICE	$1,915.00	$1,840.00	$2,187.00
LESS MONITOR AND DISK DRIVE	$1,450.00	$1,375.00	---

LNW80

- BARE PRINTED CIRCUIT BOARD & MANUAL $89.95

The LNW80 - A high-speed color computer totally compatible with the TRS-80*. The LNW80 gives you the edge in satisfying your computation needs in business, scientific and personal computation. With performance of 4 MHz, Z80A CPU, you'll achieve performance of over twice the processing speed of a TRS-80*. This means you'll get the performance that is comparable to the most expensive microcomputer with the compatibility to the world's most popular computer (TRS-80*) resulting in the widest software base.

FEATURES:
- TRS-80 Model 1 Level II Software Compatible
- High Resolution Graphics
  - RGB Output - 384 x 192 in 8 Colors
  - NTSC Video or RF MOD - 128 x 192 in 8 Colors
  - Black and White - 480 x 192
- 4 MHz CPU
- 500/1000 Baud Cassette
- Upper and Lower Case
- 16K Bytes RAM, 12K Bytes ROM
- Solder Masked and Silkscreened

LNW SYSTEM EXPANSION

- BARE PRINTED CIRCUIT BOARD AND MANUAL $69.95
WITH GOLD CONNECTORS $84.95

The System Expansion will allow you to expand your LNW80, TRS-80*, or PMC-80** to a complete computer system that is still totally software compatible with the TRS-80* Model 1 Level II.

FEATURES:
- 32K Bytes Memory
- 5" Floppy Controller
- Serial RS232 20ma I/O
- Parallel Printer
- Real Time Clock
- Screen Printer Bus
- On Board Power Supply
- Solder Masked and Silkscreened

LNDoubler & DOS PLUS 3.3D

- Assembled and Tested W/DOS PLUS 3.3D. $175.00

Double-density disk storage for the LNW Research's "System Expansion" or the Tandy's "Expansion Interface". The LNDoubler™ is totally software compatible with any double density software generated for the Percom's Doubler***. The LNDoubler™ provides the following outstanding features.

- Store up to 350K bytes on a single 5" disk
- Single and double density data separation
- Precision write precompensation circuit
- Software switch between single and double density
- Easy plug in installation requiring no etch cuts, jumpers or soldering
- 35, 40, 77, 80 track 5" disk operation
- 120 day parts and labor Warranty

*** Doubler is a product of Percom Data Company, Inc.

DOS PLUS 3.3D

Micro Systems software's double density disk operating system. This operating system contains all the outstanding features of a well developed DOS, with ease in useability.

KEYBOARD

LNW80 KEYBOARD KIT $84.95

The Keyboard Kit contains a 63 key plus a 10 key, P.C. board, and remaining components.

CASE

LNW80 CASE $84.95

The streamline design of this metal case will house the LNW80, LNW System Expansion, LNW80 Keyboard, power supply and fan, LNDoubler™, or LNW Data Separator. This kit includes all the hardware to mount all of the above. Add $12.00 for shipping

PARTS AVAILABLE FROM LNW RESEARCH
- 4116 - 200ns RAM
  - 8 chip set $26.00
  - 8 chip set $33.50
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Listing 14 continued:

```
IFCC MACR
 IFNE NARG-1                    TEST FOR VALID MACRO CALL
  IFNC \1,L
  FAIL ** ONLY ONE ARGUMENT (A RELATIONAL OPERATOR) ALLOWED **
  ENDC
 ENDC
 IFC \1,L
ISLONG SET 1            TEST FOR SHORT OR LONG BRANCH.
 ENDC
 RELCC \0               GENERATE CONDITIONAL BRANCH (FORWARD REF.)
 PUSH *-1-ISLONG        PUSH LOCATION OF FORWARD BRANCH.
ISLONG SET 0
 ENDM
*******************************************************************
*
*       WHILE --
*               THE 'WHILE' MACRO EXECUTES THE STATEMENTS FOLLOWING
*       IT UP TO THE 'ENDWH' AS LONG AS ITS CONDITIONAL EXPRESSION IS
*       TRUE. THE SNTAX IS:
*
*       WHILE <REGISTER NAME>,<RELATIONAL OPERATOR>,<ADDRESS EXPRESSION>
*
WHILE MACR
 IFNE NARG-3            TEST FOR VALID MACRO CALL.
  IFNC \3,L

  FAIL ** 'WHILE' REQUIRES 3 ARGUMENTS **
  ENDC
 ENDC
 IFC \3,L               TEST FOR LONG BRANCH INDICATOR
ISLONG SET 1
 ENDC
 PUSH *                 PUSH POINTER TO TOP OF LOOP.
 REGTST \0              TEST FOR VALID REGISTER.
 CMP\0 \2               GENERATE CMP INSTRUCTION
 RELOP \1               GENERATE CONDITIONAL BRANCH OUT OF LOOP (FORWARD)
 PUSH *-1-ISLONG        PUSH LOCATION OF FORWARD REFERENCE.
ISLONG SET 0
 ENDM
*******************************************************************
*
*       ENDWH --
*               THIS MACRO TERMINATES THE STATEMENTS WITHIN A 'WHILE'
*       LOOP.
*
ENDWH MACR
 IFC \0,L
  FAIL ** THE 'LONG' SHOULD BE PLACED ON THE 'WHILE' **
 ENDC
MCRTMP SET *
 BACK1                  GENERATE OFFSET IN FORWARD REFERENCE OF "WHILE"
 IFEQ BCKLNG
  IFGT -((MCRTMP+2)-*-1)-128
  FAIL ** LONG 'WHILE' IS REQUIRED **
  ENDC
 FCB (MCRTMP+2)-*-1     GENERATE A SHORT OFFSET
 ENDC
 IFEQ BCKLNG-1
 FDB (MCRTMP+3)-*-2     GENERATE A LONG OFFSET
 ENDC
 POP                    REMOVE POINTER TO FORWARD REFERENCE FROM STACK
 BACK1                  GET POINTER TO TOP OF LOOP
\.A EQU *
 ORG MCRTMP
 IFEQ BCKLNG            CREATE BRANCH BACK TO TOP OF LOOP
 BRA \.A                    GENERATE A SHORT BRANCH.
 ENDC
 IFEQ BCKLNG-1
 LBRA \.A                   GENERATE A LONG BRANCH
 ENDC
 POP
 ENDM
*******************************************************************
*
*       REPEAT --
*               THE STATEMENTS BETWEEN A 'REPEAT' AND AN 'UNTIL' MACRO
*       ARE REPEATED UNTIL THE CONDITIONAL EXPRESSION BECOMES TRUE
*
REPEAT MACR
 IFC \0,L
  FAIL ** PLACE 'LONG' ON THE 'UNTIL' **
 ENDC


 PUSH *                 PUSH POINTER TO TOP OF THE LOOP
 ENDM
*******************************************************************
*
```

Listing 14 continued on page 224

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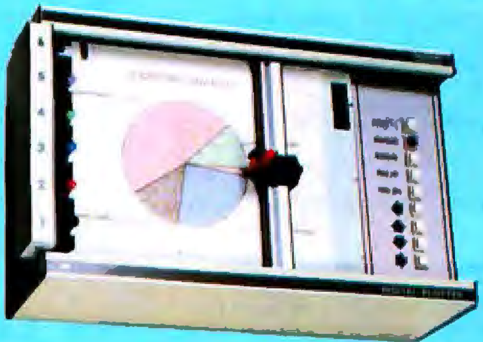

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Text continued from page 208:

• ability to define macros with substitutable parameters
• conditional assembly directives
• ability to change the value of a label

Most macroassemblers provide these three capabilities, and it is surprising that structured statements are not more widely used. In fact, structured statements may be added to an assembler that has no built-in macro facility by writing a preprocessor program to expand the structured macro statements. I will discuss this in more detail later.

Evaluation

A possible objection to the use of structured macros is that they increase translation time for a program. However, they may also save time by making it easier to read, debug, and maintain an assembly-language program. A decrease in errors, and the ability to locate these errors more quickly, will mean fewer necessary translation: and an overall decrease in time spent.

Listing 14 continued:

```
*        UNTIL --
*                 THE 'UNTIL' MACRO TERMINATES A 'REPEAT' LOOP. IT HAS
*        THE SYNTAX:
*
*        UNTIL  <REGISTER NAME>,<RELATIONAL OPERATOR>,<ADDRESS EXPRESSION>
*
UNTIL MACR
 IFNE NARG-3               TEST FOR VALID MACRO CALL
  IFNC \3,L
  FAIL ** 'UNTIL' REQUIRES 3 ARGUMENTS **
  ENDC
 ENDC
 IFC \3,L                  TEST FOR LONG BRANCH INDICATOR
ISLONG SET 1
 ENDC
MCRTMP SET *
 BACK1                     RETRIEVE POINTER TO TOP OF THE LOOP
\.A EQU *
 ORG MCRTMP
 POP                       REMOVE POINTER FROM STACK
 REGTST \0
 CMP\0 \2                  GENERATE COMPARE INSTRUCTION.
 RELOP \1                  GENERATE RELATIVE BRANCH TO TOP OF LOOP.
 ORG *-1-ISLONG
 IFEQ ISLONG               FILL IN OFFSET OF BRANCH TO LOOP TOP.
  IFGT -(\.A-*-1)-128
  FAIL ** LONG 'UNTIL' IS REQUIRED **
  ENDC
  FCB \.A-*-1                   GENERATE A SHORT OFFSET.
 ENDC
 IFEQ ISLONG-1
 FDB \.A-*-2                    GENERATE A LONG OFFSET.
 ENDC
ISLONG SET 0
 ENDM
```

It is difficult to express the degree to which these structured macros ease assembly-language programming. The improvement is mainly subjective, and it must be experienced. Macros have been heavily used for over ten months on a major programming project, the MC6839 floating-

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point ROM (read-only memory) and they have proved indispensible for reducing the complexity of that program to manageable proportions.

Extensions

An old adage states that no program is ever complete, and it is true that several other structured macros could be easily added to the existing set. Four straightforward additions would be to create TST and CC forms of the WHILE and UNTIL macros. A FOR loop, such as that in Pascal, would be useful, but would present a substantially more formidable implementation problem. At present, the equivalent of a FOR loop can be created out of a WHILE...ENDWH structure.

Macros in Other Languages

While facilities for subroutines are almost universally available, facilities for using macros are available in relatively few languages. Assembly languages are an exceptional case in that most assemblers provide at least a rudimentary mechanism for defining and using macros. As a result, the power and generality of macros are not widely appreciated.

Two notable exceptions lift macro programming out of the realm of assembly language. One is a book by Brian W Kernighan and P J Plaguer, entitled *Software Tools* (Addison-Wesley, 1976). Macros are used to add structured control statements to FORTRAN, which has resulted in a new language called RATFOR (Rational FORTRAN). *Software Tools* uses RATFOR to present a series of increasingly complex programs that culminate in a macroassembler program. This macroassembler takes a RATFOR program as input and creates an equivalent FORTRAN program, which may then be translated and executed as usual. RATFOR is an excellent example of a high-level language made more structured through the use of macros.

The second exception is the C programming language, which uses a simple macroassembler as the first step in translating C programs. Macro expansion constitutes the first step in translating a computer pro-

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gram, *and in* C, as well as RATFOR, the macroassembler consists of a separate program that is run before the main translator program. So if you possess a macro preprocessing program, you need never program in a language that lacks structured control statements.

I cannot leave the subject of macros without including one final comment about the generality of their usefulness. Macros, acting as they do at translation time, are really transformations of written text, and that text need not be a computer program. For example, a set of macros could be used to expand into standard headings and endings for writing business correspondence.

A Step in the Right Direction

The title of this article was chosen to imply a sense of progress not yet completed. The structured assembly-language statements presented here are only the first step in spreading the benefits of structured programming to languages that are currently not well structured. Control structures are easy to implement and can be added to even the most primitive programming language, but there are other aspects of structured programming that have yet to be explored in connection with assembly language. I will briefly examine two of these aspects: data structuring and subroutine structuring.

High-level languages such as Pascal and C provide *atomic data types*, such as numbers and characters, which can be built up into data structures. A *data structure* is a complex combination of data types referred to by a common name, the subparts of which can be accessed in a consistent manner. An array is just such a data structure having every element of the same data type.

The most general form of a data structure contains any number of elements of differing types (called a "record" in Pascal and a "structure" in C). Is it possible to add similar data structures to an assembly language in the same way that control structures were added? At present, the answer appears to be no.

One advantage offered by high-level languages over assembly languages is the association of a specific type to each data element. Part of the reason modern compilers are more complicated than assemblers stems from the type-checking that occurs as each use of a data item is being translated. Type-checking is too complex to be performed by a macroassembler; it could be added to an assembly language only by performing an extensive rewrite of the assembler program.

The languages PL/M, from Intel, and MPL, from Motorola, represent attempts at marrying data structures and other high-level concepts to assembly-language programming, but I am not sufficiently familiar with them to evaluate their effectiveness.

Subroutine structuring partakes of particular aspects of both structured control and structured data, but it is such an important (and complex) aspect of computer languages that it deserves separate consideration. Subroutine control structuring consists of nothing more than the run-time expansion examined earlier. Subroutines appear in a program much as the other control structures; they are made up of structuring statements that bracket a block of assembly-language statements, and that block of statements may itself contain nested subroutine calls.

However, more than control is passed to a subroutine. Data in the form of subroutine parameters is also transferred. In standard BASIC, all the data used in a subroutine is global (ie: it exists both inside and outside the subroutine). Languages like Pascal and C allow subroutines to have parameters and data that are local to the subroutine and exist in computer memory only while the subroutine is being executed.

The MC6809 and MC68000 microprocessors both contain machine instructions that aid in passing parameters to subroutines and in creating data local to a subroutine. The development of methods that will extend assembly languages in order to express these subroutine structures promises to be a fruitful area for further work. ■

MIKBUG and the TRS-80

Part 1: A Cross-Assembler for the Motorola 6800

Robert Labenski
145 Steele Rd
West Hartford CT 06119

I've always appreciated my TRS-80 Model I, largely because it's so easy to use. Recently, however, this appreciation heightened considerably when I bought the Motorola 6800 evaluation kit (MEK 6800 D1). That's when I realized I had become spoiled by the sophistication and ease of use of the Radio Shack machine.

The D1 comes with a minimum of programming support: a machine-language monitor called MIKBUG. It does a good job as a monitor, but after two years of using a disk-based editor/assembler, who wants to hand-assemble object code and load it 2 bytes at a time?

This prompted me to write a full programming system for the D1 kit. The programs run on the TRS-80, which is connected to the D1 as a terminal. As far as the D1 is concerned, the TRS-80 is nothing more than an I/O (input/output) terminal; little does the D1 know that the TRS-80 is also serving as a cross-assembler with file capabilities, a downloader, and a debugger!

To use this programming system, you need:

- the Motorola MEK 6800 D1, or any other 6800-based system running MIKBUG
- a TRS-80 Model I with 48 K bytes of programmable memory, one disk drive, and an RS-232C interface
- connecting cables from the TRS-80 to the D1 via their RS-232C channels

You don't need the disk drive if you rewrite all the file I/O sections for tape instead of disk.

I've divided this article into two parts. Part 1 describes the editor and cross-assembler—the program that inputs your 6800 source code and outputs 6800 object code. Both source and object code are saved on disk. Part 2, in next month's BYTE, describes the downloader (the program that transfers the 6800 object code into the correct memory locations in the D1 system) and the debugger, a function that allows your TRS-80 to act like an enhanced D1 terminal.

The Editor and Cross-Assembler

The editor and cross-assembler program is written in TRS-80 Disk BASIC (see listing 1).

When I write programs that have several commands associated with them, I program a help screen. Figure 1 (on page 242) is a copy of this screen. It contains all the commands needed to make the program usable.

When the prompt, "READY*", is displayed, the following general-purpose commands may be used:

H	Display the help screen of figure 1.
F	Request for file I/O. You are asked whether you wish to save or load and what files you wish to use.
R	Clear the system and restart the assembler.
C	Assemble the source code stored in the system.
S	Display the symbol table used to resolve addresses encountered during an assembly.

Text continued on page 242

Listing 1: The editor and cross-assembler program written in TRS-80 Disk BASIC.

```
100 ' MINI 6800 COMPILER FOR THE TRS-80
110 ' ROBERT LABENSKI WEST HARTFORD CONN
120 '
130 CLEAR 12000:DEFINT A-Z
140 DIMS$(200) 'SOURCE DATA
150 DIMNO$(100) 'OPERATIONS W/IMPLIED OPERANDS
160 DIMOP$(100) ' FULL OPCODES
170 DIMBR$(16) ' BRANCH INSTRUCTIONS
180 DIMOB$(200) '  OBJECT
190 DIMAD(200) 'ADDRESS
200 DIMLA$(100) ' SOURCE LABELS LC=INDEX
210 DIMLN(100) ' LINE # OF LABELS
220 DIMAR(100) ' LINES NEEDING ADDRESS RESOLUTION AC=INDEX
230 GOSUB1550 :GOTO 1200  ' GOTO OP CTRL
240 RESTORE'COMPILE
250 LC=0:AC=0:CD=0
260 IF OT THEN 340  ELSE OT=1 : GOTO310
270 CD=0:FOR X=1TOLEN(A$):Y=ASC(MID$(A$,X,1))
280 IF Y<=57 AND Y>=48 THEN Y=Y-48
290 IF Y>64 THEN Y=Y-55
300 CD=16*CD+Y :NEXT:RETURN
310 FORA=0TO100:READ NO$(A):IF NO$(A)<>"END"THEN NEXT
320 FOR A=0TO100:READOP$(A):IFOP$(A)<>"END"THENNEXT
330 FOR A=0 TO 15:READ BR$(A):NEXT
```

Listing 1 continued on page 234

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4. Have you ever lost business or money, or both, because your top management couldn't be there, when and where they were needed? Yes ☐ No ☐
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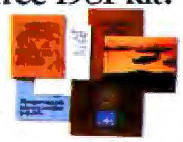

If you answered yes to any of the quiz questions, write us at Beech Aircraft Corporation, Dept.MNB, Wichita, KS 67201. We'll send you all you need to start thinking. If you answered yes to all the questions, maybe you should call collect. 316-681-8219. Ask for Del Chitwood. BYT 1201

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The 89 comes with 48K bytes RAM, expandable to 64K. It has two Z80 microprocessors, one for computer functions, one for terminal functions. And three serial I/O ports for interface with printers and modem.

The video display features a 12-inch diagonal, high-resolution CRT that's easy on the eyes. It displays up to 2,000 characters at a time, 24 lines (plus 25th status line) by 80 characters, with full cursor control. Also 33 block graphic characters for charts and graphs.

The heavy-duty keyboard follows standard typewriter format for easy operator training. All terminal functions are programmable from keyboard or I/O ports.

The 5¼-inch floppy diskette stores 100K bytes of information and interfaces on line with the Heath/Zenith 67 Hard Disk System.

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The 67 Disk System features one hard disk and one 8-inch, soft-sectored floppy for total on-line storage of 10.782 megabytes (formatted). That's a huge data base.

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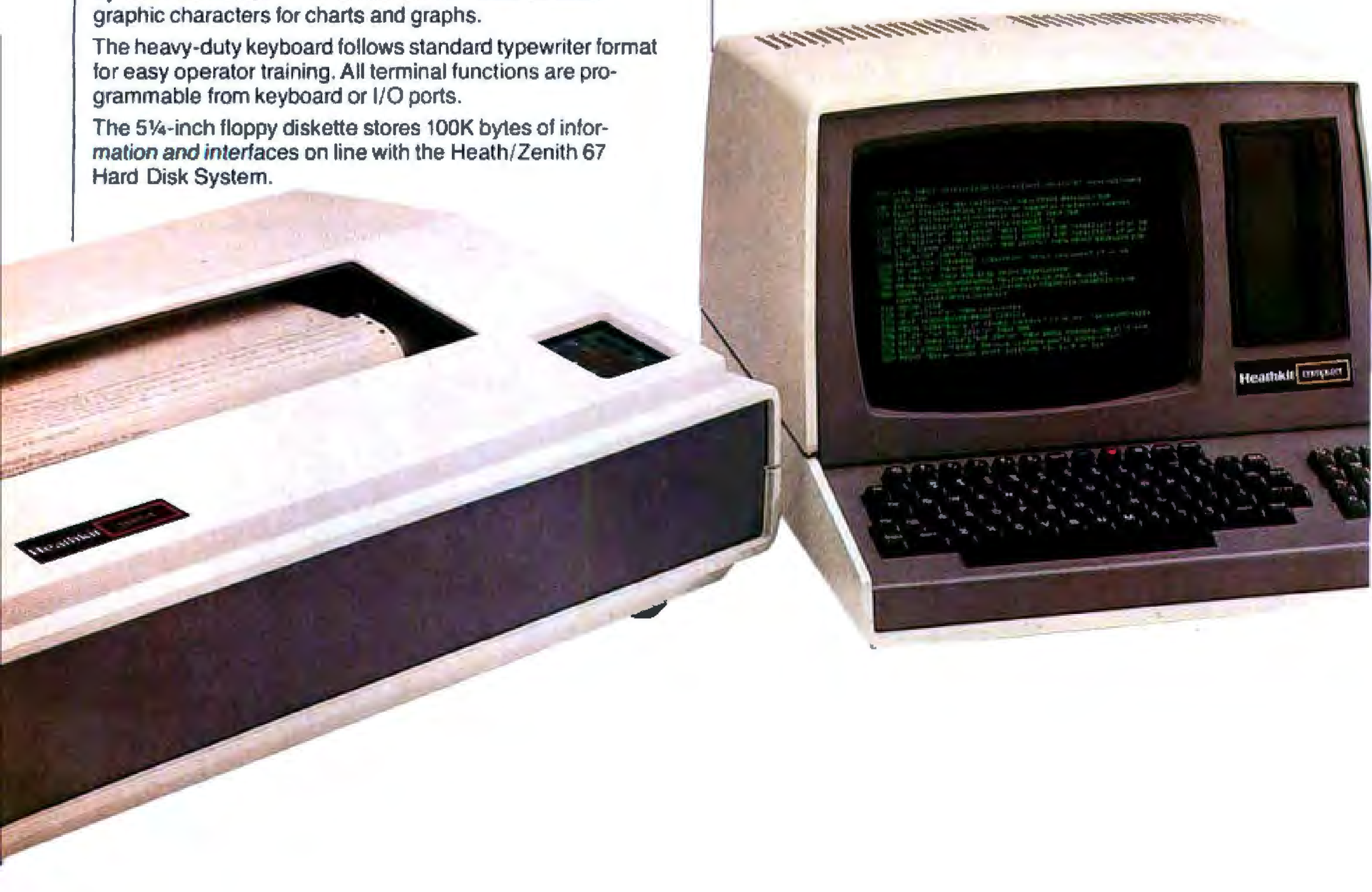

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Listing 1 continued:

```
340 OK=1'MAIN COMPILE LOOP
350 FOR A=0TON-1
360 IF LEFT$(S$(A),1)="*" OB$(A)="" AD(A)=CD:GOTO 450
370 IF MID$(S$(A),7,1)<>"&" THEN 400
380 AD(A)=CO
390 OB$(A)="":FOR B=8TO38: A$=MID$(S$(A),B,1):IF A$="&" THEN 450  ELSE Y=ASC(A$
):X=0:A$="":GOSUB950   :OB$(A)=OB$(A)+A$:CD=CD+1:NEXT
400 A$=MID$(S$(A),7,4):IF LEN(A$)=3 A$=A$+" "
410 IF A$="ORG " THEN A$=MID$(S$(A),15,4):OB$(A)="" GOSUB270   GOTO 450
420 IF LEFT$(S$(A),4)<>"    " THEN LA$(LC)=LEFT$(S$(A),4)   LN(LC)=A : LC=LC+1
430 IF LEFT$(A$,1)="B" GOTO 710
440 IF LEN(S$(A))<15 GOSUB 530  ELSE GOSUB 600
450 NEXT A
460 IF SW=0 THEN 520
470 FOR A=0 TO AC-1
480 FOR B=0TOLC-1:IF RIGHT$(OB$(AR(A)),4)<>LA$(B) THEN NEXT
490 IF MID$(S$(AR(A)),7,1)="B"THEN X=AD(AR(A)):Y=AD(LN(B)):AD(100)=Y-(X+2):C=10
0:GOSUB940   :OB$(AR(A))=LEFT$(OB$(AR(A)),2)+RIGHT$(A$,2):GOTO510
500 C=LN(B):GOSUB940   :OB$(AR(A))=LEFT$(OB$(AR(A)),2)+"0"+A$
510 NEXT A
520 RETURN
530 'IMPLIED OPERANDS
540 IF MID$(S$(A),7,1)="$" OB$(A)=RIGHT$(S$(A),LEN(S$(A))-7) : AD(A)=CD:CD=CD+(
LEN(S$(A))-7)/2:RETURN
550 FOR B=0 TO 100
560 IF LEFT$(NO$(B),4)="END" THEN OB$(A)="*ERR*" :RETURN
570 IF LEFT$(NO$(B),4)=A$ THEN OB$(A)=RIGHT$(NO$(B),2):AD(A)=CD:CD=CD+1:RETURN
580 NEXT
590 'A$=RIGHT$(S$(A),LEN(S$(A)-8)
600 ' OTHER OPS
```

Listing 1 continued on page 236

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Listing 1 continued:

```
610 AD(A)=CD
620 FOR B=0TO100
630 IF LEFT$(OP$(B),4)="END" THEN OB$(A)="*ERR*" :RETURN
640 IF LEFT$(OP$(B),4)<>A$ THEN NEXT
650 IF MID$(S$(A),15,2)="X," THEN OB$(A)=MID$(OP$(B),10,2)+MID$(S$(A),17,2):CD=
CD+2:RETURN
660 IF MID$(S$(A),15,1)="#" THEN OB$(A)=MID$(OP$(B),6,2):OB$(A)=OB$(A)+MID$(S$
(A),16,2):CD=CD+2:B$=LEFT$(OB$(A),2):IF B$<>"8C"ANDB$<>"CE"ANDB$<>"8E" THEN RE
TURN ELSE CD=CD+1:OB$(A)=OB$(A)+RIGHT$(S$(A),2):RETURN
670 IF MID$(S$(A),15,1)=" " THEN OB$(A)="*ERR*":RETURN
680 IF MID$(S$(A),15,1)="$" THENA$=MID$(S$(A),16,4) ELSE A$=MID$(S$(A),15,4):AR
(AC)=A:AC=AC+1:SW=1:A$=A$+STRING$(4-(LEN(A$)), " ")
690 IF LEN(A$)=4 THEN OB$(A)=MID$(OP$(B),12,2) :OB$(A)=OB$(A)+A$:CD=CD+3:RETURN

700 OB$(A)=MID$(OP$(B),8,2):OB$(A)=OB$(A)+A$:CD=CD+2:RETURN
710 'BRANCH INSTRUCTIONS
720 FOR B=0TO15:IF LEFT$(A$,3)=LEFT$(BR$(B),3)THEN 740  ELSE NEXT
730 OB$(A)="*ERR*":GOTO 450
740 OB$(A)=RIGHT$(BR$(B),2):AD(A)=CD:CD=CD+2:AR(AC)=A:AC=AC+1
750 A$=MID$(S$(A),15,4):OB$(A)=OB$(A)+A$+STRING$(4-LEN(A$), " "):SW=1:GOTO 450

760 OK=0:LC=0:AC=0'SOURCE COLLECTION  I , IXX
770 IF LEN(A$)>1 THEN 810
780 PRINT N;TAB(10);:LINEINPUTS$(N)
790 IF S$(N)="" RETURN
800 N=N+1:GOTO780
810 A=VAL(RIGHT$(A$,LEN(A$)-1)) : IF A>N THEN 780
820 PRINT A;TAB(10);:LINEINPUTA$
830 IF A$="" RETURN
840 FOR B=N+1 TO A STEP-1:IF B=0 THEN 850  ELSE S$(B)=S$(B-1):NEXT
```

Listing 1 continued on page 238

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Circle 391 on inquiry card.

Listing 1 continued:

```
850 S$(A)=A$:A=A+1:N=N+1:GOTO 820
860 'SOURCE DUMP  L , LXX , LXX-XX
870 IF LEN(A$)=1 A=0:B=N-1
880 IF LEN(A$)>2 A=VAL(RIGHT$(LEFT$(A$,4),3)) : B=A
890 IF LEN(A$)>3 B=VAL(RIGHT$(A$,3))
900 IF B>N :B=N-1
910 IF A>N :A=N-1
920 IF OK THENFORC=ATOB:GOSUB940  :PRINT C;TAB(6)A$;"   ";OB$(C);TAB(22)S$(C):N
EXT:RETURN
930 FORC=ATOB:PRINT C,S$(C):NEXT:RETURN
940 A$="": Y=AD(C):X=INT( Y/256):GOSUB970
950 X=INT(( Y-(X*256))/16):GOSUB970
960 X=INT( Y-(INT( Y/16)*16))
970 IF X>9 THEN A$=A$+CHR$(X+55) ELSE A$=A$+RIGHT$(STR$(X),1)
980 RETURN
990 OK=0:LC=0:AC=0'SOURCE DELETE DXX
1000  B=VAL(RIGHT$(A$,LEN(A$)-1))
1010  IF B>N RETURN
1020  FOR C=B TO N-1:S$(C)=S$(C+1):NEXT
1030  N=N-1:RETURN
1040 'SYMBOL PRINT
1050 IF OK THEN 1060 ELSE RETURN
1060 FOR A=0 TO LC-1:C=LN(A):GOSUB 940  :PRINT LA$(A);"   ";LN(A);"   ";A$:
1070 NEXT:RETURN
1080 ' FILE I/O SUBCMS l=LOAD S=SAVE
1090 INPUT "SUBCOMMAND L=LOAD S=SAVE ";B$
1100 IF (B$<>"S")*(B$<>"L") THENRETURN
1110 INPUT " FILE SPEC'S ";A$
1120 IF B$="S" THEN 1170
1130 OPEN "I",1,A$:INPUT#1,OK,N
1140 FOR A=0TON-1:INPUT#1,S$(A),OB$(A),AD(A):NEXT
```

Listing 1 continued on page 240

 Circle 9 on inquiry card. Circle 448 on inquiry card. →

Listing 1 continued:

```
1150 CLOSE:RETURN
1160 PRINT"THERE IS NO SOURCE":RETURN
1170 IF N=0 THEN 1160 ELSE OPEN "O",1,A$:PRINT#1,OK;N;
1180 FOR A=0 TO N-1:PRINT#1,CHR$(34);S$(A);CHR$(34);CHR$(34);OB$(A);CHR$(34);AD
(A);:NEXT
1190 B$="":CLOSE:RETURN
1200 'COMMAND CONTROL
1210 LINEINPUT"READY* ";A$ : B$=LEFT$(A$,1)
1220 IF B$="L" GOSUB 860
1230 IF B$="I" GOSUB 760
1240 IF B$="D" GOSUB 990
1250 IF B$="R" THEN 130
1260 IF B$="C" GOSUB 240
1270 IF B$="F" GOSUB 1080
1280 IF B$="S" GOSUB 1040
1290 IF B$="H" GOSUB 1550
1300 GOTO 1200
1310 'IMPLIED OPERANDS
1320 DATA ABA  1B,CLRA 4F,CLRB 5F,COMA 43,COMB 53
1330 DATA DECA 4A,DECB 5A,INCA 4C,INCB 5C,PSHA 36,PSHB 37
1340 DATA PULA 32,PULB 33,ROLA 49,ROLB 59,RORA 46,RORB 56
1350 DATA ASLA 48,ASLB 58,ASRA 47,ASRB 57
1360 DATA SBA  10,TAB  16,TBA  17,TSTA 4D,TSTB 5D
1370 DATA DEX  09,DES  34,INX 08,INS  31,TXS  35,TSX  30
1380 DATA NOP  02,RTI  3B,RTS  39,SWI  3F,WAI  3E
1390 DATA DAA   19,CLC   0C,CLI   0E,CLV   0A,SEC   0D,SEI   0F,SEV   0B,TAP
06,TPA   07
1400 DATA LSRA  44,LSRB  54
1410 DATA END
1420 'OTHER OPERANDS IMMED,DIRECT,INDEX,EXTENT
1430 DATA ADDA 8B9BABBB,ADDB CBDBEBFB,ADCA 8999A9B9,ADCB C9D9E9F9
1440 DATA ANDA 8494A4B4,ANDB C4D4E4F4,BITA 8595A5B5,BITB C5D5E5F5
1445 DATA CLR      6F7F,INC      6C7C,DEC      6A7A
1450 DATA CMPA 8191A1B1,CMPB C1D1E1F1,EORA 8898A8B8,EORB C8D8E8F8
1460 DATA LDAA 8696A6B6,LDAB C6D6E6F6,ORAA 8A9AAABA,ORAB CADAEAFA
1470 DATA SUBA 8090A0B0,SUBB C0D0E0F0,SBCA 8292A2B2,SBCB C2D2E2F2
1480 DATA TST      6D7D,JMP      6E7E,JSR      ADBD,
1490 DATA CPX  8C9CACBC,LDX  CEDEEEFE,LDS  8E9EAEBE
1500 DATA STX    DFEFFF,STS    9FAFBF,
1510 DATA STAA   97A7B7,STAB   D7E7F7
1520 DATA END
1530 'BRANCH INSTRUCTIONS
1540 DATA BRA20,BCC24,BCS25,BEQ27,BGE2C,BGT2E,BHI22,BLE2F,BLS23,BLT2D,BMI2B,BNE
26,BVC28,BPL2A,BSR8D,BVS29
1550 'OPERATING INSTRUCTIONS
1560 CLS:PRINTTAB(20)"*** MINI 6800 COMPILER ***":PRINT"HELP  H  THIS INSTRUCTI
ON PAGE         FILE F SAVE/LOAD"
1570 PRINT"INSERT   I ( ADD TO EXISTING TEXT)  IXX (ADD BEFORE LINE#)"
1580 PRINT"DELETE   DXX ( LINE NUMBER)      RESTART/CLEAR   R"
1590 PRINT"LIST     L (ALL TEXT IN BUFFER) LXX (LINE #) LXXX-XXX (RANGE)
1600 PRINT"COMPILE  C       SYMBOL PRINT  S"
1610 PRINT"* MOST OF THE INSTRUCTION SET IS INCLUDED *"
1620 PRINT"IMMED ADDRESSING    #XX  (    ADDA    #1A )"
1630 PRINT"DIRECT ADDRESSING   $XX  (    ADDA    $1A )"
1640 PRINT"INDEXED ADDRESSING X,XX (    ADDA    X,1A )"
1650 PRINT"EXTENDED ADDRESSING $XXXX  (    ADDA  $XXXX)"
1660 PRINT"IMPLIED           NO OPERAND
1670 PRINT"OTHER  ( ORG XXXX) LITERALS ($XX HEX)  (&XX& ASCII)
1680 PRINT"* SOURCE IS POSTIONAL ENTER AS FOLLOWS *"
1690 PRINT"LABEL(<4CH)  *TAB*   OPERATION     *TAB*     OPERAND"
1700 'ABEND PROCESSING
1710 ON ERROR GOTO 1720 :RETURN
1720 PRINT "ERROR IN ";ERL,"WAS ",(ERR/2)+1
1730 RESUME1200
```

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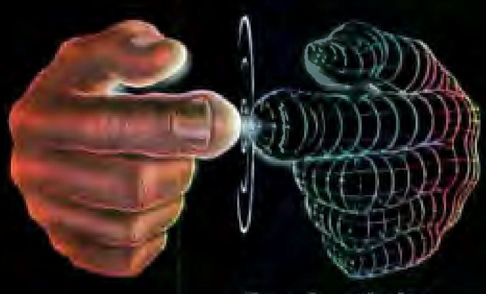

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```
                    *** MINI 6800 COMPILER ***
HELP   H  THIS INSTRUCTION PAGE          FILE F SAVE/LOAD
INSERT    I ( ADD TO EXISTING TEXT)  IXX (ADD BEFORE LINE#)
DELETE    DXX ( LINE NUMBER)       RESTART CLEAR    R
LIST      L (ALL TEXT IN BUFFER) LXX (LINE #) LXX-XX (RANGE)
COMPILE  C       SYMBOL PRINT  S
* MOST OF THE INSTRUCTION SET IS INCLUDED *
IMMED ADDRESSING    #XX  (    ADDA   #1A )
DIRECT ADDRESSING  $XX  (    ADDA   $1A )
INDEXED ADDRESSING X,XX (    ADDA   X,1A )
EXTENDED ADDRESSING $XXXX  (    ADDA  $XXXX)
IMPLIED          NO OPERAND
OTHER  ( ORG XXXX) LITERALS ($XX HEX)  (&XX& ASCII)
* SOURCE IS POSTIONAL ENTER AS FOLLOWS *
LABEL(<4CH)  *TAB*   OPERATION     *TAB*    OPERAND
READY*
```

Figure 1: *A help screen with all the commands needed to make the program usable.*

Text continued from page 229:

The rest of the commands deal with the 6800 source data. As you enter the source code, a line counter is incremented. All references are based on these line numbers:

L	List on the screen all the source text. If it has been assembled, the object is also displayed.
L*xx*	Display a single line.
L*xx*—*yy*	Display a range of lines.
D*xx*	Delete a single line. The source is renumbered.
I*xx*	Insert before line *xx*. This is a multiple insert that can be terminated by pressing ENTER on an empty line.
I	Insert at the end of the source code. Again, this is a multiple insert that is terminated by pressing ENTER on an empty line.

I have taken some liberties in designing my coding conventions. To be consistent, they are also displayed on the HELP screen. First, the operands are a single string. For example, use STAA, not STA A, to store accumulator A. This concatenated operation code and operand works for all instructions. It helps to find the correct op code quicker in the tables as I've created them. Literals are created as $*xxxx* for 2 bytes of hexadecimal and &*aaaa*&, where *aaaa* is an ASCII string of up to 30 characters. The only pseudo-op implemented is the ability to force the assembly to specific addresses with ORG *xxxx*, where *xxxx* is the address in hexadecimal where the assembly is to originate. Any number of ORG statements can be used in a single program.

Source input is done in the insert mode. Once in this mode, the TAB key plays an important role. An input line consists of up to three fields separated by tabs: label (4 or fewer characters), operation, and operand; no comments are allowed in these lines. Comments are entered by typing an asterisk in position one.

Figure 2 shows a sample session with the cross-assembler. I loaded a preassembled 6800 program called ECHO/M68 from disk. Then I listed all of it. From left to right, the contents are: line number, hexadecimal load address, assembled object code, label, operation, and operand. I assembled and then displayed the symbol table. Note that the source and object code are automatically saved on disk for use with the download function. The S command lists the statement number and hexadecimal address of each label requiring address resolution. Next, I used the I command to enter a new line at the end of the current source program. The line numbers are generated by the program. I pressed ENTER

Text continued on page 250

Cromemco introduces System One.

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Circle 22 on inquiry card.

```
SUBCOMMAND L=LOAD S=SAVE ? L

 FILE SPEC'S ? ECHO/M68

READY* L

 0     000                   * DEMO PROGRAM FOR TRS-80 CROSS ASSEMBLER
 1     000                   *
 2     000                   **** SIMPLE ECHO PROGRAM ****
 3     003                   * 1ST TIME PRINT DIRCTIONS
 4     000   FE0027          WRIT  LDX      CRLF
 5     003   BDE07E                JSR      $E07E
 6     006   FE002D                LDX      ATXT
 7     009   BDE07E                JSR      $E07E
 8     00C   FE0027                LDX      CRLF
 9     00F   BDE07E                JSR      $E07E
 10    012   FE002D                LDX      ATXT
 11    018                   * READ INPUT FOR ECHO
 12    015   BDE1AC          READ  JSR      $E1AC
 13    018   810D                  CMPA     #0D
 14    01A   2305                  BLS      END
 15    01C   A700                  STAA     X,00
 16    01E   08                    INX
 17    01F   20F4                  BRA      READ
 18    021   8604            END   LDAA     #04
 19    023   A700                  STAA     X,00
 20    025   20D9                  BRA      WRIT
 21    029                   * LITERAL FOR LINE FEED AND CR
 22    027   0029            CRLF  $0029
 23    029   000A                  $000A
 24    02B   0D04                  $0D04
 25    02D   002F            ATXT  $002F
 26    04A                   *TEXT BUFFER
 27    02F   4543484F2050524F475241402054595045204142442054E544552
              &ECHO PROGRAM TYPE AND ENTER&
 28    04A   04                    $04


READY* C

READY* S

WRIT     4     000
READ     12    015
END      18    021
CRLF     22    027
ATXT     25    02D
READY* I

29* ADDED TO END OF PROGRAM

30

READY* L

 0               * DEMO PROGRAM FOR TRS-80 CROSS ASSEMBLER
 1               *
 2               **** SIMPLE ECHO PROGRAM ****
 3               * 1ST TIME PRINT DIRCTIONS
 4               WRIT  LDX      CRLF
 5                     JSR      $E07E
 6                     LDX      ATXT
 7                     JSR      $E07E
 8                     LDX      CRLF
```

Figure 2: *Sample session with the 6800 cross-assembler program.*

Figure 2 continued on page 246

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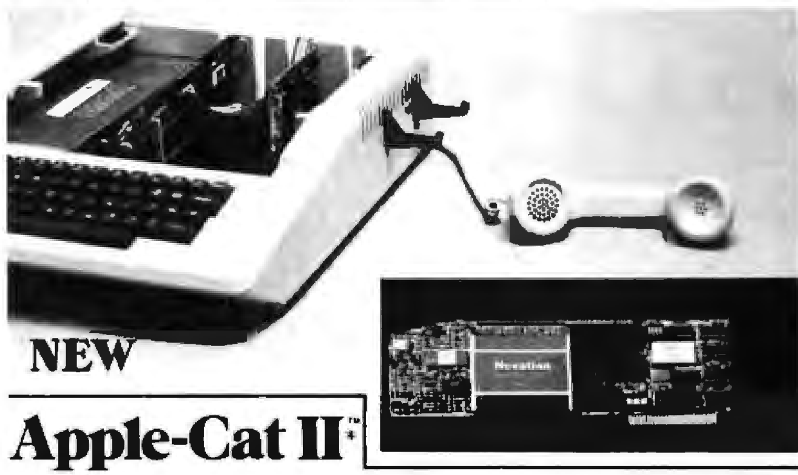

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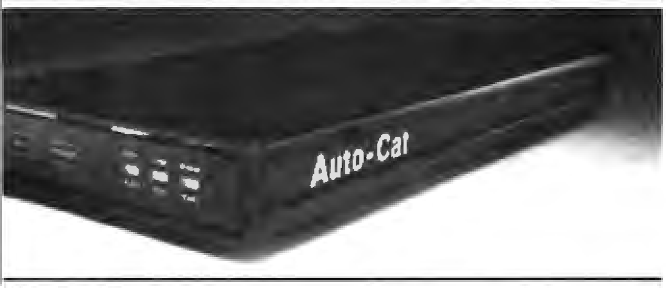

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Figure 2 continued:

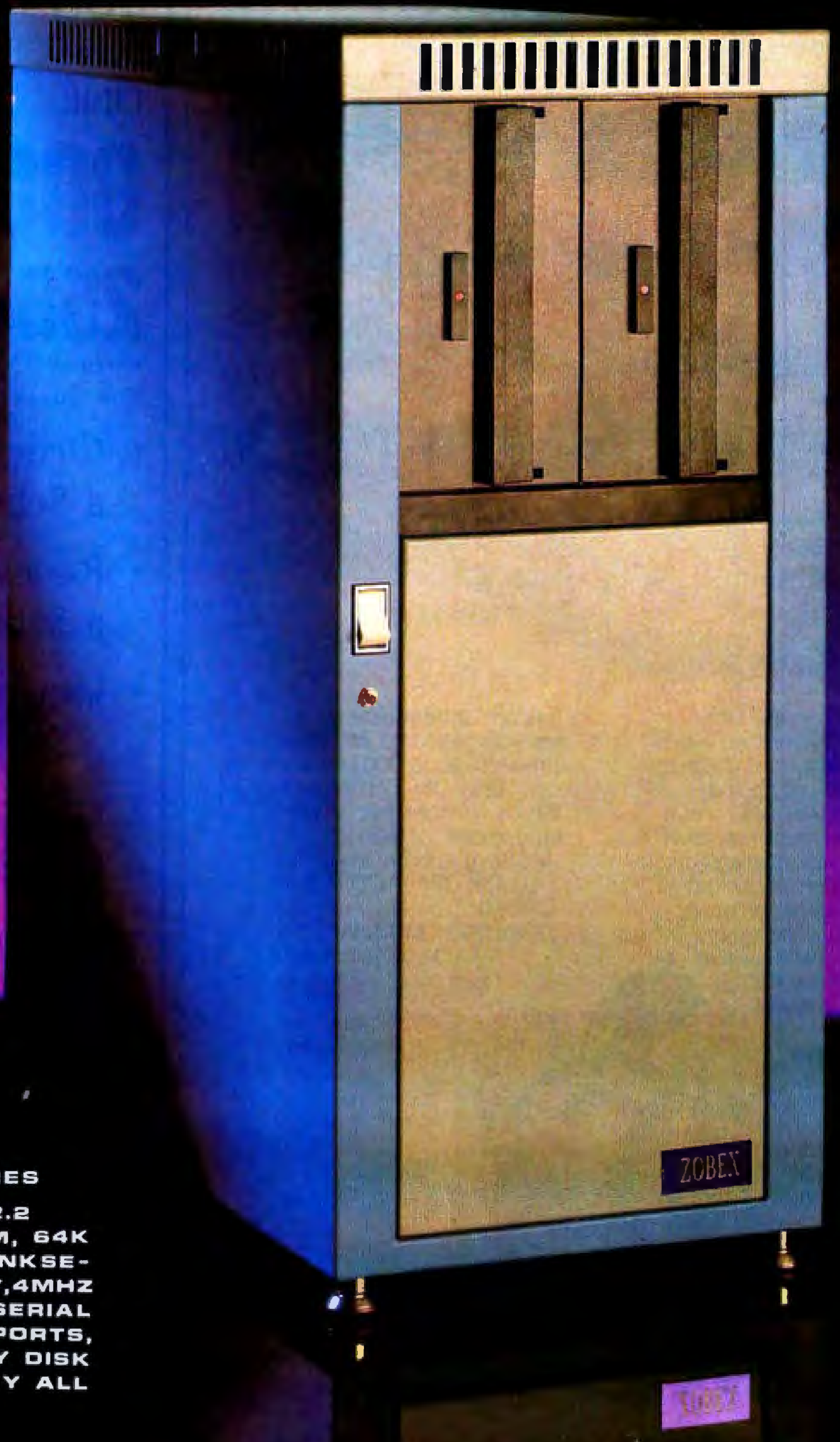
```
 9                 JSR     $E07E
 10                LDX     ATXT
 11           * READ INPUT FOR ECHO
 12           READ JSR     $E1AC
 13                CMPA    #0D
 14                BLS     END
 15                STAA    X,00
 16                INX
 17                BRA     READ
 18           END  LDAA    #04
 19                STAA    X,00
 20                BRA     WRIT
 21           * LITERAL FOR LINE FEED AND CR
 22           CRLF $0029
 23                $000A
 24                $0004
 25           ATXT $002F
 26           *TEXT BUFFER
 27                &ECHO PROGRAM TYPE AND ENTER&
 28                $04
 29           * ADDED TO END OF PROGRAM
READY* D29

READY* L27-99

 27                &ECHO PROGRAM TYPE AND ENTER&
 28                $04
READY*
Break in 1230
READY
>
```


Circle 161 on inquiry card.
Circle 445 on inquiry card. →

MULTIUSER



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Text continued from page 242:
at the end of each line and relisted the source code. The object code is not listed since I have modified the source code. Finally, I deleted the added line and listed the end of the text to see if it was gone.

The cross-assembler I developed is not instantaneous, but it really outshines my hand-assembly abilities. It doesn't have full checking or diagnostic capability because of the added time it would take to assemble using BASIC. It does, however, offer a two-pass capability. That is, you can use and reference labels that force two passes through the source to resolve and build the correct object code. Features such as relative branches are also available.

Program Organization

To help those who might like to modify or enhance the editor/cross-assembler program, here is a summary of the program's organization:

140-230 All the array and variable uses are noted in the remarks. The key ones are S$ (source), OB$ (object code for the source), and AD (assembled address of the source).
250-340 At the first assembly, the op-code dimensions are loaded so the first assembly will take a little longer.
350-760 The main assembly loop.
  370 Handle comments.
  380-400 Handle ASCII literals.
  420 Handle ORG statements.
  430-450 Select op-code routines.
  470-530 Second pass to resolve addresses.
  540-600 Process implied operands.
  610-710 Process everything except branches.
  720-760 Process branch instructions.
770-860 Source collection.
870-990 Source listing.
1000-1040 Delete command.
1050-1080 Symbol print.
1090-1200 File I/O for save/load.
1210-1310 BASIC command loop. You may add additional commands in this section.
1320-1400 Implied operand table.
1410-1510 Other op-code table.
1520-1530 Branch op-code table.
1540-1680 Help command processing.
1690-1700 Abend trap.

That's it. You now have a workable TRS-80 cross-assembler for the Motorola 6800.

In part 2, I will complete the package by presenting a Z80 I/O linkage program and a BASIC controlling program. When used, you have all the MIKBUG commands plus ten breakpoints, a 16-byte hexadecimal display, a GOTO *address* command, and a LOAD of any assembled program from the TRS-80 disk through MIKBUG to the 6800 memory.■

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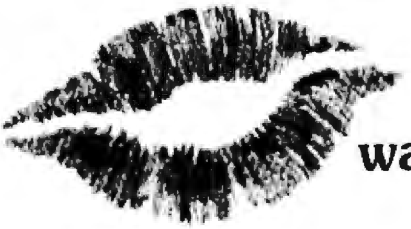
Circle 50 on inquiry card. →

KISS BASIC GOODBYE



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Customized Versions • TRS80 Mod II, TRS80 Mod III, APPLE, OSBORNE, INTERTEC, VECTOR , ZENITH

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Circle 392 on inquiry card.

Ask BYTE

Conducted by Steve Ciarcia

Mystery Card

Dear Steve,

I've seen a small circuit board for the Radio Shack TRS-80 Model I that augments the computer's disk capabilities. To use it, the FD1771 floppy-disk-controller integrated circuit is removed from the computer and installed on this mysterious card. The card is then connected to the empty 1771 socket via a ribbon cable and DIP (dual inline package) plug.

Unfortunately, I don't know any more about the board, but I'm hoping it will let me use 8-inch floppy disks on my TRS-80. Can you supply more information?

Raúl G Efrón
Rosario, Santa Fe, Argentina

To my knowledge, the only company that makes an 8-inch floppy-disk-controller for the TRS-80 Model I is Lobo Drives International. Its address is 354 S Fairview Ave, Goleta CA 93117, (805) 683-1576.

Your mystery board is called the Doubler and is made by Percom Data Company, 211 N Kirby, Garland TX 75042, (800) 527-1592; in Texas (214) 272-3421. It actually is a device that adds a double-density FD1791 disk-controller chip to the FD1771 chip in the Tandy Expansion Interface. It allows you to run either single- or double-density drives, which lets you store up to four times more data on a floppy disk. The Doubler board takes the place of the 1771, and the single-density disk-controller chip plugs into the Doubler board. To date, it costs about $220 in the US and can be purchased through authorized distributors of Percom equipment. . . . **Steve**

Control Program for Microcomputers

Dear Steve,

What is CP/M? I try to keep up on current technology, but this buzzword has got me. Has BYTE ever reviewed CP/M? If so, please tell me when so I can investigate.

Stephen Gentry
Evansville IN

CP/M (Control Program for Microcomputers) is an operating system originally designed to run on Intel's 8080 microprocessor (it also runs on Intel's 8085 and Zilog's Z80). It was written and is supported by Digital Research, POB 579, Pacific Grove CA 93950, (408) 649-3896.

CP/M uses the IBM 3740 "soft-sector" floppy-disk format and, usually, 8-inch disk drives. Many types of programs are supported on CP/M, including compilers and interpreters for languages such as BASIC and FORTRAN. Also, WordStar and Magic Wand (two word processors) and many other high-level pieces of software are available for the small-business-oriented user.

A comprehensive series of articles on CP/M's structure and format was written by Jake Epstein in S-100 Microsystems *magazine (a bimonthly publication of* Creative Computing, *39 E Hanover Ave, Morris Plains NJ 07950). This magazine is dedicated to S-100 systems, and the predominant operating system among S-100 users is CP/M.*

If after you've learned a little bit more about CP/M you want to have a list of its features, I recommend that you get the CP/M Summary Guide, *by Bruce Brigham. It can be ordered through Rosetta Stone, POB 35, East Glastonbury CT 06025. It costs $7.95 postpaid in the US. . . .* **Steve**

Lining Up Problems

Dear Steve,

Our store purchased a TRS-80 Model II. Our future plans call for a remote terminal located about 50 feet away from the computer. We are wondering what problems we may have with such a line and what precautionary steps might be taken. Should we use the RS-232C port on the Model II, or is there a better way to connect a remote terminal?

Lonnie Hartzell
Dixon IL

The RS-232C standard is specified to operate between 50 and 9600 bps (bits per second) for up to 50 feet, so you should not have any problem. If you are running at lower data rates (perhaps 1200 bps), you can separate the computer and the peripheral by as much as 500 feet and expect perfectly reliable operation. (At least that has been my experience.) Unless the cable is wrapped around an arc welder, you should have no problems at all. . . . **Steve**

Upgrading Kits

Dear Steve,

I would like to increase my TRS-80's memory capacity without spending any more money than necessary, and I don't want to blow it up in the process.

I have a Model III with 16 K bytes of memory, which isn't enough for some of my programming applications. It also limits the length of my Scripsit documents. I would like to add the maximum memory the Model III can hold (48 K bytes). Radio Shack sells 16 K-byte memory kits for $119 plus installation, while various mail-order suppliers advertising in BYTE list similar upgrade kits for around $29.

What is the difference between these memory upgrade kits? Is the installation difficult or within the capabilities of someone who is not a computer technician—like me?

Ralph W Karcher Jr
Broadalbin NY

Theoretically, any 4116-type memory rated for 200 ns access time should work in your TRS-80 Model III. If you carefully disassemble your Model III, you should be able to add them yourself. The sockets are already provided, and no jumpers are required.

While quality varies in some of the lower-priced upgrade kits, the prices of prime memory components have been dropping so fast that you can find many good values. Before you place an order make sure that the chips are guaranteed for 200 ns operation and that the supplier will not substitute any other speed. . . . **Steve**

D/A Converters

Dear Steve,

I'm currently in the process of writing music/sound generation routines for my Apple II Plus. I need a D/A (digital-to-analog) converter to put into one of the expansion slots. Do you know of a sim-

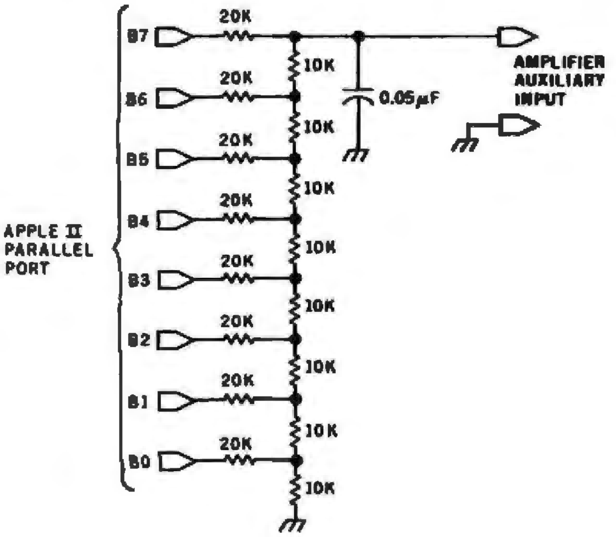

Figure 1

ple, low-cost (under $30) design? I have considered using various D/A integrated circuits, but a simple buffered resistor ladder would suffice. (The output will eventually go through my stereo amplifier.)

David R Tribble
Arlington TX

You can build a D/A converter (DAC) for about a half-dollar if you can live with some minor inaccuracies. Since you are planning on using a stereo amplifier, a DAC designed for relative (rather than absolute) accuracy should be fine.

It doesn't require very much to design a DAC: a few resistors and an 8-bit latch. First, you need to purchase or build a parallel port for your Apple II. Then, take the 8 output bits and run them through an R/2R resistor ladder as shown in figure 1.

The DAC in the figure is suitable for music and speech-synthesis applications, but it isn't exactly "laboratory grade." This particular type of inexpensive DAC is used in the popular Orchestra-80 music synthesizer for the TRS-80 (manufactured by the Software Affair, Suite 1, 473 Sapena Court, Santa Clara CA 95051). My January 1982 "Circuit Cellar" will cover more accurate D/A converters. . . . **Steve**

Missing Relays

Dear Steve,

In your article "Computerize a Home," you presented three possible techniques for interfacing a BSR X-10 home controller to a computer. (See the January 1980 BYTE, page 28.) I'm using a Radio Shack Plug 'N Power, which cannot receive ultrasonic signals, although I would have preferred a method that could. You indicated in the article that relays could be used to bundle the −20-volt control signals, instead of the keyboard, but it is unclear to me just exactly how this is done.

William J Penna
Fort Wayne IN

The relays can be attached to the X-10 unit in two ways. One would be to directly simulate the operation of CMOS (complementary metal-oxide semiconductor) multiplexers in a matrix pattern where you would close the appropriate relay in place of pressing a switch. If you look closely at a diagram of the unit, you can see that about half the relays could be eliminated by directly closing a particular relay to short the two appropriate pins together. If you don't want to have 16 separate receivers, but perhaps only eight, you could use fewer relays still.

As you mentioned, the Radio Shack Plug 'N Power does not have an ultrasonic receiver. I wrote an article for Radio Electronics *magazine in September 1980 that gave complete schematics of both the command console and various receivers. The difference between the Radio Shack unit and the Sears controller is that Sears' machine contains the circuitry for ultrasonic input. This can be added to the Radio Shack unit, or you can create the coded signal (as I did in my BYTE article).*

To do this, you would put the coded signal through an optoisolator and inject it directly into pin 7 of the 28-pin integrated circuit in the command console. In effect, this would be equivalent to receiving signals via the ultrasonic link. The unit will then function similar to the Sears controller.

OSI (Ohio Scientific) uses a similar method in its system that incorporates the BSR controller. Be careful to make sure that you optically isolate

the command console from the computer, even though you are running it on 5 V. The command console has no isolation transformer and is floating at 115 V. The opto-isolator will provide you with the proper level shift to run on the −20 V supply within the command console. Also, Radio Shack now makes a $39 computer-to-AC line BSR X-10 transmitter. . . . **Steve**

More on Burn-Outs

Dear Steve,

I have some additional information on the BSR module "burn-out" problem discussed in "Ask BYTE" (see the April 1981 BYTE, page 330).

First, it is important to identify whether it is an appliance module or a lamp module that is burning out. A short across an appliance module will more likely burn out the house fuse than the module. Because of this, the appliance module should be used in high-exposure areas like outdoor lights. There is a fuse in the appliance module, but its job is to protect the line and sensor circuit from each other and is, in my opinion, very unlikely to blow.

The fuse in the lamp module is in the line that feeds the load that the module is controlling. As such, it tends to burn out before the module's triac in the situation you were discussing. This has been my experience. I returned two lamp modules before I got frustrated and took one apart to find the fuse. I compared a burnt-out module with a good one, and I found the fuse. It's a sub-hair-sized piece of wire that vaporizes with no trace when it blows. I replaced this with a single strand of copper wire from zip cord (a single strand from the bundle that makes up one of the conductors). I think this is too big, but it works. I'll have to wait and see if the triac burns out the next time the lamp falls over and blows out the bulb. I don't think it will.

Another point not mentioned in your article is that BSR will repair the fuse for a flat $4 if you ship the damaged module to the company. A high price to replace a fuse, but much cheaper than buying a new module.

One other point: I had erratic operation of some modules from certain control units at various times of the day until I installed a 0.1 μF capacitor across the 220 V house feed. This completely solved the erratic operation and also totally eliminated outside interference from CB radios, etc. (BSR suggested this, and it works extremely well.)

T Gerald Dyar
West Hartford CT

Thanks for the information. . . . **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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What Makes Computer Games Fun?

Thomas W Malone
Cognitive and Instructional Sciences Group
Xerox Palo Alto Research Center
3333 Coyote Hill Road
Palo Alto CA 94304

Rumor has it that when the Space Invaders game was first introduced in Japan the Japanese treasury ran out of the coin that was used to operate the game. True or not, the phenomenal popularity of various computer games is obvious to anyone who has wandered through a shopping mall, an airport lounge, or a toy store in the last few years.

Why are these games so captivating? And how can the same things that make computer games captivating be used to make *learning* with computers more interesting and enjoyable? To help answer these questions, I systematically studied more than 100 people playing computer games, looking primarily at what made the games fun. Then I developed a set of guidelines for designing highly motivating educational computer programs.

Though I focused on making educational activities more fun, these guidelines can also be used in designing noneducational computer games or in making other computer programs more fun to use. All of the work I discuss in this article is described in more detail elsewhere (references 3 and 4).

Acknowledgments

This article is based on the author's PhD dissertation submitted to the Stanford University Department of Psychology. Parts of the article were previously included in the proceedings of the Association for Computing Machinery Symposium on Small and Personal Computer Systems (Palo Alto, California, September 19, 1980) and in references 3 and 4.

Survey of Preferences

As a first step toward finding what makes computer games fun, I interviewed 65 students—from kindergarten through eighth grade—about their computer-game preferences. All the children had been playing with computer games in a weekly class for at least two months and some for more than two years. The computer class teachers provided a list of the 25 games they judged most popular among the students. Then I asked each child to rate how well he or she liked each game, on a three-point scale.

Table 1 lists all the games in order of their average rating by children who had played them. One of the most interesting questions we can ask about these results is what features the popular games share that are missing in the unpopular games. To answer this I rated each game using a number of criteria that seemed likely to affect their motivational value. Table 2 shows the correlations between these game features and the average ratings the games received from the children.

The most important factor determining popularity in this sample was whether or not the game had a goal. For example, the top three games all had obvious goals (getting a high score in Petball, trapping the other person's snake in Snake2, and destroying all the bricks in Breakout), while the bottom two games had no clear goals (conversing with a simulated psychiatrist in Eliza or filling in blanks in a story in Gold). Scoring, audio effects, and randomness also had high correlations with game popularity. The children liked graphic games and significantly disliked word games.

Even though these results are interesting, it is impossible to draw strong conclusions from this kind of correlational study. Among other things, the results depend entirely on the sample of games I used. The other two studies I describe focus on a single game and systematically vary its features in a series of slightly different versions of the game; this allows us to make some stronger conclusions.

Breakout—The first game I studied in detail was Breakout. Figure 1 shows a typical screen display in the original Breakout game. The player uses a knob to control the position of the paddle on the left side of the

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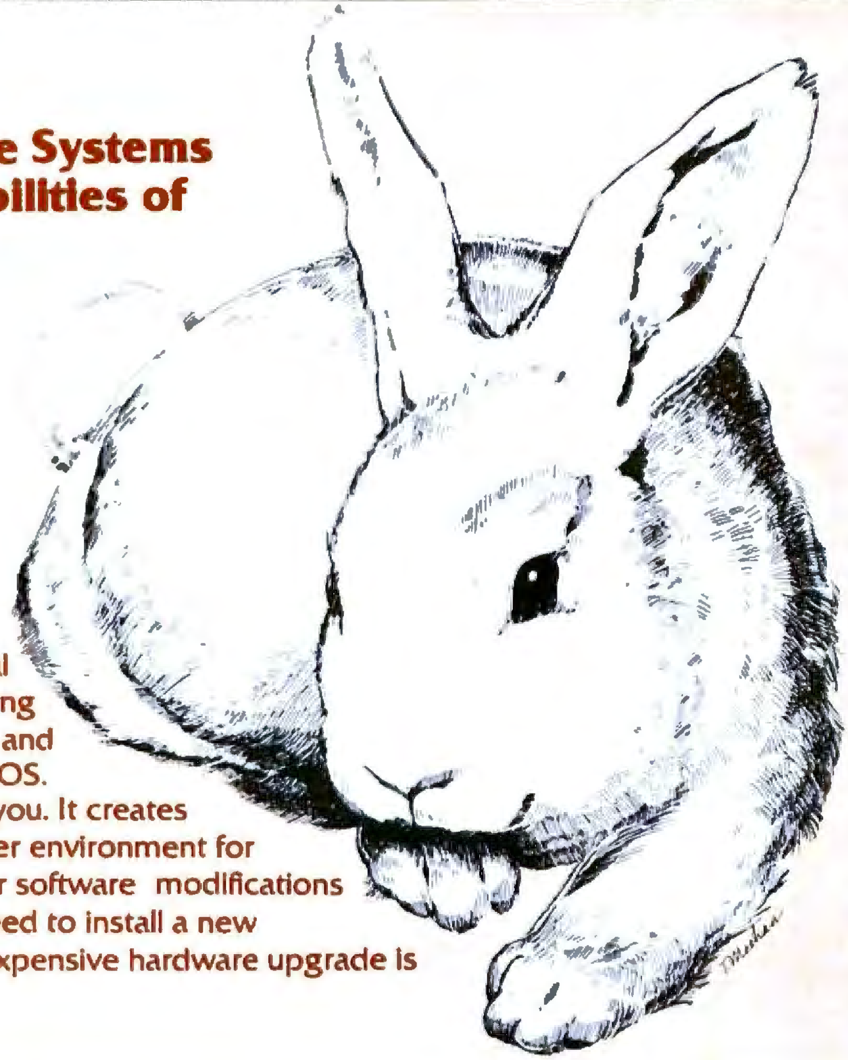

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Game	Average Rating	Description
Petball	2.8	Simulated pinball with sound
Snake2	2.6	Two players control motion and shooting of snakes
Breakout	2.6	Player controls paddle to hit ball that breaks through a wall, piece by piece
Dungeon	2.6	Player explores a cave, like Dungeons and Dragons
Chase S	2.6	Two players chase each other across an obstacle course, with sound effects
StarTrek	2.5	Navigate through space and shoot Klingon ships
Don't Fall	2.5	Guess words like Hangman but, instead of a person being hung, a person or robot advances to a cliff
Panther	2.4	Guess who committed a murder by questioning witnesses who may lie
Mission	2.4	Bomb submarines without getting your ship sunk
Chaser	2.4	Capture a moving square with perpendicular lines
Chase	2.4	Like Chase S but without sound
Horses	2.4	Bet on horses that race along track
Sink Ship	2.3	Bomb a ship from an airplane
Snake	2.3	Like Snake2 but snakes can't shoot
Lemonade	2.3	Run a lemonade stand: buy supplies, advertise, etc
Escape	2.2	Escape from moving robots
Star Wars	2.2	Shoot Darth Vader's ship on screen
Maze Craze	2.2	Escape from randomly generated maze
Hangman	2.1	Guess letters of a word before man is hung
Adventure	2.0	Explore cave with dragons, etc
Draw	2.0	Make any design on the screen
Stars	2.0	Guess a number. Clues given by number of stars
Snoopy	1.9	Shoot Red Baron by subtracting Snoopy's position on number line from Red Baron's position
Eliza	1.8	Converse with simulated psychiatrist
Gold	1.5	Fill in blanks in story about Goldilocks

Table 1: *25 computer games, listed according to preference. Sixty-five students were asked to rate the games (1=don't like; 2=like; 3=like a lot).*

Feature	Correlation with Average Preference
Goal	0.65**
Computer keeps a score	0.56**
Audio effects	0.51**
Randomness involved in game	0.48**
Speed of answers counts	0.36*
Visual effects	0.34
Competition	0.31
Variable difficulty level	0.17
Cooperation	0.02
Fantasy	0.06
Kind of game:	
Graphic game	0.38*
Math game	−0.20
Word game	−0.38*

Statistical significance levels:
*$p<0.05$
**$p<0.01$

Table 2: *Features influencing game preference, listed according to importance. The 25 games listed in table 1 were analyzed in terms of these features, and the results were correlated with the game preferences from table 1.*

screen. The paddle is used to bounce the ball against the wall of bricks on the right side of the screen. Each time the ball bounces off the wall, it knocks one brick out and adds to the score. The ultimate goal of the game is to knock out all the bricks.

My survey and other casual observations indicate that this is one of the most popular contemporary computer games. What is the "secret" of its success? Many devotees of Breakout and similar games mention their score—usually their highest one—when talking about the game. Is the challenge of getting a record-high score the principal attraction? Is it the visual stimulation of watching the bricks break out? Or is it simply the enjoyment of the sensorimotor skill involved in putting the paddle in front of the ball? There are, of course, many other features of Breakout, but these three—the score, the breaking

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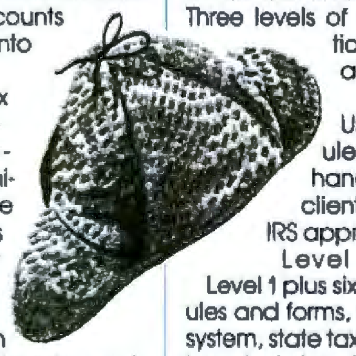

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out of the bricks, and the ball bouncing off the paddle—seem to capture the essence of the game.

To examine which of these three features was most important to the game's appeal, I constructed six different versions of the game, varying each of the three features in all sensible combinations. For example, in some versions the ball bounced back and forth between the wall and the paddle but no bricks ever broke out of the wall. In other versions the ball never bounced off the paddle; it was simply "caught" when the paddle was placed in front of it. Also, only half of the versions had a score.

I asked 10 college undergraduates to play all the versions and then rate how well they liked each one. The factor that made the most significant difference in their ratings was whether or not the bricks were broken out. It is unclear from this study what aspects of the bricks breaking out are most important, but the list of features in table 2 suggests a number of important possibilities. A partially destroyed wall of bricks presents a visually compelling goal, while acting as a graphic scorekeeping device which tells how close the player is to that goal. It thus provides a goal, a visual effect, and scoring at the same time. In fact, the wall's structure suggests many goals at different levels: knocking out a brick in the third row, destroying the first row completely, etc.

The results also showed that the versions without scores or bricks breaking out were significantly less appealing than the other versions. In other words, the versions in which there was no clear goal—other than a vague "keep the ball going as long as you can"—were significantly less fun than the others. Without a clear goal, it was not really a game at all.

I believe a similar combination of multiple-level goals and visual effects is important in the success of a number of other games, like Space Invaders, Snake2, and Petball.

Darts—The second game I studied in detail was called Darts, designed to teach elementary students about fractions (see reference 2). In the version I used, three balloons appear at random places on a number line on the screen and players try to guess their positions (see figure 2). They guess by typing in mixed numbers (whole numbers and/or fractions), and after each guess an arrow shoots across the screen to the specified position. If the guess is right, the arrow pops the balloon; if wrong, the arrow remains on the screen. The player gets to keep shooting until all the balloons are popped. Circus music is played at the beginning of the game; if all three balloons in a round are popped in four tries or less, a short song is played after the round.

To discover what features contribute most to the appeal of this game, I constructed eight different versions of the game by removing, one at a

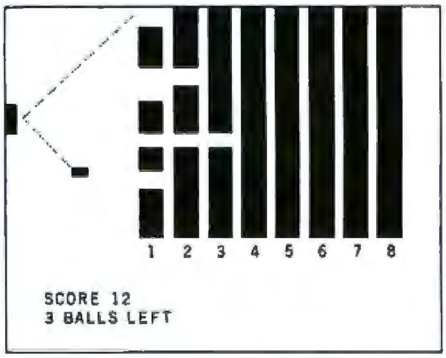

Figure 1: *A typical display from the Breakout game, which is popular because it provides a clearly defined challenge (breaking through the wall by bouncing the ball against the bricks) and provides visual and auditory stimulation.*

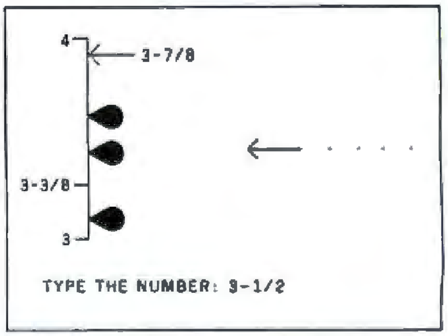

Figure 2: *A display from the Darts game, a program to teach fractions. The object is to break each balloon by typing in the mixed number corresponding to the balloon's position on the number line. This is an example of an intrinsic fantasy because the skill with fractions depends upon the fantasy of pinpointing the balloons on the line and vice versa.*

time, features that were presumably motivational. For example, some versions of the game had rectangles instead of balloons marking the place to be guessed on the number line and short lines instead of arrows marking the incorrect guesses. The features I removed in this way included the fantasy of arrows popping balloons, the music, the scorekeeping, and several different kinds of feedback.

I assigned 10 different fifth-grade students to each of the eight versions and then allowed them to play with their version of Darts or with a version of Hangman that was the same for all students. My primary measure of the appeal of different versions was how long the students played their version of Darts in comparison to Hangman. This measure was also highly correlated with how well students said they liked the game at the end.

Although important in creating interesting educational programs, fantasies must be carefully chosen to appeal to the target audience.

The results of this experiment showed a significant difference between what boys and girls liked about the game. Judging from time spent on various versions of the game, boys liked the fantasy of arrows popping balloons; girls apparently disliked it. I do not think the implication is that boys should be given one kind of fantasy and girls another. Instead, I think it would be better to let each person choose whichever fantasy seems most appealing at the time. Still, understanding sex differences like this may help avoid unintentionally designing programs that for instance appeal more to boys than girls. I think the most significant implication of this experiment is that, although they are important in creating interesting educational programs, fantasies must be carefully chosen to appeal to the target au-

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Challenge
Goal
☐ Does the activity have a clear goal? If not, is it easy for the students to determine goals of appropriate difficulty for themselves?
☐ Are the goals personally meaningful?

Uncertain outcome
☐ Does the program have a variable difficulty level?
  ☐ Determined by the student
  ☐ Determined automatically, depending on the student's skill
  ☐ Determined by the opponent's skill
☐ Does the activity have multiple goal levels?
  ☐ Scorekeeping
  ☐ Speeded responses
☐ Does the program include randomness?
☐ Does the program include hidden information selectively revealed?

Fantasy
☐ Does the program include an emotionally appealing fantasy?
☐ Is the fantasy intrinsically related to the skill learned in the activity?
☐ Does the fantasy provide a useful metaphor?

Curiosity
Sensory curiosity: audio and visual effects
☐ as decoration
☐ to enhance fantasy
☐ as a reward
☐ as a representation system

Cognitive curiosity
☐ Does the program include surprises?
☐ Does the program include constructive feedback?

Table 3: *A checklist for designing enjoyable educational programs.*

dience. Otherwise, they may actually make the environment less interesting than it would have been without them.

Guidelines

How can we use these results to make educational programs more fun for students? I think the characteristics that make instructional environments interesting can fit naturally into one of three categories:

- challenge
- fantasy
- curiosity

A checklist of these characteristics is shown in table 3.

Challenge—For an activity to be challenging, it should have a *goal* whose *outcome is uncertain*. In my survey, the feature I found most highly correlated with game popularity was the presence of an obvious goal. In the Breakout study, students rated the versions of the game with no obvious goal as significantly less enjoyable than those with a clear goal. Thus simple games, to be challenging, should probably have a single fixed goal. More complex environments (like graphics editors or computer programming languages) should be designed so that users can easily generate goals of appropriate difficulty. For example, in the LOGO system (see reference 5), students can program a moving "turtle" to draw designs on a computer screen or on the floor. The attractiveness of this environment is the ease with which children think of things they would like a moving turtle to do. But unless beginners have some help evaluating the difficulty of possible projects, they might often choose tasks that are discouragingly difficult.

Good goals are also *personally meaningful*. For example, the best are often practical or fantasy goals (like reaching the moon in a rocket or drawing a picture of a flower) rather than simply goals of using a skill (like solving arithmetic problems).

If a person is either certain to reach the goal of an environment or certain

not to reach it, the environment is unlikely to be challenging. There are several ways of ensuring that people of varying abilities (and the same person over time) will be challenged by a program. The first is simply to have a *variable difficulty level*, which can be:

- determined automatically (as in many drill-and-practice programs)
- chosen by the person (perhaps with ego-involving labels like cadet or commander)
- determined by the opponent's skill (as in chess and checkers)

Competition may be motivating simply because it provides a challenge at an appropriate difficulty level.

A more subtle way of making the outcome uncertain puts *multiple goal levels* in the same environment. For example, in the Darts game the first-level goal is simply to pop all the balloons. But players who are certain to reach this goal can still be challenged by the goal of popping all the balloons in as few tries as possible. Many motivating environments, from games like chess to activities like computer programming, have this characteristic: different people in the same general environment can pick very different goal levels.

Two features of computer games that help provide different goal levels are *scorekeeping* and *speeded responses*. Someone who can already reach the basic goal of an environment can still be challenged by trying to do it faster or better. These features are especially useful in instructional situations like drill-and-practice where the purpose is to improve previously learned skills. A third way of providing uncertainty is through *hidden information* that is selectively revealed (as in Hangman) or by *randomness* (as in all gambling games and many simulations).

Goals and challenges are captivating because they engage a person's *self-esteem*. Success in a computer game—like success in any challenging activity—can make people feel better about themselves. The opposite side of this principle is, of course, that failure in a challenging activity can lower a person's self-esteem and, if it is severe enough, decrease the person's desire to repeat the activity. One implication of this principle is simply that instructional games should have a variable difficulty level. Another implication is that performance feedback should be presented in a way that minimizes the possibility of damage to one's self-esteem. Comments like "You need more practice, dummy!" usually have no place in an educational environment.

This analysis of challenge illuminates an important distinction between *toys* and *tools*. Toys can be defined as systems used for their own sake, with no external goals (computer games, puzzles, etc). Tools can be defined as systems used to achieve external goals (text editors, programming languages, etc). With respect to challenge, the requirements for good toys and good tools are mostly opposite. Since a good tool is designed to achieve goals that are already present in the external task, it does not need to provide a goal. Furthermore, since the outcome of the external goal (such as writing a good letter or getting a program to work) is already uncertain, the tool itself should be reliable, efficient, and usually "invisible."

In a sense, a good game is supposed to be difficult to play: that increases its challenge; but a tool should be as easy as possible to use. This distinction helps explain why some users of complex computer systems may take a perverse pleasure in mastering tools that are extremely difficult to use. To the extent that these users are treating the systems as toys rather than tools, the difficulty increases the challenge and therefore the pleasure of using them.

Fantasy—One relatively easy way to increase the fun of learning is to take an existing curriculum and overlay it with a game in which the player progresses toward some fantasy goal (as in Baseball) or avoids some fantasy catastrophe (as in Hangman), depending only on whether the player's answers are right or wrong. These are examples of *extrinsic fan-*

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Some Educational Games

Game	Description	Academic Knowledge Used
Adventure	*The player explores a vast underground system of caves with dragons, etc, trying to find treasures. The cave is filled with knife-throwing dwarves and other dangers.*	*reading, writing*
Baseball	*Players advance around a baseball diamond by picking correctly spelled words from sets of alternatives.*	*spelling*
Darts	*(See text)*	*number lines, fractions, estimation*
Hangman	*The player tries to guess a word, letter by letter. After each incorrect letter guessed, one more body part of a man being hung is drawn. The player loses if the whole body is drawn.*	*spelling, vocabulary*
Hammurabi	*Player acts as king of ancient Babylonia and decides each year how much wheat to plant, how much to store, and how much to save. There are occasional plagues, rat infestations, etc. The number of people who are born, starve, etc each year is reported.*	*elementary economics*
Hurkle	*The player tries to guess where an animal called a "Hurkle" is hiding in a Cartesian coordinate grid. Feedback after incorrect guesses tells which direction to move.*	*Cartesian coordinates, map directions*
Lemonade	*The player runs a lemonade stand, buying supplies, advertising, etc. There are random fluctuations in weather, number of customers, etc. Each day's expenses, sales, and profits are computed.*	*elementary economics*
Snoopy	*Snoopy and the Red Baron appear at different positions on a signed number line. Player says how far Snoopy should shoot to hit the Red Baron (as a signed integer).*	*subtraction, number lines, negative numbers*

Extrinsic fantasies in which a fantasy goal is approached
- A train on a track is approaching a city
- A rocket is passing the other planets of the solar system on its way to earth
- A complicated building is being built, piece by piece
- A fleet of space invaders is being destroyed, one by one

Extrinsic fantasies in which a fantasy catastrophe is avoided
- A person is hung, one body part at a time
- A person advances toward the edge of a cliff, one step at a time
- A time bomb is ticking toward an explosion

Table 4: *Samples of extrinsic fantasies that could be used to add enjoyment to many educational programs. (Extrinsic fantasies are those in which the fantasy depends on using the skill but not vice versa.)*

tasies, in which the fantasy depends on the use of the skill but not vice versa.

Other factors, such as answering speed, can also affect intrinsic fantasies. For example, the Speedway game (in which students' race cars move along a racetrack depending on how fast they answer arithmetic problems) is an extrinsic fantasy. Since the use of the skill does not depend on the fantasy, the same fantasy could be used with completely different kinds of problems. For example, Baseball and Hangman fantasies could just as well be used for arithmetic problems as for spelling problems: players could be "hung" or advanced around a baseball diamond depending on whether the arithmetic problems are worked correctly. Table 4 lists a few possible extrinsic fantasies.

Conversely, *intrinsic fantasies* not only depend on the skill, but the skill also relies on the fantasy. This usually means that problems are presented in terms of fantasy-world elements, and players receive a natural constructive feedback. For example, in Darts the skill of estimating distances is applied to the fantasy world of balloons on a number line and players can see graphically whether their answers are too high or too low and, if so, by how much.

Other intrinsic fantasies in math games include the search for a hidden animal on a Cartesian grid in the Hurkle game and Snoopy shooting at the Red Baron on a number line in the Snoopy game. The Adventure game, in which a vast underground cavern system is explored in response to the player's commands, can be considered an intrinsic fantasy for the skills of reading (the cave descriptions) and writing (the commands).

I think intrinsic fantasies are more interesting and instructional than extrinsic fantasies. One advantage of intrinsic fantasies is that they often indicate how the skill could be used to accomplish some real-world goal (as in a business-simulation game like Lemonade). More importantly, intrinsic fantasies can provide meta-

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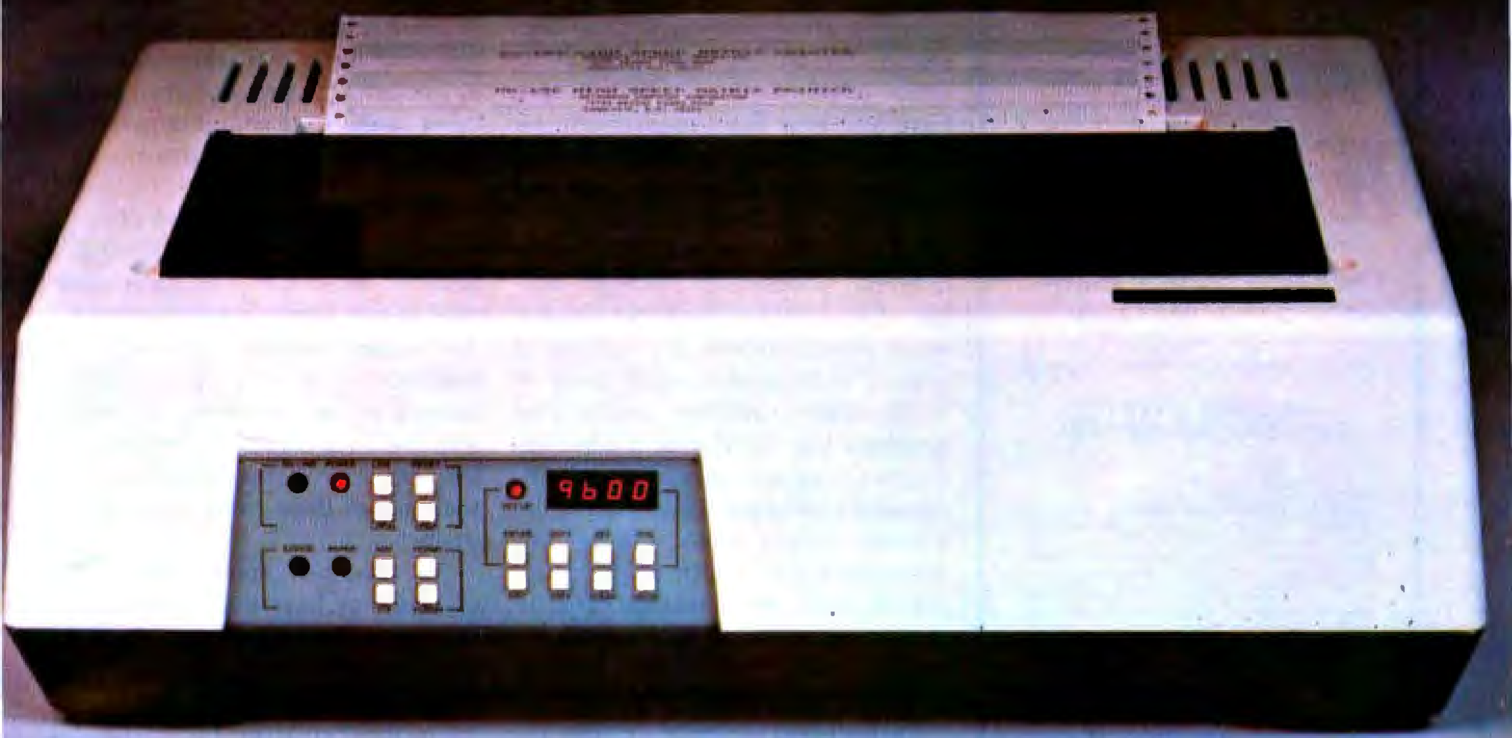

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4740 Dwight Evans Road • Charlotte, North Carolina 28210 • 704/523-8500 phors or analogies that help a learner apply old knowledge in understanding new things. For example, in the Darts game learners are able to use their old knowledge about some objects being higher or lower than others to learn about the relative sizes of fractions. Finally, by provoking vivid images related to the material being learned, intrinsic fantasies may help the learner remember the material.

Computer-game fantasies almost certainly derive some of their appeal from the emotional needs they help satisfy. Of course, it is difficult to know what emotional needs people have and how these needs might be partially met by computer games. But it is clear that different people find different fantasies appealing. If instructional designers can create many different fantasies for different people, their activities are likely to have much broader appeal. For example, it is easy to imagine a math game in which different students see the same problems but can choose the accompanying fantasy according to individual preference. Instructional designers might also create environments into which students can project their own fantasies. For instance, students could name imaginary participants in a computer game.

Curiosity—The final characteristic of intrinsically motivating instructional environments is that they stimulate and satisfy *curiosity*. Environments can evoke a learner's curiosity by providing an *optimal level of informational complexity* (see references 1 and 6). In other words, the environments should be neither too complicated nor too simple with respect to the learner's existing knowledge. They should be *novel* and *surprising* but not completely incomprehensible. In general, an optimally complex environment will be one where the learner knows enough to have expectations about what will happen, but where these expectations are sometimes unmet.

Sensory curiosity involves the attention-attracting value of changes in the light, sound, or other sensory stimuli of an environment. Colorfully illustrated textbooks and tactile teaching devices (like those used in Montessori schools) take advantage of sensory curiosity. Computers present even more possibilities for music, animation, and other *audio and visual effects*. These effects can be used:

- *as decoration* (like the circus music at the beginning of Darts)
- *to enhance fantasy*
- *as a reward*
- *as a representation system* that may be more effective than words or numbers (like the graphic representations of fractions in Darts and the different tones used to signal bounces and misses of the ball in Breakout).

An instructional program can also provoke curiosity by presenting a paradox or revealing an incompleteness in the learner's existing beliefs. To engage learners' curiosity, the feedback from a program should sometimes be *surprising*. It should also be *constructive* in helping the learners remove the misconceptions that caused them to be surprised initially.

For example, some Darts game players may have the misconception that increasing the denominator of a fraction increases the fraction. These players will be surprised when they try to shoot an arrow higher than the last one, only to see it go lower. But they will then have enough information to correct their misconception. Whether they actually *do* learn from this constructive feedback is another very interesting question. Designing programs that provide usable constructive feedback for many different misconceptions is a difficult but important task.

Another way to sustain curiosity—and facilitate learning—is to provide a sequence of increasingly complex tasks. Each one introduces a complication that may surprise the learner, but all are within the learner's ability to grasp. Providing this kind of constructive feedback and progressive complexity often requires a very detailed educational analysis of the skills being learned. It may also require an on-line model of

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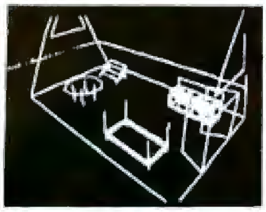

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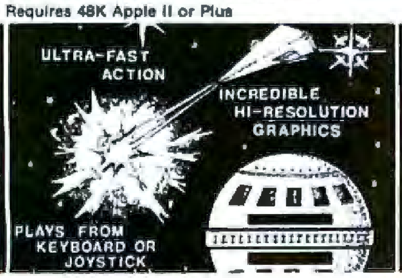

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Requires 48K Apple II or Plus, Disk II | DOS 3.2 or 3.3

the learner's knowledge so the program can automatically adapt to the learner's current abilities.

Other Factors—In concentrating on what computer games can tell us about how to design interesting educational programs, I have omitted two other important ways of making learning fun. First, since the main way of knowing what people like is by what they choose, I have taken for granted that self-motivated learners have a great deal of *choice* about their own goals. This element of being able to choose can itself be very important in making learning fun, with or without computers.

Second, I have concentrated on features that can be present in all learning environments—even those with only one person. The *involvement of other people*, both cooperatively and competitively, can also be an important way of making computer-based learning more fun.

Applications

One use of the checklist in table 3 is to suggest additions to existing or planned computer games. Almost no computer games include all the features just mentioned, and it is usually possible to determine ways in which any given game could incorporate more of them. For example, at least one-fifth of the games in table 1 have no way of varying the difficulty level and could probably be improved by adding this.

Here are more examples of how the checklist can be applied in designing educational computer programs.

A Typical Arithmetic Drill-and-Practice Program—In most of these programs, the difficulty level of arithmetic exercises is automatically adjusted according to how well the student does, and the percent of problems correct is printed at the end of each lesson. At first glance this automatic difficulty-level adjustment appears to be a good way of maintaining the program's challenge. But according to the previously described principles, a goal is the first necessary element of a challenging environment. The only thing resembling a goal in this program is the percent correct printed at the end of each lesson, and some students *do* try to get "hundred percents." But this goal is not made particularly obvious or compelling, and, given the automatic difficulty adjustment, it is fairly rare for students to get all their problems correct. In fact, since the difficulty adjustment is hidden from the students, the goal of getting all the problems correct may seem inexplicably receding as students approach it.

Aside from major curriculum revisions involving intrinsic fantasies and curiosity-driven learning, I think there are still a number of ways that extrinsic fantasies can be combined with goals and performance feedback to make this program more interesting. One simple way is to select an extrinsic fantasy like those listed in table 4 or better yet, let the students pick their own fantasies from a list.

Ideally, this fantasy can be represented graphically and will remain on the screen throughout a lesson as correct and incorrect answers affect a student's progress in

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the fantasy world. It would be nice to use sound effects for right and wrong answers. Reaching the final goal or catastrophe in the fantasy world should be accompanied by more elaborate sound and graphics.

In addition to the first two levels of goals within a lesson (getting individual right answers and reaching the fantasy goal), the automatic difficulty adjustment can provide a higher-level goal of making progress in the curriculum. If the extrinsic fantasy includes multiple goal levels, the student's movement to a higher difficulty level can be accompanied by even more fanfare in the fantasy world. Obviously, the details of these changes still have to be worked out. But this short description shows how the preceding principles can be used to suggest changes to existing programs.

A Simple Program to Teach Children How to Tell Time—In this example I will suggest how to increase the interest of a proposed computer system for teaching the relationship between three different notational systems for time: clock face, digital display, and English words. The original proposal for this system (from Laura Gould) was to have the three different representational systems displayed on the screen at the same time so that when the student changed any one representation, the other two also changed.

One insight from the above checklist is that there is no obvious goal for students working with this program. A goal is nicely provided through an analogy with the Darts game. In this new game, a time is represented in one system—say clock face—and the student tries to guess the time in one of the other systems—say digital display. Each incorrect guess is displayed on the clock face, just as the incorrect guesses in Darts are displayed on the number line. This game might be even more interesting if it included an intrinsic fantasy about setting alarm clocks and being early or late for school.

Other Educational Applications—More generally, a game can suggest analogous games in subjects very different from the original one. For example, a guessing-game structure can be used to invent games to teach many different kinds of knowledge:

- To teach an ordered list, use a guessing game that gives high/low feedback. For example, to teach the list of US Presidents in order use a game in which the players try to guess a secret President. After each guess, they are told whether their guess is before or after the secret President and perhaps how close it is. Such a game can be used to teach either the contents of a list (US Presidents, steps in a procedure, etc) or the ordering relationship ("less than" and "greater than" in a number-guessing game).
- To teach the correspondence between two representation systems, use a guessing game that gives hints in one system and asks players to guess in the other. For example, the Darts game is designed to teach the relationship between numbers represented on a number line and in mixed-number format. I just described a similar game to help teach children how to

tell time. Such a game can also be used to teach correspondences like foreign language vocabulary, Cartesian coordinates for points on a plane (Hurkle), or spelling of words (Hangman).

- To teach the characteristics of items in a set, use a guessing game in which players try to guess a target item by asking questions about its characteristics (like "twenty questions"). For example, medical students could try to guess the disease a simulated patient had by asking questions about symptoms and laboratory test results. Geography students could try to guess a target country by asking questions about its climate, economy, and so on.

This technique of using structural analogies with old games seems to be a powerful way of inventing educational games in new subject areas.

Computer Programming—In some senses, computer programming is one of the best computer games of all. In the "computer programming game," there are obvious goals and more are easily generated. The "player" gets frequent performance feedback (feedback that is often tantalizingly misleading about the nearness of the goal). The game can be played at many different difficulty levels, and many goal levels are available, both in terms of the finished product (whether it works, how fast it works, how much space it requires, etc) and the process of reaching it (how long it takes to program, etc). Self-esteem is crucially involved in this game, and occasional emotional or fantasy aspects are likely involved in controlling so completely, yet often so ineffectively, the behavior of this response entity. Finally, the process of debugging a program is perhaps unmatched in its ability to raise expectations about how the program will work, only to have the expectations surprisingly disappointed.

Conclusion

With computer costs decreasing dramatically, their spread into homes and classrooms appears inevitable. But it is not so certain that these new educational applications will use the unique capabilities of computers to make learning more efficient, more interesting, and more enjoyable. I think the guidelines I have presented here can help in creating instructional computer programs that fascinate as well as educate their users. ■

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The Game of Left/Right

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One of the more fascinating states of consciousness a person can be in is the trance. There are phrase-based trances, contemplation trances, and trances based on not thinking at all. There are Hindu, Buddhist, and Christian trances. Modern science has added two: the TV trance *and* the TV-game trance.

I first noticed the TV-game trance when the quality of my concentration changed while I was playing a game of Pong in a bar. Though still intensely aware of the game, I became cognizant of my surroundings—friends talking, the jukebox playing, a discussion at the bar—yet this state did not interfere with the game.

Since then, I have watched other TV-game players and observed a similar phenomenon; the best seem to enter a trance where they play but don't pay attention to the details of the game.

Unfortunately, the person who studies this phenomenon, either in himself or others, will find that TV games come in packages difficult to modify. Since the game's parameters cannot be changed, the experimenter cannot investigate the experience's limitations.

Here, I present a computer game that invokes the trance-like behavior and is easily modified for further study. Best of all, the game is fun to play. Written in Apple II Integer BASIC, the game should not be too difficult to implement on other computers with a minimum of equipment.

Score	Box Position	Background	Bar Colors
0–2	centered	black only	
3–5	centered	black or grey	
6–8	centered	black or grey	change at 6
9–11	left or right	black or grey	
12–14	left or right	left and right*	change at 12
15–17	left or right	left and right*	
18–20	one corner	left and right*	change at 18
21–23	one corner	corners+	
24–26	one corner	corners+	change at 24
27+	one corner	corners+	change every time

*Each side of the screen can be either black or grey, independent of the other.

+Each corner of the screen can independently be either black or grey.

Table 1: *Program complications. As the game of Left/Right progresses, the box position, the background color, and the bar colors complicate the game. More complications can be added by changing the shape of the box or having it move across the screen.*

The Game

You sit in front of a color TV set, a push-button switch in either hand. On the TV screen is a colored box and two colored bars are at the bottom. The bars line the left and right sides of the screen. The box and the left bar are the same color. You push the button in your left hand and score your first point in the game of Left/Right.

As you play, the background occasionally changes to grey. When this happens, you ignore the button for the bar whose color matches the box and press the other button. The game continues.

The box begins to appear in different positions on the

Text continued on page 292
Tables, figures and listings continued on pages 282-290

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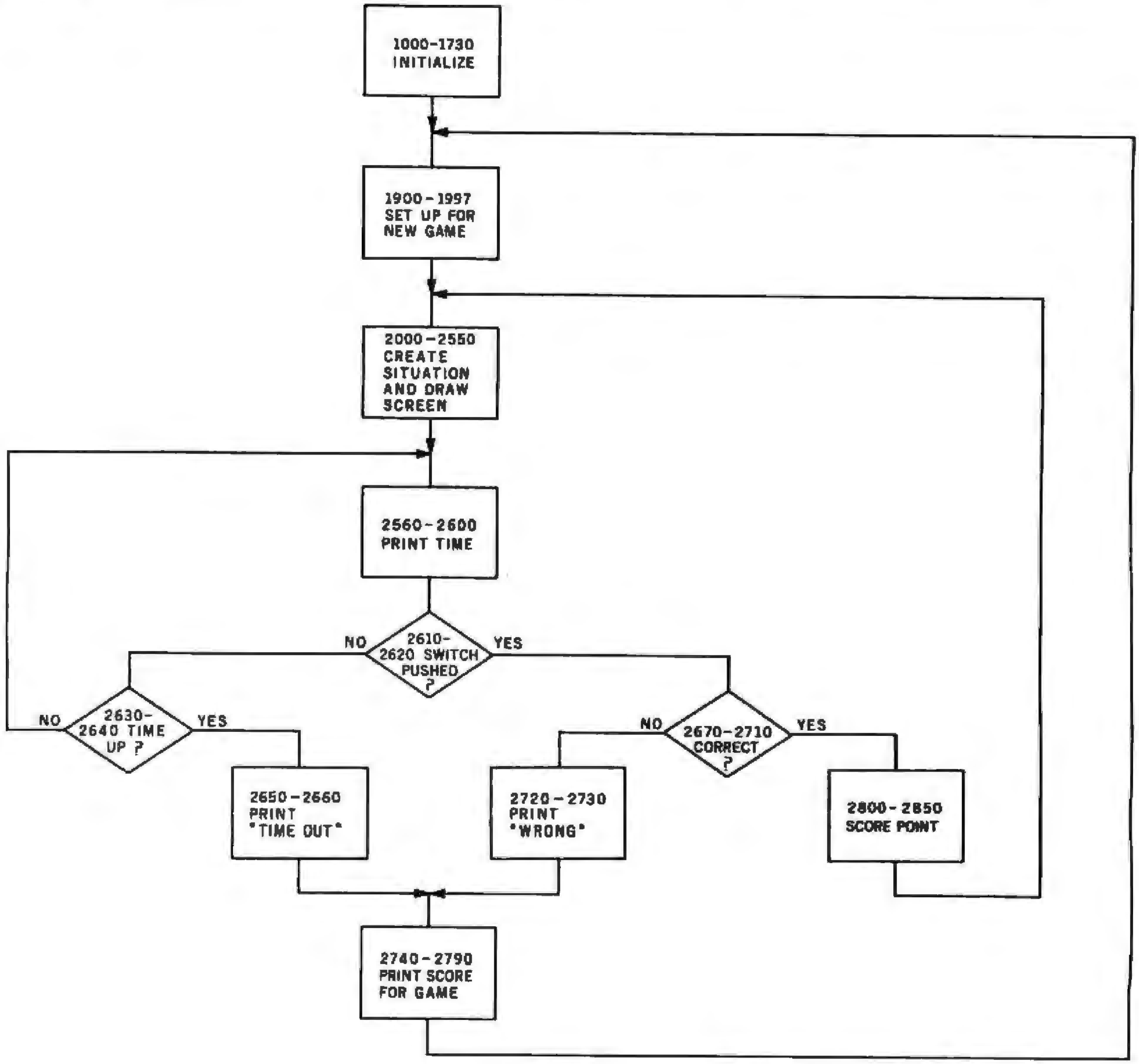

Figure 1: *Flowchart of the game of Left/Right. More details have been included for the portion of the program that determines whether the correct switch has been pushed. Line numbers refer to the program in listing 1.*


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Case	Switch Pressed	Background	Switch Hand	Matching Bar Side	Response is
1	0	0(black)	0(left)	0(left)	correct
2	0	0	0	1(right)	wrong
3	0	0	1(right)	0	wrong
4	0	0	1	1	correct
5	0	5(grey)	0	0	wrong
6	0	5	0	1	correct
7	0	5	1	0	correct
8	0	5	1	1	wrong
9	1	0	0	0	wrong
10	1	0	0	1	correct
11	1	0	1	0	correct
12	1	0	1	1	wrong
13	1	5	0	0	correct
14	1	5	0	1	wrong
15	1	5	1	0	wrong
16	1	5	1	1	correct

If switch 0 is pressed, use: BG(KPOS) = 0 AND LR = LSW
OR
BG(KPOS) ≠ 0 AND LR ≠ LSW

If switch 1 is pressed, use: BG(KPOS) = 0 AND LR ≠ LSW
OR
BG(KPOS) ≠ 0 AND LR = LSW

Table 2: *Truth table for the logic behind the BASIC expressions in lines 2680 and 2710 of listing 1. For example, if switch 0 is pressed when in the right hand, and background is grey (meaning use the opposite hand), and the matching bar is on the left (case 7), then this is the correct response.*

Listing 1: *The game of Left/Right. The program consists primarily of two nested loops: line 1900 marks the beginning of a new game, while line 2000 is the start of a new play. The program is written in Apple II Integer BASIC and should not be too difficult to implement on other machines. See table 3 for definitions of some of the BASIC commands peculiar to the Apple.*

```
 990 REM -----------------------
 991 REM  LEFT/RIGHT
 992 REM  TRUCK SMITH 3/9/80
 999 REM -----------------------
1000 REM  INITIALIZE
1010 DIM BG(4),C(8)
1020 C(1)=1
1030 C(2)=2
1040 C(3)=4
1050 C(4)=9
1060 C(5)=13
1070 C(6)=3
1080 C(7)=15
1090 C(8)=11
1100 SW0=-16287
1110 SW1=-16286
1120 TIME=500
1130 HS=0
1489 REM -----------------------
1490 REM  PRINT INSTRUCTIONS -1730
1500 TEXT
1510 CALL -936
1520 TAB 15
1530 PRINT "LEFT/RIGHT"
```

Listing 1 continued on page 286

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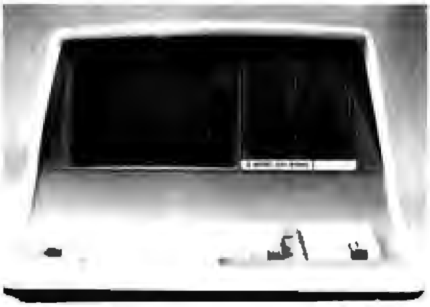

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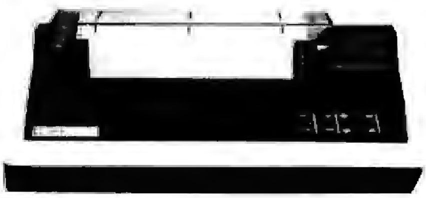

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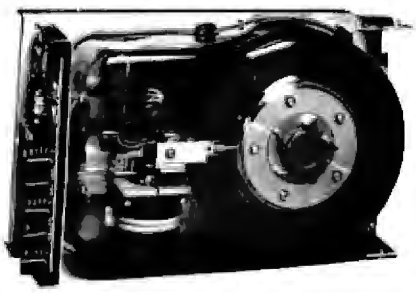

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1560 PRINT "YOU KNOW YOUR LEFT FROM YOUR RIGHT."
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1580 PRINT "THE COMPUTER WILL DRAW A COLORED BOX"
1590 PRINT "AND, AT THE BOTTOM OF THE SCREEN, TWO"
1600 PRINT "COLORED BARS.  YOU MUST DETERMINE"
1610 PRINT "WHETHER THE LEFT OR RIGHT HAND BAR"
1620 PRINT "MATCHES THE BOX'S COLOR AND PUSH THE"
1630 PRINT "CORRESPONDING BUTTON.  HOWEVER, IF THE"
1640 PRINT "BACKGROUND AROUND THE BOX IS GREY, YOU"
1650 PRINT "MUST PUSH THE OTHER BUTTON."
1660 PRINT
1670 PRINT "THE ROUND CONTINUES UNTIL YOU MAKE A"
1680 PRINT "MISTAKE OR THE TIMER RUNS OUT."
1690 PRINT
1700 PRINT "THE TIMER STARTS AT 500.  IT DOES NOT"
1710 PRINT "RUN WHILE THE COMPUTER IS DRAWING."
1720 PRINT
1730 PRINT
1899 REM ------------------------------
1900 REM  INITIALIZE FOR NEW PLAYER  -1997
1910 SC=0
1915 TAB 10
1920 PRINT "WHEN YOU ARE READY"
1930 PRINT "PRESS THE BUTTON IN YOUR LEFT HAND"
1940 IF PEEK (SW0)>127 THEN 1970
1950 IF PEEK (SW1)>127 THEN 1990
1960 GOTO 1940
1970 LSW=0
1980 GOTO 1995
1990 LSW=1
1995 GR
1996 CALL -936
1997 T=TIME
1999 REM ------------------------------
2000 REM CHOOSE MATCHING COLOR -2010
2010 LR= RND (2)
2019 REM ------------------------------
2020 REM  CHOOSE POSITION -2070
2030 HPOS= RND (2)
2040 X=5+HPOS*20
2050 VPOS= RND (2)
2060 Y=1+VPOS*19
2070 KPOS=HPOS*2+VPOS+1
2079 REM ------------------------------
2080 REM  CHOOSE BACKGROUND -2110
2090 FOR I=1 TO 4
2100 BG(I)= RND (2)*5
2110 NEXT I
2111 REM ------------------------------
2112 REM  CHOOSE COLOR PAIR -2114
2114 LC= RND (7)+1
2119 REM ------------------------------
2120 REM  SIMPLIFY -2330
2130 IF SC>26 THEN 2340
2139 REM ------------------------------
2140 REM  SIMPLIFY COLOR -2160
2150 IF SC MOD 6=0 THEN LK= RND (3)*2+1
```

Listing 1 continued on page 290


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System Notes

```
2160 LC=LK
2169 REM -------------------------
2170 REM  SIMPLIFY POSITION -2190
2180 IF SC<18 THEN Y=9
2190 IF SC<9 THEN X=15
2199 REM -------------------------
2200 REM  SIMPLIFY BACKGROUND -2330
2210 IF SC>2 THEN 2260
2220 FOR I=1 TO 4
2230 BG(I)=0
2240 NEXT I
2250 GOTO 2340
2260 IF SC>11 THEN 2310
2270 FOR I=2 TO 4
2280 BG(I)=BG(1)
2290 NEXT I
2300 GOTO 2340
2310 IF SC>20 THEN 2340
2320 BG(2)=BG(1)
2330 BG(4)=BG(3)
2339 REM -------------------------
2340 REM  DRAW SCREEN -2550
2350 REM  DRAW BACKGROUND -2450
2360 FOR I=0 TO 19
2370 COLOR=BG(1)
2380 VLIN 0,18 AT 19-I
2390 COLOR=BG(2)
2400 VLIN 19,37 AT 19-I
2410 COLOR=BG(3)
2420 VLIN 0,18 AT 20+I
2430 COLOR=BG(4)
2440 VLIN 19,37 AT 20+I
2450 NEXT I
2459 REM -------------------------
2460 REM  DRAW BARS -2500
2470 COLOR=C(LC)
2480 HLIN 5,16 AT 39
2490 COLOR=C(LC+1)
2500 HLIN 25,36 AT 39
2509 REM -------------------------
2510 REM  DRAW BOX -2550
2520 COLOR=C(LC+LR)
2530 FOR I=0 TO 16
2540 HLIN X,X+11 AT Y+I
2550 NEXT I
2559 REM -------------------------
2560 REM  WAIT -2660
2580 VTAB 22
2590 TAB 30
2600 PRINT T;" "
2610 IF PEEK (SW0)>127 THEN 2670
2620 IF PEEK (SW1)>127 THEN 2700
2630 T=T-1
2640 IF T>0 THEN 2560
2650 PRINT "THE CLOCK RAN OUT"
2660 GOTO 2740
2669 REM -------------------------
2670 REM  SWITCH 0 -2690
```

Listing 1 continued on page 292

```
2680 IF (BG(KPOS)=0 AND LR=LSW) OR (BG(KPOS)#0 AND LR#LSW) THEN 2800
2690 GOTO 2720
2699 REM -------------------------
2700 REM  SWITCH 1 -2720
2710 IF (BG(KPOS)=0 AND LR#LSW) OR (BG(KPOS)#0 AND LR=LSW) THEN 2800
2719 REM -------------------------
2720 REM  WRONG -2730
2730 PRINT "SORRY - WRONG BUTTON"
2739 REM -------------------------
2740 REM  DELAY -2790
2750 IF HS<SC THEN HS=SC
2760 PRINT "YOUR SCORE ";SC;" HIGH SCORE ";HS;" TIME ";T
2770 FOR I=1 TO 400
2780 NEXT I
2790 GOTO 1900
2799 REM -------------------------
2800 REM  RIGHT -2850
2810 SC=SC+1
2820 VTAB 22
2830 TAB 10
2840 PRINT SC;" "
2850 GOTO 2000
```

Text continued from page 278:
screen; the bars at the bottom change color. Suddenly, you are confronted with a screen that is half grey and half black. The box is on the screen's black side, so you tentatively press the button for the bar that matches the box. Correct again; the game continues.

In this version of the game, play ensues until you make a mistake or until the time runs out (about 30 seconds). Your score is the number of correct answers. The highest score yet attained is 42 points.

When your turn is finished, you hand the push buttons to the next player. Mixing them up makes no difference, since the program automatically determines which switch is in your left hand.

I dreamed up the game and wrote the original program for my Apple II in one weekend. I tried it and then introduced it to my wife, who promptly topped my best score.

I immediately reprogrammed the game to make it harder. I added the grey background, cut the screen first in half and then in quarters, and changed the bars' colors after every point. My wife's continued winning streak highlighted the futility of further changes.

I can no longer demonstrate the program because my scores are too low to exhibit all of its features. My wife has assumed the task of demonstration.

The game is easily learned, but not readily mastered. The rules are more easily demonstrated than described. Concentration and quick reactions to a complex set of stimuli are needed for a high score.

The Trance

To play the game well, you must turn a conscious, well-considered response into a subconscious one. You must then avoid thinking about the individual responses. The phenomenon of *perseveration*, and the level of logic involved in the correct decision, add to the difficulty.

Perseveration is the tendency to continue with the same response, regardless of the display. If the program gives you five "lefts" in succession, your tendency is to react with a left for the next response. This forces your continued attention to the game; it is my hunch that this is an important factor in invoking the trance state.

The level of logic insures that the responses are not simple. The first level occurs in the matching process; the second occurs in the reversal of handedness required when the background is grey. The logic could be deepened still a third level, through random changes in the box's shape (to a cross, for instance) to require yet another reversal of handedness.

The trance state originates in the combined effects of these phenomena. The need for decisions makes constant attention essential, and the decisions are too complicated to be left to natural reactions. An interesting experiment would have the level of logic continue to deepen until a trance was no longer invoked. (It may be impossible, either with this game or in general.) I will discuss this and other possible modifications after discussing the program itself.

The Program

The original version of the program evolved naturally from my given situation:

- I had an apple II, which could draw all sorts of colored pictures on my TV screen.
- The Apple II comes with two push-button switches.
- I knew I wanted to write a real-time computer game.

Text continued on page 298
Tables and listings continue on pages 294-296

Listing 2: *Variable cross-references to the program in listing 1.*

```
BG- 1010 2100 2230 2280 2280 2320 2320 2330 2330 2370 2390 2410 2430 2680 2680
      2710 2710

C- 1010 1020 1030 1040 1050 1060 1070 1080 1090 2470 2490 2520

HPOS- 2030 2040 2070

HS- 1130 2750 2750 2760

I- 2090 2100 2110 2220 2230 2240 2270 2280 2290 2360 2380 2400 2420 2440 2450
      2530 2540 2550 2770 2780

KPOS- 2070 2680 2680 2710 2710

LC- 2114 2160 2470 2490 2520

LK*- 2150 2160

LR- 2010 2520 2680 2680 2710 2710

LSW- 1970 1990 2680 2680 2710 2710

SC- 1910 2130 2150 2180 2190 2210 2260 2310 2750 2750 2760 2810 2810 2840

SW0- 1100 1940 2610

SW1- 1110 1950 2620

T- 1997 2600 2630 2630 2640 2760

TIME- 1120 1997

VPOS- 2050 2060 2070

X- 2040 2190 2540 2540

Y- 2060 2180 2540
```

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Graphics Commands

GR — Clears screen and sets low-resolution graphics mode; a 40 by 40 array of "bricks," with four lines of text at the bottom of the screen. Coordinates run from the upper left-hand corner: 0,0 is the upper left-hand corner; 0,39 the lower left-hand corner; 39,0 upper right; and 39,39 lower right.

CALL −936 — Clears text area of screen.

VLIN A,B AT C — Draws a vertical line of bricks from A to B at the column specified by C.

HLIN A,B AT C — Same as VLIN, but draws a horizontal line.

COLOR = I — Sets color used for plotting until next COLOR = I is encountered. Values for I are as follows:

1	red	9	orange
2	blue	11	pink
3	purple	13	yellow
4	green	15	white

Other Commands

VTAB N — Vertical tab to row N on the screen before printing.

TAB N — Horizontal tab to column N on the screen. This is a command, not a function, as in most BASICs.

PEEK(−16287) — Ascertains if switch 0 has been pushed. If it has, the value returned is greater than 127; otherwise, it is less.

PEEK(−16286) — Same as PEEK(−16287), but for switch 1.

RND(N) — Returns a random integer between 0 and N − 1.

Apple II Integer BASIC variable names may be of any length.

Table 3: *An explanation of some of the Apple Integer BASIC commands which may not be available on other microcomputers—useful when implementing the game of Left/Right on another machine.*

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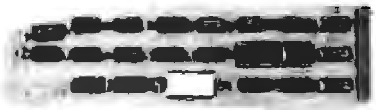

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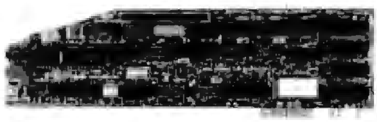

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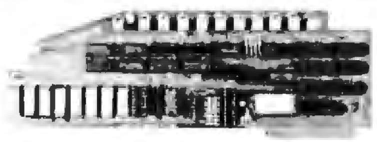

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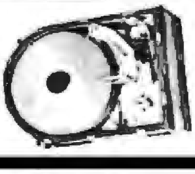

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I was playing with a program that moved boxes around on the screen when I got the idea for the Left/Right game.

Writing the program was fairly simple; most of my time went into the display design, the choice of various parameters, and, of course, the complications.

As I added complications for the player, the program grew more complicated—to the point where I rewrote it entirely for this article. Writing the program for the complicated case and then simplifying for low scores is actually easier. Table 1 shows the complications built into the program. As you can see, there is a symmetry to the complications, with a new one added roughly every third play. The symmetry would be more complete if the bars changed color only when the score equaled 6 modulo 9; but that did not produce color changes often enough to satisfy my intuitive sense of play.

Choosing colors to use was a project in itself. As long as the score is less than 27, the colors come in reasonable pairs (red/blue, green/orange, yellow/purple). After 27, not only is a new pair of colors added (pink/white), but the old colors can appear in new and harder pairs.

Listing 1 is the Apple II Integer BASIC program of Left/Right. Lines 1000 to 1730 initialize a few variables and print the instructions, while line 1900 begins the program proper. From 1900 to 1997, I set the score to zero, determine which switch is in the player's left hand, and clear the screen.

Lines 2000 to 2114 set up the general (complicated) case, choosing which bar the box will match, where the box will be, what quarters of the background will be grey, and what colors will be used. Lines 2120 to 2330 simplify the situation for low scorers like me. The simplifications are made according to table 1 (page 278.)

From line 2340 to 2550, I draw the screen: background, bars, and box. Then, from line 2560 to the end, I wait for the player to push either switch, determine whether it is right or wrong, and add one to the score or end the game.

Since the logic gets confusing at the program's end, I have provided a flowchart of the program in figure 1, with an emphasis on the last lines. Other than at the end, the program is basically two nested loops; the outer loop begins at line 1900 with each new game, and the inner loop starts at line 2000 for each play.

Table 2 is a truth table for the logic behind the expressions in lines 2680 and 2710, which test for correctness of player response. For those of you implementing this game on a machine other than an Apple, I have summarized the Apple graphic and other special commands in table 3.

Additions

Several possible changes suggest themselves. You can change the timing, eliminate it entirely, or time each point. You can increase the number of colors or divide the screen up into more areas. You can use shapes other than a box, or letters and words, with or without adding another level to the logic as I just discussed. Lacking a computer with color capability, you can base the game on shapes rather than colored bars.

A challenging modification for the player and the programmer would have the box move. To press the appropriate switch, a player would have to remember where the box started.

To increase the time limit for each player, modify line 1120. To eliminate the timing entirely, delete line 2630. To time each point, move line 1997 to 2570.

The number of colors may be increased by changing the dimension of C in line 1010 and increasing the arguments to the RND function in lines 2114 and 2150. Note that line 2150 is deliberately constructed to use fewer colors than are available. Also, since lines 2114 and 2150 choose the color pair, the maximum value allowed for LC is one less than the number of array elements. A particularly fiendish modification would use the various shades of blue which are available on the Apple as possible elements of color pairs. The box is drawn in lines 2510 to 2550; to change its shape, modify this code.

Summary

A fun game, it has been a party favorite. It's a great demonstration. Watching an experienced player (like my wife) run up a high score is just part of the fun.■

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MH1	1/Single	Hard 16	10/$39.00
MH2D	2/Double	Hard 16	10/$65.00

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Part #	Sides/Density	Sectoring	Price
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FH1-32	1/Single	Soft 32	10/$45.00
FD2-XD	2/Double	Soft	10/$65.00

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Livermore	LIV-Star 20M	$ 149.00
UDS	UDS 103	$ 189.00
UDS	UDS 202	$ 295.00

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Amdek	100-80	$ 189.00
Amdek	100G/12" Grn	$ 169.00
Amdek	Color-1 13"	$ 375.00
APF	TVM-10/10" B&W	$ 149.00
Hitachi	VM 910/9" B&W	$ 210.00
Hitachi	VM 129/12" B&W	$ 340.00
Sanyo	DM 5012/12" B&W	$ 270.00
Sanyo	DM 5112ex/12" Grn	$ 290.00
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Zenith	ZVM-121/12" Grn	$ 129.00

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Televideo	TVI 950C	$ 950.00

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Sixth, seventh, and eighth prizes: Publication of your game in BYTE

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Admit it. When you were desperately trying to justify the purchase of your personal toy . . . uh . . . computer, you had absolutely NO idea that it could be used for endless hours of game playing. Instead, you were dazzled by the possibilities for using it in applications that are on the very frontier of computer engineering. Your sights were set daringly high: "Let's see, balancing my checkbook, uh . . . phone list (there was something else . . .) turn on the lights when I'm away on business (but what about mowing the grass?), uh . . . (oh, yes) and a computerized phone list . . . . Uh, there was something else, but I forget what it was . . . ."

Two years later, you're still balancing your checkbook by hand and you don't have that computerized phone list just yet. But you do have 35 disks of something in your software library—and they aren't multiple linear regression analysis packages, either.

It's okay. Your secret is safe with us. We like games, too. In fact, we're looking for games to publish. We know that the countless hours you spend programming is for serious stuff, but if you know anybody who's into games, you might mention we're running a contest.

The Format

All games should be presented in article form for possible publication in BYTE. (Send a stamped, self-addressed, legal-size envelope for a copy of our author guide.) Submit your game in the magnetic format listed below, along with whatever documentation is necessary, a clear listing, and an introductory narrative telling us about the game and how it works. Floppy disks should be sent sandwiched between two pieces of cardboard. Be sure to keep a copy of any software you send us (just in case it does get damaged in transit).

The Computers

Prepare your game for one of the following computers, in the format indicated. (We apologize if your computer is not on this list, but we are limited to those to which we have access.) Games must be submitted in the appropriate form.

Apple II, Atari 800, Commodore PET/CBM, IBM Personal Computer, Radio Shack TRS-80 Models I or III	5-inch disk only
Commodore VIC, Radio Shack TRS-80 Color Computer	cassette tape
Radio Shack TRS-80 Model II	TRSDOS 8-inch disk
CP/M with "plain vanilla" terminal (ie: no special features)	standard 8-inch disk

The Games

What kind of games are we looking for? Graphic arcade-style games (of course); text-only simulations, role-playing games, and adventures; strategy games; abstract games; action games; historical games. Anything that's fun! And a game needn't occupy 48 K bytes of memory to be fun—it's the concept that counts! (For an example of a simple game that's fun, look at "The Game of Left/Right" for the Apple II on page 278 of this issue.)

Use your creativity to devise something new, rather than implementing something that already exists. We aren't interested in implementations of existing board or video games—we want original games only!

We'd be very interested in seeing a two-computer game. In it, two people run the same game on two computers, which are connected by an RS-232C link (or, for the Apple, possibly a 3-bit duplex connection through the game port). For an example of what's possible using two computers, see the review of Commbat on page 100 of this issue.

The Deadline

Entries must be sent to:

BYTE Game Contest
POB 372
Hancock NH 03449

and must be postmarked by March 31, 1982. The results will be published in the August 1982 issue of BYTE.

The Fine Print

•This contest will be judged by the **BYTE** editorial staff. The games will be evaluated for their playability. The judges' decision is final.

•Game submissions cannot be returned unless they are accompanied by a return envelope with sufficient postage on it.

•This contest is open to anyone except employees or immediate family of McGraw-Hill and its subsidiaries. Void where prohibited by law.

•Prize winners will exchange first serial rights (ie: the right for BYTE to publish their article first). **In all cases, the author retains all commercial rights to the software written, and BYTE readers cannot distribute and/or sell the software without the author's permission.** All eight prize winners will receive the standard payment for a BYTE article (at $50 per published magazine page).

•Only one entry is permitted per contestant.

•To repeat a rule stated earlier, cassette tapes will be accepted only for the Commodore VIC and the Radio Shack TRS-80 Color Computers. All other entries must be in the floppy-disk format specified above.

The Bottom Line

We think this contest is arranged so that anybody with a good idea has a chance to win. We won't be dazzled by fantastic graphics alone, but we will be influenced by how enjoyable a game is. We look forward to seeing your best effort and hope you'll have fun in the process.

Pascal-80

Rowland Archer
Flint Ridge Apartment 59
Hillsborough NC 27278

Even though several versions of Pascal have been available for the TRS-80 Model I computer for some time now, none of them quite succeeds in terms of completeness and compatibility with the TRS-80 system.

For example, Radio Shack's own Tiny Pascal is educational and inexpensive, but it is an extremely limited subset of Pascal. It provides integer data types, one-dimensional arrays, and Pascal control structures, but none of the type-definition facilities that make Pascal a unique language. It also provides no means of storing or retrieving data from tape or disk, eliminating it as a contender for most serious uses.

FMG Corporation's version of UCSD (University of California, San Diego) Pascal for the TRS-80 is more complete, but it suffers from a force fit to the Model I machine. FMG told me it is essentially a vehicle for teaching Pascal due to the small user-program space available (according to FMG, about 250 lines).

Having witnessed several partially successful attempts to put a Pascal system on the TRS-80, I began to think it just wasn't practical. After all, the Apple II version of UCSD Pascal requires a memory expansion to 64 K bytes and a modification to the disk operating system to support higher-density disk storage. Knowledgeable people claimed that the TRS-80 Model I, with its 48 K bytes of memory and single-density floppy-disk system, was not big enough to support Pascal.

It was thus with considerable excitement that I read TSE-Hardside's advertisement for Pascal-80 by Phelps Gates. I have used Mr Gates's excellent APL interpreter (also distributed by TSE-Hardside) for nearly a year, and it is notable for its completeness, compactness, and freedom from bugs. APL is another example of a language that many experts claimed could never be put on a TRS-80. If anyone could devise a good Pascal system for the TRS-80, it was Phelps Gates. I am happy to report he has done just that.

It is *worth saying* a few words about Gates himself, as he has an intriguing combination of professional interests. Churning out interpreters and compilers is only a sideline for him. In real life, he is an associate professor at the University of North Carolina—in the classics department! His choice of avocation becomes less surprising when you learn he specializes in linguistics, which helps explain his expertise in computer languages. That he, rather than a computer professional, has put together good, complete versions of APL and Pascal for the TRS-80 should be a lesson to all of us. The supposed experts probably never tried because they "knew" it couldn't be done.

System Overview

Pascal-80 is a stand-alone system written in Z80 machine code and distributed on a TRSDOS disk (Model I or III format). The original disk may be copied with the TRSDOS BACKUP utility. I have run Pascal-80 under NEWDOS 40 to make use of my 40-track drives. So far, I have had no problems doing so. However, I have not been able to get Pascal-80 to run under NEWDOS 80 or LDOS.

At a Glance

Name
Pascal-80

Type
TRS-80 Pascal compiler

Author
Phelps Gates

Distributor
TSE-Hardside
6 South St
Milford NH 03055
(800) 258-1790

Price
Disk plus instruction booklet, $99.95

Format
5-inch floppy disk, TRS-80 Model I or III TRSDOS format

Computer
TRS-80 Model I or III with at least 32 K bytes of memory; at least one disk drive

Documentation
14-page instruction booklet

Audience
Programmers in need of a Pascal compiler for the TRS-80 Model I or III

To start Pascal-80, you simply type in the program name under TRSDOS READY. The program starts by displaying the menu; table 1 lists the options available.

The entire system resides in memory at once—editor, compiler, and p-code interpreter. This makes Pascal-80 convenient and interactive, much like Disk BASIC. You can move quickly between editing, compiling, and running a program without the need to save intermediate forms of the program on disk. The major difference between running Disk BASIC and Pascal-80 is that with Pascal-80 you must compile a program before running it. (And there is no "immediate mode" allowing evaluation of instructions like PRINT 3/7 without embedding them inside a program. I know of no Pascal system that supports such a mode.)

EDIT	the program in memory or create a new program from scratch.
KILL	(erase) the program currently in memory.
SAVE	the program in memory to a named disk file.
LOAD	a previously saved program from disk to memory.
APPEND	from a disk file to the program in memory.
COMPILE	the program in memory, producing p-code that can be run or saved in a disk file. The program text remains in memory.
WRITE	the p-code produced by the compiler into a named disk file.
EXECUTE	a p-code file directly from disk, overwriting the compiler to gain extra memory for run-time.
RUN	the program in memory, compiling it first if necessary.
QUIT	Pascal-80 and return to the TRSDOS command interpreter.

Table 1: *Options available with the Pascal-80 monitor.*

For those of you unfamiliar with compilers, p-code, and run-time packages, here's a little background. The compiler takes your original source code, created using an editor, and translates it into an intermediate form called p-code. The p-code is then interpreted into machine language by the run-time package or p-code interpreter. For further information on this process, see the three-part article, "A 'Tiny' Pascal Compiler," starting in the September 1978 BYTE.

The compiler is very fast. TSE-Hardside claims that it converts 1000 lines of Pascal code per minute to executable p-code; my timings indicate this is very conservative. I get closer to 2000 lines per minute when the source is listed to the screen as it is compiled. When I turn off the source-listing option, I obtain compilation speeds of around 3000 lines per minute. These figures are very impressive; for comparison, Tiny Pascal, which handles only a small subset of the language, compiles about 100 lines per minute.

Naturally, there is a trade-off for the convenience and speed of having everything reside in memory at once. You are limited to compiling programs that can fit in memory all at one time. However, Pascal-80 conserves memory by using a space-compression technique: consecutive blanks are counted and stored as a single byte with the high-order bit turned on.

This technique provides ample space for user programs. In a TRS-80 with 48 K bytes of memory, there are about 23,600 bytes for user programs. With strings of blanks compressed to a single byte, the average Pascal-80 program line is about 20 bytes long. There is space for 1180 such lines of code. The actual number depends on the style of the individual programmer. The estimate of 20 bytes per line is conservative as most Pascal programs contain many lines with nothing but BEGIN or END on them.

Systems that provide a separate editor, compiler, and run-time module require only components actually in use to be resident in memory, providing more space for user programs. On the other hand, however, such systems are more cumbersome to use because you must access the disk drives frequently to load each component of the system as it is needed, usually saving the output of each phase in a separate disk file.

I like the interactive quality of Pascal-80 and wouldn't want to sacrifice that for the extra capacity of a system that uses a separate editor, compiler, and run-time module. However, there are times when extra program space comes in handy, and a simple enhancement to the compiler would provide some: a command inserted into a Pascal source program to direct the compiler to start compiling source code from a disk file. This compiler command is usually called an INCLUDE facility. It allows the compilation of programs even though the source code is larger than memory. It also allows you to create a library of useful Pascal routines that can be INCLUDEd in programs as needed, rather than being typed or chained from disk using an editor.

General Procedure for Use

Here is a summary of the steps involved in creating, compiling, and running a Pascal-80 program:

1. Type PASCAL from the TRSDOS READY prompt to load the Pascal system and enter the monitor mode. The options available are shown in table 1.
2. Type E to enter the editor, which allows you to type in the source text for your Pascal program. When you finish typing in the text, exit from the editor by typing Break M, which returns you to the monitor mode.
3. Type C to compile your program. The starting time of the compilation appears on your screen followed by the text of the program itself as it is compiled, unless you have selected the NOLIST option. If your program contains an error that prevents it from compiling properly, compilation is halted immediately. When you type E to reenter the editor to correct the mistake, the editor's cursor is positioned at the point of the error, all set for you to correct it. This is a nice touch.

- [X] Variant records.
- [X] The WITH statement.
- [X] Pointer variables and the procedures NEW and DISPOSE.
- [X] File window or "buffer" variables and the procedures PUT and GET.
- [X] The data attribute PACKED is not needed, since all structures are already packed on byte boundaries. This means that Pascal-80 is automatically as space-efficient as possible in storing data, without the need for PACKing and UNPACKing data.
- [X] The procedure PAGE is not included. You can use WRITE(LP,CHR(12)) to send an ASCII form-feed character to the line printer.
- [X] Structures of FILEs, such as ARRAY of FILE, are not permitted.
- [X] Procedures and functions may not be passed as parameters to other procedures or functions.
- [X] The total size of an expression passed as a value parameter may not exceed 510 bytes (but this is not a limitation for VAR parameters).
- [X] Sets may have no more than 256 members. If the elements of a set are numeric, they must be in the range of 0 to 255.

Table 2: *Standard Pascal features that are not implemented in Pascal-80.*

4. Once you have compiled your program with no errors, type R to run it. If you find an error during your program's execution, go back into the editor from the monitor mode, correct the error, and start the compile-and-run cycle again.
5. From the monitor mode, you can perform various kinds of program storage and retrieval: save the current source program, save the current compiled program, load a source program, or load and execute a previously compiled program from disk. This latter option has a special benefit—it gives you about 10 K extra bytes of free memory for use at run-time. Since the program has already been compiled, the compiler portion of Pascal is not needed. So when you choose this option, your program overwrites the Pascal compiler, giving you the extra memory.

Editor

The Pascal-80 system includes a simple full-screen editor. It allows you to move a blinking cursor around on the screen and type over any text to change it. Changes that appear on the screen are not actually made to the text until you press the Enter key with the cursor positioned *on* that line. This is confusing at first because it is easy to make changes to one line and then use the up-arrow or down-arrow key to move to another line, without pressing Enter to make the changes take effect.

Another bothersome aspect of this editor is the lack of character delete and insert commands. This requires you to retype most of a line that needs something inserted or deleted. There is a *line* insertion and deletion command, however. There is also a command to scroll backward or forward one page at a time in the text buffer.

It is handy to have this editor available during program debugging; it allows you to move quickly between editing, compiling, and running the program being tested. In my opinion, however, it is just too simple to serve as the primary editor for creation and heavy maintenance of large source files.

I have a suggestion to remedy this limitation: use a full-featured editor such as Radio Shack's Scripsit for program creation and major editing; use the Pascal-80 editor solely for interactive development. You can't do this with the present release of Pascal-80 because the source code is saved on disk in a compressed format that cannot be read in by a general-purpose editor. However, it shouldn't be too difficult for author Gates to add an ASCII (American Standard Code for Information Interchange) option to the SAVE and LOAD commands. It would be similar to the "A" option now available with Disk BASIC's SAVE command. That simple change would make a world of difference for Pascal programmers.

Compiler

Pascal-80 follows the description of Pascal given in the excellent tutorial by Peter Grogono, *Programming in Pascal* (Reading MA: Addison-Wesley, 1978). The compiler is based on the original language as designed by Niklaus Wirth. However, Pascal-80 does not implement

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the full Pascal language. The limitations and restrictions are listed in table 2. On the positive side, Pascal-80 provides a number of extensions to the original language. These are listed in table 3.

The standard Pascal functions are provided: ABS, ARCTAN, COS, EOF, EOLN, EXP, LN, ODD, ORD, PRED, ROUND, SIN, SQR, SQRT, SUCC, and TRUNC. They are calculated with 14-digit precision. Functions to access the Z80 ports (like BASIC's INP and OUT functions) are not provided. Also, there is no random-number generator.

Although all the TRS-80 graphics characters can be printed through use of the CHR function, there are no equivalents to BASIC's SET, RESET, and POINT functions for dealing with a single graphics pixel. There is also nothing like BASIC's PRINT @ statement that positions the cursor on the screen. Pascal procedures can be written to handle all these, but they really should be built into any language implemented for the TRS-80.

READ and WRITE statements are provided to perform sequential input and output to disk files. The statement SEEK(*expression,filename*) allows random file access by positioning to the record whose number is given by *expression*. You can thus SEEK a particular record, and then READ and/or WRITE that record, performing an update in place on the file. This powerful extension overcomes an oft-voiced objection to many implementations of Pascal disk input/output: they do not provide random file access.

I do have a few complaints and suggestions for improvements to the system.

There is a restriction on SEEK that may cause problems for some applications; you cannot SEEK past the 65,535th byte of a file. In many applications, files larger than 64 K bytes are common. Considering the space available on the double-density Model III disks, and the general trend toward increasing disk-storage space on microcomputers, I believe this SEEK limit should be remedied in a future release of Pascal-80.

One serious limitation of Pascal-80's disk-file interface is that file names are determined at compile-time. That is, you must specify the actual file name in your program when you edit it. Once compiled, that file name cannot be changed without reediting the program and compiling again. This means you cannot write a general-purpose program to work on any file, getting the specific file name from the user when the program is run.

Use of the PEEK, POKE, and CALL functions/procedures is made difficult by two things:

- Pascal-80's use of memory is undocumented; no memory-map is provided.
- No way is provided to reserve memory for user machine-language programs or data. There is nothing equivalent to BASIC's MEMORY SIZE? question. Instead, Pascal-80 uses all memory available.

These factors make it almost impossible to integrate user-written machine-language routines into the Pascal-80 environment. Regrettably, this rules out the use of nonstandard printers that require special driver routines loaded in high memory.

If I may editorialize a bit, it seems it is time to standardize the protocol to be followed when reserving TRS-80 high memory for user-defined machine-language programs. One of the smoothest things about operation of "second-generation" TRS-80 operating systems such as LDOS, NEWDOS/80, etc, is the way they handle this. The memory location hexadecimal 4049, referred to in the literature as HIGH$ and HIMEM, contains the address of the highest byte in memory available for use by any program. Memory starting at the next byte past this address is reserved. Any program that needs to use high memory should allocate it downward from the address pointed to by HIMEM, and then reset HIMEM to point

- ☑ Arrays of characters may be printed with a single statement (ie: WRITE(STRING) will write out the ARRAY of CHAR called STRING).
- ☑ In addition to type REAL, with 14-digit precision, Pascal-80 adds REAL6, with 6-digit precision. REAL6 saves space when declaring large arrays. It doesn't save much time, however, since all calculations are carried out internally with 14-digit precision. REAL6 variables that are not members of an array or record may not be passed to a procedure or function as value parameters.
- ☑ The files INPUT and OUTPUT need not be included in the PROGRAM statement, and the program name is also optional. The file LP is predefined to be the line printer.
- ☑ The CASE statement is extended to include an ELSE clause that is executed if none of the cases is satisfied. If no case is satisfied and there is no ELSE clause, control falls through to the next statement with no error condition raised.
- ☑ Output formatting is provided with the syntax WRITE(*expression* : *fieldwidth* : *digits*). This says to write the value of *expression* in a field of *fieldwidth* columns with *digits* number of digits after the decimal point. A field width of −1 results in scientific notation; a field width of 0 results in the default format, also used if no format parameters are specified (eg: WRITE(*expression*)). The default format is to print the number with a leading blank, and as many digits after the decimal point as necessary, up to 14 significant digits.
- ☑ Built-in functions and procedures:

  CHR(*n*) returns the character, type CHAR, whose ASCII value is *n*.

  CLS clears the screen.

  POKE(*address,value*) places a 1-byte *value* from 0 to 255 into the memory location *address*.

  INKEY is like the BASIC INKEY$ function; it returns a CHAR-type value corresponding to the key pressed. If no key is being pressed, it returns CHR(0).

  CALL(*address,value*) places a 1-byte *value* from 0 to 255 in the A register and calls a Z80 subroutine at *address*. The contents of the Z80's A register after the call are returned as type INTEGER.

  MEM returns the number of bytes of free memory.

  PEEK(*address*) returns the contents of *address*.

  FP(expression) returns the fraction part, or mantissa, of a REAL number.

  EX(*expression*) returns the exponent of a REAL number.

Table 3: *Enhancements and special features of Pascal-80.*

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below the block of memory it just allocated for itself. Programs such as Pascal-80 should check HIMEM when they start, and not use any memory above the current value of HIMEM. If all programs followed this protocol, life would be much easier for the user—there would be no need to worry about conflicts in memory usage between different machine-language drivers, or to remember what the highest available memory location is in order to supply it to a program such as BASIC every time it is run. I hope a future release of Pascal-80 will follow this protocol.

Performance

As far as the performance of Pascal-80 programs is concerned, I made some very rough timings and found that for a short, simple looping-type program using INTEGER variables, Pascal-80 is four to five times faster than an equivalent BASIC program. This advantage should increase for larger programs because BASIC takes longer to find the destination of a GOTO, GOSUB, etc, as program size grows, and it takes longer to look up a variable as the number of program variables increases. With Pascal-80, such things are resolved at compile-time rather than run-time; thus, the time taken at run-time is independent of program size.

Programs involving extensive floating-point computations are potentially faster in BASIC than in Pascal-80. This is due to the latter's exclusive use of double-precision arithmetic. If all you need is single-precision arithmetic for your computations, BASIC will do them faster.

Run-time errors result in clear, English error messages that specify the hexadecimal offset of the p-code instruction that caused the error. The offsets corresponding to the beginning of each line of Pascal-80 source code appear in the listing created during compilation. This method enabled me to pinpoint easily the source of every run-time error encountered. A run-time error terminates program execution. There is no provision for program trapping of run-time errors, as the ON ERROR statement of BASIC allows.

Documentation and Support

Pascal-80 comes with a small booklet that adequately describes how to use the editor, monitor, and compiler, explains the limitations and extensions Pascal-80 makes to standard Pascal, and lists the error messages generated by the compiler and the run-time system. No comprehensive description of the language implemented by Pascal-80 is provided. Examples are few and are directed toward pointing out differences between Pascal-80 and standard Pascal, rather than toward teaching about the language.

The manual does not purport to be a beginner's guide or even a reference manual, and you will definitely need a textbook such as Grogono's to use this system. I had no trouble figuring out the system, but I am an experienced programmer; this manual would be rough going for a novice. I have seen much worse documentation than this; but I have also seen much better for products costing much less.

I believe the microcomputer software market has matured sufficiently that there is no longer any excuse for incomplete, difficult-to-read documentation. For a program costing almost $100, I expect much more than a 14-page leaflet. It would pay for TSE-Hardside to invest in a professionally written manual for a major product like a Pascal compiler.

Conclusions

If my criticisms seem harsh, let me emphatically state that I am very excited about having a nearly complete implementation of Pascal for the TRS-80. Pascal-80 is better suited to the TRS-80 than any Pascal system I have seen so far. It is extremely fast, and it provides niceties like 64 significant characters in variable names, 14-digit precision on all transcendental functions, and the sheer elegance of Pascal's defined-type mechanism.

From my conversations with Gates, it is apparent he intended to provide a teaching tool people could use to learn Pascal programming as an alternative to BASIC. He has certainly done this and more. Pascal-80 is suitable for many things now being done in BASIC. In fact, it is because Pascal-80 does so much more than just provide a teaching tool that I hope he will consider implementing the minor enhancements I have suggested. It would be nice to be able to use Pascal-80 for all program development on the TRS-80, instead of being forced to use BASIC for some things.■

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News and Speculation About Personal Computing

Conducted by Sol Libes

Looking Back On 1981: Looking back on the year, I have been struck by three developments. The first is that probably more new microcomputers were introduced in 1981 than in all the previous years combined. Second, that this was the year in which the "biggies" (eg: IBM, Xerox, etc) finally realized they could no longer ignore the personal-computing market and jumped into the fray. Third, in 1981 the Japanese began exporting personal computers to the US.

IBM, whose earnings for the first half of the year rose 5.3% (one-third the inflation rate), saw minicomputer makers like DEC (Digital Equipment Corporation) increase their earnings over 35%. Personal-computer makers like Apple had an increase of more than 200%. In the course of the last 10 years, IBM has seen its share of the market decrease from more than 50% to less than 25%. If this trend were to continue, IBM would become a minor entity in the computer market within five years.

Thus, IBM had no choice but to enter the personal-computer marketplace. By hesitating on minicomputers, IBM left the field wide open for DEC. This has resulted in DEC garnering $3.2 billion in minicomputer sales and IBM having only a small slice of the minicomputer market. In the microcomputer market, Apple, for example, will probably show *about $350* million sales this year and possibly $600 million next year. The question is: *Has IBM again waited too long?*

No one doubts that the IBM Personal Computer is a terrific product. Although it offers no innovative features, it does have a new price/performance ratio from a company with the strongest marketing organization in the world. The Personal Computer is being supported by $12.5 million that IBM will spend on television and print advertising. Without a doubt, IBM did a considerable amount of market research in deciding which way to attack the personal-computing market.

Several microcomputers are already on the market with features virtually identical to the Personal Computer's—some even have more power—but none at the IBM price or with its service support. It is rumored that more than 40,000 Personal Computers were ordered on the day it was unveiled. Now, the questions are:

- How much business will IBM snatch away from Apple, Tandy, Commodore, and Atari?
- How will Apple and the others respond?
- How will the Japanese compete with IBM?

IBM's Personal Computer marks a distinct shift in the company's traditional way of doing business, which was "we make it and sell it ourselves." Actually this policy change started to take effect some time ago, but IBM tries not to talk about it. Early last year, for example, it introduced a video-display terminal that could be used with non-IBM equipment—a first—and discovered that sales for this unit were so great that delivery now requires 4 to 6 months' lead time. Only two weeks before the Personal Computer was released, IBM quietly announced the System/23, which uses the 8086 microprocessor (big brother to the 8088 used in the Personal Computer). The System/23 really begins where the Personal Computer ends, with full-size floppy disks, multiusers, etc. In effect, it provides upward compatibility for users starting out with the IBM Personal Computer who find its small disk-storage space and limited I/O (input/output) options restricting.

Another startling change in IBM policy is its selling the system through computer stores (currently there are contracts with ComputerLand and Sears Roebuck). IBM has also announced discounts for educational users and other quantity buyers. IBM's most surprising policy shift is in encouraging software development by outsiders. IBM intends to market the software and pay royalties to the authors. Probably nine out of ten of the 40,000 computers ordered on Day-One were from software developers. (What a way to sell computers!) After all, the profits for IBM are really in hardware sales and not in software. Osborne is proving this by practically giving away software with its computer. Also, it is impossible for a manufacturer to protect itself against software competition. IBM learned this when Digital Research introduced a version of CP/M for the Displaywriter (which also uses an 8086 microprocessor).

The last question is how will the microcomputer makers in the US and Japan respond to the IBM entry? Rumors are circulating that Apple is about to introduce two new computers: its long-awaited 16-bit system, using the Motorola 68000, packed with 128 K bytes of programmable memory, and available in both desktop and suitcase versions, and a low-cost version of the Apple II using 16 K-bit memory chips that later can be replaced by 64 K-bit chips when these are available in quantity. The Japanese are thought to be developing 8088- and 8086-based personal computers that will be "plug-compatible" with CP/M software developed for the IBM Personal Computer. Several Japanese companies have signed licenses for CP/M-86 and have been negotiating with Peachtree Software (supplier of the IBM accounting package), SofTech Microsystems (supplier of the IBM Pascal package), Microsoft (supplier of IBM BASIC), and Personal Software (supplier of IBM VisiCalc). It is apparent that in 1982 personal-computer buyers will be able to choose among many different computers that run the same operating systems and applications software.

Disk-Drive Happenings: Seagate Technology—a Shugart Associates spin-off and the first company to ship quantities of 5¼-inch Winchester hard disks—has announced that sales totaled almost $10

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million, with nearly $2 million in profits, in its first year of operation. Meanwhile, Shugart Associates is rumored to be redesigning its popular SA200 5-inch floppy-disk drive. It will be called the SA210, will be made in Japan by Matsushita, and will sell for less than $90 in quantity.

In other action, Amlyn Corporation, San Jose, California, has introduced a 5-inch floppy-disk drive with a selector mechanism that selects any of five 5-inch floppy disks (under computer control). This will provide up to 8 megabytes of data storage. Micropolis, which recently increased its 5-inch floppy-disk drive to 2 megabytes of storage, has disclosed that it is working on a 4-megabyte 5-inch drive for introduction at next year's National Computer Conference. Tecstor, Huntington Beach, California, has revealed that it is developing a 640-megabyte, Winchester 14-inch disk drive, the largest yet.

True Three-Dimensional Computer-Display Debuts: Genisco Computer Corporation, Costa Mesa, California, is now shipping video systems that display true three-dimensional images. The computer presents pictures of successively deeper layers of space-filling image via a moving mirror. This is done rapidly enough to create a single flicker-free image. Priced at $100,000 each, the units are expected to be useful in seismic-data analysis, oil exploration, computer-aided design, medical imaging, and earthquake prediction.

Random Rumors: This spring Fujitsu Ltd, now a second source for the 8086 and 8088 microprocessors, is expected to announce a word processor and personal computer using these chips. ... Tandy is said to be working on a system based on the 68000 to be released any day. It's also stepping up software production and is attempting to release between four and 12 new software packages a month. Following in the footsteps of IBM, it is actively soliciting software from outside developers. Tandy's biggest software push is in producing business software for the Models II and III. Tandy may offer CP/M for these machines. A VisiCalc-like product is also rumored for the low-cost Color Computer.... Xerox is reported to be working on a Z80-based computer that is less expensive than its current Model 820. It has been dubbed the *Inchworm* (the code name for the 820 was the *Worm*, for Wonderful Office Resource Machine). It is expected to sell for under $1000, have 16 K bytes of programmable memory, 64 K bytes of read-only memory, an 80 by 25 display, RS-232C printer and modem ports, and CP/M-compatibility. ... Wang is putting the final touches on its CP/M-compatible personal computer. ... DEC is rumored to be prepared to announce its TC personal computer, built around an LSI-11.... A major Japanese company has invested over $100 million in CMOS research. Look for resulting major advances in memory technology in a year or so. ... Also from Japan comes word of a new computer terminal with many of the features of the Xerox Star, but at a substantially reduced price.... Meanwhile, anticipate IBM jumping onto the UNIX bandwagon, with versions for the Series 1 and 4300 computers. The software is being developed by an independent software house. ... Vadic may be close to introducing a 4800 bps modem for voice-grade telephone lines. The price range will probably be in the $2-3000 neighborhood. Rockwell International and Racal Corporation are also said to be working on 4800 and 9600 bps modems for voice-grade lines.... Hitachi is expected to start shipping large-volume quantities of the 68000 microprocessor at substantially reduced prices. ... Rumors persist that Motorola has 13 MHz versions of the 68000 running in its lab and that Intel has 14 MHz versions of its 8086 running. ...

New Logic-Circuit Research: IBM is researching new types of logic circuits that could have far-reaching effects on the size, cost, and performance of future computers. Among the new circuits is a device called "low-voltage inverter" (LVI) logic. It is twice as fast as emitter-coupled logic (ECL), which is the fastest logic type in current use, and has the same size and power consumption as TTL (transistor-transistor logic), which is used in most mini- and microcomputers. With propagation delays of 300 picoseconds, LVI promises to be a new price/performance breakthrough.

Cornell University's Microfabrication Laboratory in Ithaca, New York, and the Naval Research Laboratory in San Diego have both disclosed that they are researching the use of electroactive polymers for molecular electronic-switching devices. Enzymes would be used to perform logic operations. Due to the fact that enzymes are organic molecules, genetic engineering and recombinant-DNA technology would be used to subassemble these organic molecules. The result would be the miniaturization of logic circuitry by two orders of magnitude beyond the current limits of optical lithography and beyond anything achievable with electron-beam or X-ray lithography. Although still in very early stages, this technology holds promise for use in future computers.

SS-50 Status Report: Although smaller than the S-100-bus-based microcomputer market, the SS-50's market is flourishing. The SS-50 bus was introduced in late 1975 for 6800-based systems. Today, the most popular microprocessor used on the SS-50 bus is the powerful 6809, although other processor cards, such as the Z80, are also available.

Four hardware vendors dominate the SS-50 marketplace: Southwest Technical Products Corporation (SwTPC), San Antonio, Texas (the creator of the bus); Gimix, Chicago, Illinois; Percom Data, Garland, Texas; and Smoke Signal Broadcasting, Westlake Village, California. By contrast, the S-100 market is shared by more than 70 suppliers. It is known that several SS-50 makers are working on implementing the 68000 for the SS-50 bus structure.

Three operating systems reign over the SS-50 market: FLEX, a single-user operating system, and UniFLEX, a multiuser system, both from Technical System Consultants, West Lafayette, Indiana; and OS-9 from Microware, Des Moines, Iowa. FLEX operates on the 6800, while UniFLEX and OS-9 operate on the 6809. UniFLEX and OS-9 provide some UNIX-like features and support multiple users. Two magazines also cater to SS-50 users.

Even though the 6800 and 6809 processors are avail-

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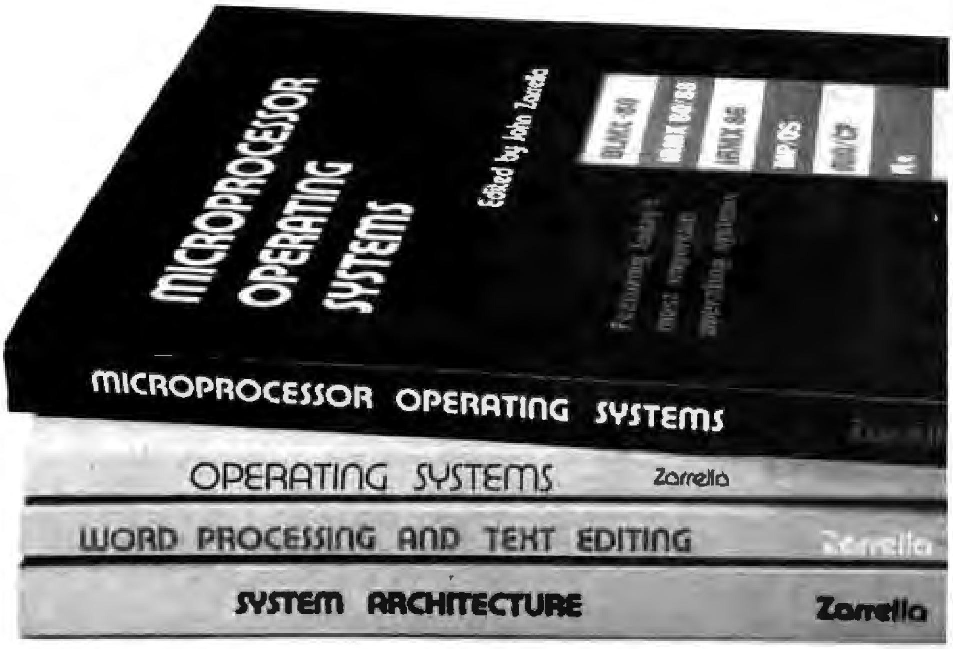

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able for other bus systems, the SS-50 bus has become the de facto standard for 6800- and 6809-based personal computers.

CP/M MUMPS Available From UCD: For the past two years, the University of California, Davis (UCD) has been distributing copies of the ANSI (American National Standards Institute) Standard MUMPS running under the CP/M operating system. This sounds reminiscent of the early days of UCSD Pascal, when the University of California, San Diego, furnished Pascal (including source code) to several clubs with copying privileges for $200. The clubs then allowed their members to copy Pascal for as little as $5, which is how UCSD Pascal got its original, wide distribution.

MUMPS is an exceptionally powerful language for database systems and string handling. UCD is offering an 8-inch CP/M disk containing MUMPS (object code) and several utility and application programs for $33. For $93, you can get the disk and a year's service (ie: updates, new applications, new releases, and a newsletter). Also, for another $33 you can get the MUMPS source code. For more information, contact Dr Richard F Walters, Department of Community Health, University of California, Davis CA 95616, or you can contact the MUMPS User Group, POB 37247, Washington DC 20013.

Random News Bits: Telesoftware has finally released its Ada compiler package for 68000-based systems. Implementing most of the features of standard Ada, it will sell for more than $5000. . . . An Ada subset, called "Janus," that runs under CP/M is available for $250 from PR Software, Madison, Wisconsin. . . . Digital Acoustics, Santa Ana, California, is expected to introduce an under-$800 Motorola 68000 processor add-on kit for the PET/CBM personal computer. An Apple II 68000 upgrade is being designed. . . . Xerox will carry the Atari personal computer in its 25 computer stores. . . . The price for 64 K-byte memory chips has dropped sharply to under $9, in medium-sized quantities. You can expect to see them being widely used in personal computers soon. . . .

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

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Computer Scrabble

Joseph J Roehrig
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Scrabble is probably the best known and most frequently played word game available. Many books have been written about playing Scrabble. Unlike chess, however, very little, if anything, can be found on playing this popular game against a computer.

Scrabble has a board containing 225 squares, 61 of which have special scoring characteristics (double-letter or -word and triple-letter or -word). One hundred flat squares containing all 26 letters of the alphabet plus blank "wildcards" are the playing pieces. The piece-movement regulations can be described in three or four pages of text, plus the largest dictionary you can find.

I have several programs that play the game of Scrabble on a microcomputer. But because of the game's complexities, certain constraints must be placed on a microcomputer version. After much experimentation, the constraint I found to work best is to have the computer make up only two- or three-letter words and to maximize the scoring potential of these words. Without this or other selected constraints, the time spent calculating a move and the memory-and file-space requirements would most likely exceed the capabilties of a microprocessor. A program can be developed using words of four or more letters with response time similar to that of my model, but that type of program could not address itself to every such word in existence nor could it maximize the selection and placement of words. The program described in this article is capable of handling every two- and three-letter word conceivable and it maximizes the placement of the selected word.

For ease of conversion, the programs are in BASIC. The machine requirements are:

- a TRS-80 Model I or III with 32 K bytes of programmable memory or
- an Intel 8080 microprocessor-based computer or equivalent with 32 K bytes of programmable memory
- North Star disk system
- a terminal

Very little information about playing Scrabble on a computer has been published.

The Programs and Files

This discussion describes the North Star version of the SCRABBLE program. My disk housing the Scrabble system contains the North Star disk operating system (DOS), North Star BASIC (a version of the BASIC language), eight BASIC programs, and three data files.

The eight program files are:

S—a program that links all of the BASIC programs into one package. To use the package only S is loaded by using the BASIC language command LOAD S. After it is loaded, S calls for all of the programs you request. (See listing 1.)
FILE—creates a blank random-access data file for the computer's vocabulary. A random-access file can be read selectively by specifying a particular address, rather than sequentially. The file created is called WORDS. (See listing 2.)
INPUT—adds or deletes words to file WORDS. (See listing 3.)
DICT—allows you to input an integer number that the computer turns into a word. (See listing 4.)
LDICT—lists the computer's current vocabulary by reading WORDS. (See listing 5.)
SCRABBLE—the main program that plays the game. This program requires 33 K bytes of memory. (See listing 6.)
SHORT—a slow version of SCRABBLE that fits into 32 K bytes of memory. (See listing 7.)
REPORT—prints a summary of the last game played. (See listing 8.)

The information contained in the three data files is:

WORDS—the computer's vocabulary.
REC—a move-by-move summary of the last game played using the program SCRABBLE.
GAME—the status of the game board the last time program SCRABBLE was run. This saves games for later.

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Listing 1: *North Star BASIC program, called S, that provides the main menu of the Scrabble system, linking together the seven programs in listings 2 through 8.*

```
5 INPUT'READY ? ',Z$\!''
10 !'WELCOME TO THE SCRABBLE SIMULATION MODEL'
20 !'YOU HAVE THE FOLLOWING SEVEN OPTIONS!'\!''
30 !'    0 END THE SIMULATION'
40 !'    1 CREATE A FILE FOR THE COMPUTER'S VOCABULARY'
50 !'    2 INPUT OR DELETE WORDS TO OR FROM THE COMPUTER'S VOCABULARY'
60 !'    3 LIST THE ENTIRE VOCABULARY'
70 !'    4 CONVERT A PROGRAM CODE NUMBER INTO A WORD'
80 !'    5 PLAY A GAME OF SCRABBLE AGAINST THE COMPUTER'
90 !'    6 GET A SUMMARY REPORT OF THE GAME JUST PLAYED'
100 !''\INPUT'YOUR SELECTION ? ',A\IFA<1THENEND\IFA>6THEN10\GOTO110
101 CHAIN'FILE'
102 CHAIN'INPUT'
103 CHAIN'LDICT'
104 CHAIN'DICT'
105 CHAIN'SCRABBLE'
106 CHAIN'REPORT'
110 ONAGOTO101,102,103,104,105,106
```

Listing 2: *The simple program FILE creates a blank random-access file, called WORDS, in which the computer's Scrabble vocabulary will be stored.*

```
10 OPEN#0,'WORDS'
15 B=0
20 FORA=0TO19682
30 WRITE#0,%B
40 NEXT
50 !'FILE CREATED'
60 CHAIN'S'
```

Running the Programs

The start of a sample run is shown in listing 9. Once S is loaded, the computer will ask:

Ready ?

Each time this prompt appears, a carriage return will erase the terminal's screen and continue execution of the Scrabble package.

Next, the seven possible option codes are printed on the terminal screen:

0—end the simulation
1—create a file WORDS for the computer's vocabulary
2—input to file WORDS
3—list the current vocabulary contained in file WORDS
4—convert a number to a computer word
5—play a game of Scrabble
6—get a summary report of the last game played

Listing 9 shows options 2 and 4 being selected. For option 2, an unlimited number of two- and three-letter words can be added to or deleted from the computer's vocabulary. A carriage return ends the process. You can enter any word or nonword you choose.

Option 4 converts a number into a word. Each letter is assigned a value from 1 to 26 (ie: a is 1, b is 2, etc). The first letter of each word is multiplied by 729, the second letter by 27, and the third by 1. Therefore, AFB is:

$$(729 \times 1) + (27 \times 6) + 2 = 893$$

In listing 10, option code 3 was selected, and the current vocabulary of 725 words is displayed. This list has been compiled from various dictionaries and books dealing with key Scrabble words.

Playing the Game

Option 5 is selected to play a game of Scrabble. (Listing 11 gives an illustration.) You can select one of 10 versions. Version 1 is the most effective opponent and also the slowest to calculate a move, while 10 is the least competitive but the fastest.

The computer numbers the squares on the Scrabble board from 1 to 225. All your moves must be entered by referring to these numbers. On the terminal display, the program can number each square or omit the numbers once you become familiar with the system.

You can continue the last game played, start a new game, or even arrange the game board as desired. The computer or the user can go first. In

Listing 3: *The program INPUT adds words to or deletes them from the dictionary file WORDS.*

```
10 OPEN#0,'WORDS'
15 F(1)=729\F(2)=27\F(3)=1\Z=1
16 INPUT'ENTER DELETE TO DELETE WORDS OR ANYTHING TO ADD ? ',Z$
17 IFZ$='DELETE'THENZ=0\GOTO20
18 !'BAD INPUT, MUST BE ALL ALPHA'
20 A$(1,3)='   '
22 INPUT'NEW WORD ? ',A$(1,3)
25 IFA$(1,3)='   'THENCHAIN'S'
28 D=0
30 FORA=1TO3
40 C$=A$(A,A)
45 C=ASC(C$)
48 IFC=32THEN60
50 IFC<65ORC>90THEN18
52 C=C-64
54 D=D+(C*F(A))
60 NEXT
66 WRITE#0%D,%Z,NOENDMARK
70 GOTO20
```

Listing 4: *Program DICT translates a given integer as interpreted by the Scrabble program (see text) into the equivalent English word.*

```
5 !'INPUT 0 TO END'
10 INPUT'GIVE TEST NUMBER ? ',A
15 IFA=0THENCHAIN'S'
20 IFA>0ANDA<19682THEN40
30 !A,' IS AN INVALID NUMBER, THE RANGE IS 0 TO 19682'\GOTO10
40 B=INT(A/729)\C=A-(729*B)\D=INT(C/27)\E=C-(27*D)
50 IFB>0THEN60\B$=' '\GOTO70
60 B$=CHR$(B+64)
70 IFD>0THEN80\C$=' '\GOTO90
80 C$=CHR$(D+64)
90 IFE>0THEN100\D$=' '\GOTO110
100 D$=CHR$(E+64)
110 !B$,C$,D$
120 GOTO10
```

Listing 5: *LDICT lists the computer's current Scrabble vocabulary by reading the file WORDS.*

```
10 OPEN#0,'WORDS'
12 !'THE CURRENT LIST OF THE COMPUTER'S VOCABULARY FOLLOWS:'
14 !''
16 !'--- --- --- --- --- --- --- --- --- --- --- --- --- --- ---',
18 !' --- --- --- --- ---'
20 FORA=0TO26\D=A+64\IFD<65THEND=32\A$=CHR$(D)
30 FORB=0TO26\D=B+64\IFD<65THEND=32\B$=CHR$(D)
40 FORC=0TO26\D=C+64\IFD<65THEND=32\C$=CHR$(D)
50 E=(729*A)+(27*B)+C
60 READ#0%E,%F
70 IFF=0THEN200
80 G=G+1
90 H=H+1
100 IFH<21THEN110
105 H=1\!''
110 IFH<>1THEN!' ',
120 !A$,B$,C$,
200 NEXT\NEXT\NEXT
210 !''\!'THE CURRENT VOCABULARY OF THE COMPUTER IS',G,' WORDS'
220 CHAIN'S'
```

listing 11, the computer goes first and has the letters I, Z, I, Q, J, P, U, by means of your input. The computer spells ZIP and asks you to supply more letters.

You are now ready to enter your move. The first information requested is the squares the move will occupy. A selection of 0,0 lets the computer move next, and a negative input, like −1,0, ends the game. You place a word on the game board by selecting valid square numbers. Because the computer only moves after 0,0, you control how many words are spelled between computer moves. Consequently, any number of players can be involved in a computer Scrabble game.

In listing 11, the player connects the word SPEARED to the computer's word ZIP by moving into squares 99 through 189. The connection is made by the "P" in square 114.

Listing 12 shows SPEARED added to the game board, and listing 13 is a summary of the completed game. The summary shows the move numbers, the square where the move began, the word spelled, and the time in seconds needed to calculate the move if the

Text continued on page 338

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Listing 6: *This is the main North Star BASIC program that plays the game of Scrabble. It requires 33 K of memory.*

```
LOAD SCRABBLE
READY
LIST

1 [illegible]
[illegible]
3 [illegible]
4 [illegible]
5 [illegible]
6 [illegible]
[illegible]
8 [illegible]
9 [illegible]
10 [illegible]
11 [illegible]
12 [illegible]
13 [illegible]
14 [illegible]
15 [illegible]
16 [illegible]
17 [illegible]
18 [illegible]
20 [illegible]
22 [illegible]
26 [illegible]
30 [illegible]
31 [illegible]
42 [illegible]
43 [illegible]
44 [illegible]
45 [illegible]
46 [illegible]
47 !"FREE MEMORY EQUALS",FREE(A)
48 [illegible]
49 CHAIN"S"
50 IFA1 0THEN100
60 INPUT"WHAT WORD DID YOU SPELL ? ",K$
61 IFA2 A1+10THEN80
62 [illegible]
63 Y9 0
64 [illegible]
65 C=C+1\D=ASC(D$)-64\B(A) D\NEXT\GOSUB8600
66 K$=K$+"########"
68 WRITE#1,A1,K$(1,7),U0
69 GOSUB8600\IFY9 3THEN72\FORY8=A1TOA2\IFF1(Y8) 10THENF1(Y8)=11
70 IFF1(Y8)=0THENF1(Y8)=1\NEXT
72 GOSUB1000\GOTO40
80 C LEN(K$)\A=((A2-A1)/15)+1\IFC ATHEN12
81 Y9=C
82 [illegible]
84 C=C+1\D=ASC(D$)-64\B(A) D\NEXT\IFY9 1THEN86\FORY8=A2TOA1STEP15
85 IFF1(Y8)=0THENF1(Y8)=10\IFF1(Y8)=1THENF1(Y8)=11\NEXT
86 GOSUB8600
87 K$ K$+"########"
88 WRITE#1,A1,K$(1,7),U0
90 GOSUB1000\GOTO40
100 GOSUB9857\U4=U1\U5=U2\U6=U3
105 FORA=0TO7\C=A*8\FORB=0TO7\D=C+B\IFA 0THEN110
107 C(0,D)=0\GOTO115
110 C(0,D)=(L(A)*729)+(L(B)*27)
115 NEXT\NEXT
120 FORA=0TO7\C=A*8\FORB=0TO7\D=C+B\IFA 0THEN130
125 C(1,D)=0\GOTO135
130 C(1,D)=L(A)*27+L(B)
135 NEXT\NEXT
140 FORA=0TO7\C=A*8\FORB=0TO7\D=C+B\IFA 0THEN150
145 C(2,D)=0\GOTO155
150 C(2,D)=(L(A)*729)+L(B)
155 NEXT\NEXT
160 !"THE COMPUTER IS SORTING IT'S LETTERS"\U0=0
200 ERRSET 400,V8,V9
201 FORA=0TO14STEPV7\B=A*15\FORC=1TO15STEPV7\D=C+B\F B(D)
202 IFF1(D)=1ORF1(D)=11THEN300
205 IFB(D)=0THEN300\V=0
210 IFC<3THEN235
215 IFB(D-1)ORB(D-2)ORB(D+1) 0THEN235
219 IFD<4THEN235
220 IFC>3ANDB(D-3) 0THEN235
225 FORE=0TO63STEPR7\G=F+C(0,E)\IFG 0THEN230\READ#0%G,&H
228 IFH=0THEN230\S1=D-2\S2=D-1\S3=INT(G/729)\S4 INT((G (729*S3))/27)
229 GOSUB3000
230 NEXT
235 F=B(D)*729
237 IFC>13THEN265
238 IFD-1<1THEN240\IFB(D-1)>0THEN265
240 IFB(D+1)ORB(D+2)>0THEN265
245 IFC<13ANDB(D+3)>0THEN265
250 FORE=0TO63STEPR7\G=F+C(1,E)\IFG=0THEN260\READ#0%G,&H
255 IFH=0THEN260\S1=D+1\S2=D+2\S4=G-(INT(G/729)*729)
257 S3=INT(S4/27)\S4=S4-(27*S3)\GOSUB3000
260 NEXT
265 F B(D)*27
268 IFC=1ORC=15THEN300
269 IFD 2<1THEN270\IFB(D-2)>0THEN300
270 IFB(D+1)ORB(D-1)ORB(D-2) 0THEN300
272 IFC 2ANDB(D-2) 0THEN300
274 IFC 14ANDB(D+2) 0THEN300
276 FORE=0TO63STEPR7\G F+C(2,E)\IFG=0THEN290\READ#0%G,&H
278 IFH=0THEN290\S1=D-1\S2=D+1\S3=INT(G/729)
280 S4 G-(S3*729)\S4 S4-(INT(S4/27)*27)\GOSUB3000
290 NEXT
300 ERRSET 300,V8,V9\NEXT\NEXT
400 ERRSET 500,V8,V9
401 FORA=0TO14STEPV7\B=A*15\FORC 1TO15STEPV7\D C+B\F B(D)
402 IFF1(D)=1ORF1(D)=11THEN500
405 IFF=0THEN500\V=0
410 IFA 3THEN435
415 IFB(D-15)ORB(D-30)ORB(D+15) 0THEN435
419 IFD 46THEN435
420 IFA 2ANDB(D-45) 0THEN435
425 FORE=0TO63STEPR7\G F+C(0,E)\IFG=0THEN430\READ#0%G,&H
428 IFH=0THEN430\S1 D-30\S2 D-15\S3 INT(G/729)\S4 INT((G (729*S3)) /27)
429 GOSUB5000
430 NEXT
435 F B(D) *729
437 IFA 12THEN465
438 IFD-15 1THEN440\IFB(D-15) 0THEN465
440 IFB(D+15)ORB(D+30)>0THEN465
```

Listing 6 continued on page 328

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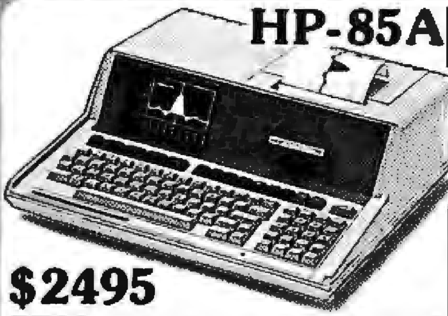
Listing 6 continued:

```
445 IFA<13ANDB(D+15)=0THEN465
450 FORE=0TOA35STEPR7\B=F+C(1,E)\IFB=0THEN460\READ#0%B,R
455 IFR=0THEN460\S1=D+15\S2=D+30\S4=B-(INT(B/729)*729)
457 S3=INT(S4/27)\S4=S4-(27*S3)\GOSUB5000
460 NEXT
465 F=B(D)*27
468 IFA>0ORA<14THEN500
469 IFD-30<1THEN470\IFB(D-30)<>0THEN500
470 IFB(D+15)ORB(D-15)ORB(D+30)<>0THEN500
471 IFD 30THEN500
472 IFA>1ANDB(D-30)<>0THEN500
474 IFA<13ANDB(D+30)<>0THEN500
476 FORE=0TOA35STEPR7\D=F+C(2,E)\IFD=0THEN490\READ#0%D,R
478 IFR 0THEN490\S1 D-15\S2=D+15\S3=INT(D/729)
480 S4 D-(S3*729)\S4 S4-(INT(S4/27)*27)\GOSUB5000
490 NEXT
500 CHSET 300,V8,V9\NEXT\NEXT
505 GOSUB9057\GOSUB8400
507 U$(1,7)="#######"\U$(1,1)=CHR$(64+M3)\U$(2,2)=CHR$(64+M4)
509 WRITE#1,M1,U$(1,7),U7
510 IFM1 =0THEN550
515 !""
520 !"THE COMPUTER CANNOT MOVE.  THEREFORE, IT IS CHANGING ALL OF"
525 !"ITS LETTERS"
540 GOTO30
550 IFM3 0THENM3 =32\IFM4=0THENM4=-32
555 D=M1*5\B$(D-4,D)="     "\B$(D-2,D-2)=CHR$(M3+64)
560 D=M2*5\B$(D-4,D)="     "\B$(D-2,D-2)=CHR$(M4+64)
570 GOSUB1000
580 B(M1)=M3\B(M2)=M4
600 !"THE COMPUTER PLACED ";CHR$(M3+64);" ON BOX";M1
610 !"THE COMPUTER PLACED ";CHR$(M4+64);" ON BOX";M2;
615 !"    CALCULATION TIME";U7;" SECONDS"
618 IFM3 0THENB(M1) 0\IFM4 0THENB(M2)=0
620 M1=0\M2=0\M3=0\M4=0
625 GOSUB8600
630 GOTO10
1000 FORA=1TO24\!""\NEXT
1001 !B$(0001,0075);"/"
1010 !B$(0076,0150);"/"
1020 !B$(0151,0225);"/"
1030 !B$(0226,0300);"/"
1040 !B$(0301,0375);"/"
1050 !B$(0376,0450);"/"
1060 !B$(0451,0525);"/"
1070 !B$(0526,0600);"/"
1080 !B$(0601,0675);"/"
1090 !B$(0676,0750);"/"
1100 !B$(0751,0825);"/"
1110 !B$(0826,0900);"/"
1120 !B$(0901,0975);"/"
1130 !B$(0976,1050);"/"
1140 !B$(1051,1125);"/"
1141 GOTO1150
1142 FORA=0TO14\FORB=1TO15\C=(15*A)+B\!N(C);\NEXT\!""\NEXT
1150 RETURN
2000 FORA=1TO1121STEP5\B$(A,A)="/"\NEXT
2005 IFR0=9THENRETURN
2010 FORA=1TO225\E=INT(A/100)\F A-(100*E)\G INT(F/10)\F F (10*G)
2012 D=(A-1)*5\D=D+2
2014 IFE=0THEN2020
2016 E=E+48
2018 B$(D,D)=CHR$(E)
2019 B$(D+1,D+1)="0"
2020 D=D+1
2030 IFG=0THEN2050
2040 G=G+48
2045 B$(D,D)=CHR$(G)
2050 D D+1\C=C+48\B$(D,D)=CHR$(C)
2060 NEXT\RETURN
3000 S5=B(D)\S5=F1(S5)\T1=0\T2=0\T3=0
3001 IFS1 0ANDF(S1) 0THENRETURN\IFS4 0ANDF(S1) 0THENRETURN
3002 FORA1=1TO3\A2=S1\A3=S4\IFA1 1THEN3010
3005 A2=S2\A3=S4
3010 IFA3=0THEN3300
3015 T=0\FORA5=A2-15TOA2-45STEP-15
3018 IFA5 1THENEXIT3040
3020 IFB(A5)=0THENEXIT3030
3025 T=T+1\NEXT
3030 IFT 2THENEXIT3999
3035 T=0\FORA5=A2+15TOA2+45STEP15
3040 IFA5 225THENEXIT3055
3045 IFB(A5) 0THENEXIT3055
3050 T=T+1\NEXT
3055 IFT 2THENEXIT3999
3060 IFT+T 2THENEXIT3999
3062 IFT+T 0THEN3300
3065 IFT 2THEN3070\T1 A2 30\T A2 15 A3 GOTO3200
3070 IFT 1ANDB 0THEN3080\GOTO3300
3075 T1 A2 A2 15\T1 A3\GOTO3200
3080 IFT 1ANDB  0THEN3090\T1 A2 15 T2 A2 15 A2 15\GOTO3200
3090 IFB  2THEN3095\T1 A2\T A2 15\T A2 30\GOTO3200
3095 IFB  1ANDB  0THEN3100\T1 A2\T A2 A2 15\GOTO3200
3100 !"WE HAVE AN ERROR IN THE PROGRAM"\END
3200 T 1729*B(T1)+(T ... )*(T ... )
3202 IFA2 T1THENT T+(729*A3)
3204 IFA2 T2THENT T+(27*A3)
3206 IFA2 T3THENT T+A3
3210 IFA5=21+... ... 0THEN3300\ 0\RETURN
3300 NEXT\GOSUB6000\RETURN
3320 RETURN
3999 T(A2) 1\RETURN
5000 S5 B(D)\S5=F1(S5)\T1 0 T  0 T3 0
5001 IFS1 0ANDF(S1) 0THENRETURN\IFS4 0ANDF(S1) 0THENRETURN
5002 FORA1 1TO3\A2 S1\A3=S3\IFA1=1THEN5010
5005 A2=S2\A3=S4
5010 IFA3=0THEN5300
5012 A6 INT((A2-1)/15)\A7=A2-(A6*15)\A6 A7
5013 R9 1
5015 T=0\FORA5=A2 1TOA2-3STEP-1
5017 A  A7-1\IFA7 1THENEXIT5030
5020 IFB(A5) 0THENEXIT5030
5025 T T+1\NEXT
5030 IFT 2THENEXIT5999
5031 R9=2
5035 U=0\FORA5=A2+1TOA2+3\A6=A6+1
5040 IFA6 15THENEXIT 5055
5045 IFB(A5)=0THENEXIT 5055
5050 U=U+1\NEXT
5055 IFU>2THENEXIT5999
5060 IFU+T 2THENEXIT5999
5062 IFT+U=0THEN5300
```

Listing 6 continued on page 330



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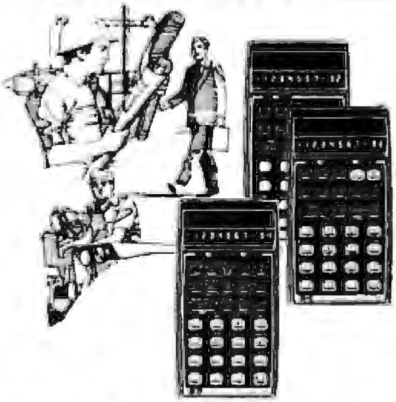

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Listing 6 continued:

```
5065 IFT 2THEN5070\T1=A2-2\T2=A2-1\T3=A2\GOTO5200
5070 IFT=1ANDU=0THEN5075\GOTO5080
5075 T1=0\T2=A2-1\T3=A2\GOTO5200
5080 IFT 1ANDU 1THEN5090\T1 A2 1\T2=A2\T3 A2+1\GOTO5200
5090 IFU 2THEN5092\T1=A2\T2 A2+1\T3 A2+4\GOTO5200
5092 IFU 1ANDT 0THEN5100\T1 0\T2 A2\T3 A2+1\GOTO5200
5100 !"WE HAVE AN ERROR IN THE PROGRAM"\END
5200 T=(7299*P(T1)+(2/*P(T2))+P(T3)
5202 IFA2=T1THENT=T+(7290A3)
5204 IFA2=T2THENT=T+(2270A3)
5206 IFA2=T3THENT=T+A3
5210 READ#3X1,A$\IFA OTHEN5300\V 0\RETURN
5300 NEXT\GOSUB6000\RETURN
5999 F(A2) 1\RETURN
6000 T(1) T1\T(2)=T2\T(3)=T3\V9=0\V 0
6005 IFT1+T2+T3 0THEN6100
6010 FORZ=1TO3\V8=T(Z)
6020 IFV8=0THEN6050
6030 IFV8 A2THEN6040\Z1=P(A2)\GOTO6050
6040 V8=P(V8)\V9 V9+P1(V8)
6050 NEXT
6055 IFT1+T2+T3=A2+0THEN6100
6060 ONZ1+1GOTO6070,6070,6070,6080,6080
6070 V9 V9+F1(A5)*Z1\V V+V9\GOTO6100
6080 VV (V9+F1(A3))*(Z1-2)\V V+V9
6100 V9 0
6105 IFS3 0THEN6140
6110 ON(S1)+1GOTO6120,6120,6130,6130
6120 V9 V9+(F1(S3)*F(S1))\GOTO6140
6130 VV V9+F1(S3)
6140 IFS4 0THEN6170
6142 ONF(S2)+1GOTO6150,6150,6160,6160
6150 V9 V9+(F1(S4)*F(S2))\GOTO6170
6160 V9 V9+F1(S4)
6170 IFF(S1) 3ANDF(1 0THENV9 V9,
6175 IFF(S2) 3ANDF(4 0THENV9 V9+2
6180 IFF(S1) 3ANDF(4 0THENV9 V9+4
6185 IFF(S2) 3ANDF(4 0THENV9 V9+4
6190 V V+V9
6200 IFV9 0THEN6RETURN
6210 V0 V\N1 S1\N2 S2\N3 S3\N4 S4\RETURN
8000 INPUT"WHAT ARE THE COMPUTER'S LETTERS ";L$(1,7)
8002 FORA 1TO7\L(A)=ASC(L$(A,A))-A4\IFL(A) 0THENL(A) 1\NEXT
8004 V 0\GOSUB9057\U4 U1\U5 U2\U6 U3
8005 FORA 0TO7\FORB 0TO7\IFB A THEN8090
8010 FORC 0TO7\IFC A ANDC BTHEN8080
8020 D L(A)+(29)+L(B)*(27)+L(C)
8030 READ#3D,A$\IFD 0THEN8080
8040 S1 F(A)\S2 F(B)\S3 F(C)
8050 S4 F(S1)+F(S2)+F(S3)
8060 IFV S4THEN8080
8070 V S4\F1 S1\F2 S2\F3 S3
8080 NEXTC
8090 NEXTB
8100 NEXTA
8105 GOSUB9057\GOSUB8400\F4=112
8110 IFF1 0THEN8150
8120!"THE COMPUTER CANNOT MOVE.  THEREFORE, IT IS CHANGING ALL OF"
8130!"ITS LETTERS"
8140 RETURN
8150 R(112)=F1\R(113)=F2\R(114)=F3
8160 B$(556,560)="     "\B$(558,558)=CHR$(F1+A4)
8170 B$(561,565)="     "\B$(563,563)=CHR$(F2+A4)
8180 B$(566,570)="     "\B$(568,568)=CHR$(F3+A4)
8181 Z$=B$(558,558)+B$(563,563)+B$(568,568)+"***"
8182 WRITE#1,F4,Z$(1,7),U7
8190 IFF1 0THENB$(558,558)=" "\GOSUB1000\RETURN
8300 FORA=0TO14
8310 !"GIVE THE FIFTEEN LETTERS FOR LINE",A+1
8320 !" 123456789012345"
8330 !" ---------------"
8340 INPUTZ$(1,15)
8350 C=A*15\FORB=1TO15\C=C+1
8360 D=C*5\B$(D-4,D)="     "\IFZ$(B,B) " "THEN8370
8365 K$=Z$(B,B)\B(C)=ASC(K$)-A4\B$(D-2,D-2)=K$
8370 NEXT\NEXT
8380 RETURN
8400 U7=0
8405 IFU1<>U4THENU7=3600
8410 U8=U2-U5\IFU8 0THEN8420
8412 U7=U7+(U8*60)\GOTO8430
8420 U7=U7+(U8*60)
8430 U7=U7+U3-U6\RETURN
8500 READ#2%0,B(1),B(2),B(3),B(4),B(5),B(6),B(7),B(8),B(9)
8510 READ#2,B(10),B(11),B(12),B(13),B(14),B(15)
8520 FORA=15TO210STEP15
8530 READ#2,B(A+1),B(A+2),B(A+3),B(A+4),B(A+5),B(A+6),B(A+7),B(A+8)
8540 READ#2,B(A+9),B(A+10),B(A+11),B(A+12),B(A+13),B(A+14),B(A+15)
8550 NEXT
8560 FORB=1TO225
8565 IFB(B)=0THEN8580
8570 D=B*5\B$(D-4,D)="     "\C=B(B)+A4\B$(D-2,D-2)=CHR$(C)
8580 NEXT\GOSUB1000
8590 RETURN
8600 WRITE#2%0,B(1),B(2),B(3),B(4),B(5),B(6),B(7),B(8),B(9)
8610 WRITE#2,B(10),B(11),B(12),B(13),B(14),B(15)
8620 FORA=15TO210STEP15
8630 WRITE#2,B(A+1),B(A+2),B(A+3),B(A+4),B(A+5),B(A+6),B(A+7),B(A+8)
8640 WRITE#2,B(A+9),B(A+10),B(A+11),B(A+12),B(A+13),B(A+14),B(A+15)
8650 NEXT\RETURN
9001 DATA 4,0,0,1,0,0,0,4,0,0,0,1,0,0,4
9002 DATA 0,1,0,0,0,2,0,0,0,2,0,0,0,1,0
9003 DATA 0,0,3,0,0,0,1,0,1,0,0,0,3,0,0
9004 DATA 1,0,0,3,0,0,0,1,0,0,0,3,0,0,1
9005 DATA 0,0,0,0,3,0,0,0,0,0,3,0,0,0,0
9006 DATA 0,2,0,0,0,2,0,0,0,2,0,0,0,2,0
9007 DATA 0,0,1,0,0,0,1,0,1,0,0,0,1,0,0
9008 DATA 4,0,0,1,0,0,0,7,0,0,0,1,0,0,4
9009 DATA 0,0,1,0,0,0,1,0,1,0,0,0,1,0,0
9010 DATA 0,2,0,0,0,2,0,0,0,2,0,0,0,2,0
9011 DATA 0,0,0,0,3,0,0,0,0,0,3,0,0,0,0
9012 DATA 1,0,0,3,0,0,0,1,0,0,0,3,0,0,1
9013 DATA 0,0,1,0,0,0,1,0,1,0,0,0,3,0,0
9014 DATA 0,3,0,0,0,2,0,0,0,2,0,0,0,1,0
9015 DATA 4,0,0,1,0,0,0,4,0,0,0,1,0,0,4
9020 DATA 1,3,3,2,1,4,2,4,1,8,5,1,3
9021 DATA 1,1,3,10,1,1,1,1,4,1,8,1,10
9057 FORU 0TO7\U(U) INT(TAB(U))\NEXTU\ 10*U(7)+U(6)
9058 U2 10*U(5)+U(4)\U3 10*U(2)+U(3)\RETURN
READY
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Listing 7: *SHORT, a slower version of the program SCRABBLE (listing 6), needs only 32 K of memory to run.*

```
LOAD SHORT
READY
LIST

1 !"THIS PROGRAM WAS WRITTEN BY"+TAB(40);"[illegible] DATA [illegible]"
2 !TAB(40);"BOX 24"\!TAB(40);"[illegible] VILLAGE, NEW YORK [illegible]"
3 !"WRITE FOR INFORMATION TO OBTAIN [illegible]"
4 !"OTHER FINE PROGRAMS ARE AVAILABLE"
5 !"THERE ARE TEN VERSIONS [illegible]"
6 !"[illegible]"
7 !"                              [illegible]"
8 [illegible]
9 INPUT"WHAT VERSION (1-10) ? [illegible] AND 10 [illegible]"
10 [illegible]
11 DIM[illegible]
12 FORA [illegible]
13 OPEN[illegible]"WORDS"[illegible]
14 INPUT"TYPE Y IF YOU DON'T WANT NUMBERS ON THE BOARD ? ";K9$\IF[illegible]
15 INPUT"TYPE Y IF YOU WANT TO CONTINUE LAST GAME [illegible] ? ";K$
16 IFK$<>"Y"THEN18
17 IFK$(1;1)="Y"THEN[illegible]
18 INPUT"TYPE Y IF YOU WISH TO [illegible] ";K$\IF[illegible]"THEN[illegible]
20 IFK$(1;1)="Y"THEN[illegible]
22 INPUT"TYPE Y IF THE COMPUTER [illegible] ";K$\IF[illegible]"THEN[illegible]
26 IFK$(1;1)="Y"THENGOSUB8000
30 INPUT"WHAT ARE THE COMPUTER'S LETTERS ";[illegible]
31 FORA [illegible] NEXT [illegible]
42 !"ILLEGAL MOVE, TRY AGAIN"
43 [illegible]"NEGATIVE TO AND FROM ENDS GAME"[illegible]"0 TO AND FROM",
44 !" ALLOWS THE COMPUTER TO MOVE"\!""
45 INPUT"ON BOX FROM AND TO OF THE LAST MOVE OR 0,0 FOR MY TURN ";A1,A
46 IFA1 [illegible]THEN50\!""\!"THANK YOU FOR THE GAME"
47 !"FREE MEMORY EQUALS";FREE(A)
48 [illegible]
49 CHAIN"S"
50 IFA1 0THEN100
60 INPUT"WHAT WORD DID YOU SPELL ? ";K$
61 IFA2 A1)0THEN80
62 C LEN(K$)\A-A2 A1)\IFC ATHEN32
64 C [illegible] A1TOA2\B A$\K$(B 4,B) "        "\K$(B 2,B  ) K$(C,C)\C A$(1,1)
65 C C+1\B ASC(B$) 64\B(A) B\NEXT\GOSUB8600
66 K$ K$+"########"
68 WRITE[illegible],A1,K$(1,7),U0
69 GOSUB8600
70 GOSUB1000\GOTO40
80 C LEN(K$)\A-((A2-A1)/15)+1\IFC ATHEN32
82 C [illegible] A1TOA2STEP15\B A$\K$(B 4,B)-"        "\K$(B 2,B 2) K$(C,C)\B K$(1,1)
84 C C+1\B ASC(B$)-64\B(A) B\NEXT
85 GOSUB8600
86 K$ K$+"########"
88 WRITE[illegible],A1,K$(1,7),U0
90 GOSUB1000\GOTO40
100 GOSUB9057\U4-U1\U5-U2\U6-U3
105 FORA-0TO7\C-A8\FORB-0TO7\D C+B\IFA BTHEN110
107 C(0,D) 0\GOTO115
110 C(0,D)-(L(A)*729)+(L(B)*27)
115 NEXT\NEXT
120 FORA=0TO7\C=A8\FORB 0TO7\D=C+B\IFA BTHEN130
125 C(1,D)=0\GOTO135
130 C(1,D)=(L(A)*27)+L(B)
135 NEXT\NEXT
140 FORA=0TO7\C=A8\FORB=0TO7\D=C+B\IFA BTHEN150
145 C(2,D)=0\GOTO155
150 C(2,D)=(L(A)*729)+L(B)
155 NEXT\NEXT
160 !"THE COMPUTER IS SORTING IT'S LETTERS"\V0=0
200 ERRSET 400,V8,V9
201 FORA=0TO14STEPV7\B=A*15\FORC=1TO13STEPV7\D=C+B\F=B(D)
202 IFT0=0THEN205
205 IFB(D)=0THEN300\V=0
210 IFC<3THEN235
215 IFB(D-1)ORB(D-2)ORB(D+1)>0THEN235
219 IFD<4THEN235
220 IFC>3ANDB(D-3)>0THEN235
225 FORE=0TO63STEPR7\G=F+C(0,E)\IFG=0THEN230\READ#0XG;$H
228 IFH=0THEN230\B1=D-2\B2=D-1\B3=INT(G/729)\B4=INT((G-(729*B3))/27)
229 GOSUB3000
230 NEXT
235 F=B(D)*729
237 IFC>13THEN265
238 IFD-1 1THEN240\IFB(D-1)>0THEN265
240 IFB(D+1)ORB(D+2)>0THEN265
245 IFC<13ANDB(D+3)>0THEN265
250 FORE=0TO63STEPR7\G=F+C(1,E)\IFG=0THEN260\READ#0XG;$H
255 IFH=0THEN260\B1=D+1\B2=D+2\B4=D-(INT(G/729)*729)
257 B3=INT(B4/27)\B4=B4-(27*B3)\GOSUB3000
260 NEXT
265 F B(D)*27
268 IFC=1ORC=15THEN300
269 IFD-2 1THEN270\IFB(D-2)>0THEN300
270 IFB(D+1)ORB(D-1)ORB(D-2)>0THEN300
272 IFC 2ANDB(D-2) 0THEN300
274 IFC 14ANDB(D+2)>0THEN300
276 FORE=0TO63STEPR7\G=F+C(2,E)\IFG=0THEN290\READ#0XG;$H
278 IFH=0THEN290\B1=D-1\B2=D+1\B3=INT(G/729)
280 B4=D-(B3*729)\B4=B4-(INT(B4/27)*27)\GOSUB3000
290 NEXT
300 ERRSET 300,V8,V9\NEXT\NEXT
400 ERRSET 500,V8,V9
401 FORA=0TO14STEPV7\B A*15\FORC=1TO15STEPV7\D=C+B\F=B(D)
402 IFT0=0THEN405
405 IFF=0THEN500\V=0
410 IFA 3THEN435
415 IFB(D-15)ORB(D-30)ORB(D+15)>0THEN435
419 IFD 46THEN435
420 IFA 3ANDB(D-45)>0THEN435
425 FORE 0TO63STEPR7\G=F+C(0,E)\IFG=0THEN430\READ#0XG;$H
428 IFH 0THEN430\B1=D-30\B2=D-15\B3=INT(G/729)\B4=INT((G (729*B3))/27)
429 GOSUB5000
430 NEXT
435 F B(D)*729
437 IFA 13THEN465
438 IFD-15 1THEN440\IFB(D-15) 0THEN465
440 IFB(D+15)ORB(D+30) 0THEN465
445 IFA 1 ANDB(D+45) 0THEN465
450 FORE 0TO63STEPR7\G F+C(1,E)\IFG=0THEN460\READ#0XG;$H
455 IFH 0THEN460\B1 D+15\B2 D+30\B4=D (INT(G/729)*729)
457 B3 INT(B4/27)\B4 B4-(27*B3)\GOSUB5000
460 NEXT
465 F B(D)*27
468 IFA 0ORA 14THEN500
```

Listing 7 continued on page 334

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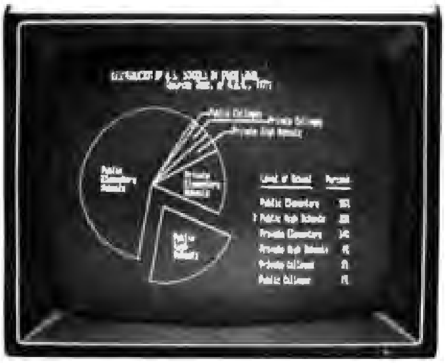

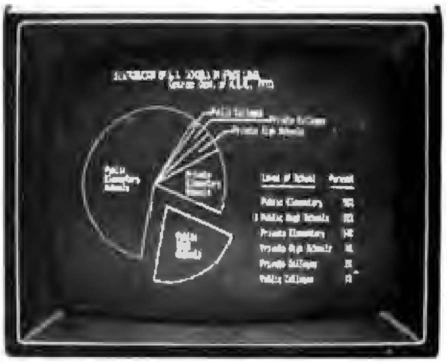

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Listing 7 continued:

```
469 IFD-30<1THEN470\IFB(D-30)>0THEN500
470 IFB(D+15)ORB(D-15)ORB(D+30)>0THEN500
472 IFA>1ANDB(D-30)>0THEN500
474 IFA<1ANDB(D+30)>0THEN500
476 FORE=0TO63STEPR7\D=F+C(2,E)\IFD=0THEN490\READ#02D,SH
478 IFH>0THEN490\S1=D-15\S2=D+15\S3=INT(S/729)
480 S4=S-(S3*729)\S4=S4-(INT(S4/27)*27)\GOSUB5000
490 NEXT
500 ERRSET 500,V8,V9\NEXT\NEXT
505 GOSUB9000\GOSUB8400
507 D$(1,7)="******"\D$(1,1)=CHR$(A4+M3)\D$(2,2)=CHR$(A4+M4)
509 WRITE#1,M1,D$(1,7),U7
510 IFM1>0THEN550
515 !""
520 !"THE COMPUTER CANNOT MOVE.  THEREFORE, IT IS CHANGING ALL OF"
525 !"ITS LETTERS"
540 GOTO30
550 IFM3>0THENM3=M3-32\IFM4>0THENM4=M4-32
555 B=M1*5\D$(B-4,B)="     "\D$(B-3,B-3)=CHR$(M3+A4)
560 B=M2*5\D$(B-4,B)="     "\D$(B-3,B-3)=CHR$(M4+A4)
570 GOSUB1000
580 B(M1)=M3\B(M2)=M4
600 !"THE COMPUTER PLACED "+CHR$(M3+A4)+" ON BOX"+M1
610 !"THE COMPUTER PLACED "+CHR$(M4+A4)+" ON BOX"+M2,
615 !"   CALCULATION TIME"+U7+" SECONDS"
616 IFM3>0THENB(M1)=0\IFM4>0THENB(M2)=0
620 M1=0\M2=0\M3=0\M4=0
625 GOSUB8400
630 GOTO30
1000 FORA=1TO24\!""\NEXT
1001 !B$(0001,0075),"/"
1010 !B$(0076,0150),"/"
1020 !B$(0151,0225),"/"
1030 !B$(0226,0300),"/"
1040 !B$(0301,0375),"/"
1050 !B$(0376,0450),"/"
1060 !B$(0451,0525),"/"
1070 !B$(0526,0600),"/"
1080 !B$(0601,0675),"/"
1090 !B$(0676,0750),"/"
1100 !B$(0751,0825),"/"
1110 !B$(0826,0900),"/"
1120 !B$(0901,0975),"/"
1130 !B$(0976,1050),"/"
1140 !B$(1051,1125),"/"
1141 GOTO1150
1142 FORA=0TO14\FORB=1TO15\C=(15*A)+B\!B(C),\NEXT\!""\NEXT
1150 RETURN
2000 FORA=1TO1121STEP5\B$(A,A)="/"\NEXT
2005 IFRO=9THENRETURN
2010 FORA=1TO225\E=INT(A/100)\F=A-(100*E)\B=INT(F/10)\C=F-(10*B)
2012 D=(A-1)*5\D=D+2
2014 IFE=0THEN2030
2016 E=E+48
2018 B$(D,D)=CHR$(E)
2019 B$(D+1,D+1)="0"
2020 D=D+1
2030 IFB=0THEN2050
2040 B=B+48
2045 B$(D,D)=CHR$(B)
2050 D=D+1\C=C+48\B$(D,D)=CHR$(C)
2060 NEXT\RETURN
3000 S5=B(D)\S5=P1(S5)\T1=0\T2=0\T3=0
3001 IFS3>0ANDF(S1)>0THENRETURN\IFS4>0ANDF(S1)>0THENRETURN
3003 FORA1=1TO2\A2=S1\A3=S3\IFA1=1THEN3010
3005 A2=S2\A3=S4
3010 IFA3=0THEN3300
3015 T=0\FORA5=A2-15TOA2-45STEP-15
3018 IFA5<1THENEXIT3030
3020 IFB(A5)=0THENEXIT3030
3025 T=T+1\NEXT
3030 IFT>2THENEXIT3999
3035 U=0\FORA5=A2+15TOA2+45STEP15
3040 IFA5>225THENEXIT3055
3045 IFB(A5)=0THENEXIT3055
3050 U=U+1\NEXT
3055 IFU>2THENEXIT3999
3060 IFU+T>2THENEXIT 3999
3062 IFT+U=0THEN3300
3065 IFT>2THEN3070\T1=A2-30\T2=A2-15\T3=A2\GOTO3200
3070 IFT=1ANDB=0THEN3075\GOTO3080
3075 T1=0\T2=A2-15\T3=A2\GOTO3200
3080 IFT>1ANDU>1THEN3090\T1=A2-15\T2=A2\T3=A2+15\GOTO3200
3090 IFU>2THEN3092\T1=A2\T2=A2+15\T3=A2+30\GOTO3200
3092 IFU>1ANDT=0THEN3100\T1=0\T2=A2\T3=A2+15\GOTO3200
3100 !"WE HAVE AN ERROR IN THE PROGRAM"\END
3200 T=(729*B(T1))+(27*B(T2))+B(T3)
3202 IFA2>T1THENT=T+(729*A3)
3204 IFA2>T2THENT=T+(27*A3)
3206 IFA2>T3THENT=T+A3
3210 READ#0%T,H\IFH>0THEN3300\V=0\RETURN
3300 NEXT\GOSUB6000\RETURN
3320 RETURN
3999 F(A2)=1\RETURN
5000 S5=B(D)\S5=P1(S5)\T1=0\T2=0\T3=0
5001 IFS3>0ANDF(S1)>0THENRETURN\IFS4>0ANDF(S1)>0THENRETURN
5002 FORA1=1TO2\A2=S1\A3=S3\IFA1=1THEN5010
5005 A2=S2\A3=S4
5010 IFA3=0THEN5300
5012 A6=INT((A2-1)/15)\A7=A2-(A6*15)\A6=A7
5013 R9=1
5015 T=0\FORA5=A2-1TOA2-3STEP-1
5017 A7=A7-1\IFA7<1THENEXIT5030
5020 IFB(A5)=0THENEXIT5030
5025 T=T+1\NEXT
5030 IFT>2THENEXIT5999
5031 R9=2
5035 U=0\FORA5=A2+1TOA2+3\A6=A6+1
5040 IFA6>15THENEXIT 5055
5045 IFB(A5)=0THENEXIT 5055
5050 U=U+1\NEXT
5055 IFU>2THENEXIT5999
5060 IFU+T>2THENEXIT5999
5062 IFT+U=0THEN5300
5065 IFT>2THEN5070\T1=A2-2\T2=A2-1\T3=A2\GOTO5200
5070 IFT=1ANDG=0THEN5075\GOTO5080
5075 T1=0\T2=A2-1\T3=A2\GOTO5200
5080 IFT>1ANDU>1THEN5090\T1=A2-1\T2=A2\T3=A2+1\GOTO5200
5090 IFU>2THEN5092\T1=A2\T2=A2+1\T3=A2+30\GOTO5200
5092 IFU>1ANDT=0THEN5100\T1=0\T2=A2\T3=A2+1\GOTO5200
5100 !"WE HAVE AN ERROR IN THE PROGRAM"\END
5200 T=(729*B(T1))+(27*B(T2))+B(T3)
5202 IFA2>T1THENT=T+(729*A3)
```

Listing 7 continued on page 336

Listing 7 continued:

```
5204 IFA2=12THENT=T+(2*A3)
5206 IFA2=13THENT=T+A3
5210 READ#0%T,B%\IFB%=0THEN5300\V=0\RETURN
5300 NEXT\GOSUB6000\RETURN
5999 F(A2)=1\RETURN
6000 T(1)=T1\T(2)=T2\T(3)=T3\V9=0\V=0
6005 IFT1+T2+T3=0THEN6100
6010 FORZ=1TO3\V8=T(Z)
6020 IFV8=0THEN6050
6030 IFV8=A2THEN6040\Z1=P(A2)\GOTO6050
6040 V8=B(V8)\V9=V9+P1(V8)
6050 NEXT
6055 IFT1+T2+T3-A2=0THEN6100
6060 ONZ1+1GOTO6070,6070,6070,6080,6080
6070 V9=V9+(P1(A3)*Z1)\V=V+V9\GOTO6100
6080 V9=(V9+P1(A3))*(Z1-2)\V=V+V9
6100 V9=B5
6105 IFS3=0THEN6140
6110 ON(P(S1))+1GOTO6120,6120,6120,6130,6130
6120 V9=V9+(P1(S3)*(P(S1)))\GOTO6140
6130 V9=V9+P1(S3)
6140 IFS4=0THEN6170
6145 ON(P(S2))+1GOTO6150,6150,6150,6160,6160
6150 V9=V9+(P1(S4)*(P(S2)))\GOTO6170
6160 V9=V9+P1(S4)
6170 IFP(S1)=3ANDS3=0THENV9=V9*2
6175 IFP(S2)=3ANDS4=0THENV9=V9*2
6180 IFP(S1)=4ANDS3=0THENV9=V9*3
6185 IFP(S2)=4ANDS4=0THENV9=V9*3
6190 V=V+V9
6200 IFV=0THENRETURN
6210 V0=V\A1=S1\A2=S2\A3=S3\A4=S4\RETURN
8000 INPUT"WHAT ARE THE COMPUTER'S LETTERS ";
8002 FORA=1TO7\
8004 V=0\GOSUB9057\U4=U1\U5=U2\U6=U3
8005 FORA=0TO7\FORB=0TO7\IFB=ATHEN8090
8010 FORC=0TO7\IFC=AORC=BTHEN8080
8020 D=L(A)*729+L(B)*27+L(C)
8030 READ#0%D,B%\IFB%=0THEN8080
8040 S1=L(A)\S2=L(B)\S3=L(C)
8050 S4=P1(S1)+P1(S2)+P1(S3)
8060 IFV>S4THEN8080
8070 V=S4\F1=S1\F2=S2\F3=S3
8080 NEXTC
8090 NEXTB
8100 NEXTA
8105 GOSUB9057\GOSUB8400\F4=U7
8110 IFF1=0THEN8150
8120 PRINT"THE COMPUTER CANNOT MOVE.  THEREFORE, IT IS CHANGING ALL OF "
8130 PRINT"ITS LETTERS"
8140 RETURN
8150 B(112)=F1\B(113)=F2\B(114)=F3
8160 B$(556,560)="     "\B$(558,558)=CHR$(F1+64)
8170 B$(561,565)="     "\B$(563,563)=CHR$(F2+64)
8180 B$(566,570)="     "\B$(568,568)=CHR$(F3+64)
8181 Z$=B$(558,558)+B$(563,563)+B$(568,568)+"????"
8182 WRITE#1,F4,Z$(1,7),U7
8190 IFF1=0THENB$(558,558)=" "\GOSUB1000\RETURN
8300 FORA=0TO14
8310 PRINT"GIVE THE FIFTEEN LETTERS FOR LINE";A+1
8320 PRINT" 123456789012345"
8330 PRINT" "
8340 INPUTZ$(1,15)
8350 C=A*15\FORB=1TO15\C=C+1
8360 D=C*5\B$(D-4,D)="     "\IFZ$(B,B)=" "THEN8370
8365 K$=Z$(B,B)\B(C)=ASC(K$)-64\B$(D-2,D-2)=K$
8370 NEXT\NEXT
8380 RETURN
8400 U7=0
8405 IFU1<>U4THENU7=3600
8410 U8=U2-U5\IFU8>0THEN8420
8412 U7=U7+(U8*60)\GOTO8430
8420 U7=U7+(U8*60)
8430 U7=U7+U3-U6\RETURN
8500 READ#2%0,%B(1),%B(2),%B(3),%B(4),%B(5),%B(6),%B(7),%B(8),%B(9)
8510 READ#2,%B(10),%B(11),%B(12),%B(13),%B(14),%B(15)
8520 FORA=15TO210STEP15
8530 READ#2,%B(A+1),%B(A+2),%B(A+3),%B(A+4),%B(A+5),%B(A+6),%B(A+7),%B(A+8)
8540 READ#2,%B(A+9),%B(A+10),%B(A+11),%B(A+12),%B(A+13),%B(A+14),%B(A+15)
8550 NEXT
8560 FORB=1TO225
8565 IFB(B)=0THEN8580
8570 D=B*5\B$(D-4,D)="     "\C=B(B)+64\B$(D-2,D-2)=CHR$(C)
8580 NEXT\GOSUB1000
8590 RETURN
8600 WRITE#2%0,%B(1),%B(2),%B(3),%B(4),%B(5),%B(6),%B(7),%B(8),%B(9)
8610 WRITE#2,%B(10),%B(11),%B(12),%B(13),%B(14),%B(15)
8620 FORA=15TO210STEP15
8630 WRITE#2,%B(A+1),%B(A+2),%B(A+3),%B(A+4),%B(A+5),%B(A+6),%B(A+7),%B(A+8)
8640 WRITE#2,%B(A+9),%B(A+10),%B(A+11),%B(A+12),%B(A+13),%B(A+14),%B(A+15)
8650 NEXT\RETURN
9001 DATA 4,0,0,1,0,0,0,4,0,0,0,1,0,0,4
9002 DATA 0,3,0,0,0,2,0,0,0,2,0,0,0,3,0
9003 DATA 0,0,3,0,0,0,1,0,1,0,0,0,3,0,0
9004 DATA 1,0,0,3,0,0,0,1,0,0,0,3,0,0,1
9005 DATA 0,0,0,0,3,0,0,0,0,0,3,0,0,0,0
9006 DATA 0,2,0,0,0,2,0,0,0,2,0,0,0,2,0
9007 DATA 0,0,1,0,0,0,1,0,1,0,0,0,1,0,0
9008 DATA 4,0,0,1,0,0,0,3,0,0,0,1,0,0,4
9009 DATA 0,0,1,0,0,0,1,0,1,0,0,0,1,0,0
9010 DATA 0,2,0,0,0,2,0,0,0,2,0,0,0,2,0
9011 DATA 0,0,0,0,3,0,0,0,0,0,3,0,0,0,0
9012 DATA 1,0,0,3,0,0,0,1,0,0,0,3,0,0,1
9013 DATA 0,0,3,0,0,0,1,0,1,0,0,0,3,0,0
9014 DATA 0,3,0,0,0,2,0,0,0,2,0,0,0,3,0
9015 DATA 4,0,0,1,0,0,0,4,0,0,0,1,0,0,4
9020 DATA 1,3,3,2,1,4,2,4,1,8,5,1,3
9025 DATA 1,1,3,10,1,1,1,1,4,4,8,4,10
9857 FORU=0TO7\U(U)=INP(168+U)\NEXT\U1=10*U(7)+U(6)
9050 U2=10*U(5)+U(4)\U3=10*U(2)+U(3)\RETURN
READY
```

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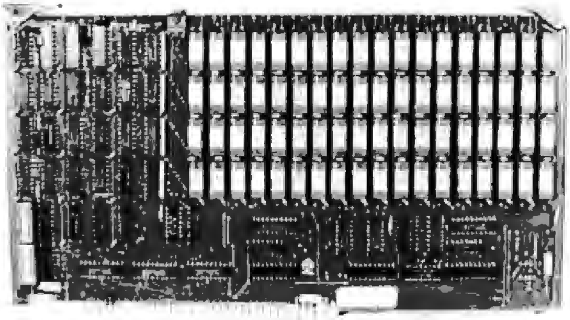

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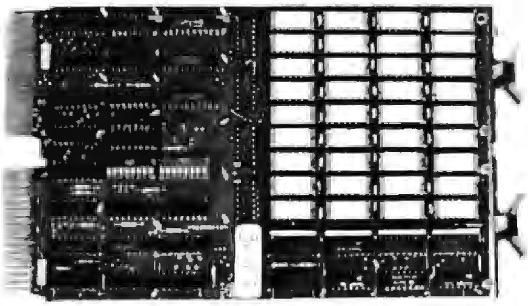

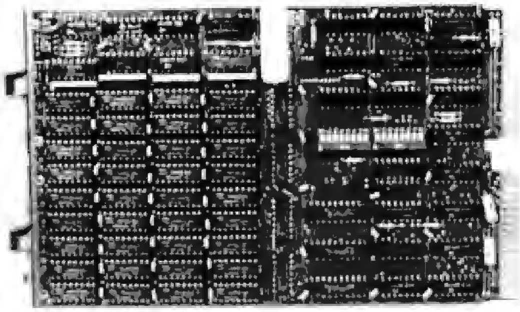

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- On-board parity generator checker.
- Power requirements are +5V 1.2A.
- Battery back-up mode.

SINGLE QTY. PRICE:
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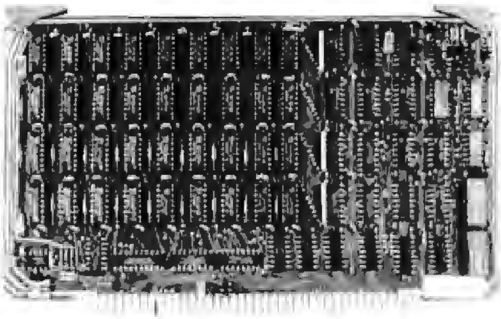

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Circle 60 on inquiry card.

Text continued from page 324:

move was performed by the computer.

In the sample game, the level 1 game was used, so the computer played slowly. As the game progressed, the possible number of moves increased. The computer needed 23 minutes and 46 seconds to calculate its final move. Fear not, listing 14 shows a replay of the sample game using computer Scrabble level 6. Using this version, all moves were made in approximately 60 seconds.

In listing 15, the final Scrabble board resulting from the sample game is displayed. This board was produced using the "continue last game" option and was generated without square numbers—giving more clarity to the display.

In listing 16, the inputs to preset a game board are shown. In listing 17, you can see what happens when the computer cannot find a legal move—it asks for new letters. Listing 18 is a TRS-80 Level II BASIC version of the SCRABBLE program.

The Scrabble simulation is very helpful in solving end-game problems. Since it specializes in placing two letters on the game board, you can use the simulation to find the highest-scoring positions for your last few letters.

The Future of Computer Scrabble

To date, the best level of the game plays a little slow, and a broader vocabulary is needed. The slowness

Text continued on page 346

Listing 8: *REPORT prints a summary of the most recent game played; data are stored in a file called REC.*

```
LIST

10 OPEN#1,'REC'
15 !'MOVE BOX LETTERS TIME'
18 !'---- --- ------- -----'
20 READ#1,A,Z$(1,7),B
30 IFA=0THEN100
40 C=C+1
50 !%4I,C,A,' ',Z$(1,7),%6I,B
60 GOTO20
100 !''\!''\!'TIME OF ? MADE BY HUMAN PLAYER.'
110 !'TIMED MOVES WERE MADE BY COMPUTER'
120 CHAIN'S'
READY
```

Listing 9: *Sample printout of the beginning of a session with a Scrabble system.*

```
LOAD S
READY
RUN

READY ?

WELCOME TO THE SCRABBLE SIMULATION MODEL
YOU HAVE THE FOLLOWING SEVEN OPTIONS:

    0 END THE SIMULATION
    1 CREATE A FILE FOR THE COMPUTER'S VOCABULARY
    2 INPUT OR DELETE WORDS TO OR FROM THE COMPUTER'S VOCABULARY
    3 LIST THE ENTIRE VOCABULARY
    4 CONVERT A PROGRAM CODE NUMBER INTO A WORD
    5 PLAY A GAME OF SCRABBLE AGAINST THE COMPUTER
    6 GET A SUMMARY REPORT OF THE GAME JUST PLAYED

YOUR SELECTION ? 2

ENTER DELETE TO DELETE WORDS OR ANYTHING TO ADD ? ADD
NEW WORD ? ZIP
NEW WORD ?

READY ?

WELCOME TO THE SCRABBLE SIMULATION MODEL
YOU HAVE THE FOLLOWING SEVEN OPTIONS:

    0 END THE SIMULATION
    1 CREATE A FILE FOR THE COMPUTER'S VOCABULARY
    2 INPUT OR DELETE WORDS TO OR FROM THE COMPUTER'S VOCABULARY
    3 LIST THE ENTIRE VOCABULARY
    4 CONVERT A PROGRAM CODE NUMBER INTO A WORD
    5 PLAY A GAME OF SCRABBLE AGAINST THE COMPUTER
    6 GET A SUMMARY REPORT OF THE GAME JUST PLAYED

YOUR SELECTION ? 4

INPUT 0 TO END
GIVE TEST NUMBER ? 893
AFB
GIVE TEST NUMBER ? 0

READY ?
```

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Listing 10: *Selecting option 3 from the main menu (which runs the program in listing 5) gives the user a list of the computer's current vocabulary of two- and three-letter words.*

```
THE CURRENT LIST OF THE COMPUTER'S VOCABULARY FOLLOWS:

___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___
 AA  AD  AE  AH  AI  AM  AN  AR  AS  AT  AX  AY  BA  BE  BY  DE  DO  EH  EL  EM
 EN  ER  EX  FA  GO  HA  HE  HI  HO  ID  IF  IN  IO  IS  IT  JA  JO  KA  LA  LI
 LO  MA  ME  MI  MU  MY  NA  NO  NU  OD  OF  OH  ON  OR  OS  OX  PA  PE  PI  RE
 SI  SO  TI  TO  UP  US  UT  WE  WO  XI  YE ABA ABY ACE ACT ADD ADZ AFT AGA AGE
AGO AHA AID AIL AIM AIN AIR AIT ALA ALB ALE ALL ALP AMA AMI AMU ANA AND ANE ANI
ANT ANY APE APT ARK ARM ART ASH ASK ASP ASS ATE AUK AVA AVE AWA AWL AWN AXE AYE
AYS AZO BAA BAD BAH BAN BAR BAT BAY BED BEE BEL BEN BET BEY BIB BID BIG BIN BIS
BIT BOA BOG BOO BOT BOW BOX BOY BRA BUG BUM BUR BUS BUT BYE CAB CAD CAM CAN CAP
CAR CAT CAY CEE CHI COB COD COG CON COO COP COS COT COX COZ CRY CUB CUD CUE CUR
CUT DAB DAG DAK DAP DAW DAY DEE DEN DEV DEW DEY DIE DIG DIM DIN DIP DOC DOE DOG
DOL DON DOR DRY DUB DUC DUE DUN DUO DUP DYE EAR EAT EAU EBB ECU EDH EEL EFF EFT
EGG EGO EKE ELD ELK ELL EME EMU END EON EPI ERA ERG ERN ERR ETA ETH EWE EYE FAD
FAB FAN FAR FAS FAT FAX FED FEE FEN FET FEU FEW FEY FEZ FIB FID FIE FIG FIN FIR
FIT FIX FIZ FLY FOB FOE FOG FOH FON FOP FOR FOX FOY FRO FRY FUB FUN FUR GAB GAD
GAE GAG GAL GAP GAR GAS GAY GED GEE GEM GET GEY GIB GID GIE GIG GIN GIP GNU GOA
GOB GOD GOO GOT GUN GUT GUY GYP HAD HAE HAG HAJ HAM HAS HAT HAW HAY HEM HER HET
HEW HEX HID HIE HIP HIS HIT HOB HOD HOE HOG HOI HOO HOP HOT HOW HOY HUB HUE HUH
HUM HUT ICE ILK ILL IMP INK ION IRK ISM ITS JAB JAG JAM JAP JAR JAW JAY JEE JET
JEU JEW JIB JIG JOB JOE JOG JOT JOW JOY JUG JUS JUT KAB KAE KAS KAY KEA KEF KEN
KEP KEX KEY KID KIP KIT KOP KOR KOS LAB LAC LAP LAR LAS LAW LAX LAY LEA LED LEE
LET LEU LEV LEX LID LIE LIP LIT LOB LOG LOO LOP LOT LOW LOX LUM LUX MAD MAE MAG
MAN MAP MAR MAS MAT MAW MAY MEL MET MHO MIB MID MIG MIL MIR MIX MOA MOB MOL MOM
MON MOO MOT MOW MUD MUN MUT NAB NAE NAG NAP NAY NEB NET NEW NIB NIL NIP NIT NIX
NOB NOD NOG NOH NOM NOO NOT NOW NTH NUB NUT OAF OAK OAR OAT OBI ODD ODE OFF OHO
OII OIL OKA OLD ONE OOT OPE ORA ORB ORE ORT OSE OUI OUR OUT OVA OWE OWL OWN PAD
PAL PAM PAN PAP PAR PAS PAT PAW PAX PAY PEA PEE PEG PEN PER PET PHI PIE PIG PIN
PIP PIT PIU PIX PLY POD POI POP POT POX PRO PRY PSI PUB PUG PUN PUP PUR PUS PUT
PYE PYX QUA QUO RAD RAG RAJ RAM RAN RAP RAT RAX RAY RED REF REI REM REP REV REX
RIB RIG RIM RIN RIP ROB ROT RUE RUN RUT RYE SAB SAC SAD SAG SAL SAP SAT SAW SAX
SAY SEA SEC SEE SEN SET SEW SEX SIB SIN SIR SIT SIX SKI SKY SOB SOD SOL SON SOP
SOT SOU SOW SOX SOY SPA SPY SUB SUM SUN SUP SYN TAB TAE TAG TAM TAN TAP TAR TAT
TAU TAX TEA TEE TEG TEN THE THO TIC TIE TIL TIN TIP TIT TOD TOE TOM TON TOO TOP
TOR TOT TOW TOY TRY TUB TUG TUN TUP TUX TWA TWO UDO UGH UIT UMP UPS URN VAN VAS
VAT VAU VAV VAW VEE VET VEX VIA VIE VIN VIS VOE VON VOX VUG WAB WAD WAE WAG WAP
WAR WAS WAT WAX WAY WEB WEE WEN WHA WHO WHY WIN WIS WIZ WOE WON WOO WOP WOT WRY
WYE YAK YAM YAP YAW YEA YEN YEP YES YET YEW YIN YIP YOD YON YOU YOW YUK ZAP ZAX
ZED ZEE ZIP ZOA ZOO
THE CURRENT VOCABULARY OF THE COMPUTER IS 725 WORDS

READY ?
```

Listing 11: *Sample game shows the computer going first and spelling the word ZIP, followed by the user spelling SPEARED.*

```
THIS PROGRAM WAS WRITTEN BY              JJR DATA RESEARCH
                                         BOX 74
                                         MIDDLE VILLAGE, NEW YORK 11379

WRITE FOR INFORMATION TO OBTAIN COPIES ON DISKETTE OR FOR TRS 80'S.
OTHER FINE PROGRAMS ARE AVAILABLE
THERE ARE TEN VERSIONS OF THIS GAME WHICH DO THE FOLLOWING:

VER WORDS CHECKED MAX TIME
=== ============= ========
 1      1.00000%  1080 SEC
 2       .50000%   540 SEC
 3       .32813%   360 SEC
 4       .25000%   270 SEC
 5       .18750%   216 SEC
 6       .15625%   180 SEC
 7       .14063%   154 SEC
 8       .12500%   135 SEC
 9       .10938%   120 SEC
10       .09375%   108 SEC


WHAT VERSION (1-10) ? VERSION 1 IS BEST AND 10 WORST ? 1
TYPE 9 IF YOU DON'T WANT NUMBERS ON THE BOARD ? 0
TYPE YES IF YOU WANT TO CONTINUE LAST GAME PLAYED ?
TYPE YES IF YOU WISH TO SET GAME BOARD ?
TYPE YES IF THE COMPUTER GOES FIRST ? YES
WHAT ARE THE COMPUTER'S LETTERS ? IZIQJPU


/  1 /  2 /  3 /  4 /  5 /  6 /  7 /  8 /  9 / 10 / 11 / 12 / 13 / 14 / 15 /
/ 16 / 17 / 18 / 19 / 20 / 21 / 22 / 23 / 24 / 25 / 26 / 27 / 28 / 29 / 30 /
/ 31 / 32 / 33 / 34 / 35 / 36 / 37 / 38 / 39 / 40 / 41 / 42 / 43 / 44 / 45 /
/ 46 / 47 / 48 / 49 / 50 / 51 / 52 / 53 / 54 / 55 / 56 / 57 / 58 / 59 / 60 /
/ 61 / 62 / 63 / 64 / 65 / 66 / 67 / 68 / 69 / 70 / 71 / 72 / 73 / 74 / 75 /
/ 76 / 77 / 78 / 79 / 80 / 81 / 82 / 83 / 84 / 85 / 86 / 87 / 88 / 89 / 90 /
/ 91 / 92 / 93 / 94 / 95 / 96 / 97 / 98 / 99 /100 /101 /102 /103 /104 /105 /
/106 /107 /108 /109 /110 /111    Z    I    P  /115 /116 /117 /118 /119 /120 /
/121 /122 /123 /124 /125 /126 /127 /128 /129 /130 /131 /132 /133 /134 /135 /
/136 /137 /138 /139 /140 /141 /142 /143 /144 /145 /146 /147 /148 /149 /150 /
/151 /152 /153 /154 /155 /156 /157 /158 /159 /160 /161 /162 /163 /164 /165 /
/166 /167 /168 /169 /170 /171 /172 /173 /174 /175 /176 /177 /178 /179 /180 /
/181 /182 /183 /184 /185 /186 /187 /188 /189 /190 /191 /192 /193 /194 /195 /
/196 /197 /198 /199 /200 /201 /202 /203 /204 /205 /206 /207 /208 /209 /210 /
/211 /212 /213 /214 /215 /216 /217 /218 /219 /220 /221 /222 /223 /224 /225 /
WHAT ARE THE COMPUTER'S LETTERS ? IJQUXAE


NEGATIVE TO AND FROM ENDS GAME
0 TO AND FROM ALLOWS THE COMPUTER TO MOVE

THE BOX FROM AND TO OF THE LAST MOVE OR 0,0 FOR MY TURN ? 99,189
WHAT WORD DID YOU SPELL ? SPEARED
```

Listing 12: *The word SPEARED has been added to the Scrabble board. The computer is now ready for the next move.*

```
/  1 /  2 /  3 /  4 /  5 /  6 /  7 /  8 /  9 / 10 / 11 / 12 / 13 / 14 / 15 /
/ 16 / 17 / 18 / 19 / 20 / 21 / 22 / 23 / 24 / 25 / 26 / 27 / 28 / 29 / 30 /
/ 31 / 32 / 33 / 34 / 35 / 36 / 37 / 38 / 39 / 40 / 41 / 42 / 43 / 44 / 45 /
/ 46 / 47 / 48 / 49 / 50 / 51 / 52 / 53 / 54 / 55 / 56 / 57 / 58 / 59 / 60 /
/ 61 / 62 / 63 / 64 / 65 / 66 / 67 / 68 / 69 / 70 / 71 / 72 / 73 / 74 / 75 /
/ 76 / 77 / 78 / 79 / 80 / 81 / 82 / 83 / 84 / 85 / 86 / 87 / 88 / 89 / 90 /
/ 91 / 92 / 93 / 94 / 95 / 96 / 97 / 98    S  /100 /101 /102 /103 /104 /105 /
/106 /107 /108 /109 /110 /111    Z    I    P  /115 /116 /117 /118 /119 /120 /
/121 /122 /123 /124 /125 /126 /127 /128    E  /130 /131 /132 /133 /134 /135 /
/136 /137 /138 /139 /140 /141 /142 /143    A  /145 /146 /147 /148 /149 /150 /
/151 /152 /153 /154 /155 /156 /157 /158    R  /160 /161 /162 /163 /164 /165 /
/166 /167 /168 /169 /170 /171 /172 /173    E  /175 /176 /177 /178 /179 /180 /
/181 /182 /183 /184 /185 /186 /187 /188    D  /190 /191 /192 /193 /194 /195 /
/196 /197 /198 /199 /200 /201 /202 /203 /204 /205 /206 /207 /208 /209 /210 /
/211 /212 /213 /214 /215 /216 /217 /218 /219 /220 /221 /222 /223 /224 /225 /


NEGATIVE TO AND FROM ENDS GAME
0 TO AND FROM ALLOWS THE COMPUTER TO MOVE

THE BOX FROM AND TO OF THE LAST MOVE OR 0,0 FOR MY TURN ?
```

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Listing 13: *Summary of a completed Scrabble game played at level 1.*

```
6

MOVE BOX LETTERS TIME
==== === ======= ====
   1 112 ZIP****    43
   2  99 SPEARED     0
   3 189 DRIVING     0
   4 154 FACTOR*     0
   5 169 IX*****   525
   6  25 TOMATO*     0
   7 166 YOGI***     0
   8  23 LITTLE*     0
   9 137 QU*****   775
  10  52 BROMIDE     0
  11 118 BASEHIT     0
  12 126 LOCKOUT     0
  13 143 HJ*****  1160
  14  52 BAR****     0
  15  76 GRINDER     0
  16  17 MODERN*     0
  17 210 YP*****  1426
  18  59 SEEN***     0
  19 213 SEAT***     0
  20  90 RAILS**     0

TIME OF 1 MADE BY HUMAN PLAYER.
TIMED MOVES WERE MADE BY COMPUTER

READY ?
```

Listing 14: *Summary of a completed Scrabble game played at level 6. The computer's final move of the game shown in listing 13 took 23 minutes and 46 seconds. At level 6, the average move took the computer less than 60 seconds.*

```
MOVE BOX LETTERS TIME
==== === ======= ====
   1 112 ZIP****    42
   2  99 SPEARED     0
   3 189 DRIVING     0
   4 154 FACTOR*     0
   5 165 JA*****    81
   6  25 TOMATO*     0
   7 136 YOGI***     0
   8  23 LITTLE*     0
   9 172 IE*****    66
  10  52 BROMIDE     0
  11 118 BASEHIT     0
  12 122 LOCKOUT     0
  13 176 FX*****    61
  14  52 BAR****     0
  15  76 GRINDER     0
  16  17 MODERN*     0
  17 131 QU*****    59
  18  59 SEEN***     0
  19  88 SEA****     0
  20 212 TAIL***     0
  21 185 AI*****    51
  22  32 ONLY***     0

TIME OF 1 MADE BY HUMAN PLAYER.
TIMED MOVES WERE MADE BY COMPUTER

READY ?
```

Listing 15: *Final board layout resulting from the sample game given in listing 13. Selecting the system option that displays the letters without the square numbers makes this display easier to read.*

```
TYPE 9 IF YOU DON'T WANT NUMBERS ON THE BOARD ? 9
TYPE YES IF YOU WANT TO CONTINUE LAST GAME PLAYED ? YES


/   /   /   /   /   /   /   /   /   /   /   /   /   /   /   /
/     M /   /   /   /   /     L   I   T   T   L   E /   /   /
/     O /   /   /   /   /   /   /     O /   /   /   /   /   /
/     D /   /   /   /     B   R   O   M   I   D   E   S /   /
/     E /   /   /   /     A /   /     A /   /   /     E /   /
  G   R   I   N   D   E   R /   /     T /   /   /     E   R /
/     N /   /   /   /   /   /     S   O /   /   /     N   A /
/   /   /   /   /   /     Z   I   P /   /   /     B /     I /
/   /   /   /   /     L /   /     E /   /   /     A /     L /
/     Q /   /   /     O /     H   A   J /   /     S /     S /
/     U /     F   A   C   T   O   R /   /   /     E /   /   /
  Y   O   G   I /     K /   /     E /   /   /     H /   /   /
/   /   /     X /     O /   /     D   R   I   V   I   N   G /
/   /   /   /   /     U /   /   /   /   /   /     T /     Y /
/   /     S   E   A   T /   /   /   /   /   /   /   /     P /
TYPE YES IF THE COMPUTER GOES FIRST ?
WHAT ARE THE COMPUTER'S LETTERS ?


NEGATIVE TO AND FROM ENDS GAME
0 TO AND FROM ALLOWS THE COMPUTER TO MOVE

THE BOX FROM AND TO OF THE LAST MOVE OR 0,0 FOR MY TURN ? -2,-3

THANK YOU FOR THE GAME
FREE MEMORY EQUALS 1140

READY ?
```

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Listing 16: *The Scrabble system has provisions for presetting a game board.*

```
TYPE 9 IF YOU DON'T WANT NUMBERS ON THE BOARD ? 9
TYPE YES IF YOU WANT TO CONTINUE LAST GAME PLAYED ?
TYPE YES IF YOU WISH TO SET GAME BOARD ? YES
GIVE THE FIFTEEN LETTERS FOR LINE 1
 123456789012345
 ===============
?A
GIVE THE FIFTEEN LETTERS FOR LINE 2
 123456789012345
 ===============
? B
GIVE THE FIFTEEN LETTERS FOR LINE 3
 123456789012345
 ===============
?  C
GIVE THE FIFTEEN LETTERS FOR LINE 4
 123456789012345
 ===============
?   D
GIVE THE FIFTEEN LETTERS FOR LINE 5
 123456789012345
 ===============
?    E
GIVE THE FIFTEEN LETTERS FOR LINE 6
 123456789012345
 ===============
?     F
GIVE THE FIFTEEN LETTERS FOR LINE 7
 123456789012345
 ===============
?      G
GIVE THE FIFTEEN LETTERS FOR LINE 8
 123456789012345
 ===============
?       H
GIVE THE FIFTEEN LETTERS FOR LINE 9
 123456789012345
 ===============
?        I
GIVE THE FIFTEEN LETTERS FOR LINE 10
 123456789012345
 ===============
?         J
GIVE THE FIFTEEN LETTERS FOR LINE 11
 123456789012345
 ===============
?          K
GIVE THE FIFTEEN LETTERS FOR LINE 12
 123456789012345
 ===============
?           L
GIVE THE FIFTEEN LETTERS FOR LINE 13
 123456789012345
 ===============
?            M
GIVE THE FIFTEEN LETTERS FOR LINE 14
 123456789012345
 ===============
?             N
GIVE THE FIFTEEN LETTERS FOR LINE 15
 123456789012345
 ===============
?              O
```

Listing 17 and listing 18 are on pages 348-351

Text continued from page 338:
can easily be corrected by changing the coding into machine language. With the increased speed of a machine-language program, four-letter words could be added. However, your memory requirements would increase due to the additional words and their size. As mentioned earlier, all words are numbers to the computer program. Therefore, the highest-value letter combination currently being evaluated is 19,682 (ie: 26(729 + 27 +1)). This number value can be stored in 8-byte words. Adding a fourth letter would be adding 26 × 19,683, raising the new high value to 531,440, which, of course, would place a greater burden on your memory requirements.

Improved computerized Scrabble will require a faster host computer with more memory capacity (internal and external). This requirement can be met by today's giant computers and, I hope, the microcomputers of the 1980s. ■

The North Star programs and the TRS-80 version of Scrabble are available on disk for $10 from IJR Data, POB 74, Middle Village NY 11379, (516) 643-1931. The TRS-80 disk version also contains a machine-language version.

OUR SECOND GENERATION DP-NET

We at Delta Products have been involved in 'NETWORKING SYSTEMS' for the past eighteen months. During this time we delivered our first net systems to beta test sites. These closely monitored field installations provided invaluable data, which Delta Products has incorporated into the design of our second generation of DP-NET systems.

SECOND GENERATION DP-NET

The S-4500 DP-NET system will support from one to ten users, and provide each with their own Z80 CPU and 64K of ram memory. Each user will also have access to 40 megabytes of hard disk storage, 17.2 megabytes of file managed tape backup, and floppy disk.

S-4500

TRUE RECORD & FILE LOCKOUT

By simply reading in the entire record or file you wish to protect, the DP-NET DISK SELECTIVE LOCKOUT guarantees complete data integrity. The DP-NET also allows the use of today's popular micro applications languages (i.e., Cbasic®, Mbasic®, Cobol®, etc.), without having to compensate for the problems inherant to these languages in the multi-user environment, while maintaining CPM compatibility.

INTERACTIVE FAMILY OF SYSTEMS

The S-4500 is but one of many DP-NET configurations utilizing parallel and/or serial communication links. Delta Products also manufacturers a wide range of conventional single and multi-user systems operating under CP/M and MP/M. Single and multi-user systems can be upgraded to DP-NET's, because their basic components are utilized in our network systems. We have intentionally developed an interactive family of systems that are completely configurable and compatible, never limiting the ability to adapt to a modification in the application. Delta Products systems are available thru a worldwide network of selective distributors and dealers. Call for the name and number of the one nearest to you.

DELTA PRODUCTS

Delta Products
15392 Assembly Lane
Huntington Beach, CA 92649
Telephone (714) 898-1112
TELEX 681 367 DELTMAR HTBH

Cbasic is a registered trademark of Compiler Systems.
Mbasic and Cobol are registered trademarks of Microsoft.
CP/M and MP/M are registered trademarks of Digital Research.

Listing 17: *When the Scrabble system cannot find a legal move, it requests a new set of letter "tiles" from the user.*

```
TYPE YES IF THE COMPUTER GOES FIRST ?
WHAT ARE THE COMPUTER'S LETTERS ? GGGGGGG


NEGATIVE TO AND FROM ENDS GAME
O TO AND FROM ALLOWS THE COMPUTER TO MOVE

THE BOX FROM AND TO OF THE LAST MOVE OR 0,0 FOR MY TURN ? 0,0
THE COMPUTER IS SORTING IT'S LETTERS

THE COMPUTER CANNOT MOVE.  THEREFORE, IT IS CHANGING ALL OF
ITS LETTERS
WHAT ARE THE COMPUTER'S LETTERS ? AEIOURE


NEGATIVE TO AND FROM ENDS GAME
O TO AND FROM ALLOWS THE COMPUTER TO MOVE

THE BOX FROM AND TO OF THE LAST MOVE OR 0,0 FOR MY TURN ? 194,224
WHAT WORD DID YOU SPELL ? END


 A                                                                            /
         B                                                                    /
                 C                                                            /
                         D                                                    /
                                 E                                            /
                                         F                                    /
                                                 G                            /
                                                         H                    /
                                                                 I            /
                                                                         J    /
                                                                         K    /
                                                                         L    /
                                                                    M    E    /
                                                                         N    /
                                                                         D  O /


NEGATIVE TO AND FROM ENDS GAME
O TO AND FROM ALLOWS THE COMPUTER TO MOVE

THE BOX FROM AND TO OF THE LAST MOVE OR 0,0 FOR MY TURN ? -8,-2

THANK YOU FOR THE GAME
FREE MEMORY EQUALS 755

READY ?
```

Listing 18: *A TRS-80 Level II BASIC version of the program SCRABBLE. This program does not require disk drives or utility programs because the vocabulary is contained in data statements (lines 102-238).*

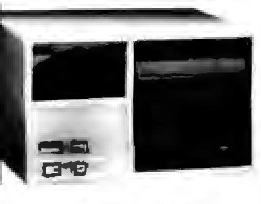
```
10 DEFINT I-N
20 DIM IVOCAB(740),IBOARD(441),ISAV(225),ILV(26),ICON(3,30,3),AT(6,4),AF(6)
25 DIM AM(6,2),AW(6,3),HBOARD(6,225)
27 CLS:INPUT"FAST OR SLOW";Z$:FAST=0:IF Z$="FAST"THENFAST=1
30 FORJ=1TO441:IBOARD(J)=-1:IBOARD([illegible]) [illegible]:NEXT
35 FORJ=44TO358STEP21:FORJ1 0TO12:IBOARD(J+J1)=-1:NEXT
40 FORJ1=1TO170:IBOARD(J+J1)=-1:NEXTJ1,J
50 FORJ=1TO6:FORJ1=1TO4:READ AT(J,J1):NEXTJ1,J
55 DATA  3,-2,-1,1,-2,-1,1,2,-3,1,2,3
57 DATA -63,-42, 21,21,-42,-21,21,42,-21,21,42,63
60 FORJ=1TO6:READAF(J):NEXT
65 DATA 0,12,24,20,14,56
80 FORJ=1TO6:FORJ1 1TO2:READAM(J,J1):NEXTJ1,J
85 DATA -2, 1,-1,1,1,2, 42,-21,-21,21,21,42
90 FORJ=1TO3:FORJ1=1TO3:READAW(J,J1):AW(J+3,J1)=-AW(J,J1):NEXTJ1,J
92 DATA 229,27,1,229,1,27,27,1,229
100 FORI=1TO443:READIVOCAB(I):NEXT:FORJ=444TO740:READ I:IVOCAB(J)=J1+10000:NEXT
102 DATA 28,31,32,35,36,40,41,45,46,47,51,52,56,59,79,113
104 DATA 124,143,147,148,149,153,159,164,204,217,221,225,231
106 DATA 247,249,257,258,262,265,271,285,298,325,333,339,352
108 DATA 356,360,372,376,379,393,399,409,411,413,419,423,424
110 DATA 429,433,437,441,491,522,528,549,[illegible],[illegible],586,587,626,636
112 DATA 657,680,784,808,815,830,841,863,911,919,973,931,946,976
114 DATA 984,985,986,990,992,1054,1055,1058,1065,1067,1081,1089
116 DATA 1101,1108,1111,1112,1114,1127,1142,1166,1181,1226,1228
118 DATA 1235,1250,1253,1258,1261,1274,1307,1324,1320,[illegible]
120 DATA 1362,1364,1382,1409,1424,1446,1486,1489,1493,1499
122 DATA 1503,1505,1510,1597,1598,1605,1607,[illegible],1618,1203
124 DATA 1705,1708,1715,1720,1721,1864,1870,1878,1883,1886
126 DATA 1887,1888,1945,2042,2048,2043,2044,2045,2138,2216
128 DATA 2218,2227,2228,2230,2232,2234,2239,2427,2412,[illegible]
130 DATA 2596,2599,2606,2607,2608,2611,2612,2616,2618,2698
132 DATA 2756,2758,2759,2772,2774,2945,2950,2954,2959,2966
134 DATA 2968,3056,3065,3073,3074,3076,3164,3166,3172,3173
136 DATA 3175,3374,3326,3328,[illegible],3335,3339,[illegible],3405,3406
138 DATA 3488,3497,3498,3499,[illegible],[illegible],[illegible],[illegible],[illegible],[illegible]
140 DATA 3761,3792,3813,3827,[illegible],3849,[illegible],[illegible],[illegible],[illegible]
```

Listing 18 continued on page 350

BETA COMPUTER DEVICES

AVAILABLE NOW ... SYSTEM 2800 FROM SYSTEMS GROUP

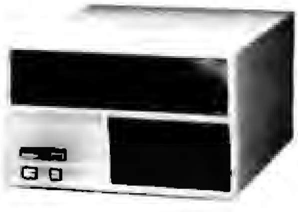
FEATURES



Model 2812/14/24

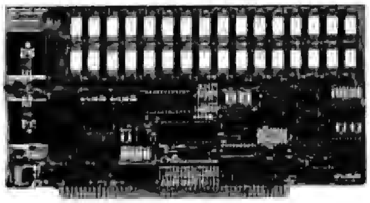
- IEEE S-100 Bus Compatible Systems, Z80A Based
- Two 8-Inch Drives: Single or Double Sided, Double Density Floppy Disk Drives or 10MB Winchester Hard Disk Drive
- 20MB Winchester and Tape Backup
- 8-Slot Shielded and Terminated Motherboard
- System Software Selection includes CP/M*, MP/M* or OASIS**
- Single-User or Multi-User Systems, Expandable to 6 Users
- Table Top or Rack Mountable
- Two Switched AC Outlets on Rear Panel
- One Year Warranty on Entire System

2812 CP/M, 2 Single Sided Floppies	$3775.00
2814 CP/M, 2 Double Sided Floppies	4425.00
2819 CP/M, 1 10 MB Winchester & 1 Double Sided Floppy	6675.00
2824 MP/M, 2 Double Sided Floppies	5235.00
2829 MP/M, 1 10 MB Winchester & 1 Doubled Sided Floppy	7500.00



Model 2819/29

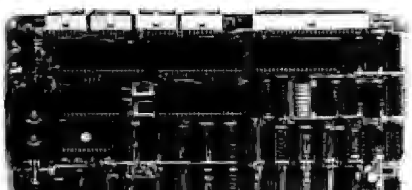
S-100 PRODUCTS



QUALITY RAM FROM SYSTEMS GROUP

- Z-80 4MHZ operation with no wait states
- IEEE compatible timing - 200 NS 4116's
- Factory assembled, tested & burned in

DMB6400 64K (Bank Select, shown)	$ 740.00
DM6400 64K	540.00
DM4800 48K	510.00
DM3200 32K	475.00



CONFIGURE A COMPLETE S-100 SYSTEM WITH 2nd GENERATION* PRODUCTS FROM SYSTEMS GROUP.

- CPC 2810 (shown) Z-80A processor board (4MHZ) with 4 serial & 2 parallel ports....$369.00
- CPC2813 - same as CPC2810 but 2 serial ports only....$345.00
- FDC2801/8 - 8" floppy disk controller board, up to 4 single/double sided drives, single or double density....$349.00
- INO-2804 - 4 channel serial I/O.... 329.00
- CRA-100 - Cromix* adaptor board.. $55.00

CALL US FOR OUR MOST CURRENT PRICES!

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PAPER TIGER PRINTERS

IDS 460G 9x9 Dot Matrix Printer	$890.00
IDS 560G Wide Carriage Printer	1099.00

TERMINALS

ADDS Viewpoint	$569.00
TeleVideo 910	579.00
TeleVideo 912C	679.00
TeleVideo 920C	729.00
TeleVideo 950	929.00

8" DISK DRIVES

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NEC FD1160 (double sided)	589.00

DYNAMIC RAMS

4116 (200ns) .... set of 8	$24.00
4164 (64Kx1)	$18.00

wabash

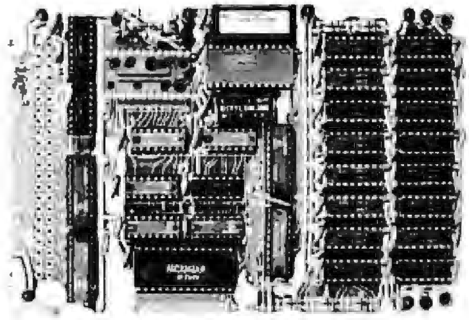
8" or 5¼" flexible diskettes certified 100% error free with manufacturer's 5-year limited warranty on all 8" media. Soft-sectored in boxes of 10. 5¼" available in 10-sector.

(Add $3.00 for plastic library cases)

8" single sided, single density	$27.50
8" single sided, double density	35.50
8" double sided, double density	45.50
5¼" single sided, single density	27.50
5¼" single sided, double density	29.50

6502 PRODUCTS

6502DM



BETA 32K BYTE EXPANDABLE RAM FOR 6502 AND 6800 SYSTEMS

AIM 65 KIM SYM PET S44-BUS

- Plug compatible with the AIM-65/SYM expansion connector by using a right angle connector (supplied).
- Memory board edge connector plugs into the 6800 S44 bus.
- Connects to PET using an adaptor cable.
- Uses +5V only, supplied from the host computer.
- Full documentation. Assembled and tested boards are guaranteed for one full year. Purchase price is fully refundable if board is returned undamaged within 14 days.

Assembled with 32K RAM	$349.00
& Tested with 16K RAM	329.00
Bare board, manual & 6 hard-to-get parts.	99.00
PET interface kit. Connects the 32K RAM board to a 4K or 8K PET	$ 69.00

AIM Professional Enclosure...$175.00

TERMS: Minimum order $15.00. Minimum shipping and handling $3.00. Calif. residents add 6% sales tax. Cash, checks, Mastercard, Visa and purchase orders from qualified firms are accepted. (Please allow two weeks for personal checks to clear before shipment.) Product availability and pricing subject to change without notice.

INTERNATIONAL ORDERS: *Add 15% to purchase price for all orders. Minimum shipping charge is $20.00. Orders with insufficient funds will be delayed. Excess funds will be returned with your order. All prices are U.S. only.*

BETA COMPUTER DEVICES
1230 W. COLLINS AVE.
ORANGE, CA 92668
(714) 633-7280

VISA

Circle 44 on inquiry card.

Listing 18 continued:

```
142 DATA 4001,4017,4027,4064,4086,4132,4138,4145,4149,4186
144 DATA 4193,4271,4325,4405,4408,4415,4419,4420,4431,4425
146 DATA 4513,4514,4523,4529,4530,4532,4534,4535,4619,4621
148 DATA 4622,4624,4631,4635,4637,4641,4643,4723,4781,4784
150 DATA 4786,4787,4793,4795,4797,4803,4804,4875,4885,4943
152 DATA 4955,4959,5132,5134,5135,5137,5142,5146,5148,5149
154 DATA 5155,5242,5243,5251,5258,5263,5348,5350,5351,5353
156 DATA 5160,5162,5502,5509,5510,5512,5523,5528,5684,5690
158 DATA 5695,5794,5863,5864,5866,5869,5872,5878,5879,5882
160 DATA 5884,5900,5985,5987,5990,5991,6079,6080,6091,6094
162 DATA 6095,6239,6241,6242,6244,6246,6252,6253,6257,6260
164 DATA 6262,6401,6404,6407,6412,6419,6647,6896,6897,6928
166 DATA 6950,6980,7058,7087,7120,7319,7324,7330,7333,7335
168 DATA 7340,7342,7430,7445,7446,7448,7535,7540,7697,7700
170 DATA 7702,7715,7718,7720,7864,7876,7877,8048,8051,8065
172 DATA 8071,8155,8160,8168,8170,8178,8179,8266,8278,8282
174 DATA 8440,8442,8443,8777,8778,8791,8793,8794,8798,8799
176 DATA 8800,8804,8807,8808,8903,8904,8905,8907,8995,8996
178 DATA 9007,9011,9155,9160,9168,9169,9173,9176,9177,9328
180 DATA 9339,9508,9509,9511,9518,9520,9522,9523,9524,9527
182 DATA 9529,9624,9632,9708,9722,9724,9727,9738,9744,9883
184 DATA 9884,9894,9895,9896,9897,9902,9905,48,58,64,235,238
186 DATA 240,249,258,343,361,364,451,461,465,469,473,613,615
188 DATA 618,619,624,626,631,634,754,775,793,968,973,980,982
190 DATA 998,1047,1048,1103,1166,1187,1190,1233,1263,1318,1360
192 DATA 1372,1422,1423,1426,1441,1453,1511,1520,1522,1530,1561
194 DATA 1568,1670,1695,1703,1704,1705,1707,1709,1710,1711,1714
196 DATA 1715,1716,1800,1804,1806,1813,1817,1819,1889,1912,1914
198 DATA 1921,1923,1927,1928,1931,2013,2073,2078,2085,2089,2093
200 DATA 2165,2175,2186,2233,2238,2245,2247,2249,2250,2251,2344
202 DATA 2363,2961,2965,2975,3153,3156,3159,3162,3163,3165,3169,3173
204 DATA 3174,3261,3263,3266,3270,3273,3279,3281,3367,3372,3378
206 DATA 3379,3381,3529,3547,3694,3703,3709,3802,3880,3881,3882
208 DATA 3885,3890,3894,3898,3901,3902,3903,3987,3989,3991,4000
210 DATA 4006,4009,4010,4096,4108,4112,4114,4118,4157,4173,4258
212 DATA 4260,4268,4270,4272,4276,4277,4279,4280,4281,4284,4308
214 DATA 4420,4431,4432,4434,4540,4609,4612,4614,4620,4621,4623
216 DATA 4625,4627,4628,4631,4716,4720,4722,4729,4801,4811,4826
218 DATA 4828,4835,4837,4839,4843,4989,4990,4998,4999,5000,5001
220 DATA 5003,5005,5008,5010,5091,5149,5154,5161,5163,5171,5202
222 DATA 5216,5432,5506,5572,5674,5760,5809,6079,6084,6085,6086
224 DATA 6087,6088,6178,6193,6197,6282,6286,6295,6300,6448,6457
226 DATA 6467,6612,6796,6798,6799,6801,6810,6812,6813,6814,6818
228 DATA 6819,6904,6907,6916,6984,6998,7008,7024,7029,7036,7177
230 DATA 7186,7187,7188,7192,7278,7447,8263,8265,8268,8275,8361
232 DATA 8374,8376,8379,8380,8383,8482,8484,8634,8644,8651,8653
234 DATA 8803,8997,9005,9093,9094,9213,9360,9374
236 DATA 9999,9999,9999,9999,9999,9999,9999,9999
238 DATA 9999,9999,9999,9999,9999,9999,9999
300 FORJ=1TO225:READ ISBV(J):NEXT
302 DATA 4,0,0,1,0,0,0,4,0,0,0,1,0,0,4
304 DATA 0,3,0,0,0,2,0,0,0,2,0,0,0,3,0
306 DATA 0,0,3,0,0,0,1,0,1,0,0,0,3,0,0
308 DATA 1,0,0,3,0,0,0,1,0,0,0,3,0,0,1
310 DATA 0,0,0,0,3,0,0,0,0,0,3,0,0,0,0
312 DATA 0,2,0,0,0,2,0,0,0,2,0,0,0,2,0
314 DATA 0,0,1,0,0,0,1,0,1,0,0,0,1,0,0
316 DATA 4,0,0,1,0,0,0,3,0,0,0,1,0,0,4
318 DATA 0,0,1,0,0,0,1,0,1,0,0,0,1,0,0
320 DATA 0,2,0,0,0,2,0,0,0,2,0,0,0,2,0
322 DATA 0,0,0,0,3,0,0,0,0,0,3,0,0,0,0
324 DATA 1,0,0,3,0,0,0,1,0,0,0,3,0,0,1
326 DATA 0,0,3,0,0,0,1,0,1,0,0,0,3,0,0
328 DATA 0,3,0,0,0,2,0,0,0,2,0,0,0,3,0
330 DATA 4,0,0,1,0,0,0,4,0,0,0,1,0,0,4
340 FORJ=1TO26:READ ILV(J):NEXT
342 DATA 1,3,3,2,1,4,2,4,1,8,5,1,3
344 DATA 1,1,3,10,1,1,1,1,4,4,8,4,10
350 CLS:INPUT"HOW MANY K SYSTEM 16,32,48";N
351 N=INT(N/16)-1:IFN<0ORN>2THEN350
352 POKE16421,2:POKE16422,0:POKE16424,127+(N*64)
353 FORV0=32512+(16384*N)TO32584+(16384*N)
354 READN1:IFN1=127THENN1=N1+(64*N)
355 V2=V0:IFV2>32767THENV2=V2-65536
356 POKEV2,N1:NEXT
358 DATA 229,197,245,58,72,127,254,1,40
360 DATA 32,62,1,50,72,127,211,233,219,233
362 DATA 230,248,246,4,50,71,127,211,254
364 DATA 219,233,230,7,33,63,127,6,0,79,9
366 DATA 126,211,233,241,193,225,219,244
368 DATA 203,119,40,250,121,211,235,204
370 DATA 13,32,4,14,10,24,239,201,34,60
372 DATA 85,102,119,170,204,238,0,0
380 GOSUB9000:GOTO400
390 PRINT@878,"ILLEGAL MOVE";:PRINT@942,"                    ";:FORJ=1TO1000:NEXT
400 PRINT@870,"MOVE FROM,TO";:PRINT@942,"                    ";
410 PRINT@942," ";:INPUTJ1,J2:IFPEEK(15423)=191THENGOSUB9000
415 IFJ1=-99THENGOSUB9800
416 IFJ1=-99THEN400
417 IFJ1>=0THEN420
418 PRINT"GAME ENDED FREE MEMORY EQUALS ";MEM:END
420 IFJ1=0THEN500
425 IFJ1>J2THEN400
430 [illegible]:PRINT@878,"WHAT WORD    ";:PRINT@942,"                    ";
440 PRINT@942," ";:INPUT IW$:IFPEEK(15423)=191THENGOSUB9000
450 [illegible]THEN400
452 J3=LEN(IW$):J4=[illegible]:IFJ3<>J4THEN390
454 [illegible]:J5=INT((J-1)/15):J6=J-(15*J5):J7=N+(21*J5)+J6
455 J5=15[illegible](64*J5)+(3*J6)
456 [illegible]:POKEJ5+2,32
458 [illegible]MID$(IW$,J1,1):J5=J5+1:J6=ASC(W$):POKEJ5+1,J6
460 [illegible](J7)=J6-64:NEXT
470 GOTO400
480 [illegible]LEN(IW$):J4=((J3-J1)/15)+1:IFJ3<>J4THEN390
485 GOTO450
490 PRINT@870,"ILLEGAL 7   ";:PRINT@942,"LETTER MAX ";
492 FORJ=1TO1000:NEXT
500 PRINT@870,"7RS LETTERS ";:PRINT@942,"                    ";:PRINT@942," ";:INPUTIW$
510 J=LEN(IW$):IFJ>7THEN490
515 PRINT@[illegible]
520 FORJ1=1TOJ:W$=MID$(IW$,J1,1):L(J1)=ASC(W$)-64:NEXT
535 [illegible]
540 J3=L(J2):J4=L(J2+1):IFILV(J3)>=ILV(J4)THEN550
545 [illegible]:L(J2)=J4
550 [illegible]THEN535
552 IFISTART>0THEN400
553 ISTART=1
555 FORJ1=1TOJ:FORJ2=1TOJ:FORJ3=1TOJ
560 IFJ1=J2ORJ1=J3ORJ2=J3THEN590
565 IW=(729*L(J1))+(L(J2)*27)+L(J3)
567 GOSUB9100:IFIW=0THEN590
570 FORJ4=15826TO15834:POKEJ4,32:NEXT
572 POKE15827,L(J1)+64:POKE15830,L(J2)+64:POKE15833,L(J3)+64
```

Listing 18 continued:

```
574 IBOARD(220)=L(J1):IBOARD(221)=L(J2):IBOARD(222)=L(J3)
575 PRINT@230,TIME$;
576 PRINT@622,"LAST MOVE TRS 80";:PRINT@686,"SPELT  ";CHR$(L(J1)+64);CHR$(L(J2)+64);CHR$(L(J3)+64);
    :GOTO400
590 NEXTJ3,J2,J1:PRINT@878,"TRS 80 WANTS";:PRINT@942,"NEW LETTERS";:FORJ=1TO2500:NEXT:GOTO400
600 IFJ>1THEN700
610 FORI1=67TO361STEP21:FORI2=0TO14:I=I1+I2:IFIBOARD(I)=0THEN690
615 IFIBOARD(I-21)<>0ORIBOARD(I-1)<>0ORIBOARD(I+1)<>0THEN690
620 IFIBOARD(I-20)<>0ORIBOARD(I+20)<>0THEN690
625 IW=(L(1)*27)+IBOARD(I):GOSUB9100:IFIW=0THEN690
630 IBOARD(I-1)=L(1):L9=I-1:GOSUB9700
634 L1=INT((L9-1)/15):L9=L9-(15*L1)
638 J=15358+(3*L9)+(64*L1):POKEJ,L(1)+64:POKEJ+1,32
639 PRINT@238,TIME$;
640 PRINT@622,"LAST MOVE TRS 80";:Z$=CHR$(L(1)+64)+CHR$(IBOARD(I)+64)
642 PRINT@686,"SPELT   ";Z$;:GOTO400
690 NEXTI2,I1:PRINT@622,"TRS 80 DOES NOT  ";:PRINT@686,"MAKE A MOVE";:GOTO400
700 REM CHECK BOARD
705 LO=0
710 FORI1=67TO361STEP21:FORI2=0TO14:I=I1+I2:IFIBOARD(I)=0THEN900
720 IO=(INT((I1-67)/21)*15)+I2+1
730 J3=IBOARD(I)
735 REM CHECK SIX POSSIBLE MOVES
740 FORK=1TO6:IFHBOARD(K,IO)=0THEN875
750 GOSUB9300:IFIW=0THEN875
755 K2=21:IFK>3THENK2=1
760 REM CHECK FOR CONFLICTS
770 FORJ1=1TOJ:FORJ2=1TOJ:IFJ1=J2THEN850
780 IW=(L(J1)*AM(K,1))+(L(J2)*AM(K,2))+(J3*AM(K,3))
790 GOSUB9100:IFIW=0THEN850
800 M2=I+AM(K,1):M4=L(J1):GOSUB9400
810 IFIW=0THEN850
820 M5=K7:M6=K8:M1=M2:M3=M4
830 M2=I+AM(K,2):M4=L(J2):GOSUB9400
840 IFIW=0THEN850
845 M7=K7:M8=K8:GOSUB9600
850 NEXTJ2,J1
855 IFFAST=0THEN875
869 IFLO=0THEN950
875 NEXTK
900 NEXTI2,I1
910 IFLO=0THEN950
920 PRINT@878,"TRS 80 WANTS";:PRINT@942,"NEW LETTERS";:FORJ=1TO2500:NEXT:GOTO400
950 IBOARD(L1)=L3:IBOARD(L2)=L4
952 IFL6>3THENL6=L6-3
954 ON L6 GOTO 955,956,957
955 Z$=CHR$(L3+64)+CHR$(L4+64)+CHR$(L5+64):GOTO958
956 Z$=CHR$(L3+64)+CHR$(L5+64)+CHR$(L4+64):GOTO958
957 Z$=CHR$(L5+64)+CHR$(L3+64)+CHR$(L4+64)
958 PRINT@622,"LAST MOVE TRS 80";:PRINT@686,"SPELT ";Z$;:PRINT@238,TIME$;"    ";
959 PRINT@750,LO;" POINTS";
960 L9=L1:GOSUB9700:L1=INT((L9-1)/15):L9=L9-(15*L1)
962 J=15358+(3*L9)+(64*L1):POKEJ,L3+64:POKEJ+1,32
964 L9=L2:GOSUB9700:L2=INT((L9-1)/15):L9=L9-(15*L2)
966 J=15358+(3*L9)+(64*L2):POKEJ,L4+64:POKEJ+1,32
968 GOTO400
9000 CLS:N=66:FORN1=0TO14:N2=N+(21*N1):N3=15*N1
9020 FORN5=1TO15:N6=IBOARD(N2+N5):IFN6=0THEN9050
9030 N8=(N1*15)+N5:N7=INT(N8/100):N6=N8-(100*N7)
9040 PRINT USING"###";N6;:GOTO9060
9050 PRINT" ";CHR$(64+N6);" ";
9060 NEXT:IFN1=1THENPOKE15424,191
9065 IFN1<14THENPRINT""
9068 NEXT:RETURN
9100 FORN=20TO740STEP20
9105 IFIW=IVOCAB(N)THEN 9250
9110 IFIW<IVOCAB(N)THEN9200
9115 NEXT:GOTO 9275
9200 N=N-19
9205 N1=N+18
9210 FOR N2=NTON1:IFIW=IVOCAB(N2)THEN9250
9220 NEXT:GOTO9275
9250 IW=1:N=66:RETURN
9275 IW=0:N=66:RETURN
9300 REM SEE IF BOARD IS OPEN FOR TYPE OF MOVE
9310 K9=I+KT(K,2):IFIBOARD(K9)<>0THEN9350
9320 K9=I+KT(K,3):IFIBOARD(K9)<>0THEN9350
9325 K9=I+KT(K,1):IFIBOARD(K9)<>0THEN9350
9330 K9=I+KT(K,4):IFIBOARD(K9)<>0THEN9350
9340 IW=1:RETURN
9350 IW=0:HBOARD(K,IO)=1:RETURN
9400 REM CHECK CROSS WORDS
9405 K3=M2-K2-K2-K2:K4=M2+K2+K2+K2:K6=-1:K7=0
9410 FORK5=K3TOK4STEPK2:K6=K6+1:IFIBOARD(K5)<>0ANDK5<>M2THEN9412
9412 IFIBOARD(K5)=0ANDK5<>M2THEN9440
9414 GOTO9420
9415 K7=0:GOTO9430
9420 K7=K7+(2[K6)
9430 NEXT
9440 FORK5=1TO6:IFK7=KF(K5)THEN9460
9450 NEXT:HBOARD(K,IO)=1:IW=0:RETURN
9460 ON K5 GOTO 9470,9480,9510,9540,9560,9580
9470 K7=0:K8=0:IW=1:RETURN
9480 K7=IBOARD(M2-K2):IW=(27*K7)+M4:GOSUB9100
9490 K8=0:RETURN
9510 K7=IBOARD(M2+K2):IW=K7+(27*M4):GOSUB9100
9520 K8=0:RETURN
9540 K7=IBOARD(M2-K2):K8=IBOARD(M2+K2):IW=(729*K7)+(27*M4)+K8
9550 GOSUB9100:RETURN
9560 K7=IBOARD(M2-K2-K2):K8=IBOARD(M2-K2)
9570 IW=(729*K7)+(27*K8)+M4:GOSUB9100:RETURN
9580 K7=IBOARD(M2+K2):K8=IBOARD(M2+K2+K2)
9590 IW=(729*M4)+(27*K7)+K8:GOSUB9100:RETURN
9600 L9=M1:GOSUB9700:M1=L9:M4=1:GOSUB9750:M1=M2:M3=M4
9610 L9=M2:GOSUB9700:M2=L9:M4=1:GOSUB9750:M1=ILV(M3)*M1:M2=ILV(M4)*M2
9620 LM=0:IFM5+M6=0THEN9640
9630 LM=(ILV(M5)+ILV(M6)+M1)*M3
9640 IFM7+M8=0THEN9660
9650 LM=LM+((ILV(M7)+ILV(M8))+M2)*M4
9660 LM=LM+((ILV(J3)+M1+M2)*(M3*M4))
9680 IFLM<LOTHEN9690
9685 RETURN
9690 LO=LM:L5=J3:L6=K:L1=M1:L2=M2:L3=M3:L4=M4:RETURN
9700 L9=L9-44:L8=INT(L9/21):L9=L9-(L8*21):L9=(15*L8)+L9-2
9710 RETURN
9750 L9=ISDV(L9):IFL9=0THENRETURN
9760 ON L9 GOTO 9762,9764,9766,9768
9762 M3=2:RETURN
9764 M3=3:RETURN
9766 M4=2:RETURN
9768 M4=3:RETURN
9800 FORL1=0TO14:L4=64*L1:FORL2=0TO63:LPRINTCHR$(PEEK(L3+L4+L2));
9810 NEXT:LPRINT" ":NEXT:RETURN
```

Generating Programs Automatically

Let Your Apple II Do the Programming

Jacob R Jacobs
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Wouldn't it be great if your computer could write programs? Or if it could write those portions of your programs that you find most tedious? With the three utility programs described in this article, you simply answer a few questions interactively, and the computer automatically generates the Applesoft BASIC program for you.

The three programs are written in Applesoft BASIC, but they can be easily modified to run in, and generate programs for, another version of BASIC. The utility programs generate BASIC programs for these three sections:

- Data entry section: the area where repetitive prompting, input, and range checking are performed.
- Data output section: the part of your program that requires a careful determination of the tabs for printing headings and for printing the data in columns where the first or last character or decimal point lines up.
- Instruction section: most programs begin with instructions on how to use them, or provide some introductory text. You must be careful that the text doesn't wrap on the screen in the middle of words. It is also time consuming to center headings.

To create a program using these utilities, simply run the utility program and answer the questions. When you are finished, the utility will generate a BASIC program and store it in a text file. To use the text file, just EXEC it into your program.

Listing 1a shows a sample dialog for the input program. Assume that you want to enter a product name, price, and quantity, and then print out a formatted invoice that shows quantity, product name, price, extended price, and total. These utilities will help you write the program, but they won't do the entire job. You must fill in the middle, and modify the automatically generated programs where necessary.

First, run the CREATE INPUT program. After it has finished, a BASIC program will be generated and displayed on the screen. You will be asked if you want to save this program on the disk, and if so, under what name. Listing 1b shows the program that results from this dialog.

You are also asked to indicate the number of variables you are using, in this case three: ITEM$, PR, and QN. You are then asked to provide the dimensions of the arrays that these variables will require. In this example we will have not more than 20 items on an invoice. Note that you are asked if you want range checks for numeric data only, not for string data such as ITEM$.

Listing 1: *Products of the CREATE INPUT program. Listing 1a shows the sample dialog (the user's inputs are indicated in lowercase), while listing 1b shows the program generated in response to CREATE INPUT's queries.*

1a

```
HOW MANY VARIABLES? 3

DIMENSION OF ARRAYS? 20

NAME OF VARIABLE 1 ($ FOR STRING)

?item$

PROMPT LINE FOR ITEM:

?enter product description

NAME OF VARIABLE 2 ($ FOR STRING)

?pr

PROMPT LINE FOR PR:

?unit price

DO YOU WANT A RANGE CHECK (Y/N)? y

MINIMUM ACCEPTABLE VALUE? 0

MAXIMUM ACCEPTABLE VALUE? 10000

NAME OF VARIABLE 3 ($ FOR STRING)

?qn

PROMPT LINE FOR QN:

?quantity

DO YOU WANT A RANGE CHECK (Y/N)? y

MINIMUM ACCEPTABLE VALUE? 1

MAXIMUM ACCEPTABLE VALUE? 144

VAR. INDEX FOR TERMINATION? 1

WHAT IS THE TERMINATING VALUE? end

STARTING PROGRAM LINE? 1000

INCREMENT FOR PROGRAM? 10
```

1b

```
1000 DIM ITEM$(20),PR(20),QN(20)
1010 I=1
1020 PRINT "ENTRY ";I
1030 INPUT "ENTER PRODUCT DESCRIPTION
     ";ITEM$(I)
1040 IF ITEM$(I)="END" GOTO 1100
1050 INPUT "UNIT PRICE ";PR(I)
1060 IF PR(I)<0 OR PR(I)>10000 GOTO 10
     50
1070 INPUT "QUANTITY ";QN(I)
1080 IF QN(I)<1 OR QN(I)>144 GOTO 1070
1090 I=I+1
   : GOTO 1020
```

Listing 2: *Sample dialog from the CREATE OUTPUT program.*

```
HOW MANY VARIABLES?  4
NAME OF VARIABLE 1 ($ FOR STRING)
? QN
WIDTH OF FIELD?  4
DECIMAL DIGITS?  0
HEADING 1?  QUAN
HEADING 2?
HEADING 3?  ----
NAME OF VARIABLE 2 ($ FOR STRING)
? ITEM$
WIDTH OF FIELD?  12
HEADING 1?  PRODUCT
HEADING 2?  DESCRIPTION
HEADING 3?  -----------
NAME OF VARIABLE 3 ($ FOR STRING)
? PR
WIDTH OF FIELD?  8
DECIMAL DIGITS?  2
HEADING 1?  UNIT
HEADING 2?  PRICE
HEADING 3?  -----
NAME OF VARIABLE 4 ($ FOR STRING)
? EP
WIDTH OF FIELD?  10
DECIMAL DIGITS?  2
HEADING 1?  EXTENDED
HEADING 2?  PRICE
HEADING 3?  --------
STARTING PROGRAM LINE?  3000
INCREMENT FOR PROGRAM?  10
SPACE BETWEEN COLUMNS?  1
```

Listing 3: *Sample dialog from the CREATE INSTR program.*

```
APPROXIMATELY HOW MANY LINES?  20
TYPE 'CONTROL-Q' TO QUIT
ANSWER QUESTIONS WITH 'Y' OR 'N'

TYPE LINE 1
           INVOICE PROGRAM
TYPE LINE 2

TYPE LINE 3
THIS PROGRAM WILL PRINT AN INVOICE OR
TYPE LINE 4
PURCHASE ORDER FOR UP TO 20 ITEMS.
TYPE LINE 5
WHEN PROMPTED TYPE PRODUCT DESCRIPTION,
TYPE LINE 6
UNIT PRICE AND QUANTITY.  TYPE 'END'
TYPE LINE 7
FOR PRODUCT DESCRIPTION WHEN DONE.
TYPE LINE 8


           INVOICE PROGRAM

THIS PROGRAM WILL PRINT AN INVOICE OR
PURCHASE ORDER FOR UP TO 20 ITEMS.
WHEN PROMPTED TYPE PRODUCT DESCRIPTION,
UNIT PRICE AND QUANTITY.  TYPE 'END'
FOR PRODUCT DESCRIPTION WHEN DONE.

DO YOU WANT TO CHANGE A LINE?  Y
WHAT LINE?  1
           INVOICE PROGRAM

IS THIS THE RIGHT LINE?  Y
TYPE LINE 1
           INVOICE PROGRAM

           INVOICE PROGRAM

THIS PROGRAM WILL PRINT AN INVOICE OR
PURCHASE ORDER FOR UP TO 20 ITEMS.
WHEN PROMPTED TYPE PRODUCT DESCRIPTION,
UNIT PRICE AND QUANTITY.  TYPE 'END'
FOR PRODUCT DESCRIPTION WHEN DONE.

DO YOU WANT TO CHANGE A LINE?  N
STARTING PROGRAM LINE?  10
INCREMENT FOR PROGRAM?  10
10?TAB(13);"INVOICE PROGRAM"
20?
30?"THIS PROGRAM WILL PRINT AN INVOICE OR"
40?"PURCHASE ORDER FOR UP TO 20 ITEMS."
50?"WHEN PROMPTED TYPE PRODUCT DESCRIPTION,"
60?"UNIT PRICE AND QUANTITY.  TYPE 'END'"
70?"FOR PRODUCT DESCRIPTION WHEN DONE."
```

Listing 4: *The completed invoice recording program. Lines 5, 1100, 2000 through 2040, and 4000 through 4040, were added by the programmer. Lines 2500 through 2530 were generated by CREATE INSTR, as were lines 10 through 70 and line 4050. All other lines were generated automatically.*

```
    5 HOME
   10 PRINT TAB(13);"INVOICE PROGRAM"
   20 PRINT
   30 PRINT "THIS PROGRAM WILL PRINT AN
       INVOICE OR"
   40 PRINT "PURCHASE ORDER FOR UP TO 2
      0 ITEMS."
   50 PRINT "WHEN PROMPTED TYPE PRODUCT
       DESCRIPTION,"
   60 PRINT "UNIT PRICE AND QUANTITY.
      TYPE 'END'"
   70 PRINT "FOR PRODUCT DESCRIPTION WH
      EN DONE."
   80 PRINT
 1000 DIM ITEM$(20),PR(20),QN(20)
 1010 I=1
 1020 PRINT "ENTRY ";I
 1030 INPUT "ENTER PRODUCT DESCRIPTION
      ";ITEM$(I)
 1040 IF ITEM$(I)="END" GOTO 1100
 1050 INPUT "UNIT PRICE ";PR(I)
 1060 IF PR(I)<0 OR PR(I)>10000 GOTO 10
      50
 1070 INPUT "QUANTITY ";QN(I)
 1080 IF QN(I)<1 OR QN(I)>144 GOTO 1070
 1090 I=I+1
    : GOTO 1020
 1100 M=I-1
 2000 TT=0
 2010 FOR N=1 TO M
 2020 EP(N)=QN(N)*PR(N)
 2030 TT=TT+EP(N)
 2040 NEXT N
 2500 PRINT TAB(4);"INVOICE FOR"
 2510 PRINT TAB(14);"ACME COMPANY"
 2520 PRINT TAB(14);"1234 MAIN STREET"
 2530 PRINT TAB(14);"ANYWHERE, USA"
 3000 PRINT
 3010 PRINT TAB(2);"QUAN";
 3020 PRINT TAB(9);"PRODUCT";
 3030 PRINT TAB(22);"UNIT";
 3040 PRINT TAB(30);"EXTENDED";
 3050 PRINT
 3060 PRINT TAB(4);"";
 3070 PRINT TAB(7);"DESCRIPTION";
 3080 PRINT TAB(21);"PRICE";
 3090 PRINT TAB(31);"PRICE";
 3100 PRINT
 3110 PRINT TAB(2);"-----";
 3120 PRINT TAB(7);"------------";
 3130 PRINT TAB(21);"------";
 3140 PRINT TAB(30);"---------";
 3150 PRINT
 3160 FOR I=1 TO M
 3170 A=QN(I)
 3180 W%=4
    : D%=0
 3190 GOSUB 60000
 3200 PRINT TAB(6-LEN(A$));A$;
 3210 A$=ITEM$(I)
 3220 PRINT TAB(19-LEN(A$));A$;
 3230 A=PR(I)
 3240 W%=8
    : D%=2
 3250 GOSUB 60000
 3260 PRINT TAB(28-LEN(A$));A$;
 3270 A=EP(I)
 3280 W%=10
    : D%=2
 3290 GOSUB 60000
 3300 PRINT TAB(39-LEN(A$));A$;
 3310 PRINT
 3320 NEXT I
 4000 A=TT
 4010 GOSUB 60000
 4020 PRINT
 4030 PRINT "  TOTAL";TAB(39-LEN(A$));A
      $
 4040 PRINT
 4050 PRINT "PLEASE REMIT WITHIN 30 DAY
      S.  THANK YOU"
 5000 END
60000 A=INT(A*10^D%+.5)/(10^D%)
60010 A$=STR$(A)
60020 RETURN
```

In order to terminate the data-entry loop, you are asked to give the index of the variable on which to terminate. In this case you answer 1 (ie: the first variable, ITEM$). The terminating value is END, since you have no item called END. Finally, you are asked for the starting program line and increment. Since you will be pulling these program segments from text files by using the EXEC feature, you must be sure that the program ranges do not overlap.

You must write the substance of the program yourself. In line 1040 there is a GOTO target that does not exist. This will be the first line of your own program. It will set M=I−1; M now contains the number of items in the invoice. Here is the program you might add:

```
2000 TT =0
2010 FOR N = 1 to M
2020 EP(N) = QN(N)*PR(N)
2030 TT = TT + EP(N)
2040 NEXT N
```

TT is the running total. Next you run the CREATE OUTPUT program. This program calls a small subroutine, which is to be located at line 60000:

```
60000 A=INT(A*10^D%+.5)/(10^D%)
60010 A$=STR$(A)
60020 RETURN
```

This subroutine converts the numeric variable A to a string variable A$. W% and D% are the width and number of decimal places, respectively. W% is not used in this version of the subroutine.

The CREATE OUTPUT program asks for the names of the variables you are using. In this case, you would answer: QN, ITEM$, PR, EP, since you want the data printed in a different order than it was input. You are asked to provide three lines of heading for each column. The heading widths cannot be larger than those specified in the WIDTH OF FIELD? question. The complete dialog is shown in listing 2. Note that you can also specify the space between columns.

The last program creates screens full of instructions for you. It is a simple-minded text editor that generates print statements with the proper tabs. After you type in the text (without the line numbers and *PRINT* symbol), you have a chance to change any lines that need correction. Since lines are not numbered, you have to guess which line number is in error. The program confirms the line by printing it before you are asked to replace it. No line or character insertions or deletions are permitted, but you can always edit the completed BASIC program by adding or deleting lines.

Listing 3 shows the dialog for creating the instructions for your invoice program. Listing 4 shows the completed program, including the subroutine at 60000. Lines 4000 through 4040 had to be added to print the total. Listing 5 is a sample run of the invoice program. The CREATE INSTRUCTIONS program has also been used to create the company heading (ACME COMPANY) on the invoice. Only some of the line numbers of the generated program had to be changed. The example in listing 3 does not show the creation of the invoice heading.

All of the programs work in essentially the same way. The variable PLC (Program Location Counter, a term borrowed from assemblers) is used to keep track of the statement number assigned to each created program step. In the INPUT and OUTPUT programs, each line is placed in the variable L$(J), where J is the Jth line. Let's decompose statement 360 in the CREATE INPUT program.

Text continued on page 362

BYTE

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Listing 5: *Sample run of the invoice program of listing 4.*

```
                INVOICE PROGRAM

 THIS PROGRAM WILL PRINT AN INVOICE OR
 PURCHASE ORDER FOR UP TO 20 ITEMS.
 WHEN PROMPTED TYPE PRODUCT DESCRIPTION,
 UNIT PRICE AND QUANTITY.  TYPE 'END'
 FOR PRODUCT DESCRIPTION WHEN DONE.

 ENTRY 1
 ENTER PRODUCT DESCRIPTION  DOG
 UNIT PRICE  19.95
 QUANTITY  5
 ENTRY 2
 ENTER PRODUCT DESCRIPTION  CAT
 UNIT PRICE  12.95
 QUANTITY  1
 ENTRY 3
 ENTER PRODUCT DESCRIPTION  ELEPHANT
 UNIT PRICE  999.75
 QUANTITY  3
 ENTRY 4
 ENTER PRODUCT DESCRIPTION  END




    INVOICE FOR
             ACME COMPANY
             1234 MAIN STREET
             ANYWHERE, USA

  QUAN   PRODUCT       UNIT    EXTENDED
       DESCRIPTION    PRICE     PRICE
  ---- -----------    -----    --------
     5          DOG    19.95      99.75
     1          CAT    12.95      12.95
     3     ELEPHANT   999.75    2999.25

   TOTAL                        3111.95

 PLEASE REMIT WITHIN 30 DAYS.  THANK YOU
```

Listing 6: *The program-generating utilities, CREATE INPUT, CREATE OUTPUT, and CREATE INSTR.*

CREATE INPUT

```
 10 INPUT "HOW MANY VARIABLES? ";N
 20 INPUT "DIMENSION OF ARRAYS? ";M
 30 FOR I=1 TO N
  : MODE(I)=0
  : NEXT
 40 FOR I=1 TO N
 50 PRINT "NAME OF VARIABLE ";I;" ($ FOR STRING)"
 60 INPUT V$(I)
 70 IF RIGHT$(V$(I),1)="$" THEN MODE(I)=3
 80 PRINT "PROMPT LINE FOR ";V$(I);": "
 90 INPUT P$(I)
100 IF MODE(I)=3 GOTO 160
110 INPUT "DO YOU WANT A RANGE CHECK (Y/N)? ";Z$
120 IF Z$<>"Y" THEN MODE(I)=1
  : GOTO 160
130 INPUT "MINIMUM ACCEPTABLE VALUE? ";LV$(I)
140 INPUT "MAXIMUM ACCEPTABLE VALUE? ";HV$(I)
150 MODE(I)=2
160 NEXT I
170 INPUT "VAR. INDEX FOR TERMINATION? ";T
180 INPUT "WHAT IS THE TERMINATING VALUE? ";TV$
190 INPUT "STARTING PROGRAM LINE? ";FR
200 INPUT "INCREMENT FOR PROGRAM? ";INC
210 DIM L$(5+3*N)
220 PLC=FR
  : J=1
230 L$(J)=STR$(PLC)+" DIM "
240 FOR I=1 TO N
```

Listing 6 continued on page 358

BOY, IS THIS COSTING YOU.

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Ashton-Tate

Listing 6 continued:

```
250 L$(J)=L$(J)+V$(I)+"("+STR$(M)+"),"
260 NEXT I
270 L$(J)=LEFT$(L$(J),LEN(L$(J))-1)
280 GOSUB 620
290 L$(J)=STR$(PLC)+" I=1"
300 GOSUB 620
310 LOOP=PLC
320 L$(J)=STR$(PLC)+" ?"+CHR$(34)+"ENTRY "+CHR$(34)+"; I"
330 GOSUB 620
340 FOR I=1 TO N
350 ER=PLC
360 L$(J)=STR$(PLC)+" INPUT "+CHR$(34)+P$(I)+" "+CHR$(34)+"; "+V$(I)+"(I)"
370 GOSUB 620
380 IF I<>T GOTO 440
390 DN=J
400 Q$=""
410 IF MODE(I)=3 THEN Q$=CHR$(34)
420 L$(J)=STR$(PLC)+" IF "+V$(I)+"(I)="+Q$+TV$+Q$+" GOTO "
430 GOSUB 620
440 IF MODE(I)<>2 GOTO 470
450 L$(J)=STR$(PLC)+" IF "+V$(I)+"(I)<"+LV$(I)+" OR "+V$(I)+"(I)>"+HV$(I)+" G
    OTO "+STR$(ER)
460 GOSUB 620
470 NEXT I
480 L$(J)=STR$(PLC)+" I=I+1:GOTO "+STR$(LOOP)
490 GOSUB 620
500 L$(DN)=L$(DN)+STR$(PLC)
510 PRINT
  : PRINT
520 FOR K=1 TO J
  : PRINT L$(K)
  : NEXT
530 INPUT "DO YOU WANT TO SAVE ON DISK?";Z$
540 IF Z$<>"Y" THEN END
550 INPUT "TEXT FILE NAME? ";F$
560 D$=CHR$(4)
570 PRINT D$;"OPEN";F$
580 PRINT D$;"WRITE";F$
590 FOR K=1 TO J
  : PRINT L$(K)
  : NEXT K
600 PRINT D$;"CLOSE";F$
610 END
620 PLC=PLC+INC
  : J=J+1
  : RETURN
```

CREATE OUTPUT

```
 10 INPUT "HOW MANY VARIABLES? ";N
 20 FOR I=1 TO N
  : MODE(I)=0
  : NEXT
 30 FOR I=1 TO N
 40 PRINT "NAME OF VARIABLE ";I;" ($ FOR STRING)"
 50 INPUT V$(I)
 60 IF RIGHT$(V$(I),1)="$" THEN MODE(I)=3
 70 INPUT "WIDTH OF FIELD? ";W%(I)
 80 IF MODE(I)=3 THEN 100
 90 INPUT "DECIMAL DIGITS? ";D%(I)
100 INPUT "HEADING 1? ";P1$(I)
110 IF LEN(P1$(I))>W%(I) GOTO 100
120 INPUT "HEADING 2? ";P2$(I)
130 IF LEN(P2$(I))>W%(I) GOTO 120
140 INPUT "HEADING 3? ";P3$(I)
150 IF LEN(P3$(I))>W%(I) GOTO 140
160 NEXT I
170 INPUT "STARTING PROGRAM LINE? ";FR
180 INPUT "INCREMENT FOR PROGRAM? ";INC
190 INPUT "SPACE BETWEEN COLUMNS? ";SP
200 DIM L$(100)
210 PLC=FR
  : J=1
220 L$(J)=STR$(PLC)+" ?"
230 GOSUB 2120
240 T=0
```

Listing 6 continued on page 360

Listing 6 continued:

```
250 FOR I=1 TO N
260 T=T+W%(I-1)+SP
270 L$(J)=STR$(PLC)+" ? TAB("+STR$(INT(T+(W%(I)-LEN(P1$(I)))/2+1))+");"+CHR$(
    34)+P1$(I)+CHR$(34)+";"
280 GOSUB 2120
290 NEXT I
300 L$(J)=STR$(PLC)+" ?"
310 GOSUB 2120
320 T=0
330 FOR I=1 TO N
340 T=T+W%(I-1)+SP
350 L$(J)=STR$(PLC)+" ? TAB("+STR$(INT(T+(W%(I)-LEN(P2$(I)))/2+1))+");"+CHR$(
    34)+P2$(I)+CHR$(34)+";"
360 GOSUB 2120
370 NEXT I
380 L$(J)=STR$(PLC)+" ?"
390 GOSUB 2120
400 T=0
410 FOR I=1 TO N
420 T=T+W%(I-1)+SP
430 L$(J)=STR$(PLC)+" ? TAB("+STR$(INT(T+(W%(I)-LEN(P3$(I)))/2+1))+");"+CHR$(
    34)+P3$(I)+CHR$(34)+";"
440 GOSUB 2120
450 NEXT I
460 L$(J)=STR$(PLC)+" ?"
470 GOSUB 2120
480 L$(J)=STR$(PLC)+" FOR I = 1 TO M"
490 GOSUB 2120
495 T=0
500 FOR I=1 TO N
510 IF MODE(I)=3 THEN L$(J)=STR$(PLC)+" A$="+V$(I)+"(I)"
  : GOSUB 2120
  : GOTO 585
520 L$(J)=STR$(PLC)+" A="+V$(I)+"(I)"
525 GOSUB 2120
550 L$(J)=STR$(PLC)+" W%="+STR$(W%(I))+": D%="+STR$(D%(I))
560 GOSUB 2120
570 L$(J)=STR$(PLC)+" GOSUB 60000"
580 GOSUB 2120
585 T=T+W%(I-1)+SP
590 L$(J)=STR$(PLC)+" ? TAB("+STR$(INT(T+W%(I)+1))+"-LEN(A$)); A$;"
595 GOSUB 2120
600 NEXT I
620 L$(J)=STR$(PLC)+" ?"
630 GOSUB 2120
640 L$(J)=STR$(PLC)+" NEXT I"
650 GOSUB 2120
2010 PRINT
   : PRINT
2020 FOR K=1 TO J
   : PRINT L$(K)
   : NEXT
2030 INPUT "DO YOU WANT TO SAVE ON DISK?";Z$
2040 IF Z$<>"Y" THEN END
2050 INPUT "TEXT FILE NAME? ";F$
2060 D$=CHR$(4)
2070 PRINT D$;"OPEN";F$
2080 PRINT D$;"WRITE";F$
2090 FOR K=1 TO J
   : PRINT L$(K)
   : NEXT K
2100 PRINT D$;"CLOSE";F$
2110 END
2120 PLC=PLC+INC
   : J=J+1
   : RETURN
```

CREATE INSTR

```
10 HOME
20 INPUT "APPROXIMATELY HOW MANY LINES? ";I
30 DIM S$(INT(I*1.5))
40 D$=CHR$(4)
50 EQ$=CHR$(34)
60 CR$=CHR$(13)
70 BS$=CHR$(8)
80 QQ$=CHR$(17)
```

Listing 6 continued on page 362

NEWDOS/80 Version 2.0 The Support Keeps Coming.

Apparat's newest disk operating system for the TRS-80®, NEWDOS/80 Version 2.0, has added many new enhancements and features to make your Model I or III computer more powerful. We've kept one thing the same. Our support.

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- Enhanced compatability between Model I and III
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- Can display basic listings page by page
- Automatic repeat function key
- Routing for peripheral handling
- Enhanced disassembler
- Command chaining
- Superzap to scan files
- Fast sort function in basic

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Circle 26 on inquiry card.

Listing 6 continued:

```
 90 NAK$=CHR$(21)
100 PRINT "TYPE 'CONTROL-Q' TO QUIT"
110 PRINT "ANSWER QUESTIONS WITH 'Y' OR 'N'"
120 LN=1
130 REM
140 PRINT
150 PRINT "TYPE LINE ";LN
160 GOSUB 640
170 IF CH$<>QQ$ THEN  GOTO 140
180 NL=LN-1
190 PRINT
  : PRINT
200 FOR I=1 TO NL
210 PRINT S$(I)
220 NEXT I
230 PRINT
240 INPUT "DO YOU WANT TO CHANGE A LINE? ";Z$
250 IF Z$<>"Y" GOTO 360
260 INPUT "WHAT LINE? ";LN
270 IF LN>NL OR LN<1 GOTO 260
280 PRINT S$(LN)
290 PRINT
300 INPUT "IS THIS THE RIGHT LINE? ";Z$
310 IF Z$<>"Y" GOTO 260
320 S$(LN)=""
330 PRINT "TYPE LINE ";LN
340 GOSUB 640
350 GOTO 190
360 INPUT "STARTING PROGRAM LINE? ";PLC
370 INPUT "INCREMENT FOR PROGRAM? ";INC
380 FOR I=1 TO NL
390 L=LEN(S$(I))
400 FOR J=1 TO L
410 IF L=0 THEN S$(I)=STR$(PLC)+"?"
  : GOTO 480
420 IF LEFT$(S$(I),1)<>" " GOTO 450
430 S$(I)=RIGHT$(S$(I),LEN(S$(I))-1)
440 NEXT J
450 S1$="TAB("
  : S2$=");"
  : SJ$=STR$(J)
460 IF J=1 THEN S1$=""
  : S2$=""
  : SJ$=""
470 S$(I)=STR$(PLC)+"?"+S1$+SJ$+S2$+EQ$+S$(I)+EQ$
480 PLC=PLC+INC
490 NEXT I
500 FOR I=1 TO NL
510 PRINT S$(I)
520 NEXT I
530 PRINT
540 INPUT "DO YOU WANT TO SAVE ON DISK? ";Z$
550 IF Z$<>"Y" THEN END
560 INPUT "TEXT FILE NAME ";F$
570 PRINT D$;"OPEN";F$
580 PRINT D$;"WRITE";F$
590 FOR I=1 TO NL
600 PRINT S$(I)
610 NEXT I
620 PRINT D$;"CLOSE";F$
630 END
640 GET CH$
650 IF CH$<>CR$ AND CH$<>BS$ AND CH$<>QQ$ AND CH$<>NAK$ THEN PRINT CH$;
  : S$(LN)=S$(LN)+CH$
  : GOTO 640
660 IF CH$=BS$ AND LEN(S$(LN))<=1 THEN S$(LN)=""
  : HTAB 1
  : GOTO 640
670 IF CH$=BS$ THEN PRINT CH$;
  : S$(LN)=LEFT$(S$(LN),LEN(S$(LN))-1)
  : GOTO 640
680 IF CH$=NAK$ THEN CH$="?"
  : GOTO 650
690 IF CH$=CR$ THEN LN=LN+1
  : RETURN
700 IF CH$=QQ$ THEN RETURN
710 STOP
```

Text continued from page 354:

L$(J) is the concatenation of a number of substrings:

STR$(PLC)
" INPUT "
CHR$(34)
P$(I)
" "
CHR$(34)
" ; "
V$(I)
"(I)"

These substrings form INPUT statements, such as line 1050 in listing 1:

1050 INPUT "UNIT PRICE "; PR(I)

STR$(PLC) generates the current statement number, 1050; " INPUT " generates the INPUT token; CHR$(34) is the quote mark, " :P$(I) is the string for the prompt string of the Ith variable, in this case UNIT PRICE; and " " adds a space after PRICE. The trailing quote is then added. Next, a semicolon is placed in the string. Finally, the variable name for the Ith variable is inserted, followed by the subscript index, (I). Remember that the I in V$(I) is completely different from the I in "(I)": the first I is the index for the Ith variable in the CREATE INPUT program; the second I is the index for the Ith item in the invoice program.

The first step in creating your own automatic program generators is to decide which parts of your programs *can* be generated automatically. Sections that are easily parameterized are prime candidates. Next, you must be able to write the program yourself. Once you do this, break the program down into those parts that are general and those that are to be customized. Create an interactive entry program (using the programs shown in listing 6) to define the customized parts. Then, following the examples given here, write the statements that create the strings for each program statement. These three utilities allow you to write programs for yourself or friends, clients or customers, in very little time. Using these techniques, the invoice program takes about ten minutes to write. Which is all to say—let your computer do the programming!■

Circle 98 on inquiry card.

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NEC Friction Tractor Printer
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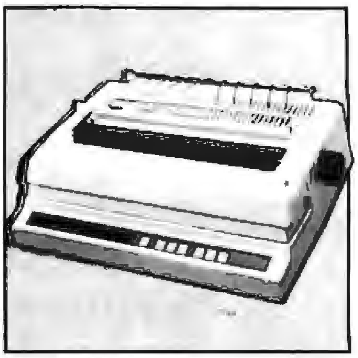

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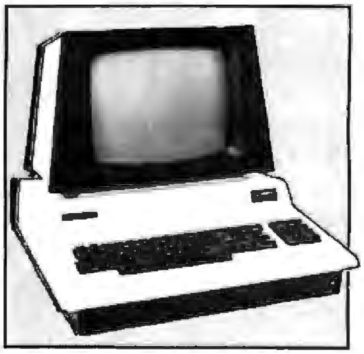

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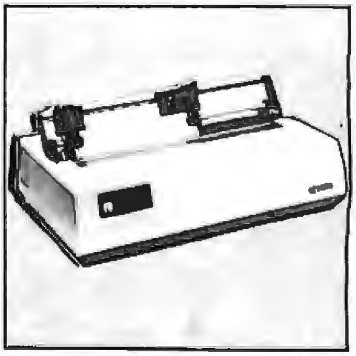

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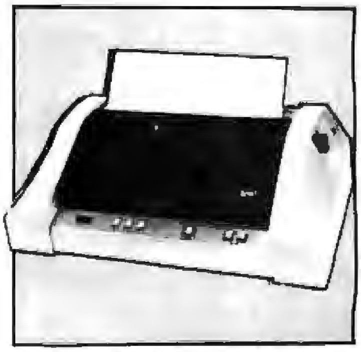

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Circle 313 on inquiry card.

BYTE CUMULATIVE INDEX
September 1975 — December 1981

"Can you tell me when you ran the article on the Hewlett-Packard computer? I think it was about two years ago."

"What issue of BYTE had Steve Wozniak's description of Sweet 16? I don't remember the exact title, but it appeared at least three years ago."

"Have you ever reviewed the Heath H-14 printer?"

Questions, questions, questions! Well, what do you expect in the age of information? If you've got it, you can be sure there's someone out there looking for it. The real question, then, becomes "How can I find it?"

This month, as a service to our readers, BYTE presents a comprehensive, cumulative index that covers every issue of the magazine, up to and including the one you're holding in your hand. Among the information represented is every article and product review that has appeared in the pages of BYTE for the past 75 issues.

All entries in the index are arranged by subject descriptors, and an article may be listed under several descriptors. Any article for which a correction was published has an asterisk after its title. The correction can be found under the heading "BYTE Corrections." The figure below shows a typical index entry and describes what the different parts mean.

We would like to thank Joseph H Ward Jr, president of Microcomputer Information Services, and his staff for the tremendous effort they put into preparing this index. For those who require information beyond what is presented here, MIS publishes *Microcomputer Index*, which covers 20 microcomputer-oriented magazines and includes abstracts for each entry. *Microcomputer Index* will also be going online early next year (1982) as part of Lockheed's Dialog system. For those who need information fast, it will feature all the search capabilities of that system. For more information on the *Microcomputer Index*, you can reach MIS by calling (408) 241-8381.

Index Entry:

(Descriptor Term Title Author)

PROGRAMMING INSTRUCTION Programmable character generator, part 2: software. Weinstein, Larry.

art 3:6 Jun78 p14-22 * * * Graphics / Character Generator

(Kind of Material Volume/Issue Date Pages Other Descriptors)

Key to Abbreviations

art	article	L1	program listing in BASIC
br	book review	L2	program listing in machine language
col	column	L3	program listing in assembly language
hr	hardware review	L4	program listing in FORTRAN
let	letter	L5	program listing in COBOL
sr	software review	L6	program listing in Pascal
*	see BYTE Corrections	L7	program listing in FORTH
***	marker symbol for other descriptors	L8	program listing in C programming language
		L9	other programming language


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1802

1802 op codes. Walton, Henry. art 4:6 Jun79 p146-147 *** Programming Instruction

Addition and subtraction: the 1802 versus the Z80. Merrin, Stephen. col 6:3 Mar81 p224-228 *** Binary / Z-80 / Mathematics

2650

Mini-disassembler for the 2650. Teja/Gonnella. art L3 4:5 May79 p233-237 *** Disassembler

My experiences with the 2650 (Signetics 2650 microprocessor). Moran, Brian. art 2:11 Nov77 p66-67 *** Microprocessor / Children

6501

Son of Motorola (or, the $20 CPU chip). Fylstra, Daniel. art L3 1:3 Nov75 p56-62 *** Microprocessor / 6800 / Programming Instruction

6502

6502 gets microprogrammable instructions. Harrod, Dennette. art L3 5:10 Oct80 p282-285 *** Hardware Modification / Programming Instruction

6502 loop control. Campbell, Gordon. col L3 5:9 Sep80 p322 *** Programming Instruction

6502 op code table. Fugitt, Lemuel. col 2:3 Mar77 p36 *** Programming Instruction

6502 personal system design: Kompuutar. Brader, David. art L3 2:11 Nov77 p94-141 *** Hardware Construction / Design / Microcomputer System

Adding an interrupt driven real time clock. Sneed, James. art L3 2:11 Nov77 p72-74 *** Clock / Hardware Construction

Apple X10 control. Arczynski, Wayne. col L3 6:12 Dec81 p469-472 *** Control / Home / Apple II

Audio processing with a microprocessor. O'Haver, Tom. art L3 3:6 Jun78 p166-173 *** Digital Audio / Sound Effects / Audio Processing

Build a super simple floppy-disk interface, part 2: software. Nicholson/Camp. art L3 6:6 Jun81 p302-340 *** Floppy Disk Drive / Interface / Operating Systems

Correct order of operations can shorten code: pointer decrementation. Hooper, Philip. col L3 5:3 Mar80 p242-244 *** Programming Instruction

Easy-to-use A/D converter. Daggit, Robert. art L3 6:6 Jun81 p378-383 *** Analog/Digital Circuit / Hardware Construction

Fast, ancient method for multiplication. Nyberg, Jostein. col L3 6:10 Oct81 p376-377 *** Mathematics / Programming Instruction

Faster BASIC for the Ohio Scientific. Sauter, John. col L1 6:5 May81 p236-242 *** Programming Instruction / OSI / BASIC

Indirect addressing for the 6502. Shier, Kenneth. art L3 5:1 Jan80 p118-120 *** Programming Instruction

Little bit on interrupts. Wier, Robert. art 2:12 Dec77 p118-129 *** Programming Instruction / 8080 / 6800

Making 6502 indirect subroutine calls efficient. Hooper/Fallgatter. col L3 5:9 Sep80 p98-100 *** Programming Instruction

More music for the 6502. O'Haver, T.C. art L3 3:6 Jun78 p140-141 *** Music / KIM

Navigation with Mini-O: part 3, software. Salter, Richard. art L3 2:4 Apr77 p100-109 *** Interface / Hardware Construction / Navigation

Recursive procedures for the 6502 microprocessor. Dennis, Phillip. col L3 6:10 Oct81 p467-469 *** Programming Instruction / Apple II

SWEET 16: the 6502 dream machine (Apple pseudo machine interpreter)*. Wozniak, Stephen. art L3 2:11 Nov77 p150-159 *** Apple II / Interpreter / Programming Instruction

Simple implementation of multitasking. Brown, Wendell. art L3 6:10 Oct81 p176-192 *** Multi-tasking / Programming Instruction

Using interrupts on the Apple II system. White, George. art L3 6:5 May81 p280-294 *** Programming Instruction / Apple II

XF and 17 instructions of the MOS Technology 6502. Gordon, H.T. col 2:12 Dec77 p72 *** Programming Instruction

6516

Compare new processors carefully. Kemp, David. col 4:5 May79 p213-216 *** Microprocessor / 6809

6800

6800 Selectric II printer program. Guzzon, Fulvio. art L3 2:6 Jun77 p140-142 *** Printer / Utility Program / IBM

6800 disassembler. Lentz, Bob. art L3 4:5 May79 p104-108 *** Disassembler / SWTPC

6800 program relocator*. Carpenter, Andrew. col L3 2:11 Nov77 p197 *** Utility Program

DEMON5: a symbolic debugging monitor. Halsema, A.I. art L3 6:5 May81 p326-358 *** Debugging / Monitor / Disassembler

Do you need the real time?. Trollope, Gregory. art L3 2:11 Nov77 p166-169 *** Clock / MIKBUG / Hardware Modification

Implementing the Tiny Assembler. Emmerichs, Jack. art L3 2:5 May77 p84-96 *** Assembler / Bar Codes

Introduction to code tightening / Mining the skip chain for extra bytes... Gass, Geoffrey. col L3 5:2 Feb80 p146-148 *** Program Optimization / Assembly Language

Jack and the machine debug...or reading the traces of a wild program. Grappel/Hemenway. art 2:12 Dec77 p91+ *** Debugging / MIKBUG / Utility Program

6800 (CONTINUED)

MIKBUG roadmap...*. Mathney, John. art L3 2:2 Feb77 p96-99 *** MIKBUG / Monitor

Memory pattern sensitivity test. Kinzer, Don. art L3 3:10 Oct78 p12-16 *** Memory / Test

Serendipitous circles (circle drawing program with surprises). Anderson/Galway. art L3 2:8 Aug77 p70-75 *** Art / Graphics

Speeding up MIKBUG IO routines. Moore, T.W. col 3:6 Jun78 p132-134 *** MIKBUG / Hardware Modification / Input/Output

Test loader routine. Berenbon, Howard. col L3 4:9 Sep79 p129 *** Utility Program

Thompson lister (for 6800 programs). Thompson, Noel. col L3 1:14 Oct76 p99 *** MIKBUG / Utility Program / Printer

8080

Fast Fourier comes back (correction for "Fast Fourier for the 6800"). Roxburgh, Alastair. col L3 6:5 May81 p458-461 *** Fourier Transforms / 8080 / BYTE Corrections

Little bit on interrupts. Wier, Robert. art 2:12 Dec77 p118-129 *** Programming Instruction / 8080 / 6502

Odd tones (Machine language puzzler - 6800 and 8080). Strangio, C. col L3 4:3 Mar79 p92 *** Puzzles / 8080

Pseudorandom number generator*. Grieser, Daniel. col L3 2:11 Nov77 p218 *** Random Numbers / 8080

CONTROL

Computer-controlled light dimmer, part 2: implementation. Gibson, John. art L3 5:2 Feb80 p72-80 *** Control / Hardware Construction

Floppy disk interface*. Allen, David. art L3 3:1 Jan78 p58-76 *** Floppy Disk Drive / Interface / Disk Controllers

Give your micro some muscles*. Grappel, Robert. art 2:3 Mar77 p9-11+ *** Control

DESIGN

Design of an M6800 LISP interpreter. Taft, S. Tucker. art L3 4:8 Aug79 p132-152 *** Interpreter / LISP / Design

How to multiply in a wet climate, part 1: use and basis for a design. Bryant/Swasdee. art L3 3:4 Apr78 p28-35+ *** Mathematics / Design / Microprocessor

Time-sharing/multi-user subsystem for microprocessors. Kinzer, Don. art L3 5:6 Jun80 p122-134 *** Timesharing / Multi-user Systems / Design

GAMES

Eighteen with a die: a learning game player. Yost, Russell. art L3 5:1 Jan80 p212-229 *** Games / Artificial Intelligence / Strategy

Landing module simulation with random surface. Young, S.J. art L3 5:3 Mar80 p130-139 *** Simulation / Games / Arcade

HARDWARE CONSTRUCTION

Add a kluge harp to your computer*. Helmers, Carl. art L3 1:2 Oct75 p14-18 *** Music / Hardware Construction

Build a 6800 system with this kit. Kay, Gary. art 1:4 Dec75 p72-76 *** Hardware Construction / SWTPC / Microcomputer System

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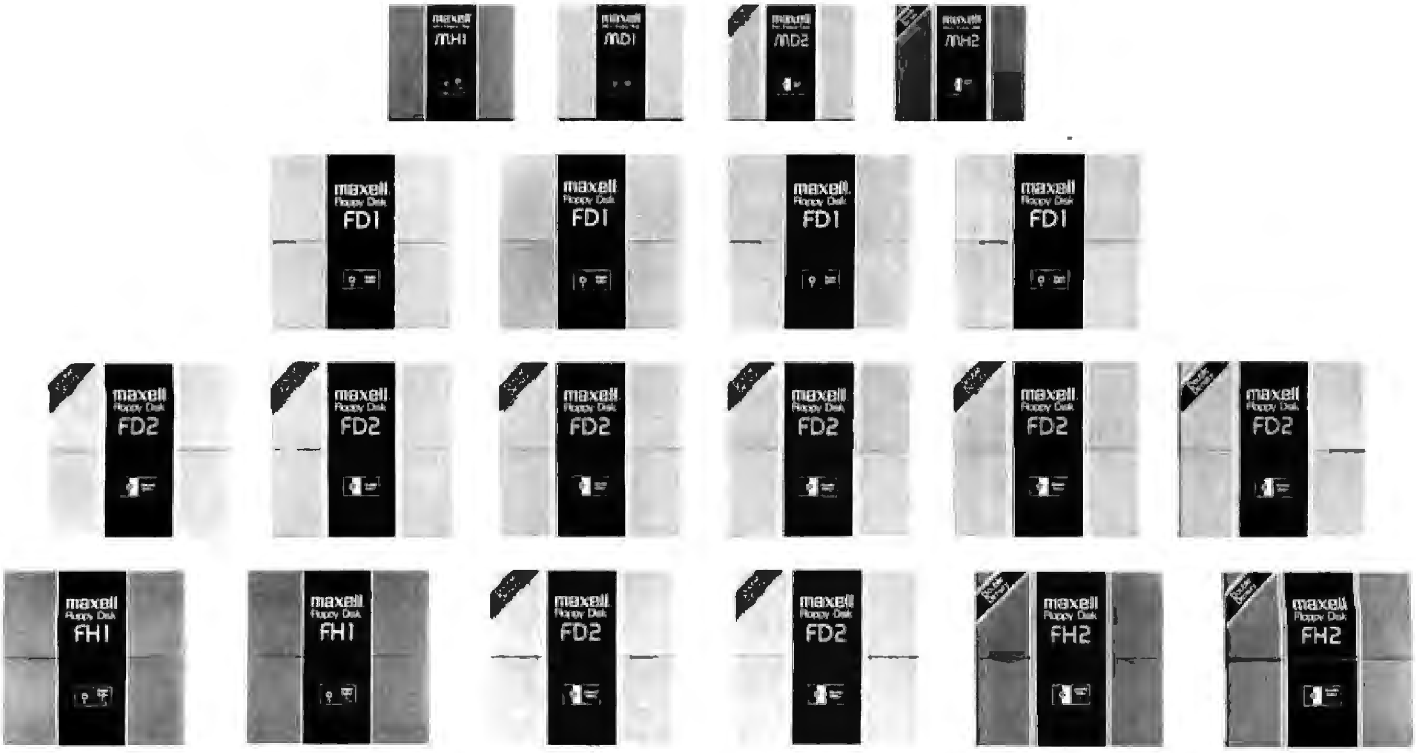

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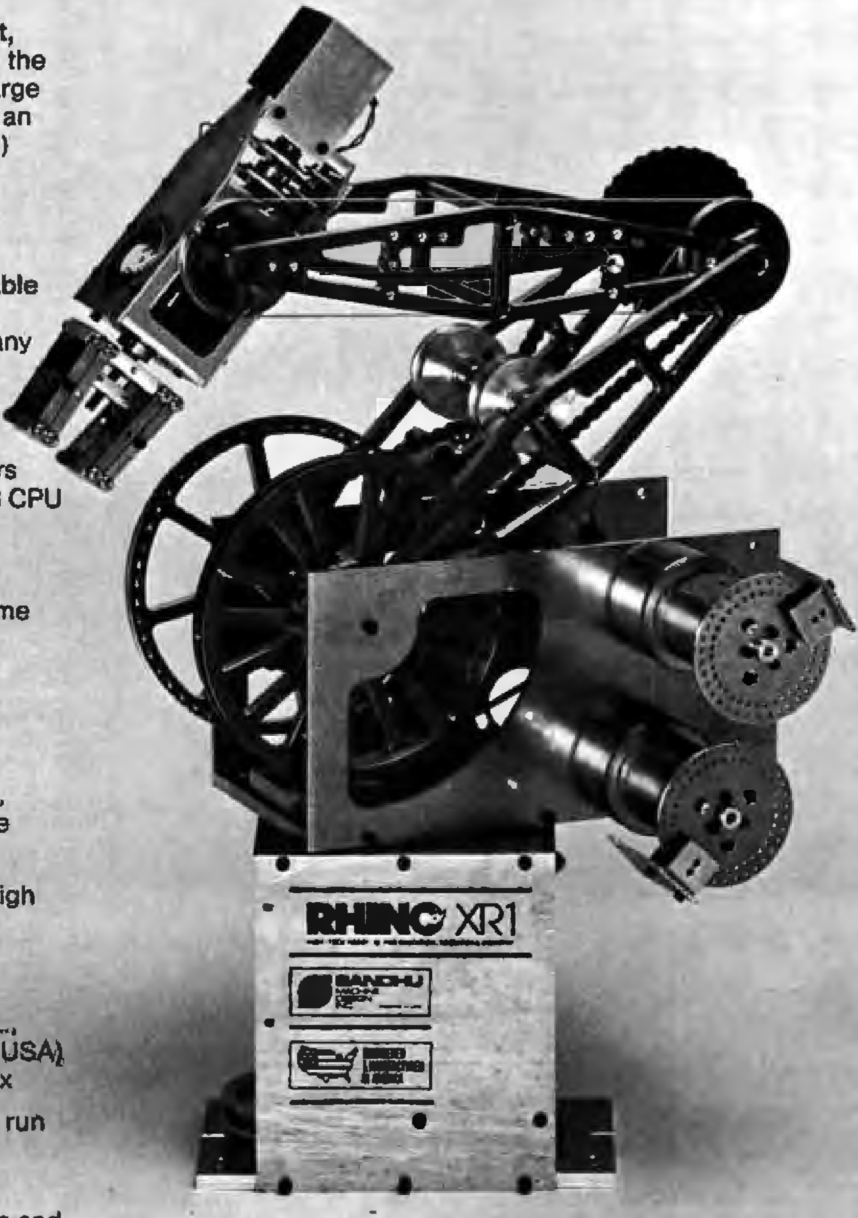

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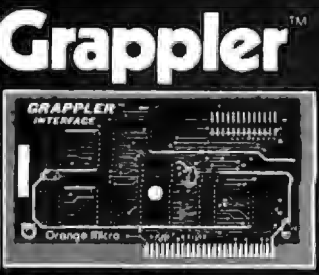

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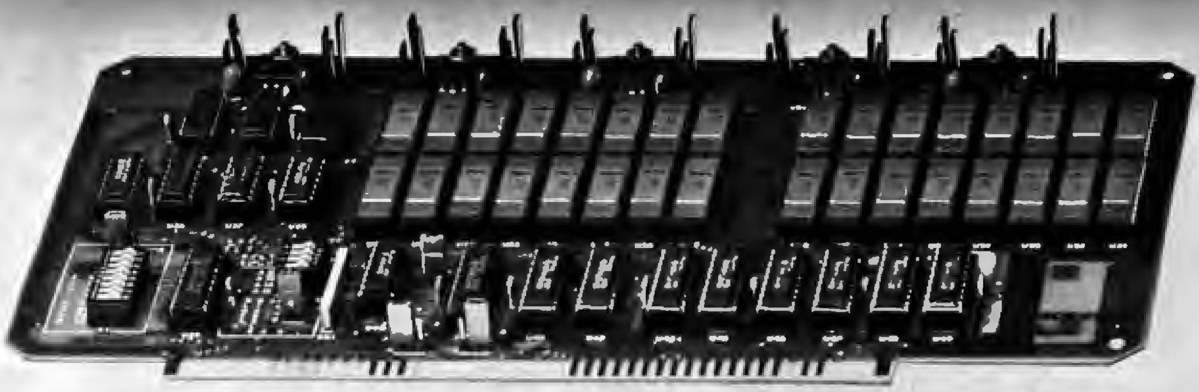

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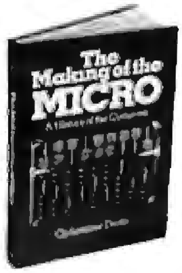

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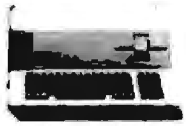

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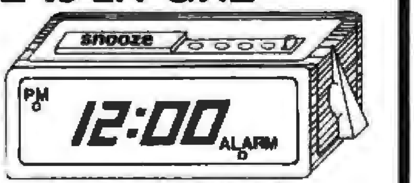

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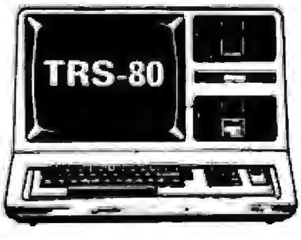

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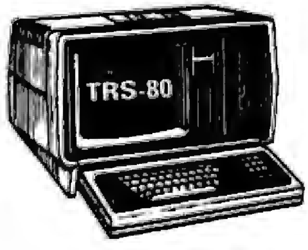

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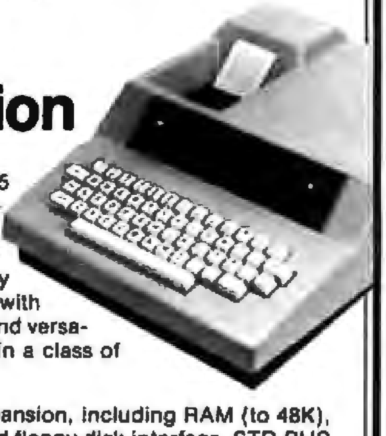

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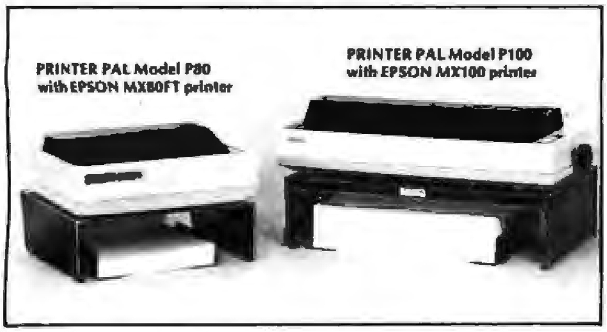

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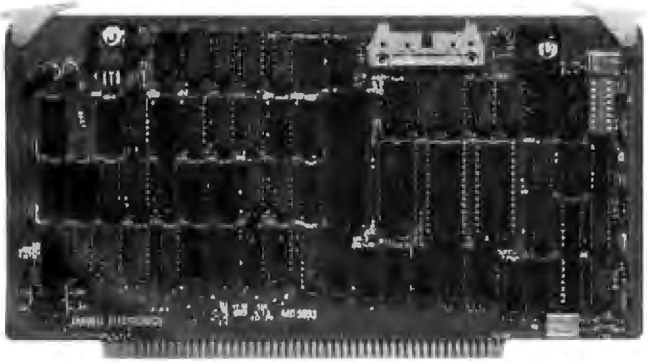

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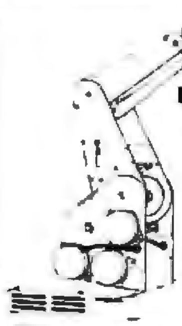

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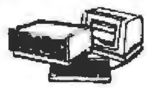

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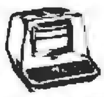

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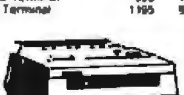

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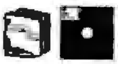

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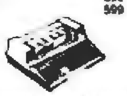

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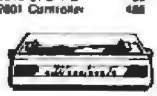

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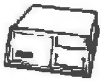

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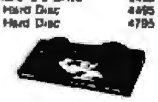

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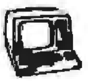

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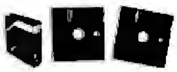

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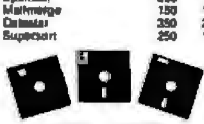

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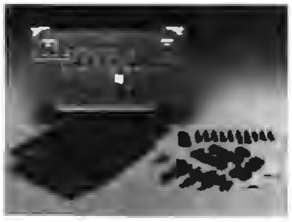

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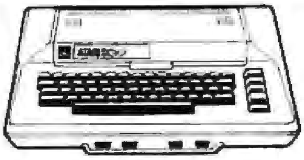

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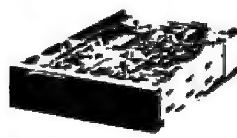

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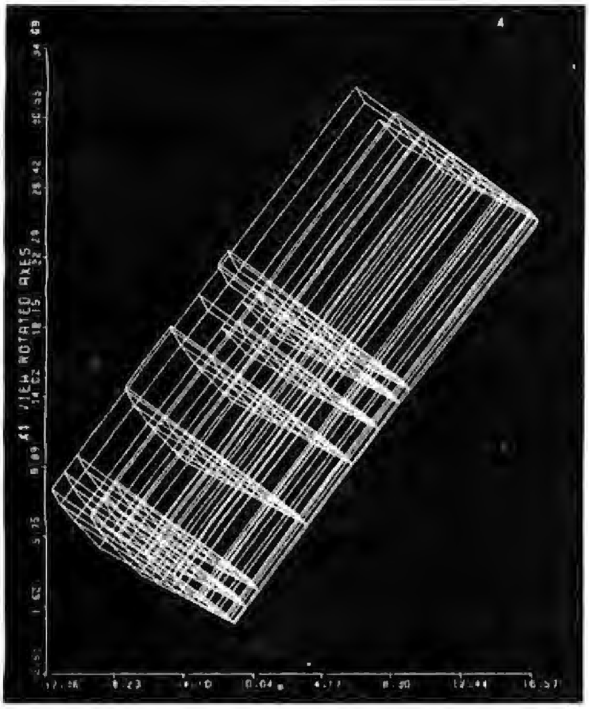

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Online Information Retrieval

Promise and Problems

Steven K Roberts
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How many times have you experienced the frustration of showing someone your computer system and finding yourself confronted with such questions as: "Can I ask it something?" or "Have you got anything in there on me?" Thanks to a wealth of naive fiction and movies, the general public (still!) thinks of even the smallest computer as a great, mysterious storehouse of information that dwarfs human minds and invades personal privacy.

We all know that our little micros hardly justify this reputation, but some systems out there do harbor astonishing volumes of information. That isn't news, but recent developments have brought some of these robust resources within the grasp of the personal computer user.

An example: not long ago, when the words were coming far too slowly on a book project, I fell into a tea-sodden brainstorming session with one of my associates concerning schemes which might bring us wealth. Both design engineers with a degree of entrepreneurial fervor, we naturally settled upon high-tech products. As avid cyclists, we chose as one of our potential projects a digital bike odometer/speedometer with liquid crystal display, trip memory, and zero-drag interface with the machine.

After we refined this idea and rejected most of the other harebrained schemes, the time came for some serious research.

In five minutes I reviewed the US patent history of bicycle odometers.

I picked up the phone, dialed the local Telenet access number, specified the Lockheed Dialog system, entered my password, and informed the system that I would begin with the Magazine Index (file #47). [**Editor's note:** *For more information about Dialog, see Stan Miastkowski's review, "Information Unlimited: The Dialog Information Retrieval Service," in the June 1981 BYTE.*] All this was taking place through my Cromemco Z-2D system, which had been converted into a simple dial-up terminal via the command CHAT.

Once the big West Coast system acknowledged my presence in the Magazine Index, I said:

```
SELECT BICYCLE?
AND ODOMETER?
```

(The "?" symbols are wild-card characters to accommodate plural forms of the words.) The system responded with the fact that there were, in its files, 904 articles on bicycles, two on odometers, and one dealing with both. When I directed the system to provide the details about that article, I received a bibliographic reference (and a short abstract) for the article, "How Far Did You Cycle Today?" by Arthur V Clark, which appeared in the May 1980 issue of *Popular Electronics*. On a hunch, I tried:

```
SELECT BICYCLE?
AND SPEEDOMETER?
```

and received two more references—one to a Beaber article in *Radio-Electronics* and the other to a Sandler piece in *Popular Mechanics*. Further

About the Author

Steve Roberts is a freelance writer and microprocessor systems consultant who lives in Dublin, Ohio. He is the author of two books and some 40 articles and, when he tears himself away from the word processor, enjoys photography, bicycling, and music.

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probing yielded pieces on bicycle accessories in *Better Homes and Gardens* and *Consumer Guide*.

This was all very interesting and likely to yield some ideas, but what about marketing? I directed the system to change to the "Encyclopedia of Associations" database and quickly located the addresses and phone numbers of the Cycle Parts and Accessories Association and the Bicycle Wholesale Distributors Association. Both groups would probably be useful in assessing the market potential of our device. If not, there were 17 other groups listed that were somehow connected with cycling.

We also needed to know about related patents. Would our device infringe on an existing patent? Would we be spending thousands of dollars on research and development just to conclude that round is the optimum shape of a wheel? Or, looking at it somewhat differently, could we take advantage of someone else's development effort, modifying it slightly and presenting it to the world as our own?

Formerly, a patent search was expensive and represented a major portion of the cost associated with filing a new invention, but no longer. I merely typed "B 25", to begin searching in database 25 (CLAIMS—US Patent Abstracts), and then issued the identical command that I used in the Magazine Index. Instantaneously, the system informed me that since 1978 there have been 1255 patents related to bicycles, 100 linked to odometers, and five somehow corresponding to both.

It was easy to get a lengthy description of those five, including the assignee's name, an explanation of the technique, descriptions of drawings, etc. In about five minutes, I had reviewed the recent US patent history of bicycle odometers. A quick check revealed nothing of interest from 1971-1977.

It's tempting to offer esoteric descriptions of methods for deriving information from a bicycle wheel and accumulating the data in a nonvolatile counter; but that's not the point here. Of interest to us is that much of the preliminary research was conveniently completed in a few minutes with a home computer, in a process that hardly exercised the capabilities of the interactive information-retrieval system at the other end of the data link.

Five Prerequisites

Information hasn't always been that accessible. Not until the development of at least five crucial ingredients could an untrained, casual user like me rapidly obtain so much information.

First, the obvious: there had to be great volumes of data in machine-readable form. Dialog alone houses over 35 million records—each heavily cross-indexed in ways ranging from a simple directory listing to a thorough bibliographic citation containing an abstract.

Much of this machine-readable information began to appear in the mid 1960s, when publishers discovered the wonders of computer phototypesetting and began compiling directories, magazines, handbooks, and the like in a form that could be read directly by computer. The original motivation for creating databases was thus not so much the anticipation of interactive information-retrieval systems as it was the economic considerations of the publishing industry.

Second, the development of computer hardware and relatively low-cost mass storage facilities progressed throughout the 1960s and '70s, yielding facilities that could host masses of data and allow multiple users simultaneous access to it. This was a major achievement, for the amount of data involved in a system like Dialog would have dwarfed the systems of the '60s, which also lacked the resources required for efficient information access and timesharing.

Third, all the fine hardware, then as now, was of little use without decent software. Early approaches centered around batch mode, in which a user's information requests were handled open-loop—frequently overnight. This precluded the kind of system whose responses to a person's

queries guide the selection or refinement of further queries—altogether a more efficient and desirable way of doing things. Such interactive software presents problems that have occupied designers for years, and complaints about "friendliness" and resolution of ambiguities still exist. But the combination of good search software and high-speed machines has reduced system response time, even during peak-load periods, to an average of perhaps three or four seconds.

The big and fast machines, good code, and an abundance of useful information were fine. But there were still two things needed to make database systems practical for users outside well-funded research environments.

One was the development of data communication networks (such as Tymnet and Telenet) that could lift the burden of long-distance charges from those not blessed with WATS lines and accommodating department budgets.

The final requirement was filled with the advent of the microprocessor. Along with all its other accomplishments, the microprocessor has lowered equipment costs to the point where just $250 can buy a reasonably decent video terminal with a built-in modem. Some people (mostly long-time owners of expensive systems, no doubt) would call this obscene, but the major economic barriers to serious widespread computer use have been removed.

Well . . . almost. A quick glance down Dialog's list of over 120 databases shows hourly "connect time" rates ranging from $25 to $300. This, to the casual observer, seems anything but cheap.

What's Your Time Worth?

Bibliographic information, such as that derived from the Magazine Index, is readily available from a well-stocked public library (although usually not so efficiently). But travel time and the extra digging made necessary by the lack of centralized indexing can make the typical goal-directed library visit trying. Unless you know what to look for and where to find it, you might end up just browsing.

Of course, you can always browse in the Dialog system, though connect time charges averaging $1 per minute discourage that. Instead, a session online is best approached with a "search strategy," which minimizes the time spent chasing down loosely related information. In our example, we took advantage (at a rather low level) of the Boolean operators (which include OR and NOT, as well as AND) to eliminate the need to check all 904 bicycle articles for references to odometers. I decided on this approach before signing on and interacted with the system as briskly as possible, with no time out for coffee breaks, chitchat, or manual retrieval of the referenced articles (which, it turned out, were on my bookshelf all along).

In most cases, this approach produces intense interplay with the machine that takes only as long as necessary—rarely more than 10 minutes for a specific search. The resulting charge is far cheaper than the gas and time that might otherwise be required, and the scope of the references is far greater than what would be found in a typical library.

It is this last point that underscores the value of online information retrieval. The Magazine Index is only one of Dialog's many databases, yet it provides cover-to-cover indexing of more than 370 publications. The index is updated monthly, with cumulation since January 1977.

Even more impressive are the specialized files: BIOSIS, for example, covers life sciences research with roughly 200,000 citations per year from 8000 serial publications, as well as books, notes, symposia, etc. In the engineering disciplines, there are COMPENDEX (100,000 citations per year in a variety of fields), INSPEC (150,000 per year in electrical engineering and computer fields), ISMEC (15,000 per year in mechanical engineering), SAE (800 per year in automotive engineering), and many more. It should be noted

that some of these are found in the *SDC ORBIT* system; others both there and in Dialog.

Any consideration of the economics of using databases must include the scope of the available information. What combination of traditional information resources could offer the multidisciplinary abundance of frequently updated material in Dialog? You can even obtain reports on SEC filings of corporations, find the student-teacher ratio in your old grade school, poke around in a worldwide index of doctoral dissertations, or find out how your congressman voted on a recent issue.

Add to this the facility, in most databases, of obtaining the full-text documents of interest through an online ordering facility. At first glance, this ultimate dependence on paper appears to be a system weakness, though far superior to online transmission of documents at 300 bits per second (bps), especially in light of the connect-time charges.

Cheaper Searching

With the exception of certain dedicated systems, such as Mead Data Central's LEXIS (a legal research database) and Pergamon's VIDEO PATSEARCH (a patent database), database facilities are designed to be accessed by any dial-up terminal. Therefore, all of the system resources are housed at the far end of the data link.

Although this minimizes the equipment requirements placed on the person who desires access to the system, this approach is hardly efficient. In using Dialog and ORBIT, I have already noticed my creeping panic at the rapidly accumulating cost of online time—especially when I employ inefficient search strategies to locate something about whose classifications I am uncertain. The clock's ticking tends to encourage haste and inhibit use of some of the system's more subtle capabilities. Even line editing costs $35-$300 per hour, depending on the database.

But with a local processor, a database searcher can prepare most messages associated with a session prior to the sign-on. This allows a calmer approach to preparing a search strategy, increasing precision and efficiency. Such an approach would have helped during a brief Dialog demonstration that I gave while preparing this article. Workmen were installing a security system in my house as I wrote, the din of men and machines drowning out the gentle pattering of the Hazel's keyboard. The workmen needed a break at about the time I needed some information, so I called them over to see the system. To lend a personal touch, I interrogated the Newspaper Index for references to articles about their company, Warner Security Systems. My command was:

SELECT WARNER AND SECURITY

I should have known better. Of the five articles referenced, only one was related to the company. One extraneous piece touched on Volney F Warner's opinions about national security. Another contained a quote from John W Warner Jr, concerning the conduct of security services during the attempt on President Reagan's life in March 1981.

Since I was paying $1.25 per minute for 300 bps transmission of these references, I should have issued a more specific search command. The following command, for example, yields only the article of interest (a *Wall Street Journal* piece from March 12, 1980):

SELECT WARNER AND SECURITY
(W)SYSTEM?

(Incidentally, SELECT is normally abbreviated S, and in the above command the (W) implies that the words SECURITY and SYSTEM must be adjacent to one another.)

My first exploration of the CLAIMS database covering US patents was equally inept. For reasons of prurience, I inquired about sex-related inventions. The very first one displayed was a method for inducing the early flowering of young deciduous trees!

A Larger Perspective

So far, my emphasis on the Rolls-Royces of the database world has neglected a new wave of economy models that together address a larger market. The Source and Compuserve have brought large-system resources to the individual at much less intimidating prices. Providing electronic mail and a variety of consumer-related services, these less expensive databases represent a service that rests between the giant systems already described and those that will ultimately appear in the living room of Mr and Mrs John Q Smith of Anytown, USA. But the mass market presents several challenges. One is achieving "user-friendliness." Another lies in the choice of a "delivery mechanism" that can accommodate millions of users. Marketing and copyright and other legal snags pose still other challenges. Let's consider these separately.

Friendly Systems

A long-standing problem in all computer systems—the lack of intuitively obvious ways to interact with the machine—is especially troublesome to untrained users lacking interest in computers. A "veteran" like me can forgive an antique text editor its idiosyncracies: the idea of a "virtual pointer" is solidly established in my head, and I know most of the 25 or so commands by heart. But I have sometimes had to turn clerical personnel loose on the system, with discouraging results. The difference between string and insert modes becomes a mystery, and the commands seem like black magic.

Of course, screen editors (such as Wordstar and VEDIT) solve this problem by allowing the objects of interest to be manipulated more directly and making the results of any change immediately visible on the screen. But systems must go further to be palatable to the masses. Future systems must incorporate many of the characteristics that make arcade games fun: provision for developing competence without having to study manuals or even use reference cards; direct correlation between hand movement and visual results; freedom from intimidating error messages (like the cryptic ERROR CODE 19); and fostering of graceful evolution from novice to expert, with enjoyment and challenge at every level.

To this end, current developments in "object-oriented programming" (like Smalltalk) offer interesting alternatives to the classic, command-oriented style of system use. For database and information utility systems to win wide acceptance, they must enable a newcomer to step up to a teletext terminal (or whatever), play around, and within a few minutes begin to derive some satisfying result, without reading any documentation or instructions. For the present, systems like Dialog and The Source, with their counterintuitive command syntaxes and their unforgiving error-handling facilities, will serve only those who need them badly enough to tolerate their inhuman natures.

Delivery of Online Services

If you want to research the world's literature on bicycle odometers, you dial your Telenet access number, specify the network address of the online vendor of choice, enter your password, and go to it. But if 43,608 Chicago residents simultaneously decide to check with their viewdata systems for movie information, news headlines, "yellow pages" service, airline schedules, and horse racing results, something other than a dial-up network must be available. And so it is: cable TV and all its permutations. However, since no subscriber possesses his own private cable, some clever means must be provided to give at least the illusion of a "dedicated" system.

One approach involves continuous transmission of a full database and interception of desired frames by an intelligent local terminal. Another technique, called a hybrid network, accommodates the widely divergent bandwidth requirements of user input and video display. It uses the phone line for communication from the user to the system and the cable TV network for information flow in the other direction (a sort of video packet-switching scheme).

Whatever the solution, the cost will clearly be great, and numerous competing technologies will ensure a lack of standardization for many years.

Yes, You Need This System!

Before the world becomes a community of electronic cottages, someone must do a very clever selling job. Ask a person who's not already involved with computers what he or she would do with a home system or with access to an information utility, and the answer will likely be: "Huh? I dunno." But the reality is that everyday almost everyone uses information resources that are amenable to "computerization." The online telephone directory is already under development by the French Postal Telegraph and Telephone Agency (PTT), which plans to produce 200,000 electronic-directory terminals for free distribution. PTT expects to recover the $50 million manufacturing cost through the obsolescence of telephone books. As a fringe benefit to the users, the terminal is compatible with Teletel (the French videotex service), as well as database, electronic mail, funds transfer, and shopping services.

In addition to telephone-directory service, we take many other information sources for granted. News media, airline and theater schedules, stock market data, and classified advertising—all are continually updated compendia of information that the bulk of the population uses routinely. And, although people are paying for these compendia in a variety of ways, cost to the individual is not obvious.

Monthly billing based on usage time for a home information terminal, however, would be very obvious. This fact may frustrate the marketing of information services for some time, especially since most potential customers will initially have trouble seeing the need for the service.

The Fine Print

We are already confronting another problem that will require landmark legal decisions before we can enter the era of online databases for the masses. Now that data storage is becoming cheap enough to permit storage of "full text" in databases, instead of offering mere bibliographic references, interesting copyright questions arise. For example, if I sell only "first serial rights" on an article to a magazine, I may not be enthusiastic about the article's subsequent appearance in an online information utility from which anyone can draw at will. In some countries, this same problem, in the nonelectronic arena of library loans, has already spawned "Public Lending Right" laws that require royalties for the author upon each borrowing of a book. If access to books in machine-readable form becomes widespread, some modifications of copyright laws will be necessary to provide compensation to authors for electronic consumption of their work.

Other legal hurdles remain. Printers' unions are likely to resist the erosion of their industry by electronic data transmission. We'll probably also see lawsuits claiming restraint of trade, monopolistic practices, invasion of privacy, copyright infringement, and unfair labor practices.

Despite these four problem areas, the information industry is experiencing explosive growth at all levels of sophistication. Though many field trials have failed, there has been enough positive feedback from users to convince corporate giants that there's big money to be made in this business. At the 1981 National Online Meeting in New York City, the largest draw of the entire three-day conference was a panel discussion on mergers and acquisitions. The intensity and scope of this industry were clear.

A Look to the Future

We must consider a broad range of database services to achieve a clear perception of the information industry: everything from consumer-oriented, cable-delivered teletext to encyclopedic "research-grade" repositories. Some database services are reputedly simple enough for a child to use and others so complex that the online vendors must routinely offer seminars and consulting services.

We are likely to see a convergence of these extremes into systems that combine depth of scope with ease of use. Present videotex services have limited appeal to the professional market, and other potential users may prefer hard copy. But if new concepts of easier and more productive use of computer systems (the subject of a three-day conference in Ann Arbor, Michigan this May) enter the design of online systems, then the robust services will become much more palatable.

It is a situation comparable to the personal computer's market penetration at the consumer level: beyond games, there has to be some distinct practical value (not contrived, either—show me a recipe filing program that can beat the *Joy of Cooking* and a 3 by 5 card index!) before people will spend a few hundred dollars on something they suspect is a toy.

Above this level, however, development is proceeding apace. In most cities, small firms, calling themselves "database intermediaries," are preparing to provide infrequent users with search services. This relieves people of the need to develop expertise in using complex systems. Considering the problems associated with categorizing all of reality in a way that would allow anyone to find one item easily, such sales of expertise may represent the wave of the future.

The problem of categorizing reality becomes even more awkward where images are concerned. Superficially amenable to standard database techniques, images become troublesome when multilayered meanings call for widely divergent classifications. Should a particular painting of the crucifixion be considered in its iconographic context, or as a skinny man hanging on a cross? The question seems absurd in the twentieth century, but similar confusions of meaning have plagued art historians through the ages and render every system of classification ambiguous and ultimately traceable to the cultural biases of a few people.

The question of categorizing images is especially important, because the new technology of videodiscs has given us a powerful tool for the storage and retrieval of graphic and textual information. One commercial service (VIDEO PATSEARCH from Pergamon) already combines online database access with a local library of drawings on videodisc. With at least one manufacturer's disc capable of storing 108,000 video frames, there is great potential for the inclusion of graphics, as well as "full-text," in specialized database systems.

The online storage capabilities described here seem to presage enormous changes in the library of the future. We can only assume that mass storage of all types will continue to grow cheaper as human time becomes more expensive; it follows that ever-better tools for information seekers will continue to develop. As we gain facilities that far surpass the efficiency of books, shelves, and call slips, perhaps we can somehow avoid losing the human warmth of libraries.■

Event Queue

December 1981

December
McGraw-Hill Conferences/ Seminars, various sites throughout the US. *Electronics* and *Data Communications* magazines, published by McGraw-Hill, are sponsoring a number of conferences covering a wide range of computer-related topics. For complete details, contact McGraw-Hill Conference Center, 1221 Avenue of the Americas, New York NY 10020, (212) 997-1221.

December 9-11
The 1981 Winter Simulation Conference (WSC 81), Peachtree Plaza, Atlanta GA. WSC 81 will feature papers, panel discussions, and tutorials on discrete and combined simulation and modeling. The conference will be organized into tutorial, methodology, and application sessions. For information, contact John Carson, WSC 81 Registration Chairman, School of Industrial and Systems Engineering, Georgia Institute of Technology, Atlanta GA 30332, (404) 894-2308.

December 15-19
Gulf Computer Exhibition, Dubai International Trade Centre, Dubai, United Arab Emirates. IBM, NCR, Apple, Honeywell, Philips, Wang, Hewlett-Packard, Data General, and other well-known manufacturers will be represented at this first exhibition of computer equipment in Dubai. The scope of the show takes in systems ranging from microcomputers to mainframes. Details are available from the Trade Centre Management Company, POB 9292, Dubai, United Arab Emirates, Telex 47474 DITC EM, and from Diana Clifton Sewell, International Office, Seymour House, 17 Waterloo Pl, London, SE1Y 4AR, England.

December 16-18
The Twentieth IEEE Conference on Decision and Control (CDC), Vacation Village Hotel, San Diego CA. The CDC is the annual meeting of the IEEE (Institute of Electrical and Electronics Engineers) Control Systems Society. It is held in cooperation with the Society for Industrial and Applied Mathematics. The conference will include contributed and invited sessions plus tutorials and presentations on all aspects of the theory and applications of systems involving decision, control, and adaptation. Topics of interest include linear and nonlinear system theory, stability theory, large-scale system theory and decentralized control, estimation, identification, signal processing and stochastic control, and control systems. For more information, contact the Institute of Electrical and Electronics Engineers Inc, 445 Hoes Ln, Piscataway NJ 08854.

December 28-30
Computer Modeling of Linguistic Theory, Grand Hyatt Hotel, New York NY. The Association for Computational Linguistics (ACL) is sponsoring three sessions on computer modeling of linguistic theory in conjunction with the annual meeting of the Linguistic Society of America (LSA). New models for grammars and new strategies for parsing will be the areas of most attention. Readings of contributed papers will also be featured. For general information, contact Stan Petrick, IBM Research Center, POB 218, Yorktown Heights NY 10598. To register, contact Margaret W Reynolds, LSA, 3520 Prospect St NW, Washington DC 20007, (202) 298-7120

January 1982

January-March
Writing for Results: A Course for Computer Professionals, various sites throughout the US. This three-day course is presented by the American Management Associations (AMA). It is designed to teach computer professionals how to get complex ideas across to technical and nontechnical readers in clear and simple prose. Individual fees are $575 for AMA members, $660 for nonmembers. Team fees are $490 per person for AMA members, $575 for nonmembers. For a complete schedule of times and locations, contact the American Management Associations, 135 W 50th St, New York NY 10020, (212) 586-8100. To register by phone, call (212) 246-0800.

January-April
Fundamentals of Data Processing for Administrative Assistants and Office Support Staff, various sites throughout the US. The American Management Associations (AMA) has designed this three-day course for secretaries, assistants, supervisors, and other personnel desiring to learn the fundamentals of data processing and its use in offices. Computer hardware and software, programming languages, and technology will all be covered. The team fee for AMA members is $470 per individual and $550 for nonmembers. For a schedule of dates and locations, contact the AMA, 135 W 50th St, New York NY 10020, (212) 586-8100. To register by phone, call (212) 246-0800.

January 6-8
The Fifteenth Annual Hawaii International Conference on Systems Sciences (HICSS-15), Honolulu HI. This conference is cosponsored by the University of Hawaii and the University of Southwestern Louisiana in cooperation with the Association for Computing Machinery. HICSS-15 is intended for medical information-processing researchers and practitioners. Some of the topics to be covered are diagnosis by computer, computer-based medical instrumentation, computers and the handicapped, and the use of computers in individual and group practices, medical laboratories, and hospitals. Contact Dr Bruce D Shiver and Dr Terry M Walker, c/o HICSS-15 Medical Information Processing, University of Southwestern Louisiana, POB 44330, Lafayette LA 70504.

January 7-10
The 1982 Winter Consumer Electronics Show (CES), Las Vegas Convention Center, Hilton Hotel, and the Jockey Club, Las Vegas NV. Conferences, workshops, seminars, sales meetings, press events, and exhibits of audio and video equipment, computers, telephones, and other consumer items highlight this show. For details, contact Consumer Electronic Shows, Suite 1607, Two Illinois Center, 233 N Michigan, Chicago IL 60601, (312) 861-1040.

January 12-15
Communication Networks Conference and Exposition, Georgia World Congress Center, Atlanta GA. The Communication Networks Conference is designed to bring users and the telecom-

munications industry together. The Conference features sessions, panel discussions, and tutorials on voice, data, and electronic-mail communications. For information, contact Communication Networks, 375 Cochituate Rd, POB 880, Framingham MA 01701, (617) 879-0700.

January 15-16
Microcomputers in Education, Arizona State University, Tempe AZ. The Tenth Annual Math/Science Conference will emphasize the microcomputer as a medium for instruction, as a tool for research, and as an information manager. Workshops, demonstrations, panel discussions, and problem-solving groups will be offered. Contact Nancy Watson, 203 Payne Hall, Arizona State University, Tempe AZ 85287. Vendors interested in exhibiting may call Dr Gary Bitter at (602) 965-3322.

January 19-22
Peripheral Array Processors for Signal Processing and Simulation, Sheraton National Hotel, Washington DC. The fee for this course is $795. For complete details, contact the Continuing Education Institute, Suite 1030, 10889 Wilshire Boulevard, Los Angeles CA 90024, (213) 824-9545.

January 19-22
The Which Computer? Show, National Exhibition Centre, Birmingham, England. Information about this show can be obtained from Clapp & Poliak Inc, 245 Park Ave, New York NY 10167, (800) 223-1956; in New York, (212) 661-8410.

January 20-22
Texas Computer Show, Dallas Convention Center, Dallas TX. Conferences, panel discussions, and seminars will be featured at this show. The exhibition will include word- and data-processing equipment plus peripherals. For details, contact the Texas Computer Show, POB 214035, Dallas TX 75221, (214) 761-9108; in Georgia, (404) 452-0114; and in Canada, (416) 252-7791.

January 21-22
Local Network Equipment Seminar, Phoenix AZ. This seminar will emphasize local-network equipment rather than the theory of local networks. General principles of local networks and future developments will be covered. These sessions will look at the Ungermann-Bass Net/One, the Network Systems Corporation Hyperchannel and Hyperbus, the Apollo Domain System, Sytek Localnet, Amdax Cablenet, Nestar Cluster 1, and other systems.

The cost of this two-day seminar is $550, which includes lecture notes, textbook, and refreshments. For details, contact Local Network Equipment Seminar, Architecture Technology Corporation, POB 24344, Minneapolis MN 55424, (612) 925-2930.

January 28-30
Conference on Modeling and Simulation on Microcomputers, Bahia Hotel, San Diego CA. The Society for Computer Simulation (SCS) is presenting this conference, which features papers, panel discussions, and tutorials on discrete and continuous simulation on microcomputers. Contact SCS, POB 2228, La Jolla CA 92038, (714) 459-3888.

February 1982

February 22-24
The Eighth Annual Federal DP Expo, Sheraton Washington Hotel, Washington DC. More than 150 computer industry companies will display and demonstrate hardware, software, systems, and services. Approximately 120 speakers will speak on a wide variety of topics during the conference portion of the program. Contact The Interface Group, 160 Speen St, Framingham MA 01701, (800) 225-4620; in Massachusetts, (617) 879-4502. ■

Books Received

Analog I/O Design, Patrick H Garrett. Reston VA: Reston Publishing, 1981; 15.5 by 23.5 cm, 264 pages, hardcover, ISBN 0-8359-0208-0, $21.95.

Apple Pascal, Arthur Luehrmann and Herbert Peckham. New York: McGraw-Hill, 1981; 16 by 23.5 cm, 428 pages, softcover, ISBN 0-07-049171-2, $14.95.

The Atari Assembler, Don Inman and Kurt Inman. Reston VA: Reston Publishing, 1981; 15.5 by 23.5 cm, 270 pages, hardcover, ISBN 0-8359-0237-4, $14.95; softcover, ISBN 0-8359-0236-6, $9.95.

The Community Computerists Directory, no. 3, Jeff Love and Stephen Pizzo. Guerneville CA: Alternet Inc, 1981; 21 by 27.5 cm, 72 pages, softcover, ISBN none, $3.50.

Computer/Law Journal, vol. II, no. 3 (Summer 1980), "Computer Crime, Part II," Jay Becker, ed. Los Angeles CA: Center for Computer/Law, 1981; 17 by 25.5 cm, 332 pages, softcover, ISSN 0164-8756, $16.

Data Base Architecture, Ivan Flores. New York: Van Nostrand Reinhold, 1981; 15.5 by 23.5 cm, 408 pages, hardcover, ISBN 0-442-22729-9, $26.50.

Data Book 1981, Intersil Inc. Cupertino CA: Intersil Inc (10710 N Tantau Ave), 1981; 18 by 23 cm, 1228 pages, softcover, ISBN none, $5.

Digital Technology with Microprocessors, Frank E Cave and David L Terrell. Reston VA: Reston Publishing, 1981; 18 by 24 cm, 372 pages, hardcover, ISBN 0-8359-1326-0, $21.95.

Evaluating Data Base Management Systems, Judy M King. New York: Van Nostrand Reinhold, 1981; 16 by 23.5 cm, 296 pages, hardcover, ISBN 0-442-23994-7, $21.95.

Feedback and Control Systems, A C McDonald and H Lowe. Reston VA: Reston Publishing, 1981; 15.5 by 23.5 cm, 532 pages, hardcover, ISBN 0-8359-1898-X, $22.95.

Fundamentals of Electronic Circuits, David A Bell. Reston VA: Reston Publishing, 1981; 18.5 by 24 cm, 720 pages, hardcover, ISBN 0-8359-2128-X, $21.95.

Graphic Software for Microcomputers, B J Korites. Duxbury MA: Kern Publications, 1981; 28 by 21.5 cm, 184 pages, softcover, ISBN 0-940254-01-8, $19.95.

Microprocessor Software: Programming Concepts and Techniques, G A Streitmatter. Reston VA: Reston Publishing, 1981; 18 by 24 cm, 357 pages, hardcover, ISBN 0-8359-4375-5, $18.95.

Natural Language Processing, Harry Tennant. Princeton NJ: Petrocelli Books, 1981; 14 by 21 cm, 276 pages, softcover, ISBN 089433-100-0, $17.50.

Optoelectronics, Robert G Seippel. Reston VA: Reston Publishing, 1981; 18 by 24 cm, 254 pages, hardcover, ISBN 0-8359-5255-X, $21.95.

Raster Graphics Handbook, Conrac Division, Conrac Corporation. Covina CA: Conrac Corporation (600 N Rimsdale Ave), 1981; 13.5 by 21 cm, 246 pages, softcover, ISBN 0-9604972-0-X, $20.■

This is a list of books received at BYTE Publications during this past month. Although the list is not meant to be exhaustive, its purpose is to acquaint BYTE readers with recently published titles in computer science and related fields. We regret that we cannot review or comment on all the books we receive; instead, this list is meant to be a monthly acknowledgment of these books and the publishers who sent them.

Clubs and Newsletters

Used Computer Exchange

The UCE (Used Computer Exchange) matches buyers and sellers of used microcomputer equipment. A listing of equipment with commission rates dependent on conclusion of a sale is available. Buyers must register with the UCE to use its services.

UCE also has consulting and referral services for those seeking the lowest prices on new computers or guidance on small-business systems hardware and software matches. For more information, contact the Used Computer Exchange, 2329 Hunters Woods Plaza, Reston VA 22091.

Purser Pursues the Atari

Purser's Atari Magazine is a special edition of *Purser's Magazine* that contains articles and reviews on almost every piece of software available for Atari computers. It's available for $1. Write to *Purser's Magazine*, POB 466, El Dorado CA 95623.

Keep Up with the Networks

The *Localnetter* covers major developments in local computer networks. Ethernet standards, products, and people in the news are some of the topics covered in this monthly newsletter. All makes and kinds of networks are investigated by the publication. *Localnetter* costs $250 per year in the United States and $300 elsewhere. Back issues are available. *Localnetter* is published by Architecture Technology Corporation, POB 24344, Minneapolis MN 55424.

Micro Cornucopia

Micro Cornucopia is devoted to the Big Board single-board computer made by Digital Research Computers of Garland, Texas. Articles on power supplies, memory protection, the monitor program, and more are included. A yearly (six-issue) subscription is $12 in the United States, $15 in Canada, and $20 elsewhere. Contact *Micro Cornucopia*, 11740 NW West Rd, Portland OR 97229.

Atari Group in the North

TAIG (Twin-City Atari Interest Group) meets on the last Sunday of each month. An interest in Atari computers and $10 annual dues are the membership requirements. A monthly newsletter, a group library of programs, and a discount at certain computer stores are all part of the membership. Write to A Middleton, 1794 James Ave, St Paul MN 55105, or call Steve Crowley at (612) 937-1001.

TRS-80 Users in New Jersey

The TRS-80 Users Group of Cherry Hill meets the fourth Monday of the month at the Cherry Hill library at 7:30 PM. The club publishes a newsletter and is interested in exchanges. Contact Bryan McPhee, 418 Virginia Dr, Browns Mills NJ 08015.

Connecticut CP/M Users Group

For more information on the Connecticut CP/M users group, contact The Wordsmith Network, 110 Day Hill Rd, Windsor CT 06095, (203) 683-2427.

Bulletin Board in Operation

SEB Computer has started a free computer bulletin board in Jacksonville, Florida. The system is up each day from 6 PM to 8 AM. The access number is (904) 743-7050.

About Telecommunications

The Viewdata/Videotex Report is a monthy publication that is concerned with viewdata/videotex, teletext, and other systems of information distribution. Articles on Prestel, Telidon, video terminals, Compuserve, and other related subjects are featured. The *Report* is available for $295 per year by Link Resources Corporation, 215 Park Ave South, New York NY 10003, (212) 473-5600.

Color Computer News

Color Computer News has information on hardware, software, and products for the TRS-80 Color Computer. *Color Computer News* is available for $9 per year (six issues) from Remarkable Software, POB 1192, Muskegon MI 49443.

Hackers from the University of Dayton

The University of Dayton Microprocessor Systems Development Group is a nuts-and-bolts group. Most of its members have built the Explorer-85 microcomputer by Netronics. The group is looking for interested hackers to join in its pursuits, which are mostly concerned with 8085/8086 applications. We also publish a newletter called *The Stack*. Contact the Microprocessor Systems Development Group, Rm KL-341, Kettering Labs, University of Dayton, Dayton OH 45469, or contact the club president, Bill Salyuo, POB 11, Dayton OH 45409, (513) 229-3614.

Home Computer Newsletter

Home Computer Newsletter is for anyone who has purchased a computer or plans to do so soon. It includes programming help, hardware and software reviews, product sources, and reader-contributed programs. The subscription rate is $20 a year. Contact *Home Computer Newsletter*, POB 616, Silverton OR 97381, (503) 873-5012.

Computer Science Group

The NECSL (New England Computer Science League) administers monthly computer-science contests for high school students throughout the country. Contests are held at each school, and an unlimited number of students from all grade levels can compete. Students are given short theoretical and applied questions and a practical problem to solve using their schools' computer facilities. The NECSL tabulates the results and announces winners and prizes. If your school would like to learn more about NECSL, contact the League at POB 2417A, Providence RI 02906, (401) 863-3300.■

Software Received

Apple II

Alkalabeth–World of Doom, a fantasy role-playing game for the Apple II. Floppy disk, $34.95. California Pacific Computer Company, Suite B, 1623 Fifth St, Davis CA 95616.

Apple-Oids, a graphics arcade game for the Apple II. Floppy disk, $29.95. California Pacific Computer Company (see address above).

Apple Panic, a graphics arcade game for the Apple II. Floppy disk, $29.95. Brøderbund Software, POB 3266, Eugene OR 97403.

Autobahn, a racing simulation for the Apple II. Floppy disk, $29.95. Sirius Software, 2011 Arden Way #225A, Sacramento CA 95825.

Bill Budge's Space Album, arcade games for the Apple II. Floppy disk, $39.95. California Pacific Computer Company (see address above).

Bill Budge's Trilogy of Games, arcade games for the Apple II. Floppy disk, $29.95. California Pacific Computer Company (see address above).

Both Barrels, an arcade game for the Apple II. Floppy disk, $24.95. Sirius Software (see address above).

Castle Wolfenstein, a graphics adventure for the Apple II. Floppy disk, $29.95. Muse Software, 330 N Charles St, Baltimore MD 21201.

Cranston Manor, a graphics adventure for the Apple II, Floppy disk, $34.95. On-Line Systems, 36575 Mudge Ranch Road, Coarsegold CA 93614.

Cross Clues, a word game for the Apple II. Floppy disk, $29.95. Science Research Associates, 155 N Wacker Dr, Chicago IL 60606.

Cyber Strike, a strategy game for the Apple II. Floppy disk, $39.95. Sirius Software (see address above).

Galactic Saga IV–Tawala's Last Redoubt, a strategy game for the Apple II. Floppy disk, $29.95. Brøderbund Software (see address above).

Gamma Goblins, a graphics adventure for the Apple II. Floppy disk, $29.95. Sirius Software (see address above).

Gobbler, an arcade game for the Apple II. Floppy disk, $24.95. On-Line Systems (see address above).

Gorgon, an arcade game for the Apple II. Floppy disk, $39.95. Sirius Software (see address above).

Hi-Res Football, sports simulation for the Apple II. Floppy disk, $39.95. On-Line Systems (see address above).

Hi-Res Soccer, sports simulation for the Apple II. Floppy disk, $29.95. On-Line Systems (see address above).

International Gran Prix, a racing simulation for the Apple II. Floppy disk, $30. Riverbank Software, POB 128, Smith's Landing Rd, Denton MD 21629.

Missile Defense, an arcade game for the Apple II. Floppy disk, $29.95. On-Line Systems (see address above).

Mission: Asteroid, a graphics adventure for the Apple II. Floppy disk, $19.95. On-Line Systems (see address above).

NORAD, an arcade game for the Apple II. Floppy disk, $29.95. Western MicroData Enterprises Ltd, POB G 33, Postal Station G, Calgary, Alberta, T3A 2G1, Canada.

Phantoms Five, an arcade game for the Apple II. Floppy disk, $29.95. Sirius Software (see address above).

Pulsar II, an arcade game for the Apple II. Floppy disk, $29.95. Sirius Software (see address above).

Sabotage, an arcade game for the Apple II. Floppy disk, $24.95. On-Line Systems (see address above).

Snoggle, an arcade game for the Apple II. Floppy disk, $32.95. Brøderbund Software (see address above).

Space Eggs, an arcade game for the Apple II. Floppy disk, $29.95. Sirius Software (see address above).

Space Warrior, an arcade game for the Apple II. Floppy disk, $24.95. Brøderbund Software (see address above).

Star Cruiser, an arcade game for the Apple II. Floppy disk, $24.95. Sirius Software (see address above).

Ultima, a fantasy role-playing game for the Apple II. Floppy disk, $39.95. California Pacific Computer Company (see address above).

Wizard and the Princess, a graphics adventure for the Apple II. Floppy disk, $32.95. On-Line Systems (see address above).

Atari

Alpha Fighter, arcade games for the Atari 800. Floppy disk, $18.95. Dynacomp Inc, 1427 Monroe Ave, Rochester NY 14618.

Chomp-Othello, strategy board games for the Atari 800. Floppy disk, $15.95. Dynacomp Inc (see address above).

Eastern Front (1941), a graphics war game for the Atari 800. Floppy disk, $29.95. Atari Program Exchange, POB 427, 155 Moffet Park Dr, Sunnyvale CA 94086.

Fantasyland 2041 AD, a multipart, fantasy role-playing game for the Atari 800. Floppy disks, $59.95. Crystalware, 12215 Murphy Ave, San Martin CA 95046.

Galactic Empire, a strategy game for the Atari 400/800. Cassette, $19.95. Adventure International, POB 3435, Longwood FL 32750.

Giant Slalom, an arcade game for the Atari 800. Floppy disk, $18.95. Dynacomp Inc (see address above).

Intruder Alert, a graphics arcade game for the Atari 800. Floppy disk, $20.95. Dynacomp Inc (see address above).

Kayos, an arcade game for the Atari 800. Floppy disk, $34.95. Computer Magic Ltd, 176 Main St, Port Washington NY 11050.

Star Trek 3.5, a strategy game for the Atari 800. Cassette, $19.95. Adventure International (see address above).

Triple Blockade, an arcade game for the Atari 800. Floppy disk, $18.95. Dynacomp Inc (see address above).

World War III, a war game for the Atari 800. Floppy disk, $29.95. Crystalware (see address above).

Commodore PET

Adventure at Pearl Harbor, a war game for 16 K- or

This is a list of software packages that have been received by BYTE Publications during the past month. The list is correct to the best of our knowledge, but it is not meant to be a full description of the product or the forms in which the product is available. In particular, some packages may be sold for several machines or in both cassette and floppy-disk format; the product listed here is the version received by BYTE Publications.

This is an all-inclusive list that makes no comment on the quality or usefulness of the software listed. We regret that we cannot review every software package we receive. Instead, this list is meant to be a monthly acknowledgment of these packages and the companies that sent them. All software received is considered to be on loan to BYTE and is returned to the manufacturer after a set period of time. Companies sending software packages should be sure to include the list price of the packages and (where appropriate) the alternate forms in which they are available.

32 K-byte PETs. Cassette, $19.95. United Software of America, 750 3rd Ave, New York NY 10017.

Space Intruders, an arcade game for 8 K- to 32 K-byte PETs. Cassette, $19.95. United Software of America (see address above).

Super Gomoku, a board game for 8 K- to 32 K-byte PETs. Cassette, $9.95. United Software of America (see address above).

TRS-80

Bridge 2.0, card game program for the TRS-80 Model I. Floppy disk, $21.95. Dynacomp Inc, 1427 Monroe Ave, Rochester NY 14618.

Cribbage 2.0, board game program for the TRS-80 Model I. Floppy disk, $18.95. Dynacomp Inc (see address above).

Hearts 1.5, card game program for the TRS-80 Model I. Floppy disk, $19.95. Dynacomp Inc (see address above).

Nominoes Jigsaw Puzzle, a graphics puzzle for the TRS-80 Model I. Floppy disk, $20.95. Dynacomp Inc (see address above).

Voyage of the Valkyrie, a graphics war game for the TRS-80 Models I or III. Floppy disk, $39.95. Advanced Operating Systems, Suite 792, 450 St John Rd, Michigan City IN 46360.

Other Computers

Backgammon 2.0, a board game program for CP/M. 8-inch floppy disk, $21.45. Dynacomp Inc, 1427 Monroe Ave, Rochester NY 14618.

Flight Simulator, a flight-simulation program for CP/M. 8-inch floppy disk, $24.45. Dynacomp Inc (see address above).

Poker Party, a game simulation for CP/M. 8-inch floppy disk, $24.45. Dynacomp Inc (see address above).

Star Trek 3.2, a strategy game for CP/M. 8-inch floppy disk, $18.45. Dynacomp Inc (see address above). ■

Apple X10 Control

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I compliment Steve Ciarcia on his fine article describing the BSR X-10 Home Control Unit. Using the information outlined in his article "Computerize a Home" (see the January 1980 BYTE, page 28), and after reading Alan Trimble's article, "A $5.25 Interface to the BSR X-10 Home Control System," (in the September 1980 issue of BYTE, page 314), I created the program in listing 1. This program uses an Apple II computer (or other 6502-based computer with a 1 MHz clock). To control the BSR X-10 command module, you need only a 40 kHz transducer (available from The Micro Mint of Woodmere, New York for $6).

Implementing home control using an Apple II is simple. First enter the machine-language program into page three of memory, then hook up the transducer to annunciator zero (pin 15) and ground (pin 8) of the game-paddle connector. You are now ready to control lights and appliances with your Apple.

Like Trimble's program, mine has two subroutines that handle critical timing. The first is FRTY, which generates a 40 kHz signal to annunciator zero. The second is DLY, which generates the delay necessary between the 40 kHz transmit bursts. Subroutines SND0 and SND1 transmit the pulse train necessary for 0 and 1, while TERM generates the required termination sequence. The MAIN ROUTINE loads the accumulator with the command byte (from location FF hexadecimal, 255 decimal), saves the complement, and serially transmits the command. The complement is then loaded into the accumulator and transmitted serially. Finally, the termination sequence is transmitted.

In my program, the *command byte* is stored at location 255 decimal, and a CALL 768 is executed (in machine language: JSR $300). All registers are saved and restored by the program; therefore, only location 255 decimal must be reserved for the program. The program may be relocated to a different location in memory, although care must be taken to verify that no timing loops cross page boundaries. This is not a severe limitation since the program fits into a single page of memory.

To use my program with Steve's BASIC program in the January 1980 BYTE, make the following changes to his program:

- change: OUT 9, C(X)
  to: POKE 255, C(X) : CALL 768
- change: OUT 9, F
  to: POKE 255, F : CALL 768
- remove: OUT 9, 128
- remove: GOSUB XXXX :REM DELAY TIMER

You don't have to turn off the timer or wait for the byte to be transmitted in the last two items because the assembler program only transmits one command per call and returns to the calling program only after transmission is complete.■

Listing 1: *6502 assembly-language program to run the BSR X-10 system from one bit of an Apple II parallel-output port.*

```
:ASM

*
*     **************************
*     *                        *
*     *  APPLE X-10 CONTROL    *
*     *          BY            *
*     *  WAYNE S. ARCZYNSKI    *
*     *   NOVEMBER 5, 1980     *
*     *                        *
*     **************************
```

Listing 1 continued on page 470

```
                 0990 *
                 1000 *    BSR X-10 CONTROLLER
                 1010 *
                 1020 *    GENERATE THE SIGNAL REQUIRED
                 1030 *        TO DRIVE A 40KHZ TRANSDUCER
                 1040 *    TO TRANSMIT COMMANDS TO THE
                 1050 *        BSR X-10 COMMAND CONSOLE
                 1060 *
                 1070 *
                 1080 *    COMMAND BYTE (DECIMAL):
                 1090 *    ALL OFF   = 1
                 1100 *    LIGHTS ON = 3
                 1110 *    ON        = 5
                 1120 *    OFF       = 7
                 1130 *    DIM       = 9
                 1140 *    BRIGHT    = 11
                 1150 *
                 1160 *    CH1 = 12      CH9  = 14
                 1170 *    CH2 = 28      CH10 = 30
                 1180 *    CH3 = 4       CH11 = 6
                 1190 *    CH4 = 20      CH12 = 22
                 1200 *    CH5 = 2       CH13 = 0
                 1210 *    CH6 = 18      CH14 = 16
                 1220 *    CH7 = 10      CH15 = 8
                 1230 *    CH8 = 26      CH16 = 24
                 1240 *
                 1242 *    COMMAND BYTE IS LOCATION $FF
                 1244 *    BASIC:   POKE 255, CMND
                 1246 *    M/L:     LDA CMND
                 1248 *             STA $FF
                 1250 *
                 1260 *    VARIABLES
                 1265 *
                 1270 ANON .EQ $C059     SET ANNUNCIATOR ZERO ( AN0 )
                 1275 ANOF .EQ $C058     CLEAR AN0
                 1280 CTR1 .EQ $FD       XMIT BIT COUNTER
                 1285 COMP .EQ $FE       COMPLEMENT OF COMMAND BYTE
                 1290 CMND .EQ $FF       COMMAND BYTE
                 1295 *
                 1300 *    MAIN ROUTINE
                 1305      .OR $300
0300- 08         1310 STRT PHP           SAVE REGISTERS
0301- 48         1320      PHA
0302- 8A         1330      TXA
0303- 48         1340      PHA
0304- 98         1350      TYA
0305- 48         1360      PHA
0306- A5 FD      1362      LDA CTR1
0308- 48         1364      PHA
0309- A5 FE      1366      LDA COMP
030B- 48         1368      PHA
                 1369 *
030C- A5 FF      1370      LDA CMND      GET COMMAND BYTE
030E- 2A         1372      ROL           POSITION COMMAND
030F- 2A         1374      ROL
0310- 2A         1376      ROL
0311- 49 FF      1380      EOR #$FF      COMPLEMENT CMND
```

```
0313- 85 FE     1390        STA COMP      SAVE COMPLEMENT
0315- 49 FF     1400        EOR #$FF      UNCOMPLEMENT COMMAND BYTE
                1410 *
0317- A2 05     1414        LDX #5        SETUP TO TRANS
0319- 86 FD     1416        STX CTR1         5 BITS
031B- 20 52 03  1420        JSR SND1      TRANSMIT START BIT
                1421 *
                1422 *      NOTE: TRANSMITTING A BURST
                1423 *            ( ZERO OR ONE ) TAKES
                1424 *            48US IN ASSEMBLER
                1425 *            INSTRUCTIONS
                1426 *
031E- 2A        1430 XLP1 ROL
031F- 90 03     1440        BCC SKP1
0321- 20 52 03  1450        JSR SND1      XMIT 1 IF CARRY IS SET
0324- B0 03     1460 SKP1 BCS SKP2
0326- 20 5D 03  1470        JSR SND0      XMIT 0 IF CARRY IS CLEAR
0329- C6 FD     1480 SKP2 DEC CTR1
032B- D0 F1     1490        BNE XLP1      LOOP UNTIL 5 BITS HAVE BEEN SENT
032D- A2 05     1500        LDX #5        SETUP TO XMIT
032F- 86 FD     1510        STX CTR1         5 BITS
0331- A5 FE     1520        LDA COMP      SETUP FOR COMP
0333- 2A        1530 XLP2 ROL
0334- 90 03     1540        BCC SKP3
0336- 20 52 03  1550        JSR SND1      XMIT 1 IF CARRY IS SET
0339- B0 03     1560 SKP3 BCS SKP4
033B- 20 5D 03  1570        JSR SND0      XMIT 0 IF CARRY IS CLEAR
033E- C6 FD     1580 SKP4 DEC CTR1
0340- D0 F1     1590        BNE XLP2      LOOP UNTIL 5 BITS HAVE BEEN SENT
                1600 *
0342- 20 68 03  1610        JSR TERM      XMIT TERMINATION SEQUENCE
0345- 68        1620        PLA           RESTORE REGISTERS
0346- 85 FE     1622        STA COMP
0348- 68        1624        PLA
0349- 85 FD     1626        STA CTR1
034B- 68        1628        PLA
034C- A8        1630        TAY
034D- 68        1640        PLA
034E- AA        1650        TAX
034F- 68        1660        PLA
0350- 28        1670        PLP
0351- 60        1680        RTS           END OF MAIN
                1690 *
                1700 *
                2000 *      SND1          XMIT A ONE
0352- A0 A0     2010 SND1 LDY #160      4MS OF 40KHZ
0354- 20 8F 03  2020        JSR FRTY      XMIT 40KHZ BURST
0357- A2 4F     2030        LDX #79       DELAY 4MS
0359- 20 9F 03  2040        JSR DLY       DELAY REMAINING TIME
035C- 60        2050        RTS
                2100 *
                2110 *      SND0          XMIT A ZERO
035D- A0 30     2120 SND0 LDY #48       1.2MS OF 40KHZ
035F- 20 8F 03  2130        JSR FRTY      XMIT 40KHZ BURST
0362- A2 87     2140        LDX #135      DELAY 6.8MS
0364- 20 9F 03  2150        JSR DLY       DELAY REMAINING TIME
0367- 60        2160        RTS
                2170 *
```

Listing 1 continued on page 472

```
                    2200 *    TERM          TERMINATION SEQUENCE OF 15MS OF 40KHZ
0368- C6 FD         2210 TERM DEC CTR1      DELAY 20US
036A- C6 FD         2212      DEC CTR1
036C- C6 FD         2214      DEC CTR1
036E- C6 FD         2216      DEC CTR1
0370- A0 A0         2218      LDY #160      4MS OF 40KHZ
0372- 20 8F 03      2220      JSR FRTY      XMIT 40KHZ BURST
0375- A0 A0         2230      LDY #160      REPEAT FOR
0377- 20 8F 03      2240      JSR FRTY        15MS OF
037A- A0 A0         2250      LDY #160        CONTINUOUS
037C- 20 8F 03      2260      JSR FRTY        40KHZ TONE
037F- A0 A0         2270      LDY #160
0381- 20 8F 03      2280      JSR FRTY
0384- A2 F0         2290      LDX #240      DELAY OF 12MS
0386- 20 9F 03      2295      JSR DLY
0389- A2 F0         2300      LDX #240      DELAY OF 12MS
038B- 20 9F 03      2305      JSR DLY       TOTAL 24MS DELAY
038E- 60            2310      RTS
                    2320 *
                    2400 *    FRTY          GENERATE FORTY KILOHERTZ SIGNAL
                    2410 *    REG Y = DURATION
                    2420 *
038F- 8D 59 C0      2430 FRTY STA ANON      SET ANNUNCIATOR TO A HIGH LEVEL
0392- EA            2440      NOP           12US AT HIGH LEVEL
0393- EA            2450      NOP
0394- EA            2460      NOP
0395- EA            2470      NOP
0396- 8D 58 C0      2480      STA ANOF      CLEAR ANNUNCIATOR
0399- EA            2490      NOP           13US AT LOW LEVEL
039A- EA            2500      NOP
039B- 88            2510      DEY
039C- D0 F1         2520      BNE FRTY      LOOP FOR THE DURATION SET BY REG Y
039E- 60            2530      RTS
                    2540 *
                    2550 *
                    2600 *    DLY           DELAY BETWEEN TRANSMIT BURSTS
                    2610 *
                    2620 *    REG X = DURATION
                    2630 *    DURATION = ( X * 50US + 5US )
                    2640 *
039F- A0 08         2650 DLY  LDY #8        2US
03A1- 88            2660 DLP1 DEY           39US LOOP
03A2- D0 FD         2670      BNE DLP1      3US NORM, 2US Y=0
03A4- EA            2680      NOP           2US
03A5- EA            2690      NOP           2US
03A6- CA            2700      DEX           2US
03A7- D0 F6         2710      BNE DLY       3US NORM, 2US X=0
03A9- 60            2720      RTS
                    9999      .EN
```

SYMBOL TABLE

```
ANON    C059    ANOF    C058    CTR1    00FD
COMP    00FE    CMND    00FF    STRT    0300
XLP1    031E    SKP1    0324    SKP2    0329
XLP2    0333    SKP3    0339    SKP4    033E
SND1    0352    SND0    035D    TERM    0368
FRTY    038F    DLY     039F    DLP1    03A1
```

Handi-Writer

A Video Note Pad for the Physically Handicapped

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For the first 50 years of her life, severe cerebral palsy prevented Lois from answering questions that required more than a simple yes or no. But an inexpensive computer and special hardware and software have now enabled Lois to communicate complex thoughts and ideas. Using her new Handi-Writer system, Lois has shown herself to be an intelligent, alert woman who can interact effectively with those around her.

The usual cause of cerebral palsy is damage at birth to the part of the brain that controls motor coordination. Cerebral palsy usually leaves innate intelligence unimpaired. The distinction between intelligence and knowledge is vital here: simply put, intelligence is the ability to learn, and knowledge is what has been learned. It is difficult to measure either intelligence or knowledge in a person severely afflicted with cerebral palsy. Physical impairments prevent Lois and other sufferers from responding to questions about complex thoughts and abstractions. The mind, however bright, is prisoner of the body.

Requirements for Communication

The first step in helping Lois to communicate was to understand the nature of the physical impairments that had to be overcome. Lois is severely spastic and has very little control over the movement of her hands and arms. She cannot move around on her own. She cannot talk. Although she has enough strength in her arms to bend a sturdy mechanical joystick, she cannot control it well enough for use as an input/output device. Because of a caring family that has spent much time with her, she can read.

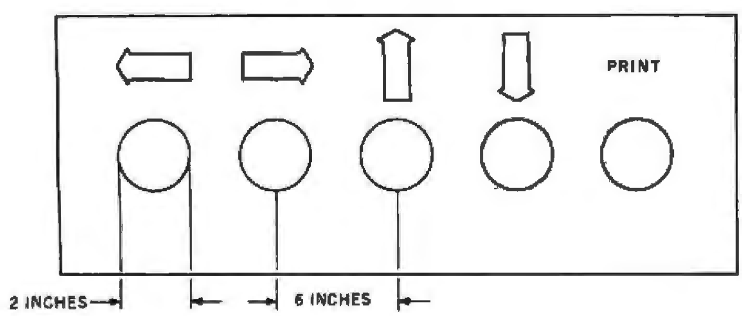

Figure 1: Arrangement of controls on the selector panel. Industrial "panic-button" switches are easily grasped by a handicapped user.

A system to help Lois engage in two-way communication had to meet the following requirements:

- Most important, the system had to be small, portable, reliable, and inexpensive.
- The number of physical actions required of Lois had to be kept to the minimum. Since she could not operate a keyboard with many separate keys, software would have to do nearly all the decision making.
- The system had to permit selection of the most common words and phrases with a single, easy action, but still permit construction of more complex words and phrases.
- The system had to be able to correct spelling errors caused by unintentional selection of a character or a word.

System Overview

Before taking a close look at each component of the Handi-Writer system that we developed to meet these requirements, I'll give you a quick overview of the finished system.

I based the system on my own TRS-80 Model I with 16 K bytes of memory using Level II BASIC. The string-handling functions of Level II BASIC are essential to the Handi-Writer software, which displays characters and words on a video screen. The user selects a character or word by moving a variable-size blinking cursor to it. If the cursor is on an item that is a single character, the character blinks; if the cursor is on an item that is a word, the whole word blinks. Four cursor-control buttons are placed on a small, separate, five-button panel, as shown in figure 1. Pushing the fifth button on the panel will print a selected character or word—whichever item is blinking—on a four-line work space at the bottom of the screen. The Handi-Writer interface between the TRS-80 and the selector panel consists of a 3-by-5-inch printed-circuit board housed in a separate cabinet.

Although I used the TRS-80 as the basis for Handi-Writer, the hardware *and software* described in this article could be modified to interface with almost any popular computer.

The Screen Display

Handi-Writer is menu-driven, but the menu is unusual. The user sees the screen shown in figure 2. The alphabet and numbers are at the left of the screen and 29 common words are at the right. Although a screen format of 64 characters per line would have accommodated more words on the screen, the format of 32 characters per line suits this application better; the larger characters reduce the degree of visual discrimination required to select items from the menu.

We tried many arrangements of the alphabet and the other menu items before we arrived at the best menu for Lois, which is what figure 2 represents. A different arrangement might better meet the needs of another person. Once the Handi-Writer system was functioning, it enabled Lois to tell us what words she wanted on the menu. We used no punctuation except the question mark because the user can indicate the end of a thought or a sentence by inserting extra spaces. Besides characters, figures, and words, the menu includes four editing functions and a RECALL function, all described below.

An important goal of screen design was to minimize the amount of motion and effort required to select a menu item. Consequently, the cursor moves in units of whole menu items. As you look at figure 2, IS is only one unit of cursor movement to the right of I'M, despite the appearance of several blanks between the two items. WHY is only one unit of cursor movement to the right of the 2. SPACE is only one unit below either 7, 8, or 9. The question mark is only one unit to the right of SPACE, regardless of whether the cursor was on the 7, the 8, or the 9 before the user moved the cursor to SPACE.

Once the Handi-Writer was functioning, it enabled Lois to tell us what words she wanted on the menu.

Furthermore, Handi-Writer implements both vertical and horizontal wraparound in cursor movement. PLEASE, at the top of the screen, is only one unit down if the cursor is on WORD. LINE is one unit up from THANKS. COME is one unit left from Q, and Y is one unit right from THIRSTY. By moving the cursor only one unit, the user can also go from ALL in the lower right corner of the menu to A in the upper left corner.

To prevent the user from having to select SPACE too often, the software automatically inserts a space before each word listed on the right side of the menu. No space is inserted before the ending ING, also on the right side of the menu.

How It Works

The bottom four lines of the screen form a work space, separated from the menu above by a single blank line. When the desired letter or word is blinking, the user presses the PRINT button and the letter or word appears in the work space. Repeated depression of the PRINT button will cause repeated printing of the blinking item. There is automatic line adjustment if a word won't fit on the current line.

The user can correct errors in the printed text in the work space by using one of four editing functions: LTR, WORD, LINE, and ALL. The user selects the editing functions just as he or she selects other menu items. However, when the user selects an editing function, it blinks at a rate three times faster than the blink-rate for the other items on the menu.

All four editing functions are located on the menu's ERASE line, which is the first line of menu items above the work space. If LTR is made to blink, then pressing the PRINT button will delete the last letter printed in the work space. If WORD or LINE is blinking, then pressing the PRINT button will delete the last word or line in the work space. Pressing the PRINT button when ALL is blinking will clear the entire work space, but to prevent accidents, the screen will ask ERASE SCREEN TEXT? Then the user must press the PRINT button again.

When the user comes to the end of the fourth line of the work space and prints another word or letter, the software automatically scrolls the displayed text up one line. The last three lines are still displayed. Lines that scroll up out of view go into a text buffer that can hold eight four-line "pages" of text, or a total of 32 lines. If more than 32 lines are scrolled up, the first line in the buffer is lost. An asterisk appears on the menu below the E in ERASE to warn the user.

The user recalls four-line blocks of text from the buffer by selecting RECALL on the menu and pressing the PRINT button. Like the editing functions, RECALL blinks at three times the normal rate to indicate that it is a function rather than a printable word. The first four lines displayed are the first four lines that went into the buffer, not the four lines that most recently went into the buffer. Pushing the PRINT button repeatedly when RECALL is blinking recalls the next four lines, and the next, and so on. After all the text in the buffer has been recalled for display, the message END OF TEXT appears. After that, continuing to press the PRINT button causes repeated scrolling through the same text.

The user can clear the text buffer by using the ALL editing function

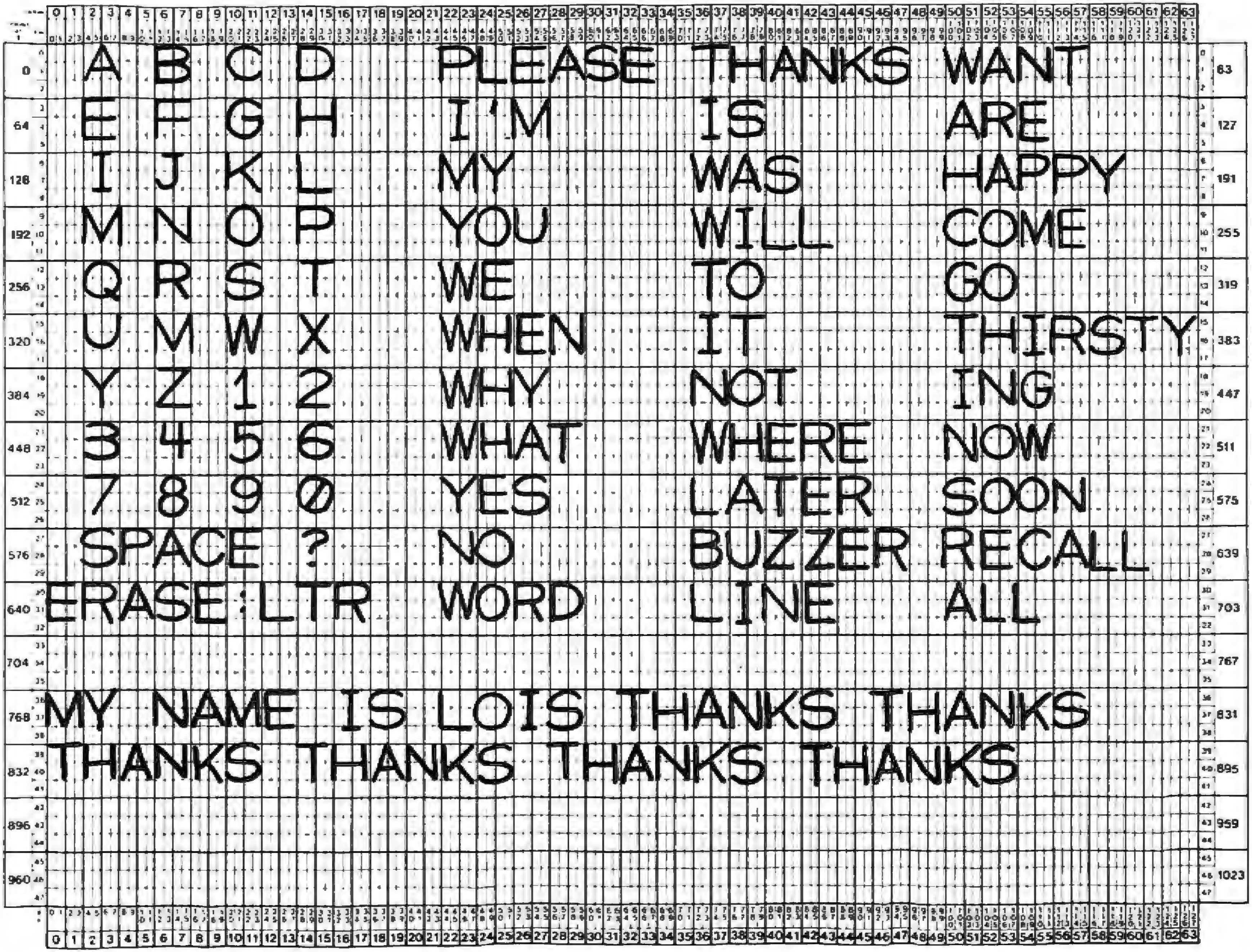

Figure 2: *The screen display of the Handi-Writer system.*

repeatedly. Handi-Writer gives warning messages and requires confirmation before actually erasing the stored text.

The Screen Software

The Handi-Writer software is shown in listing 1. The program uses about 8 K bytes of memory. The screen software works by dimensioning a string array into which the alphabet and menu items are stored; the 74 successive array elements are then arranged visually into a nominal 7 by 11 matrix, but the software still treats them as a 74 by 1 array with sequentially numbered indexes.

The current item blinks about once each second, but the rate can be altered by changing the value of the variable *K* in the Handi-Writer program shown in listing 1. Table 1 provides a list of the program's numeric and string arrays and variables.

If you decide to change menu items in the listing, do not introduce as a menu item any phrase that has a space in it, such as I AM. Use words only, and limit them to six letters plus the leading space for the first two columns of words on the screen, or seven letters plus the leading space for the third column.

The Hardware

Figure 3 is a schematic diagram of the Handi-Writer interface. Figure 4 is a diagram of the placement of parts on the printed-circuit board, and table 2 is a list of parts keyed to the placement diagram. The entire circuit, including power supply, fits on one 3-by-5-inch printed-circuit board. The design uses widely available CMOS (complementary metal-oxide semiconductor) instead of the 74LS series TTL (transistor-transistor logic) normally used for computer interfacing. As a result, the design eliminates all but one current requirement for the CMOS logic but still provides a three-state interface for the computer's address bus, data bus, and control lines. The only remaining requirement is that the CMOS must be operated at +5 *volts* in order to maintain TTL-logic-level compatibility with the TRS-80.

IC4 and IC5 are quad CMOS switches, each independently controllable. When pin 13 of IC4 is low (logic 0), the switch between pins 1 and 2 is open; ie: it presents a very high impedance (on the order of several hundred megohms) between pins 1 and 2. This is exactly the same condition as that of a 74LS367 three-state buffer when in the high-impedance mode. However, when pin 13 of IC4 goes high (logic 1), the internal switch is closed; ie: a low resistance (on the order of 200 to 400 ohms) is presented between pins 1 and 2. The switch is bidirectional in the sense that pin 1 can be used either as the output or input, and pin 2 can be used either as an input or output. In many applications, this feature of

Listing 1: *The Handi-Writer program. Written in TRS-80 Level II BASIC and requiring 16 K bytes of memory, this program handles communications between the Handi-Writer interface and the TRS-80.*

```
95 REM  -- LOGO AND INITIALIZATION --
100 CLS: PRINTCHR$(23): PRINT@198,"HELP FOR THE HANDICAPPED": PRINT@272,"VERSION
 1.7": PRINT@448,"JANUARY 1981 HOWARD F. BATIE"
110 PRINT "PO BOX 667, HERNDON VA 22070": PRINT@714,"FOR TRS-80 MODEL I": PRINT@
782,"LEVEL II, 16K"
120 CLEAR 1200: DIM M(74),M$(74),P$(4),T$(33):  II=0: LS=0: L=1: LP=1: EB=0: TC=
1: PT=0: FOR I=1 TO 2000: NEXT: CLS: PRINTCHR$(23)
125 REM  -- PRINT DISPLAY --
130 FOR I=1 TO 74: READ A: READ X$: M(I)=A: M$(I)=X$: PRINT@A,X$;: NEXT I: PRINT
@640,"ERASE:";
135 REM  -- SELECT MENU ITEM TO BE PRINTED --
140 IF M(L)<690 AND M(L)<>612 THEN B=0: EB=0: GOSUB 740
150 II=0: GOSUB 230: IF L>68 THEN K=5 ELSE K=15
152 A=INP(0): IF A=255 THEN II=II+1 ELSE 170
154 IF II<K THEN 152
156 II=0: GOSUB 240
158 A=INP(0): IF A=255 THEN II=II+1 ELSE 170
160 IF II=2*K THEN 150 ELSE 158
170 IF A=239 GOSUB 240: GOTO 250: REM -- PRINT --
180 GOSUB 230: GOSUB 240: IF A=254 L=L+1: IF L>74 L=L-74: GOTO 220: ELSE IF L=65
 OR L=66 L=67: GOTO 220: REM -- RIGHT --
190 IF A=253 L=L-1: IF L<1 L=L+74: GOTO 220: ELSE IF L=65 OR L=66 L-64: GOTO 220
: REM -- LEFT --
200 IF A=251 THEN IF L>3 AND L<8 L=L+67: GOTO 220: ELSE IF L>0 AND L<4 L=L+63: G
OTO 220: ELSE IF L>70 L=L-4: GOTO 220: ELSE L=L-7: GOTO 220: REM -- UP --
210 IF A=247 THEN IF L>66 AND L<71 L=L+4: GOTO 220: ELSE IF L=64 OR L=65 OR L=66
 L=L-63: GOTO 220: ELSE IF L>70 L=L-67: GOTO 220: ELSE L=L+7: GOTO 220: REM -- D
OWN --
220 GOSUB 230: GOSUB 240: GOSUB 590: GOTO 140
230 PRINT@M(L),STRING$(LEN(M$(L))," ");: FOR J=1 TO 50: NEXT J: RETURN
240 PRINT@M(L),M$(L);: RETURN
```

Listing 1 continued on page 478

Listing 1 continued:

```
245 REM  -- ERASE ALL --
250 IF M(L)<690 THEN 300
260 ON EB+1 GOTO 270, 280, 290, 292
270 PRINT@718,"ERASE SCREEN TEXT?";: EB=1: GOTO 140
280 GOSUB 390: LP=1: PRINT@730,"TEXT MEMORY";: EB=2: GOTO 140
290 GOSUB 740: PRINT@722,"ARE YOU SURE?";: EB=3: GOTO 140
292 PRINT@718,"TEXT MEMORY ERASED";: EB=0: FOR I=1 TO 33: T$(I)="": NEXT I: PRIN
T@704," ";: GOSUB 590: GOSUB 740: TC=1: GOTO 140
295 REM  -- ERASE LAST PRINTED LETTER --
300 GOSUB 740: IF M(L)=652 THEN GOSUB 420: GOSUB 590: GOTO 140
305 REM  -- ERASE LAST PRINTED WORD --
310 IF M(L)=662 THEN GOSUB 460: GOSUB 590: GOTO 140
315 REM  -- ERASE LAST PRINTED LINE --
320 IF M(L)=676 THEN GOSUB 400: GOSUB 590: GOTO 140
325 REM  -- PRINT SPACE --
330 IF M(L)=578 THEN B$=" ": GOTO 500
335 REM  -- RECALL TEXT FROM T$ MEMORY --
340 IF M(L)=626 THEN B$="": GOTO 600
345 REM  -- ACTIVATE EXTERNAL BUZZER --
350 IF M(L)=612 AND B=0 THEN PRINT@720,"TURN ON BUZZER?";: B=1: GOTO 140
360 IF M(L)=612 AND B=1 THEN OUT 0,0: PRINT@720,"BUZZER TURNED ON";: GOSUB 590:
GOSUB 590: B=0: GOSUB 740: GOTO 140
370 IF B>0 THEN B=0: GOSUB 740
375 REM  -- PRINT CHARACTER/WORD --
380 B$=M$(L): PT=0: GOTO 500
385 REM  -- ERASE PRINTED LINES AND P$ BUFFERS --
390 FOR I=1 TO 4: PRINT@704+64*I,STRING$(31," ");: P$(I)="": NEXT I: RETURN
395 REM  -- ERASE LAST PRINTED LINE --
400 GOSUB 560: P$(LP)="": LP=LP-1: IF LP<1 THEN LP=1
410 RETURN
415 REM  -- ERASE LAST PRINTED LETTER --
420 LS=LEN(P$(LP)): IF LS<1 THEN P$(LP)="": LP=LP-1
430 IF LP<1 THEN LP=1: RETURN
440 IF LS>0 THEN P$(LP)=LEFT$(P$(LP),LS-1): GOSUB 560: PRINT@704+64*LP,P$(LP);
450 RETURN
455 REM  -- ERASE LAST PRINTED WORD --
460 LS=LEN(P$(LP))
465 FOR I=LS TO 0 STEP -1: IF I<2 THEN GOSUB 400: RETURN
470 X$=MID$(P$(LP),I,1): IF X$=" " THEN B$=RIGHT$(P$(LP),LS-I): P$(LP)=LEFT$(P$(
LP),I-1): GOSUB 560: PRINT@704+64*LP,P$(LP);: RETURN
480 NEXTI
485 REM  -- PRINT ALL FOUR LINES OF TEXT --
490 FOR I=1 TO 4: IF P$(I)="" THEN RETURN: ELSE PRINT@704+64*I,P$(I);: LP=I: NEX
T I: IF LP>4 THEN LP=4: RETURN: ELSE RETURN
495 REM  -- SCROLL AND LOAD T$ BUFFERS IF LAST LINE TOO LONG --
500 IF LP>4 THEN LP=4
510 P$(LP)=P$(LP)+B$: LS=LEN(P$(LP)): IF LS<31 THEN GOSUB 490: GOSUB 590: GOTO 1
40
520 GOSUB 465: LP=LP+1: IF LP>4 THEN LP=4: GOSUB 550: T$(TC)=P$(1): FOR I=1 TO 3
: P$(I)=P$(I+1): NEXT I: P$(4)=B$: GOSUB 490: TC=TC+1: IF TC>29 THEN TC=29: GOSU
B 540: GOSUB 590: GOTO 140: ELSE GOSUB 590: GOTO 140
530 P$(LP)=P$(LP)+B$: GOSUB 490: GOSUB 590: GOTO 140
540 PRINT@704,"*";: FOR M=1 TO 32: T$(M)=T$(M+1): NEXTM: RETURN
545 REM  -- CLEAR ALL TEXT FROM SCREEN ONLY --
550 FOR I=1 TO 4: PRINT@704+64*I,STRING$(31," ");: NEXT I: RETURN
555 REM  -- CLEAR LAST LINE PRINTED FROM SCREEN ONLY---
560 IF LP>4 THEN LP=4
570 PRINT@704+64*LP,STRING$(31," ");: RETURN
575 REM  -- BLINK DISPLAY FOR MULTIPLE MOVES --
580 PRINT@M(L),STRING$(LEN(M$(L))," ");: FOR Y=1 TO 50: NEXT Y: RETURN
585 REM  -- DELAY BETWEEN ENTRIES --
590 FOR J=1 TO 200: NEXT J: RETURN
595 REM  -- RECALL TEXT FROM T$ BUFFERS --
600 FOR I=1 TO 4: IF TC+I<34 THEN T$(TC+I-1)=P$(I): NEXT I
610 ET=0: TC=1: PRINT@720,"--RECALL TEXT--";: T$(33)=""
620 GOSUB 550: LP=1: TC=TC-1
```

Listing 1 continued:

```
630 TC=TC+1: IF TC=33 OR T$(TC)="" THEN 650 ELSE X=704+64*LP: IF X>999 THEN 660
640 PRINT@X,T$(TC);: LP=LP+1: GOTO 630
650 PRINT@720,"((END OF TEXT))";: ET=1: GOTO 690
660 A=INP(0): IF A=255 THEN 660
670 GOSUB 590: IF A=239 AND ET=0 THEN 620
680 IF A=239 AND ET=1 THEN 610
690 FOR I=32 TO 1 STEP -1: IF T$(1)="" THEN NEXT I
700 LP=1: TC=I-3: IF TC<1 THEN TC=1
710 FOR I=0 TO 3: P$(1+I)=T$(TC+I): NEXT I
720 GOSUB 550: GOSUB 490: GOSUB 590: GOSUB 590: GOSUB 740: GOTO 140
740 PRINT@718,STRING$(20," ");: RETURN
745 REM  -- DISPLAY DATA --
750 DATA2,"A",6,"B",10,"C",14,"D",20," PLEASE",34," THANKS",48," WANT",66,"E",70
,"F",74,"G",78,"H",84," I'M",98," IS",112," ARE",130,"I",134,"J",138,"K",142,"L"
,148," MY",162," WAS"
760 DATA176," HAPPY",194,"M",198,"N",202,"O",206,"P",212," YOU",226," WILL",240,
" COME",258,"Q",262,"R",266,"S",270,"T",276," WE",290," TO",304," GO",322,"U",32
6,"V",330,"W",334,"X"
770 DATA340," WHEN",354," IT",368," THIRSTY",386,"Y",390,"Z",394,"1",398,"2",404
," WHY",418," NOT",434,"ING",450,"3",454,"4",458,"5",462,"6",468," WHAT",482," W
HERE",496," NOW",514,"7"
780 DATA518,"8",522,"9",526,"0",532," YES",546," LATER",560," SOON",578,"SPACE",
578,"SPACE",578,"SPACE",590,"?",596," NO",612,"BUZZER",626,"RECALL",652,"LTR",66
2,"WORD",676,"LINE",690,"ALL"
790 END
```

the CMOS can be used to reduce the complexity and parts count of a circuit as well as the current requirements.

In this project, it is not necessary to fully decode all eight address lines to establish the port location since only one input/output port is required. We chose address lines A0, A1, and A4 because they are near one another and also are near the traditional data-bus pins on the TRS-80 rear edge connector. This arrangement simplified constructing the cable to the computer. IC3a and IC3b decode addresses separately; the former decodes the output-port location and the latter the input-port location. The location of the input and output ports is the same; however, providing a port with a location other than 255 makes it possible to leave the cassette permanently connected to the computer. For the Handi-*Writer*, port location 32 is used, but the wiring would permit addressing the input and output ports by any number from 0 to 255 that has the A0, A1, and A4 lines of the address bus at logic 0.

When this condition is met and the $\overline{IN}$ control line strobe goes low, pin 13 of IC3 goes high and pin 10 of IC2c goes high, but only for the duration of the $\overline{IN}$ strobe. Either $\overline{IN}$ or $\overline{OUT}$ can be low at any one time, but not both simultaneously. Therefore, during the time when $\overline{IN}$ is low, switches b, a, and d of IC4 are closed, and the information on the three address lines is presented to and decoded by IC3b. The resulting logic 1 at pin 13 of IC3 closes switch c of IC4 and all switches of IC5. If one of the five selector-panel switches has been pressed during this time, one of the five data lines D0 through D4 will be low. This binary value on the data bus is assigned to the variable *A* and appropriate action is taken by the software. If no switch is pressed ($A=255$) or if two or more switches are simultaneously pressed, line 220 jumps to line 140 without any evident

Handi-Writer Arrays	Function
M Array (74 x 1)	Holds video locations of characters/words (See L)
M$ Array (74 x 1)	Characters/words displayed on screen (See DATA)
P$ Array (4 x 1)	Printed lines in video work space area
T$ Array (33 x 1)	Text held in memory for recall
X$ String	Temporary string variable (length = 1)
B$ String	Program string variable
Handi-Writer Variables	**Function**
A	Program Variable
B	Turn on Buzzer? (1 = YES, 0 = NO)
I,J,M,Y	Loop variables
K	Blinking rate of selected character/word (5 or 15)
L	Location on screen of selected character/word (See DATA)
X	Program variable
EB	Erase T$ text Buffer? (> 0 = YES, 0 = NO)
ET	End of Text (RECALL)? (1 = YES, 0 = NO)
LP	Line being Printed on screen (1-4) (See P$)
LS	Length of P$ String being printed in work space (0-31)
PT	Printing Text from T$ buffer (RECALL)? (1 = YES, 0 = NO)
TC	Text line Counter in T$ memory (1-32)

Table 1: *The arrays and variables used in the Handi-Writer program shown in listing 1, with a brief description of their functions.*

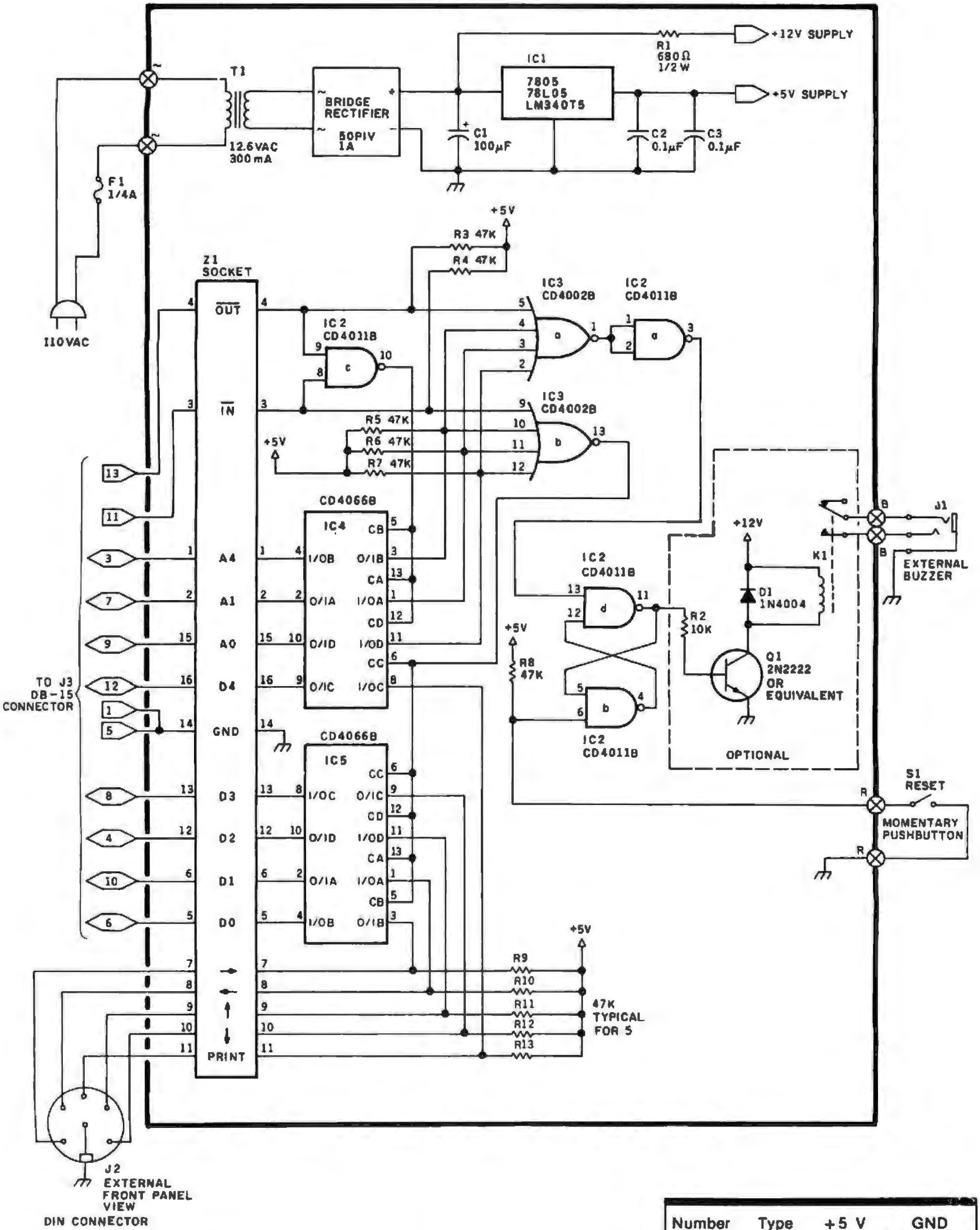

Figure 3: *A schematic diagram of the Handi-Writer interface. The circuit is used to connect a TRS-80 to the five-button selector panel that lets the usef choose items for printing. The area in dotted lines at the right of the diagram is an optional circuit that enables the user to sound a buzzer by selecting an item from the Handi-Writer menu.*

Number	Type	+5 V	GND
IC1	7805	SEE	SCHEMATIC
IC2	CD4011B	14	7
IC3	CD4002B	14	7
IC4	CD4066B	14	7
IC5	CD4066B	14	7

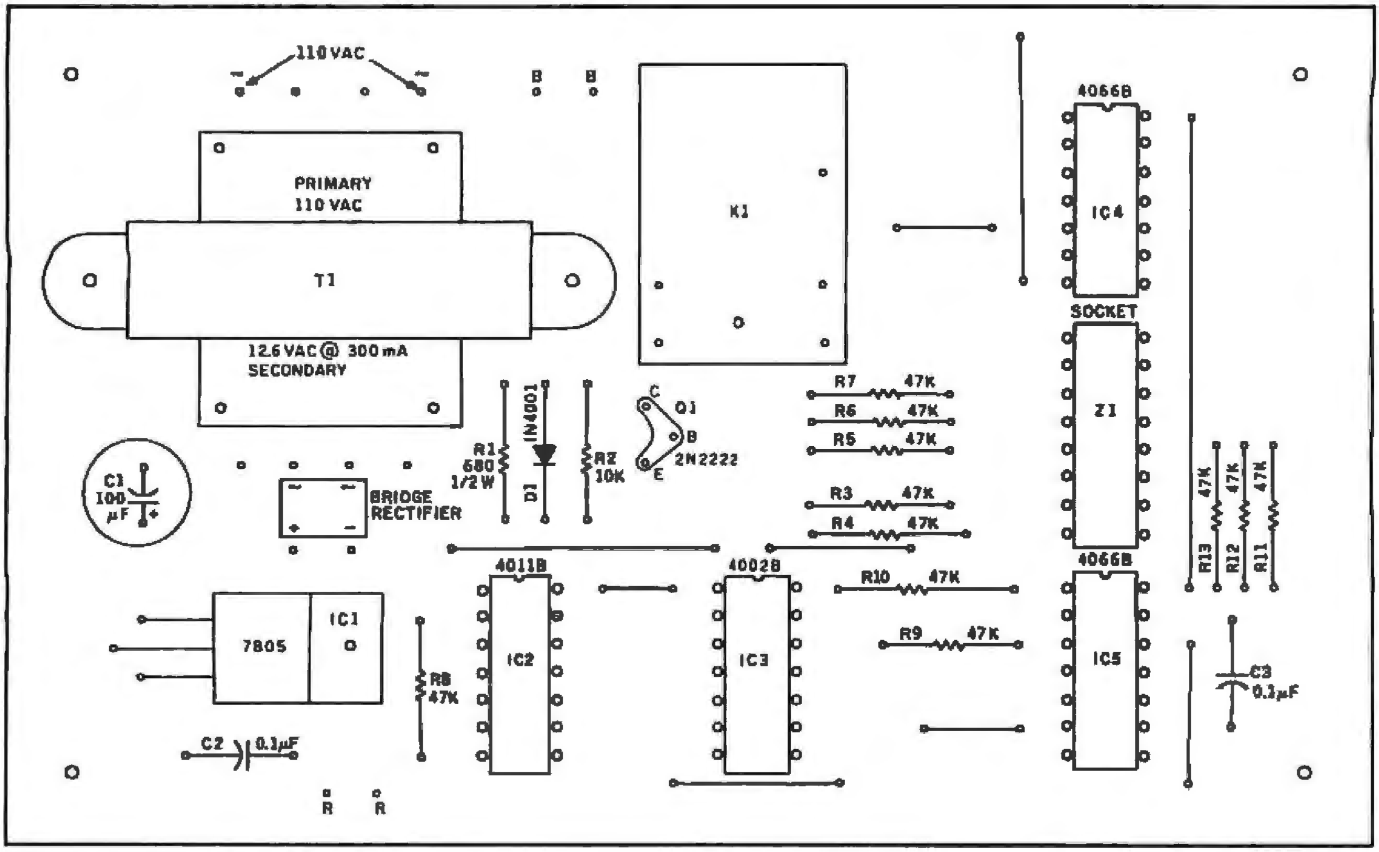

Figure 4: *A diagram of the placement of parts on the Handi-Writer printed-circuit board. The parts are listed in table 2.*

Part Numbers in Placement Diagram	Description	Radio Shack number
C1	100μF/35V electrolytic (PC mount)	272-1028
C2	0.1μF disk capacitor	272-1069
D1	IN4001 rectifier diode	276-1101
FWB	1-amp 50PIV Full Wave Bridge (DIP)	276-1161
J1	3-way open circuit phone jack	274-312
J2	6-conductor DIN jack	
J3	15-conductor DB-15 jack	
K1	12-volt relay, 1k-ohm coil	275-003
Q1	2N2222 or equivalent NPN silicon transistor	276-2016
R1	680-ohm ½-watt carbon resistor	271-021
R2	10k-ohm ¼-watt carbon resistor	271-1335
R3-R13	47k-ohm ¼-watt carbon resistor	271-1342
S1	SPST Mom. contact switch (normally open)	275-619
T1	12.6V @300 mA transformer	273-1385
U1	+5 V regulator (7805, 78L05, LM340T5, etc.)	
U2	4011B quad 2-input NAND CMOS IC	276-2411
U3	4002B dual 4-input NOR CMOS IC	
U4, U5	4066B quad bilateral switch CMOS IC	276-2466
Z1	16-pin header	276-1980
	or prewired 6" ribbon cable w/DIP plug	276-1976

Other Parts	R/S Number
Cabinet	270-269
¼-amp fast-acting fuse	270-1270
Fuse holder (chassis mount)	270-364
110 VAC line cord	278-1255
14-pin IC sockets (5)	276-1999
16-pin IC socket (1)	276-1998
15-pin "D" plug for cable to computer	
40-pin edge connector for TRS-80	276-1558
6-pin DIN plug for cable to selector panel	
Selector panel switches as appropriate (5) (momentary contact, normally open)	

Table 2: *Parts list for the Handi-Writer, keyed to figure 4.*

action. Since the input port is repeatedly addressed within this GOSUB-RETURN loop, the effect is to scan the input switches continually and jump out of the loop only if one of the selector-panel switches is pressed.

If the same port location is addressed as an output port, the execution of a BASIC OUT statement drives the TRS-80 $\overline{\text{OUT}}$ edge connector pin low, drives IC2 pin 10 high (which closes the address switches b, a, and d of IC4, allowing the address-bus lines A0, A1, and A4 to be decoded by IC3a), and drives IC3a pin 5 low. The combination of $\overline{\text{OUT}}$, A0, A1, and A4 all low at pins 2 through 5 of IC3a drives IC3a pin 1 high. This signal is inverted and fed to pin 13 of IC2, which is the $\overline{\text{SET}}$ input of a cross-connected RS flip-flop. Once pin 13 is taken low, pin 11 will remain high until manually reset by S1. As long as IC2 pin 11 is high, base drive saturates Q1 and keeps relay K1 closed. The switch contacts of relay

K1 can then be used to activate an external device such as a buzzer going to the nurse's station. This could be an indispensable aid for a quadriplegic or anyone else who is physically unable to activate a conventional hospital-type buzzer to summon aid.

The board accommodates all components required to include this buzzer option. If you don't want the buzzer feature, simply omit the buzzer circuit components (shown inside the dotted lines on the right in figure 3) and lines 350 through 370 of listing 1. Also, in line 780, change "BUZZER" to another menu word you'd like, and edit line 160 to read "IF L>69 K=8 ELSE K=24".

A conventional full-wave bridge rectifier circuit powers the unit. Note that there is no ON-OFF switch required (although you can add one if you want). The AC line is fused with a ¼-amp fast-acting fuse element. A low-power 78L05 5-volt regulator in a TO-92 case was used; but a standard 7805 or LM340T5 in a TO-220 case will work and will fit the PC board layout with no changes. R1 is a dropping resistor to lower the coil voltage of relay K1 to about 12 volts. The relay specified in the parts list (and for which the PC board is tailored) has a coil resistance of 1 kilohm and therefore draws about 12 milliamperes when activated.

Connecting the Handi-Writer

The Handi-Writer board requires 5 input signals from the pushbutton switches and 11 computer lines (including ground), as shown in figure 3. The board connection to the appropriate chassis jacks is simplified by using a 16-pin socket at Z1 to accept either a 16-pin header or a preconnected ribbon cable with header. For the prototypes we used a 6-pin DIN jack for the external switch-selector panel connectors and a 15-pin "D" socket for the cable leading to the computer. Do not use a standard 5-pin DIN audio cable since this will not permit the required ground connection.

We found the use of shielded cables between the Handi-Writer cabinet, the computer, and the switch-selector panel to be unnecessary. We made the six-wire cable to the selector panel with DIN plugs on both ends so that the cable can be removed, coiled, and stored when not in use. Although the DIN plug and the jack made firm electrical connection, if the selector panel is accidentally dropped or if the cable is inadvertently kicked or pulled, the cable can separate from either the selector panel or the Handi-Writer front panel without damage.

Of course, all the equipment must be placed conveniently for the user. The TRS-80 video display may require a specially made shelf or table. The selector panel can go on a separate table or it can be held in the user's lap. The Handi-Writer cabinet, TRS-80 computer, power supply, and cassette recorder can be placed with the video display unit or out of sight. With Lois's installation, all equipment is left on around the clock except for the video display, which is turned off when not in use. Leaving the equipment on eliminates the need to CLOAD the tape each time the system is used.

The Selector Panel

The physical limitations of the user will dictate the arrangement of the five switches on the selector panel. In Lois's case, we used industrial "panic-button" switches; these have about a half-inch travel for the elevated plunger tops, which are two inches in diameter. We found that the mushroom shape of these switches allowed Lois to hook her fingers around the back of the plunger head and depress the plunger with the palm of her hand. Lois's lack of motor control required placing the five switches about six inches apart and in a nearly straight line.

Other switch arrangements and types are possible, and can be selected to meet the individual physical requirements. For example, a quadriplegic with motor control of only the head, or perhaps only the tongue, could use an appropriately designed custom harness with more sensitive microswitches. Another possibility is fabrication of a corset, necklace, or armband that can respond to contractions of various muscles in the abdomen, chest, neck, jaw—whichever muscles the person can control. Handi-Writer requires only that five motions or movements be distinguishable and that these motions close a normally open switch.

In the beginning, we considered using a selector panel with either touch-activated switches or interruptible light beams. But a dragging motion of the hand across panels of those kinds would continually activate the wrong switch. Both those approaches also add unnecessary electronic complexity to the selector panel. The final selector-panel design uses only simple, normally open switches, is virtually damage-proof, and is impervious to spilled liquids. But individual needs will determine the best approach for switch selection and arrangement.

Conclusions

Handi-Writer demonstrates that a personal computer can serve as the basis for a system that helps handicapped people to communicate. Together with instruction and therapy, Handi-Writer can enable a severely handicapped person to lead an intellectually active life. Although Handi-Writer uses the TRS-80 Model I, other popular computers could be used if the Handi-Writer software were adapted to the characteristics of each computer's video display and version of BASIC.

The Handi-Writer's value became clear when Lois, the system's first user, repeatedly printed the message, "THANKS THANKS THANKS THANKS THANKS" for the system's developers. Handi-Writer can give many other physically handicapped persons something to be thankful for. ■

For More Information

Readers interested in obtaining the Handi-Writer printed-circuit board can do so from the author. A detailed, illustrated step-by step assembly manual and the commercial-quality printed-circuit board are available for $13.50 postpaid. Operating instructions for the Handi-Writer system are also included.

Book Reviews

Apple Machine Language

Don Inman and
Kurt Inman
Reston VA
Reston Publishing Co
1980, 224 pages
$14.95 hardcover
$9.95 softcover

Reviewed by
John Figueras
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Apple Machine Language is an instructional masterpiece that should prove invaluable to anyone trying to learn 6502 machine language for the Apple. The authors pay close attention to good teaching methods, returning to each concept frequently to help reinforce learning; despite the repetition, the book never gets dull.

With its sprightly style and clever cartoons, *Apple Machine Language* is truly fun to read. Each chapter concludes with a set of well-chosen exercises designed to test the reader's comprehension. The book uses an abundance of detailed examples in which each step is carefully explained. In addition, each new piece of information is introduced with a minimum of extraneous detail. The Inmans' clear, jargon-free English provides a welcome contrast to much of the language used in computer literature.

The book assumes the reader is familiar with Applesoft BASIC, and it uses this familiarity as a bridge to understanding machine language. The Inmans draw parallels between assignments, conditional test statements, and loops in BASIC and in machine language.

Apple Machine Language begins with a brief but thorough review of BASIC, with emphasis on PEEK, POKE, and CALL (commands used in what is essentially an assembler written in Applesoft). The authors show how to develop the BASIC Operating System for entering machine language programs, and in the process, they provide an excellent example of how to go about planning a program. PEEKs, POKEs, and CALLs in Applesoft require decimal parameters, but machine-language commands and addresses require hexadecimal. The BASIC Operating System, therefore, must incorporate a hexadecimal-to-decimal conversion routine, prompting a discussion of number systems.

After the BASIC Operating System is running, you can enter the first machine-language programs for such functions as plotting points in low-resolution graphics, displaying text, and generating music. Because these operations require use of Apple monitor subroutines, the book teaches the beginner how to take advantage of subroutines. This feature does, however, make the book unsuitable for owners of 6502-based systems other than APPLE.

After you've had enough practice to feel more comfortable with machine language, the book shows you how to enter programs directly through the system monitor, and, finally, how to use the mini-assembler built into some versions of the Apple monitor. The description of the mini-assembler is particularly good, compensating for the skimpy treatment given the subject in the red Apple technical manual. Once you have mastered the mini-assembler, you're ready to progress to more sophisticated assemblers.

While moving from BASIC Operating System to system monitor to mini-assembler, the book slowly introduces new machine-language commands with programs to show their application. Elementary but thorough consideration is given to binary-to-hexadecimal conversion, the ASCII (American Standard Code for Information Interchange) code, representation of negative numbers, status flags, and addressing modes. The tables at the back of the book should prove useful even to mature Apple machine-language programmers.

The book's few weaknesses do not mar its overall quality. The authors erroneously identify # as the sign for *unequal* in Applesoft. Actually this sign is used in Integer BASIC, and Applesoft requires a <> sign. A few errors in the index direct readers to the wrong page, and the program for the BASIC Operating System could have been written more efficiently (although it is adequate for the authors' purposes).

My greatest argument with the book is its failure to more carefully explain the difference between indirect-indexed and indexed-indirect addressing modes. The authors remark that the names are confusing, but as a beginner in machine language, I found the *concepts* confusing as well. I'm surprised that the authors, who are otherwise very sensitive to the beginner's needs, slighted this source of misunderstanding.

My only regret while reading this book was that it was not available a few years ago, when I was struggling with machine-language programming. How much effort it would have saved me! ■

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APL Runs Circles

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As a professional APL programmer, I was delighted to see the extension of the language into the home-computer market. (See "Three Versions of APL" by Gregg Williams, April 1981 BYTE, page 188.) Now, perhaps, younger programmers will learn the beauty of programming, instead of assuming that they "know computing" from exposure to BASIC.

While the review was thorough, a transcription problem resulted in two errors appearing in the definition of the CIRCLE function. The definition published is shown in listing 1.

To produce the results given in that example, statement 7 should have read as shown in listing 2. (Incidentally, the localization of RD is not needed.) Mr Williams might have produced a more readable program if he had used a leading-decision, rather than a trailing-decision loop as shown in listing 3.

It's regrettable that the looping approach to this problem found its way into print in the first place. The reader is left with the impression that APL is just another interpretive "grinder," with very little more array-processing ability than, say, BASIC. In reality, loops are rarely needed in APL, and properly written nonlooping APL code is far faster than the nested DO LOOP exemplified in the CIRCLE routine. In addition to the elimination of excessive interpretive overhead, the nonlooping approach more nearly approximates human thought processes. Most of us do not think in loops; we should not have to program in loops either.

Listing 4 is the nonlooping version of the CIRCLE routine. If it appears that this is a much more elaborate program than the original, note that most of the statements are comments. The entire function can be rewritten as a "one-liner" as in listing 5. I list this version only to demonstrate the conciseness of the language; I would be horrified if I ever came across it in that form in a production environment.

A point that is all too often overlooked in considering interpretive languages is that each statement must be reinterpreted each time it is executed. This means that in the original version of CIRCLE, for example, statement 7 would have to be interpreted 81 times for the arguments shown (the total number of statements interpreted is, in fact, 330). In CIRCLE3 and CIRCLE4, each statement is interpreted only once. The effect of this reduction in interpretation will become obvious if you study the timing comparisons in table 1.

While I do not have access to a small computer to perform timing comparisons, I did compare processing time for the versions I have mentioned on an IBM Model 3033 using the IBM APL.SV. implementation. To make the timings meaningful, I increased the size of the right argument to 50 by 50 and changed the left argument to 30 20 15 8. (CIRCLE1 is the original CIRCLE routine with my corrections.) The results of the comparisons are shown in table 1.

It is interesting to note that the "one-liner" in CIRCLE4 is actually a tad slower than the CIRCLE3 version. CIRCLE4 would also produce severe space problems in a limited workspace environment. ■

Function Name	Average Processing Time	Ratio (compared to CIRCLE3)
CIRCLE1	1555.4 ms	15.55
CIRCLE2	1538.8 ms	15.39
CIRCLE3	100.0 ms	1.00
CIRCLE4	101.4 ms	1.01

Table 1

Listing 1

```
     ∇ B←AR CIRCLE A;RD;ROW;COL
[1]   ⍝AR CONTAINS [1]ROW COORD [2]COL COORD [3]RADIUS [4]VALUE ADDED
[2]    B←A
[3]    ROW←AR[1]-AR[3]+1
[4]   NEXTROW:ROW←ROW+1
[5]    COL←AR[2]-AR[3]+1
[6]   NEXTCOL:COL←COL+1
[7]    →(AR[3]≤(((ROW-AR[1])*2)+(COL+AR[2])*2)*0.5)/ENDLP
[8]    B[ROW;COL]←B[ROW;COL]+AR[4]
[9]   ENDLP:→(COL<AR[2]+AR[3])/NEXTCOL
[10]   →(0,NEXTROW)[1+ROW<AR[1]+AR[3]]
     ∇
```

Listing 2

```
→(AR[3]<(((ROW-AR[1])*2)+(COL-AR[2])*2)*0.5)/ENDLP
```

Listing 3

```
     ∇ B←AR CIRCLE2 A;ROW;COL
[1]   ⍝AR CONTAINS [1]ROW COORD [2]COL COORD [3]RADIUS [4]VALUE ADDED
[2]    B←A
[3]   ⍝START WITH ROW AT CENTER COORDINATE MINUS RADIUS
[4]    ROW←¯1+-/AR[1 3]
[5]   NEXTROW:
[6]    →((+/AR[1 3])<ROW←ROW+1)⍴0
[7]   ⍝START WITH COLUMN AT CENTER COORDINATE MINUS RADIUS
[8]    COL←¯1+-/AR[2 3]
[9]   NEXTCOL:
[10]   →((+/AR[2 3])<COL←COL+1)⍴NEXTROW
[11]   →(AR[3]<(((ROW-AR[1])*2)+(COL-AR[2])*2)*0.5)⍴NEXTCOL
[12]   B[ROW;COL]←B[ROW;COL]+AR[4]
[13]   →NEXTCOL
     ∇
```

Listing 4

```
     ∇ Z←A CIRCLE3 B
[1]   ⍝NON-LOOPING SOLUTION TO THE CIRCLE PROBLEM FROM BYTE MAGAZINE
[2]   ⍝RIGHT ARGUMENT -- NUMERIC MATRIX
[3]   ⍝LEFT ARGUMENT --
[4]   ⍝    [1]ROW COORDINATE OF CENTER OF CIRCLE
[5]   ⍝    [2]COLUMN COORDINATE OF CENTER OF CIRCLE
[6]   ⍝    [3]RADIUS OF CIRCLE
[7]   ⍝    [4]VALUE TO BE ADDED
[8]   ⍝EXPLICIT RESULT -- MATRIX FROM RIGHT ARGUMENT, WITH VALUE ADDED AT
[9]   ⍝    COORDINATES WITHIN THE CIRCLE
[10]  ⍝BUILD VECTOR OF ROW ADDRESSES WITH SQUARE OF DISTANCES FROM CENTER
[11]   Z←((⍳1↑⍴B)-A[1])*2
[12]  ⍝ADD COLUMN ADDRESSES WITH SQUARE OF DISTANCES FROM CENTER
[13]   Z←Z∘.+((⍳¯1↑⍴B)-A[2])*2
[14]  ⍝TAKE SQUARE ROOT TO CALCULATE ACTUAL DISTANCES
[15]   Z←Z*0.5
[16]  ⍝FIND THOSE WITHIN THE RADIUS SPECIFIED
[17]   Z←Z≤A[3]
[18]  ⍝ADD THE VALUE TO THE INCOMING ARRAY
[19]   Z←B+Z×A[4]
     ∇
```

Listing 5

```
     ∇ Z←A CIRCLE4 B
[1]    Z←B+A[4]×A[3]≥((((⍳1↑⍴B)-A[1])*2)∘.+((⍳¯1↑⍴B)-A[2])*2)*0.5
     ∇
```

Starfighter

Eric Grammer
95 Old Street Road
Peterborough NH 03458

Adventure International recently released Starfighter, an arcade-type game that it describes as the "Penultimate Space War Game." According to my Webster's New Collegiate Dictionary, *penultimate* means "next to the last." Therefore, it was with some wariness that I booted the disk and prepared to blast off. Fortunately, I've played several games since then, so you need not anticipate any *penult* to your life experience—just a good time at the keyboard.

Object of the Game

Starfighter is somewhat similar to Atari's Star Raiders, both in its format and goals. More than a simple "shoot-em-up" game, Starfighter requires both strategy and skill.

You represent the SGA (Solar Galactic Authority), and your duty is to destroy the spacecraft of your enemy, the PRC (Petro Resource Conglomerate). The PRC has four different fighter craft, and the SGA has three fighter and three nonfighter craft. Three other spacecraft do not belong to either side. You can get into a lot of trouble by shooting a neutral vessel. You must destroy enemy craft only!

The SGA has eight Landbases that offer various services. The most important, Landbase Central, is where you receive your rank review and performance ratings. The other Landbases provide these services: Landbase 1, craft overhaul; Landbases 2 and 7, refueling; Landbase 3, tow tickets (in case you run out of fuel); Landbase 5, hypercharge replenishment; and Landbases 4 and 6, bounty (for the enemy craft you destroy).

Your Craft

Your craft, the SC-78503 Starfighter, can exceed the speed of light. To do so requires an energy source called "hypercharge." (If you enjoy speculative "physics," you'll love the detailed descriptions of hypercharge theory.) Should you run out of hypercharge, you can get a full charge at Landbases 5 or 7.

One of Starfighter's best qualities is its Training Lab. At the beginning of the game, new pilots can either shoot at any of 12 targets or can practice simulated combat.

The instructions are written as if Starfighter were an authentic military operation. The 32-page manual explains the function of each of your craft's controls in just about any imaginable situation. It also presents six sample games, all of which are fully annotated by author Sparky Starks. Adventure International also includes a handy quick-reference card.

Getting Started

You must choose option B to begin the game. After you leave Landbase Central, you should familiarize yourself with your spacecraft and your "universe." There are only few practical things to do. You can explore each Landbase or you can go to a "gravity source" (ie; a spacecraft).

To do the former, press the number of the desired Landbase. If a number shows up just below your on-screen range indicator, press that number and the D key. That will drive you to the Landbase. If no number shows

At a Glance

Name
Starfighter

Type
Arcade-style game

Manufacturer
Adventure International
POB 3435
Longwood FL 32750
(305) 862-6917

Price
$29.95 ($24.95 for cassette version)

Author
Sparky Starks

Format
5¼-inch floppy disk

Language
Z80 machine language

Computer
TRS-80 Model I with 32 K bytes of memory (Tape version, TRS-80 Model I or III with 32 K bytes of memory)

Documentation
32-page softcover

Audience
Anyone interest in computer arcade games and space-simulation games

up, the Landbase is unavailable to you in your space/time location. To leave a Landbase, press the D key again.

To drive to a source of gravity, press the E key and wait for a number to show up below the range indicator. A number will always show up, but you may need to be patient. Your intelligent scanners insure that the gravity readings are for spacecraft and do not include any Landbases.

Other starting options include: waiting for another craft to drive into your space/time locus, practicing craft maneuvers, or crash-driving (driving in one direction with no destination in mind).

Playing the Game

Because your goal is to destroy enemy fighters, you will want to track and confront other spacecraft. Once you've approached an unknown vessel, you should press the C key to enter Combat mode (in case you've discovered a PRC craft). Next, press a W or B to ready your weapons (W means wave and B means beam, as described in the manual) and press T for tracking and O to unlock your keyboard. To help you distinguish friend from foe, press the I key (for identification). The other combat controls are described in the manual.

If you run out of hypercharge, press P to summon a tractor craft rescue unit. This rescue craft will come only if you have purchased a tow ticket at Landbase 3 (see the manual for other constraints on the rescue unit's appearance).

Possible Improvements

Several weak points in Starfighter could stand improvement.

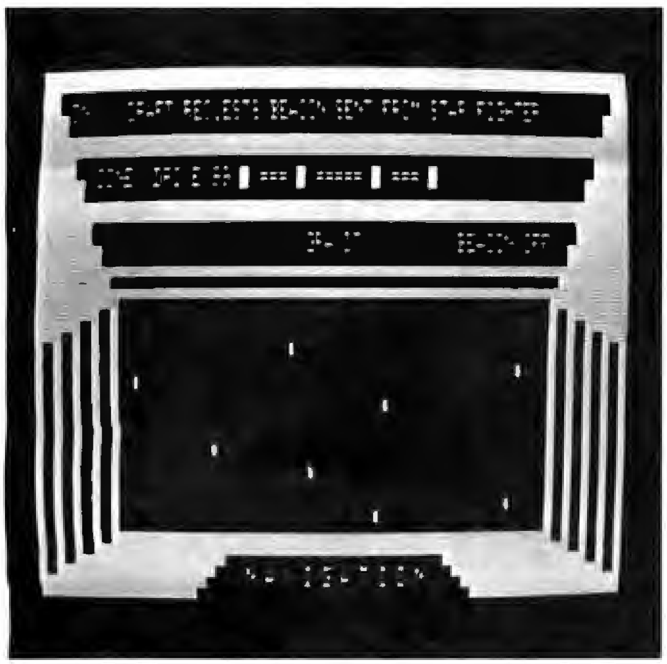


Photo 1: *Adventure International's Starfighter game in progress.*

- It takes too long for your weapon to ready itself, which means that a PRC Exonerator can fry you before you can defend yourself.
- It would be nice if you could drive without requiring a zero-velocity condition.
- It would also be nice if you did not have to clear the keyboard to "arrow" the directions.
- Much of the display screen is used for a graphic design; it really should be used more constructively.
- When first starting out, there are no skill levels to choose from.
- After driving away from a Landbase, the drive process is so extended that it cuts into the game time.

Conclusions

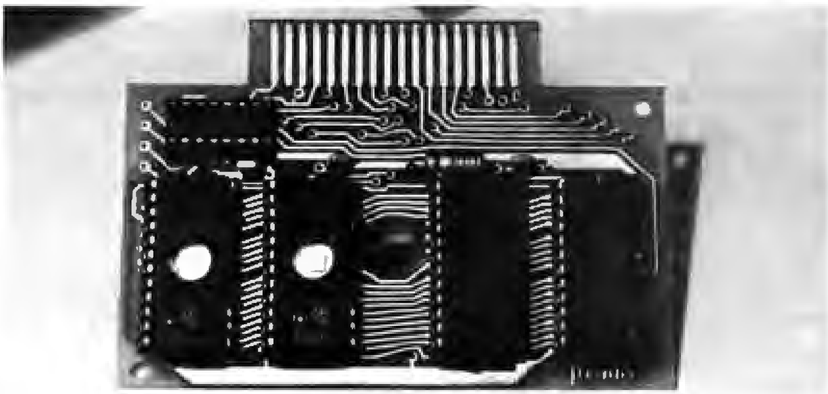
Starfighter is a well-made program, despite its weak points. It is the kind of space adventure that requires strategic thinking to be played successfully. Starfighter offers excitement and excellent use of TRS-80 graphics and sound.

You need to read the documentation, which should answer most of your questions. However, it contains quite a bit of technical information that I found useless.

Starfighter can be played on a TRS-80 Model I or III microcomputer with 32 K bytes (or more) of memory. (A version for the Apple II is also available from Adventure International.)■

What's New?

MISCELLANEOUS



More for the TRS-80 Color Computer

The 8 K-byte CMEMORY cartridge for the *TRS-80* Color Computer can be divided into any combination of 2 K blocks of RAM (random-access read/write memory) and/or 2716 EPROMs (erasable prorammable read-only memories). The cartridge can be filled with RAM while debugging a program and then replaced by EPROM once debugging is completed. The CMEMORY occupies the unused address space hexadecimal C000 to E000 normally reserved for plug-in game cartridges. By adding a jumper, the Color Computer can automatically execute a program in EPROM whenever the Reset button is pressed. The CMEMORY cartridge without any memory sells for $24.95 from Micro-Labs Inc, 902 Pinecrest, Richardson TX 75080.

Circle 550 on inquiry card.

5 V DC at 3 A Supply

Deltron has introduced the HVQ series of linear open-frame power supplies. Four single-output regulated models have voltages of 5 to 24 V DC with ratings up to 3 A. All 5 V DC models have built-in fixed crowbar OVP (overvoltage protection). Shielded transformers, socketed semiconductors, dual AC input, and barrier block terminals are among the other features of the HVQ series.

Adjustable OVP is available for 12, 15, and 24 V DC models as an option. Reverse-voltage protection is also available as an option. The 5 V DC models have a suggested price of $21. For more information, contact Deltron Inc, Wissahickon Ave, POB 1369, North Wales PA 19454, (215) 699-9261.

Circle 553 on inquiry card.

Memory for the STD Bus

The CD0331 is a 64 K-byte dynamic memory card for the STD bus from Computer Dynamics Inc. The CD0331 features include 6 MHz operation with no wait states. A version of the card is available for critical, high-temperature, or industrial requirements. The card is compatible with all Z80-based STD bus systems. It provides memory options of 16 K, 32 K, 48 K, or 64 K bytes and will support speeds of 2.5, 4, or 6 MHz.

Prices range from $210 for a 2.5 MHz card with sockets only, to $695 for a complete 6 MHz unit with memory installed. For complete details, contact Computer Dynamics Inc, 105 S Main St, Greer SC 29651, (803) 877-7471.

Circle 551 on inquiry card.

Disk-Duplicating Service

Allenbach Industries' floppy-disk-duplicating service can copy disks formatted for Apple, Atari, TRS-80, North Star, Heath, and other microcomputers. Special word-processing formats, such as Lanier's "No Problem," CPT 8000, and Micom, can also be copied. For more information, contact Allenbach Industries, 4322 Manchester Ave, Olivenhain CA 92024, (800) 854-1515; in California (714) 436-4351.

Circle 552 on inquiry card.

Rectifier Modules

The B48-2 series of single- and three-phase rectifier modules are rated at 50 A (three-phase). They are available in voltages from 200 to 1200 V and with diode-doubler and half- and full-wave circuit configurations.

The B48-2 package is fully isolated, and the insulation will withstand a 4000 V test. To request price information and other details, plus a catalog, contact Gentron Corporation, 6667 N Sidney Pl, Milwaukee WI 53209, (414) 351-1660.

Circle 554 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 judgment the information might be of interest to the personal computing experimenters and homebrewers who read BYTE, we print it in some form. We openly solicit releases and photos from manufacturers and suppliers to this marketplace. The information is printed more or less as a first-in first-out queue, subject to occasional priority modifications. While we would not knowingly print untrue or inaccurate data, or data from unreliable companies, our capacity to evaluate the products and companies appearing in the "What's New?" feature is necessarily limited. We therefore cannot be responsible for product quality or company performance.

What's New?

MISCELLANEOUS

Recycled Ribbons

Reloaded multistrike film ribbons are available from Torres Ribbon Services. Cartridges are reloaded for printers such as NEC, Diablo, Qume, and Radio Shack and for word-processing systems including Wang, Lanier, IBM, Savin, and Vydek. All cartridge parts are cleaned or replaced where necessary. Broken ribbons with substantial unused life will be repaired at no charge when submitted as part of an order. Each ribbon costs $2.50 with the exchange of used cartridges. Details are available from Torres Ribbon Services, 11154-PC S Mt Vernon Ave, Colton CA 92324, (714) 792-0831.

Circle 555 on inquiry card.

Memory and I/O Cards for the AIM-65

Expand your AIM-65's memory and I/O (input/output) performance with the Series 100 boards from Unique Data Systems. The basic board, the Model UDS-100, has two data-rate-selectable asynchronous serial RS-232C channels and 20 programmable parallel I/O lines. Sockets are provided for eight 1 K by 4 static programmable memory circuits and six 2 K by 8 EPROMs (erasable programmable read-only memories). Jumpers allow reconfiguration for higher-density memory devices.

The Series 100 boards interface to the AIM-65 without bus buffering. Each board has an experimenter's area for custom circuitry. The basic assembly costs $259 or $296 with battery backup. For more details, contact Unique Data Systems Inc, 15041 Moran St, Westminster CA 92683, (714) 895-3455.

Circle 556 on inquiry card.

PROCAP

PROCAP is a statistics and probability package that gives the TRS-80 Model I or III computational capabilities for analyzing, forecasting, and producing a wide range of professional football statistics. Using PROCAP, you can rapidly predict the outcome of weekly games with probable scores and point spreads, evaluate a team's offensive and defensive strengths, and review divisional standings and team and divisional power ratings. PROCAP will let you review the scores of past games and peek at the upcoming schedule.

PROCAP uses the game scores you enter each week to determine the outcome of future games and to rank teams according to performance. Ratings are computed by comparing a team's offensive and defensive strengths against those of its opponents. PROCAP costs $49.95 and is available from the Trinity Group, 829 Malin Rd, Newtown Square PA 19073, (800) 543-3000, operator 400; in Ohio (800) 582-1364, operator 400.

Circle 557 on inquiry card.

MX-80/70 Friction-Feed Kit

The Gosub friction-feed kit will allow you to use your letterhead stationery and single-sheet or roll paper with the Epson MX-80/70 printers. The kit uses an opposing roller system for the feed. You load and adjust the paper as you would for a typewriter. Carbon copies present no problem.

The Gosub friction-feed kit comes with a paper-roll rack for 8½-inch Teletype rolls and costs $49.95. It's available from Gosub International, Hardware Division, POB 275, Wichita KS 67201.

Circle 558 on inquiry card.

TAB Books Catalog

Learn how to build robots and computers, program in BASIC and FORTRAN, and design and troubleshoot circuits with books from TAB Books Inc, Blue Ridge Summit PA 17214, (717) 794-2191. The company's free catalog lists and describes hundreds of computer-related books.

Circle 559 on inquiry card.

The Latest In Slit-N-Wrap

The P184-7 AC-powered wire-wrapping tool features an electronic turns counter. Developed by Vector Electronic Company, the tool permits daisy-chain or point-to-point wrapping in an average of 1 second per post without measuring, cutting, or stripping.

Here's how the P184-7 works: a spool with 300 feet of wire is mounted on top of the tool. The operator selects from three to nine turns by setting a switch, then positions the tool and wraps. As the wire passes through the tool, the insulation is stripped before the wire is bound to the post. The turns are counted, and the operation is stopped at the selected number.

The P184-7's counter can be bypassed when using stripped wire. A 300-foot spool of wire provides 900 post wraps with seven turns and an average lead length of 2 inches. A sleeve notch eliminates the need to hold the wire. The P184-7 tool costs $198. Replacement bits are $10.60, and a 300-foot spool of wire costs $14.95. Available from Vector Electronic Company Inc, 12460 Gladstone Ave, Sylmar CA 91342, (213) 365-9661.

Circle 560 on inquiry card.

What's New?

MISCELLANEOUS

Z80B-Based Microcomputer

Zelco S.R.L.'s MCW (microcomputer Winchester) uses a 6 MHz Z80B microprocessor and is set up for a multiprogramming, multiuser environment. In the multiuser configuration, the MCW has a minimum capacity of 112 K bytes of programmable memory with 48 K bytes for each user and 16 K bytes shared. MCW includes Shugart's 8- or 14-inch Winchester hard-disk drives with a minimum storage capacity of 10 megabytes and a maximum of more than 150 megabytes. The controller serves up to four units, three of which are Winchester drives; the other is an 8-inch 1.2-megabyte floppy-disk drive or 10-megabyte cartridge unit. The system includes RS-232C ports.

MCW's disk operating system is based on Zilog's RIO and is compatible with all programs that can run under RIO. The operating system can handle four mass-storage units, each with up to 2 gigabytes of data. Another operating-system utility allows the exchange of messages between users without altering normal operations.

The price for a two-user system with 112 K bytes of programmable memory and a Centronics-compatible port is approximately $10,000. Contact Zelco S.R.L., Via V Monti 21, 20123 Milan, Italy, Telex 335346 ZELCO.

Circle 561 on inquiry card.

North Star Business Software

More than 20 business and utility programs for the North Star computer are listed and described in a free catalog from Omni Software Systems Inc, 146 N Broad St, Griffith IN 46319, (219) 924-3522.

Circle 562 on inquiry card.

Data Acquisition and Control System

ASC's (Applied Systems Corporation's) Data Acquisition and Control System uses either Intel's 8085/8086, Zilog's Z80/Z8000, or Motorola's 6800/68000 microprocessors as central-processing units. The system has a 0.5μs instruction cycle, multilevel priority interrupts, fast multiply and divide arithmetic, macro-logical operations and interfacing for high-speed A/D (analog-to-digital) conversion, serial data-communications modules, and 8-, 16-, and 32-bit commands. It incorporates full digital computer and analog signal processing capabilities, RAM (random-access memory), PROM (programmable read-only memory), peripheral controllers, and IEEE/S-100, MULTI, and EXOR bus compatibility for data acquisition and automation installations in production monitoring, process and machine control, automatic testing, or laboratory-analysis applications.

The system is offered with options for standard 19-inch rack-mounting chassis, NEMA (National Electrical Manufacturers Association) industrial cabinets, or miniature portable enclosures. Standard plug-in cards permit installation of expansion modules for multiple A/D converters, high- or low-level multiplexers, disk-drive controllers, digital I/O (input/output) adapters, and more. Among the optional system features are additional I/O capabilities for analog multiplexers for up to 256 inputs, transducer amplifiers for ± 50 mV to ± 15 V, high-speed A/D conversion, IEEE-488 interface adapters, high-resolution color graphics, and character or matrix printer adapters.

Prices for the Data Acquisition and Control System start at $1900. A card-only version is available for approximately $900. For details, contact ASC, 26401 Harper Ave, St Clair Shores MI 48081, (313) 779-8700.

Circle 563 on inquiry card.

Testing One, Two, Three

Solid State Testing Inc is an independent service that specializes in testing microprocessors, programmable and read-only memories, custom LSI (large-scale integration) chips, and MOS (metal-oxide semiconductor) integrated circuits. Solid State will also burn-in static and dynamic memory devices. Among the circuits the company tests are the Z8, 6800, Z80A, 8085A, and microprocessor-support circuits. Solid State Testing will test prototype to production quantities.

For additional details, contact Solid State Testing Inc, 56 Middlesex Turnpike, Burlington MA 01803, (617) 272-0972. In New Jersey, contact Solid State Testing at 620 Route 23, Pompton Plains NJ 07444, (201) 839-8220. In Florida, the address is 406 Kirby Ave, Palm Bay FL 32905, (305) 729-0670.

Circle 564 on inquiry card.

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OKIDATA Microline 80, 80 cps, 9x7 dot matrix		$495
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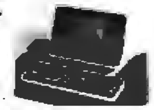

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Circle 431 on inquiry card.

What's New?

SYSTEMS

S-100 Gets a 68000 Board

The CPU/68000 processor board is designed for the S-100 bus. It has 32-bit internal architecture, seven prioritized interrupt levels, and up to 16 megabytes of direct addressing using the S-100 standard 24-line address bus. A ROM- (read-only memory) resident monitor is provided onboard. The 8 MHz board runs with all 4 MHz S-100 peripherals.

The CPU/68000 board is included in the Model 68KS system. The 68KS has 32 K bytes of nonvolatile memory, 32 K bytes of EPROM (erasable programmable ROM), and serial input/output ports in a 12-slot cabinet with power supply. The battery-backed memory stores programs even when the power is off.

The Model 68KS system costs $3685. The CPU/68000 card alone costs $1195. For additional details on these products, contact Dual Systems Control Corporation, 1825 Eastshore Highway, Berkeley CA 94710, (415) 549-3854. **Circle 574 on inquiry card.**

Z80 Card for H-8 Microcomputers

The HA-8-6 Z80 card is designed to replace the 8080A microprocessor supplied with the Heath H-8 computer. The card is compatible with all current Heath-disk-based software for the H-8. The HA-8-6 is based on the Z80, so it runs faster than the 8080A. With the HA-8-6, H-8 owners do not need to purchase the extended configuration option before adding the Heath CP/M system or Heath H-47 8-inch floppy-disk drives. The HA-8-6 Z80 card is assembled and tested and costs $179. Contact Heath Company, Benton Harbor MI 49022, (616) 982-3210. **Circle 575 on inquiry card.**

Three-Processor Microcomputer

Using a 16-bit 68000 microprocessor for main control, a 68000 for virtual-memory control and number-crunching, and a 6809 to handle I/O (input/output), the MiniFrame is designed for 12 MHz operation with no wait states. MiniFrame can address up to 4 billion bytes and handles demand-paged virtual memory in 16-megabyte increments. The computer works with floppy and/or hard disks and is designed for single- or multi-user operation under UNIX.

A single-user MiniFrame starts at under $12,000, which includes 256 K bytes of programmable memory, 2 megabytes of 8-inch floppy-disk storage, six RS-232C ports, four parallel ports, one direct-memory-access port, and the UNIX Version 7 operating system. The UNIX package includes FORTRAN-77, C, BASIC, and text- and file-processing utilities. The MiniFrame will also support CBASIC, FORTH, LISP, APL, and most Microsoft languages. Contact MicroDaSys Inc, 68 K Division, 2811 Wilshire Boulevard, Santa Monica CA 90403, (213) 829-6781. **Circle 576 on inquiry card.**

Portable Attache

The Attache is a portable microcomputer that weighs 18 pounds and features a Z80A microprocessor, a 5-inch video display, two 180 K-byte floppy-disk drives, a standard keyboard that flips down, and 64 K bytes of programmable memory. A second microprocessor takes care of the disk drives and two serial ports.

Standard software supplied is CP/M, an enhanced WordStar word-processing program, and extended BASIC. The UCSD Pascal system is also available, and any programs written for CP/M or UCSD Pascal can be run on the Attache. Options include graphics, AC or battery operation, and a multifunction board with a general-purpose interface, parallel input/output, and analog input. Contact Otrona Corporation, 2500 Central Ave, Boulder CO 80301, (303) 444-2274. **Circle 577 on inquiry card.**

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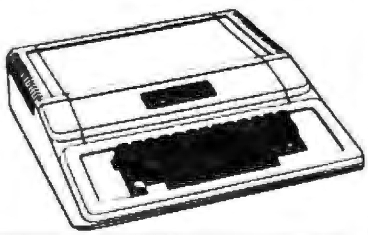

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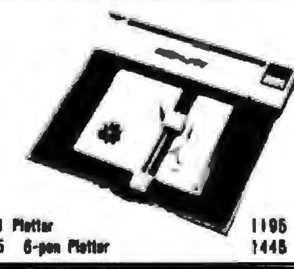

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PERIPHERALS

8-Megabyte, 5-Inch Floppy-Disk Drive

Amlyn Corporation has designed a family of 5-inch floppy-disk drives that use a 5-disk cartridge to provide up to 8 megabytes of storage. The Model 5850 is interface-compatible with Shugart SA-850 drives, and each cartridge appears to the controller and software as an SA-850 drive. The Model A506 is storage-compatible with Seagate Technology ST506 hard-disk drives.

The disk cartridge holds five special 5-inch floppy disks and is designed to allow users to easily change an entire cartridge at a time or individual disks within it. Because of the mechanical selection and insertion of disks, possible operator-handling damage is eliminated.

Both models use an Intel 8051 microprocessor to handle the control functions. Disks recorded at densities of 48, 96, or 100 tpi (tracks per inch) can be read by these drives. The microprocessor provides control to compensate for disk-dimensional changes. Head positioning is referenced to a single track on each disk. The disks can handle a 9500-bit-per-inch recording density. Typical unformatted capacities are 4 megabytes per cartridge with 800 K bytes per disk in single-density recording and 8 megabytes per cartridge—1600 K bytes per disk and 10.4 K bytes per track—in double-density mode. The capacity using the IBM format is slightly less. The Seagate ST506 format allows double-density capacities of 6.3 megabytes per cartridge. The transfer rate for these capacities is 250 kbps (thousand bits per second) in single-density and 500 kbps in double-density. The average seek time is 70 ms. The Amlyn drives are physically compatible with existing 5-inch drives and cost approximately $1250. Contact Amlyn Corporation, 1758-H Junction Ave, San Jose CA 95112, (408) 275-8616.

Circle 578 on inquiry card.

Digital-Cassette System

The LG 1 digital minicassette system can be used for backup, data logging, and transmission. It features an RS-232C port or 20 mA current loop and it can store 96 K bytes per tape. The LG 1 contains an operating system, has variable data rates, and automatically checks for errors and performs retries. All I/O (input/output) is buffered.

The LG 1 digital-cassette system is available for $399 without a case or $499 with a case. Contact ADPI, 815 Diana Dr, Troy OH 45373, (513) 339-2241.

Circle 579 on inquiry card.

26-Megabyte Drive Down in Price

The Discus M26 26-megabyte, 14-inch hard-disk drive costs less than $173 per megabyte. The price of this S-100-based system has been reduced by $500 to $4495. The M26 features a Shugart SA4000 Winchester-style drive with a data-transfer rate of up to 900 k bytes per second. It delivers a full 26 megabytes of formatted storage and can be expanded up to 104 megabytes by daisy-chaining drives. An S-100 controller supervises all data transfers and can generate system interrupts at the completion of each data-exchange command. Database security is maintained by write-protecting each sector.

The M26 runs under CP/M and can be run under North Star and Cromemco disk operating systems. The Discus M26 system consists of the hard-disk drive, cabinet, power supply, all cables, S-100 controller, and CP/M 2.2. For further information, contact Morrow Designs, 5221 Central Ave, Richmond CA 94804, (415) 524-2101.

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Circle 581 on inquiry card.

Computerized Dictionary

Release 2 of the Computerized Dictionary checks text for spelling errors and runs under the FLEX operating system. Misspelled words are highlighted and can be changed automatically by the system. In the interactive mode, any words not found in the dictionary file are displayed. The operator can ignore the word, replace it, or add it to the dictionary file. Frequently misspelled words can be automatically changed by the system. In the list mode, the text is printed or displayed as it is being processed with misspelled words highlighted. A full page of text, about 425 words, can be edited in 3½ minutes. Current licensees can receive release 2 for $25. The package has a one-time charge of $100 from Davidson Software Systems, POB 21002, Lansing MI 48909, (517) 332-5989. **Circle 584 on inquiry card.**

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Compatible with Digital Research's CP/M operating system, TurboDOS handles program loading six times faster than CP/M and is up to 10 times faster in file-oriented applications. The speed-up is accomplished by a buffer manager that performs multilevel buffering of disk I/O (input/output) and by a feature that scans the allocation map of a file, determines the sequentially allocated segments of the file, and loads these segments at the maximum transfer rate of the disk controller. The elimination of warm-start and disk log-on delays is another feature of TurboDOS. Changes of disk side and density formats are automatically handled by the system. Most CP/M programs will operate under TurboDOS without modification provided that the programs do not rely on internal CP/M data structures or use bit maps. CP/M BDOS functions and direct BIOS calls are fully supported. An alternative to the CP/M format increases the storage capacity on each floppy disk to hold 25 to 35% more data.

TurboDOS can be configured as a single- or multi-user system. It will support hard disks in excess of 1000 megabytes without partitioning and allows random access to files up to 67 megabytes. Provisions are made for independent drive operation permitting system start-up from any disk drive. Up to 16 spooler queues are supported, which allows a single printer to print from many queues or a single queue to feed several printers. Multiple commands are accepted, and multilevel nesting of command files is possible.

TurboDOS is available for IMS S-100 computers, TRS-80 Model IIs, and Info 2000 systems. Depending upon configuration, TurboDOS costs from $195 to $700. Contact Data-Rx Inc, 686 Lighthouse Ave, Monterey CA 93940, (408) 375-2775.

Circle 582 on inquiry card.

CP/M Magnetic Cartridge Archive

MCSave is designed to interface the 67-megabyte 3-M HCD-75 magnetic-tape-cartridge drive and controller to any Z80 CP/M, CDOS, or Cromix system. Features provided by MCSave (Magnetic Cartridge Save) are transfer of files from disk to tape, tape to disk, or tape to tape for any multiple tape-drive configuration. Date and time of tape-file creation, ambiguous file names, batch/submit capability, relative file names, and self-test diagnostics are all supported.

MCSave is shipped ready to interface to a Cromemco 8PIO card, but the program can be customized for different hardware systems. It requires 48 K bytes of memory and a 24-line by 80-column video display. MCSave with documentation and one year of free update service is $295. A complete system, which includes the tape drive and controller, S-100 interface card, tapes, power supply, and MCSave, is $4995. Contact Microcomputer Consulting Services, 8308 Juniper, Fort Worth TX 76180, (817) 498-6390.

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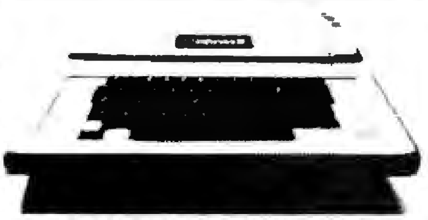

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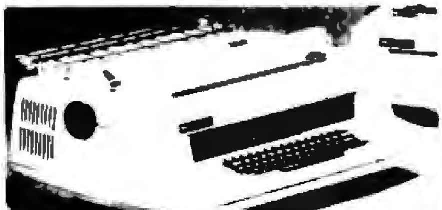

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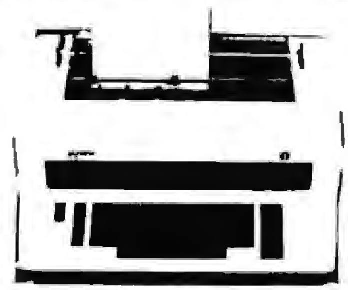

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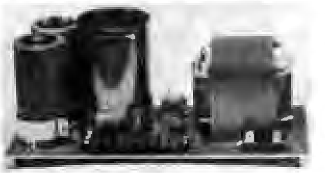

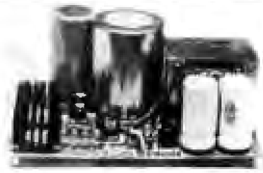

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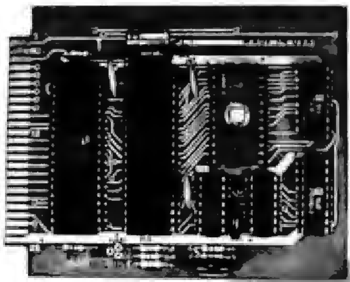

Z-80 MPU, Z-80 PIO, 2716 EPROM 2114 RAM single board computer. Single 5 volt power supply at 300 Ma. Two independent 8 bit I/O ports with handshake lines. RC controlled 2MHz clock.

Complete documentation. I/O lines use 50 pin edge connector data and address lines are not accessible. Mod. for 2532 is included. EPROM is not included. 1K RAM, 2K EPROM, 2 I/O ports.

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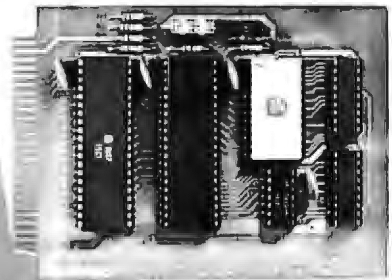

6502 MPU, 6522 VIA, 2716 EPROM 2114 RAM single board computer. Single 5 volt power supply at 400 Ma. Two independent 8 bit I/O ports with handshake lines. RC controlled 1 MHz clock.

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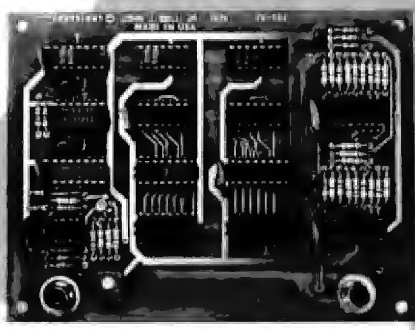

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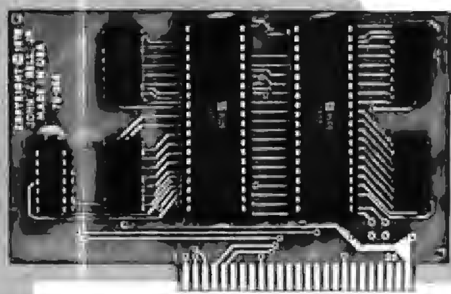
6522 APPLE II INTERFACE



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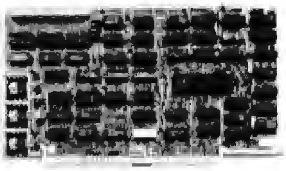

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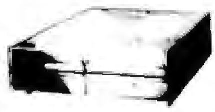

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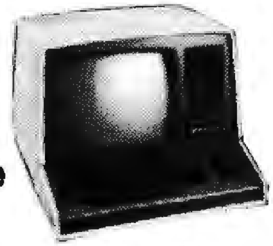

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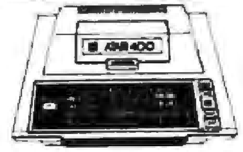

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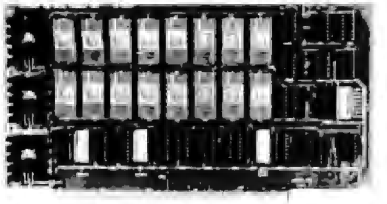

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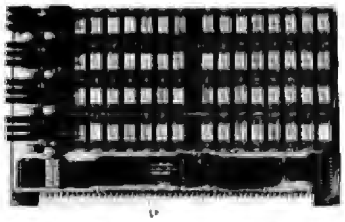

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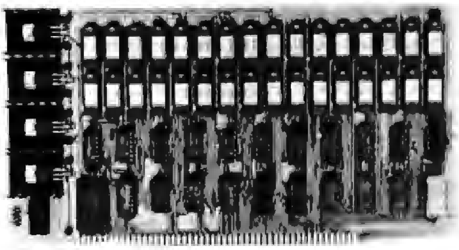

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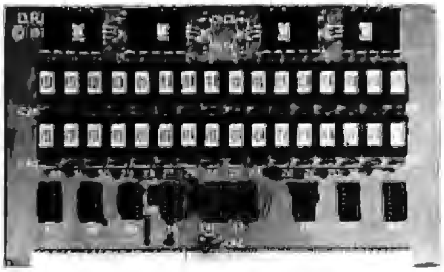

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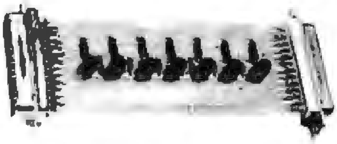

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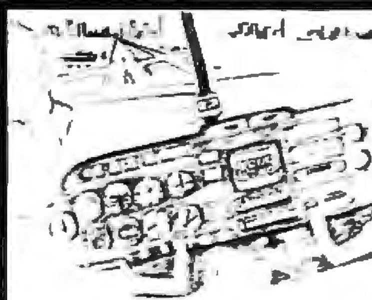

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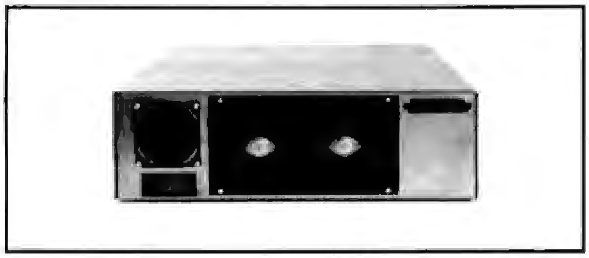

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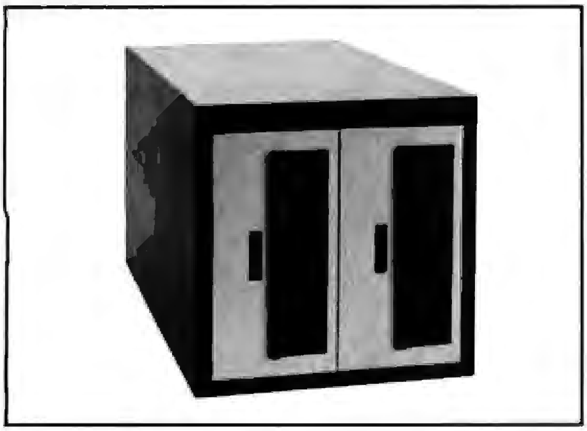

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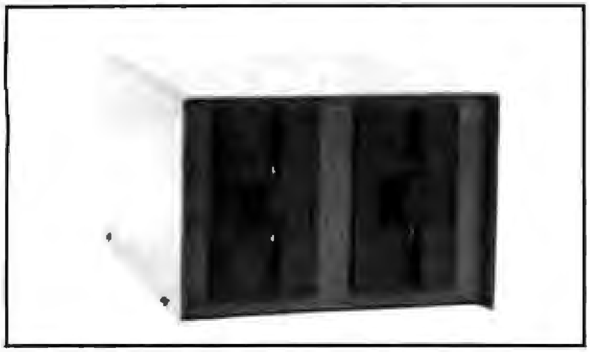

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By Fred Huntington

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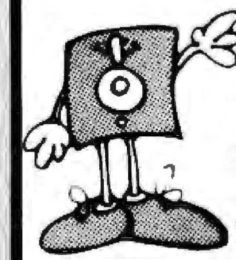

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26	IDH26SRB	2.75	IDH26WRB	5.35
34	IDH34SRB	3.75	IDH34WRB	6.25
40	IDH40SRB	3.75	IDH40WRB	7.35
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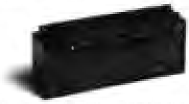
.1" Spacing. Mounts on PC Board & Mates with IDS Socket below. Ejector Bars - 4/1.00.



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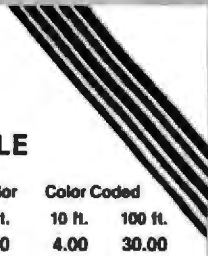
Size	Part No.	Price
10	IDE10B	$3.95
20	IDE20B	4.35
26	IDE26B	5.00
34	IDE34B	6.05
40	IDE40B	6.90
50	IDE50B	7.50

.1" Spacing. Crimps onto cable with ordinary vise & mates with standard .062" Card Edge.



RIBBON CABLE

	Solid Color		Color Coded	
Size	10 ft.	100 ft.	10 ft.	100 ft.
10	2.90	17.00	4.00	30.00
14	3.40	23.80	5.00	42.00
16	3.70	27.20	5.60	48.00
20	4.40	34.00	7.00	60.00
24	5.00	40.80	8.00	72.00
26	5.40	44.20	8.60	78.00
34	6.80	57.80	11.00	102.00
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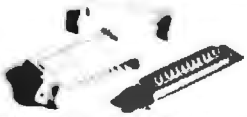

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Cover	IDB25C	1.60

Solder Style solders onto cable, IDC Style crimps onto cable with vise. 9, 15, 37 and 50 pin available also.

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Size	Part No.	Price
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16	IDP16B	1.65
24	IDP24B	2.50
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.1" Spacing. Crimps onto cable with ordinary vise & plugs into standard IC Socket.

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WIRE WRAP WIRE

#30 Wire Wrap Wire

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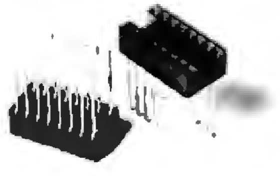
4.5"	1.63	5.21	9.39
5.0"	1.69	5.54	10.04
5.5"	1.74	5.92	10.69
6.0"	1.82	6.23	11.34
6.5"	2.11	7.08	12.99
7.0"	2.19	7.44	13.68
7.5"	2.29	7.78	14.40
8.0"	2.35	8.12	15.10
8.5"	2.40	8.46	15.80
9.0"	2.46	8.92	16.51
9.5"	2.53	9.15	17.22
10.0"	2.63	9.58	17.91

All lengths are overall, including 1" strip on each end. Choose from colors; Red, Blue, Black, Yellow, White, Green, Orange, and Violet.



Size	Part No.	Each	Tube
08	ICN083WBSG	.44	52x .39 = $20.28
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16	ICN163WBSG	.58	26x .50 = $13.00
18	ICN183WBSG	.78	23x .68 = $15.64
20	ICN203WBSG	1.00	21x .85 = $17.85
22	ICN224WBSG	1.07	19x .92 = $17.48
24	ICN246WBSG	1.09	17x1.09 = $15.98
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500	4"	500	6"

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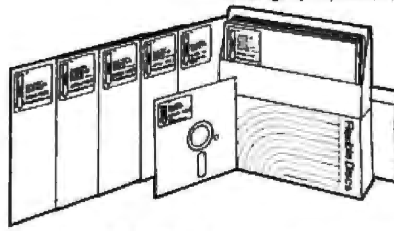

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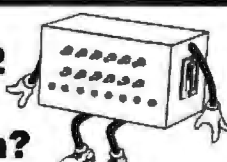

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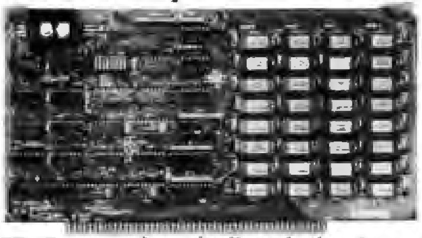
ExpandoRAM III

64K to 256K expandable RAM board



SD Systems has duplicated the famous reliability of their ExpandoRAM I and II boards in the new ExpandoRAM III, a board capable of containing 256K of high speed RAM. Utilizing the new 64K x 1 dymanic RAM chips, you can configure a memory of 64K, 128K, 192K, or 256K, all on one S-100 board. Memory address decoding is done by a programmed bipolar ROM so that the memory map may be dip-switch configured to work with either COSMOS/MPM-type systems or with OASIS-type systems.

Extensive application notes concerning how to operate the ExpandoRAM III with Cromemco, Intersystems, and other popular 4 MHz Z-80 systems are contained in the manual.

MEM-65064A	*64K A & T*	$495.00
MEM-65128A	*128K A & T*	$639.95
MEM-65192A	*192K A & T*	$769.95
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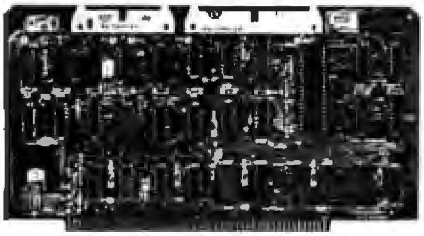
Versafloppy II

Double density controller with CP/M 2.2



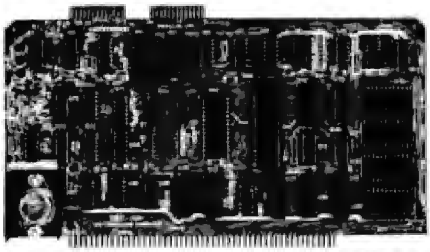
• S-100 bus compatible • IBM 3740 compatible soft sectored format • Controls single and double-sided drives, single or double density, 5¼" and 8" drives in any combination of four simultaneously • Drive select and side select circuitry • Analog phase-locked loop data seperator • Vectored interrupt operation optional • CP/M 2.2 disk and manual set included • Control/diagnostic software PROM included

The Versafloppy II is faster, more stable and more tolerant of bit shift and "jitter" than most controllers. CP/M 2.2 and all necessary control and diagnostic software are included.

IOD-1160A *A & T with CP/M 2.2* .. $370.00

SBC-200

2 or 4 MHz single board computer



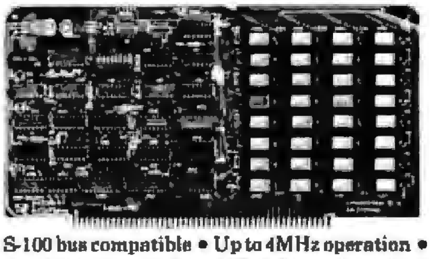
• S-100 bus compatible • Powerful 4MHz Z-80A CPU • Synchronous/asynchronous serial I/O port with RS-232 interface and software programmable baud rates up to 9600 baud • Parallel input and parallel output port • Four channel counter/timer • Four maskable, vectored interrupt inputs and a non-maskable interrupt • 1K of on-board RAM • Up to 32K of on-board ROM • System monitor PROM included

The SBC-200 is an excellent CPU board to base a microcomputer system around. With on-board RAM, ROM, and I/O, the SBC-200 allows you to build a powerful three-board system that has the same features found in most five-board microcomputers. The SBC-200 is compatible with both single-user and multi-user systems.

CPU-30200A *A & T with monitor* . $299.95

ExpandoRAM II

16K to 64K expandable RAM board



• S-100 bus compatible • Up to 4MHz operation • Expandable from 16K to 64K • Uses 16 x 1 4116 memory chips • Page mode operation allows up to 8 memory boards on the bus • Phantom output disable • Invisible on-board refresh

The ExpandoRAM II is compatible with most S-100 CPUs. When other SD System' series II boards are combined with the ExpandoRAM II, they create a microcomputer system with exceptional capabilities and features.

MEM-16630A	*16K A & T*	$325.00
MEM-32631A	*32K A & T*	$345.00
MEM-48632A	*48K A & T*	$365.00
MEM-64633A	*64K A & T*	$385.00

COSMOS

Multi-user operating system

• Multi-user disk operating system • Allows up to 8 users to run independent jobs concurrently • Each user has a seperate file directory

COMOS supports all the file structures of CP/M 2.2, and is compatible at the applications program level with CP/M 2.2, so that most programs written to run under CP/M 2.2 or SDOS will also run under COSMOS.

SFC-55009039F *COSMOS on 8" disk* $395.00

Multi-User System

SBC-200, 256K ExpandoRAM III, Versafloppy II, MPC-4 COSMOS Multi-User Operating System, C BASIC II

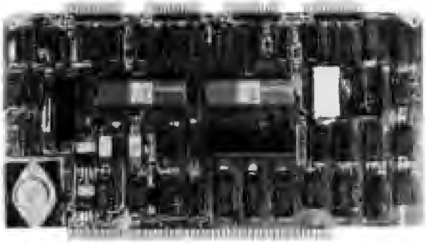
$1995.00

Two Z-80A CPUs (4 MHz), 256K RAM, 5 serial I/O ports with independently programmable baud rates and vectored interrupts, parallel input port, parallel output port, 8 counter/timer channels, real time clock, single and double sided/single or double density disk controller for 5¼" and 8" drives, up to 36K of on-board ROM, CP/M 2.2 compatible COSMOS interrupt driven multi-user disk operating system, allows up to 8 users to run independent jobs concurrently, C BASIC II, control and diagnostic software in PROM included.

-All boards are assembled and tested-

MPC-4

Intelligent communications interface



• Four buffered serial I/O ports • On-board Z-80A processor • Four CTC channels • Independently programmable baud rates • Vectored interrupt capability • Up to 4K of on-board PROM • Up to 2K of on-board RAM • On-board firmware

This is not just another four-port serial I/O board! The on-board processor and firmware provide sufficient intelligence to allow the MPC-4 to handle time consuming I/O tasks, rather than loading down your CPU. To increase overall efficiency, each serial channel has an 80 character input buffer and a 128 character output buffer. The on-board firmware can be modified to make the board SDLC or BISYNC compatible. In combination with SD's COSMOS operating system (which is included with the MPC-4), this board makes a perfect building block for a multi-user system.

IOI-1504A *A & T with COSMOS* .. $495.00

Place Orders Toll Free

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For Technical Inquires or Customer Service call.

213-973-7707

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TERMS of SALE: Cash, checks, credit cards, or Purchase Orders from qualified firms and institutions. **Minimum Order $15.00.** California residents add 6% tax. Minimum shipping & handling charge $3.00 Pricing & availibility subject to change

Circle 205 on inquiry card.

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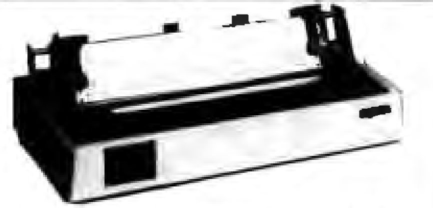
Printers



BETTER THAN EPSON ! - Okidata

Microline 82A *80/132 column, 120 CPS, 9 x 9 dot matrix, friction feed, pin feed, adjustable tractor feed (removable), handles 4 part forms up to 9.5" wide, rear & bottom feed, paper tear bar, 100% duty cycle/200,000,000 character print head, bi-directional/logic seeking, both serial & parallel interfaces included, front panel switch & program control of 10 different form lengths, uses inexpensive spool type ribbons, double width & condensed characters, true lower case descenders & graphics*

PRM-43082 *with FREE tractor* **$539.95**

Microline 83A *132/232 column, 120 CPS, handles forms up to 15" wide, plus all the features of the 82A.*

PRM-43083 *with FREE tractor* **$749.95**

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PRA-27082A *Apple cable* **$19.95**
PRA-27087A *TRS-80 cable* **$24.95**
PRA-43080 *Extra ribbons pkg. of 2* ... **$9.95**

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PRM-27070 *List $459* **$399.95**

MX-80 *80 column, 80 CPS, bi-directional/logic seeking printing, 9 x 9 dot matrix, adjustable tractor feed, & 64 graphics characters*

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MX-80FT *same as MX-80 with friction feed added.*

PRM-27082 *List $745* **$559.95**

MX-100 *132 column, correspondence quality, graphics, up to 15" paper, friction feed & adjustable tractor feed, 9 x 9 dot matrix, 80 CPS.*

PRM-27100 *List $945* **$759.95**

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PRA-27088 *Serial intf & 2K buffer* .. **$144.95**
PRA-27081 *Apple card* **$74.95**
PRA-27082 *Apple cable* **$22.95**
PRA-27086 *IEEE 488 card* **$52.95**
PRA-27087 *TRS-80 cable* **$32.95**
PRA-27085 *Graftrax II* **$95.00**
PRA-27083 *Extra ribbon* **$14.95**

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NEC Spinwriter w/Intelligent Controller

Standard serial, Centronics parallel, and current loop interfaces • Selectable baud rates 50 to 19,200 • Automatic bidirectional printing • Logic seeking • 650 character buffer with optional 16K buffer • 55 characters per second print speed • Comes with vertical forms tractor, ribbon, thimble and cable • Diablo compatible software • Available with or without optional front panel

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PRD-55515 *1K w/front panel* **$2995.00**
PRD-55516 *16K w/front panel* ... **$3095.00**

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New from NEC - the 3500 series Spinwriters. Incorporates all the features and reliability of the 5500 and 7700 series Spinwriters into an inexpensive 30 CPS letter quality printer with an optional bi-directional tractor assembly.

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PRA-55100 *Deluxe tractor option* .. **$300.00**

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16K MEMORY UPGRADE

Add 16K of RAM to your TRS-80, Apple, or Exidy in just minutes. We've sold thousands of these 16K RAM upgrades which include the appropriate memory chips (as specified by the manufacturer), all necessary jumper blocks, fool-proof instructions, and our 1 year guarantee.

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MEX-16101K *Apple kit* **$25.00**
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Z-80* CARD for APPLE

Two computers in one, Z-80 & 6502, more than doubles the power & potential of your Apple, includes Z-80 CPU card, CP/M 2.2, & BASIC-80*

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8" DISK CONTROLLER

New from Vista Computer, single or double sided, single or double density, compatible with DOS 3.2/3.3, Pascal, & CPM 2.2, Shugart & Qume compatible

IOD-2700A *A & T* **$499.95**

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Complete package includes: Two 8" double-density disk drives, Vista double-density 8" disk controller, cabinet, power supply, & cables, DOS 3.2/3.3, CP/M 2.2, & Pascal compatible

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CPS MULTICARD - Mtn. Computer

Three cards in one! Real time clock-calendar, serial interface, & parallel interface - all on one card.

IOX-2300A *A & T* **$199.95**

AIO, ASIO, APIO - S.S.M.

Parallel & serial interface for your Apple (see Byte pg 11)

IOI-2050K *Par & Ser kit* **$139.95**
IOI-2050A *Par & Ser A & T* **$169.95**
IOI-2052K *Serial kit* **$89.95**
IOI-2052A *Serial A & T* **$99.95**
IOI-2054K *Parallel kit* **$69.95**
IOI-2054A *Parallel A & T* **$89.95**

A488 - S.S.M.

IEEE 488 controller, uses simple basic commands, includes firmware and cable, 1 year guarantee, (see April Byte pg 11)

IOX-7488A *A & T* **$399.95**

Modems

CAT MODEMS - Novation

CAT *300 baud, acoustic, answer/orginate*

IOM-5200A *List $189.95* **$149.95**

D-CAT *300 baud direct connect, answer/orginate*

IOM-5201A *List $199.95* **$169.95**

AUTO-CAT *Auto answer orginate, direct connect*

IOM-5230A *List $299.95* **$239.95**

Apple-CAT - Novation

Software selectable 1200 or 300 baud, direct connect, auto-answer auto-dial, auxiliary 4-wire RS232C serial port for printer

IOM-5232A *Save $50.00!!!* **$325.00**

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Sophisticated direct-connect auto-answer auto-dial modem, touch-tone or pulse dialing, RS-232C interface, programmable

IOM-5400A *Smartmodem* **$269.95**

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6502 computer with alphanumeric display, printer, & keyboard, and complete instructional manuals

CPK-50165 *1K AIM* **$424.95**
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SFK-74600008E *8K BASIC ROM* .. **$64.95**
SFK-64600004E *4K assembler ROM* **$43.95**
PSX-030A *Power supply* **$64.95**
ENX-000002 *Enclosure* **$54.95**

4K AIM, 8K BASIC, power supply, & enclosure

Special package price **$649.95**

Z-80 STARTER KIT - SD Systems

Complete Z-80 microcomputer with RAM, ROM, I/O, keyboard, display, kludge area, manual, & workbook

CPS-30100K *KIT* **$299.95**
CPS-30100A *A & T* **$469.95**

SYM-1 - Synertek Systems

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15 MHz bandwidth, 700 lines/inch, P31 green phosphor, switchable 40 or 80 columns, small, light-weight & portable.

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VDC-801310 *13" Color I* **$379.95**

12" COLOR MONITOR - NEC

Hi-res monitor with audio & sculptured case

VDC-651212 *Color Monitor* **$479.95**

12" GREEN SCREEN - NEC

20 MHz, P31 phosphor video monitor with audio, exceptionally high resolution - A fantastic monitor at a very reasonable price

VDM-651200 *Special Sale Price* **$199.95**

Video Terminals

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Detachable keyboard, amber on black display, 7 x 9 dot matrix, 10 program function keys, 14 key numeric pad, 12" non-glare screen, 50 to 19,200 baud, direct cursor control, auxiliary bi-directional serial port

VDT-351200 *List $795.00* **$645.00**

VIEWPIONT - ADDS

Detachable keyboard, serial RS232C interface, baud rates from 110 to 19,200, auxiliary serial output port, 24 x 80 display.

VDT-501210 *Sale Priced* **$639.95**

TELEVIDEO 950

VDT-901250 *List $1195.00* **$995.00**

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VDT-230080 *List $1195.00* **$895.00**

JADE

Computer Products

S-100 CPU Boards

THE BIG Z* - Jade
2 or 4 MHz switchable Z-80 CPU with serial I/O, accomodates 2708, 2716, or 2732 EPROM, baud rates from 75 to 9600*
CPU-30201K *Kit* $139.95
CPU-30201A *A & T* $189.95
CPU-30200B *Bare board* $35.00

2810 Z-80* CPU - Cal Comp Sys
2-4 MHz Z-80A CPU with RS-232C serial I/O port and on-board MOSS 2.2 monitor PROM, front panel compatible.*
CPU-30400A *A & T* $269.95

CB-2 Z-80 CPU - S.S.M.
2 or 4 MHz Z-80 CPU board with provision for up to 8K of ROM or 4K of RAM on board, extended addressing, IEEE S-100, front panel compatible.
CPU-30300K *Kit* $239.95
CPU-30300A *A & T* $299.95

S-100 PROM Boards

PROM-100 - SD Systems
2708, 2716, 2732 EPROM programmer w/software
MEM-99520K *Kit* $189.95
MEM-99520A *A & T* $249.95

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2708, 2716 EPROM board with built-in programmer
MEM-99510K *Kit* $154.95
MEM-99510A *A & T* $219.95

EPROM BOARD - Jade
16K or 32K uses 2708's or 2716's, 1K boundary
MEM-16230K *Kit* $79.95
MEM-16230A *A & T* $119.95

S-100 Video Boards

VB-3 - S.S.M.
80 characters x 24 lines expandable to 80 x 48 for a full page of text, upper & lower case, 256 user defined symbols, 160 x 192 graphics matrix, memory mapped, has key board input.
IOV-1095K *4 MHz kit* $349.95
IOV-1095A *4 MHz A & T* $439.95
IOV-1096K *80 x 48 upgrade* $39.95

VDB-8024 - SD Systems
80 x 24 I/O mapped video board with keyboard I/O, and on-board Z-80A.*
IOV-1020A *A & T* $459.95

VIDEO BOARD - S.S.M.
64 characters x 16 lines, 128 x 48 matrix for graphics, full upper/lower case ASCII character set, numbers, symbols, and greek letters, normal/reverse/blinking video, S-100.
IOV-1051K *Kit* $149.95
IOV-1051A *A & T* $219.95
IOV-1051B *Bare board* $34.95

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Silent, simple, and on sale - a better motherboard
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MBS-061A *A & T* $49.95
12 Slot (9¾" x 8¾")
MBS-121B *Bare board* $29.95
MBS-121K *Kit* $69.95
MBS-121A *A & T* $89.95
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MBS-181B *Bare board* $49.95
MBS-181K *Kit* $99.95
MBS-181A *A & T* $139.95

S-100 RAM Boards

MEMORY BANK - Jade
4 MHz, S-100, bank selectable, expandable from 16K to 64K
MEM-99730B *Bare Board* $49.95
MEM-99730K *Kit no RAM* $199.95
MEM-32731K *32K Kit* $239.95
MEM-64733K *64K Kit* $279.95
Assembled & Tested .... add $50.00

64K RAM - Calif Computer Sys
4 MHz bank port - bank byte selectable, extended addressing, 16K bank selectable, PHANTOM line allows memory overlay, 8080 - Z-80 - front panel compatible.
MEM-64565A *A & T* $575.00

64K STATIC RAM - Mem Merchant
64K static S-100 RAM card, 4-16K banks, up to 8MHz
MEM-64400A *A & T* $789.95

32K STATIC RAM - Jade
2 or 4 MHz expandable static RAM board uses 2114L's
MEM-16151K *16K 4 MHz kit* $169.95
MEM-32151K *32K 4 MHz kit* $299.95
Assembled & tested .... add $50.00

16K STATIC RAM - Mem Merchant
4 MHz 16K static RAM board, IEEE S-100, bank selectable, Phantom capability, addressable in 4K blocks, "disable-able" in 1K segments, extended addressing, low power
MEM-16171A *A & T* $164.95

S-100 Disk Controllers

DOUBLE-D - Jade
Double density controller with the inside track, on-board Z-80A, printer port, IEEE S-100, can function on an interrupt driven buss*
IOD-1200K *Kit* $299.95
IOD-1200A *A & T* $375.00
IOD-1200B *Bare board* $59.95

DOUBLE DENSITY - Cal Comp Sys
5¼" and 8" disk controller, single or double density, with on-board boot loader ROM, and free CP/M 2.2 and manual set.*
IOD-1300A *A & T* $374.95

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S.P.I.C. - Jade
Our new I/O card with 2 SIO's, 4 CTC's, and 1 PIO
IOI-1045K *2 CTC's, 1 SIO, 1 PIO* .. $179.95
IOI-1045A *A & T* $239.95
IOI-1046K *4 CTC's, 2 SIO's, 1 PIO* $219.95
IOI-1046A *A & T* $299.95
IOI-1045B *Bare board w/ manual* ... $49.95

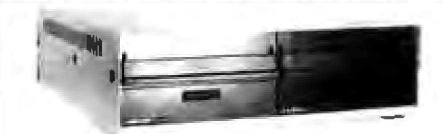
I/O-4 - S.S.M.
2 serial I/O ports plus 2 parallel I/O ports
IOI-1010K *Kit* $179.95
IOI-1010A *A & T* $249.95
IOI-1010B *Bare board* $35.00

S-100 Mainframes

MAINFRAME - Cal Comp Sys
12 slot S-100 mainframe with 20 amp power supply
ENC-112105 *Kit* $329.95
ENC-112106 *A & T* $399.95

DISK MAINFRAME - N.P.C.
Holds 2 8" drives and a 12 slot S-100 system. Attractive metal cabinet with 12 slot motherboard & card cage, power supply, dual fans, lighted switch, and other professional features
ENS-112325 *with 25 amp p.s.* $699.95

Disk Drives



Handsome metal cabinet with proportionally balanced air flow system • Rugged dual drive power supply • Power cable kit • Power switch, line cord, fuse holder, cooling fan • Never-Mar rubber feet • All necessary hardware to mount 2-8" disk drives, power supply, and fan • Does not include signal cable

Dual 8" Subassembly Cabinet
END-000420 *Bare cabinet* $59.95
END-000421 *Cabinet kit* $225.00
END-000431 *A & T* $359.95

8" Disk Drive Subsystems
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END-000424 *A & T w/2 FD100-8Ds* $1124.95
END-000433 *Kit w/2 SA-801Rs* $999.95
END-000434 *A & T w/2 SA-801Rs* $1195.00

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END-000427 *A & T w/2 DT-8s* $1424.95
END-000436 *Kit w/2 SA-851Rs* $1495.00
END-000437 *A & T w/2 SA-851Rs* $1695.00

QUME DT-8

8" Double-Sided, Double-Density Disk Drive

1 Drive ... $524.95 each
2 Drives . $499.95 each
10 Drives $479.95 each

Jade Part Number MSF-750080

Shugart 801R

8" Single-Sided, Double-Density Disk Drive

1 Drive ... $394.95 each
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Jade Part Number MSF-10801R

SIEMENS 8"

8" Single-Sided, Double-Density Disk Drive

1 Drive ... $384.95 each
2 Drives . $349.95 each
10 Drives $324.95 each

Jade Part Number MSF-201120

MPI B-51

5¼" Single-Sided, Double-Density Disk Drive

1 Drive ... $234.95 each
2 Drives . $224.95 each
10 Drives $219.95 each

Jade Part Number MSM-155100

END-000213 *Case & power supply* $74.95

Circle 206 on inquiry card.

Circle 8 on inquiry card.

Circle 8 on inquiry card.

7400

SN7400N	.20	SN7472N	.29	SN74156N	.79
SN7401N	.20	SN7473N	.35	SN74157N	.69
SN7402N	.25	SN7474N	.35	SN74160N	.89
SN7403N	.25	SN7475N	.49	SN74161N	.89
SN7404N	.25	SN7476N	.35	SN74162N	.89
SN7405N	.25	SN7479N	5.00	SN74163N	.89
SN7406N	.35	SN7480N	.50	SN74164N	.89
SN7407N	.35	SN7482N	.99	SN74165N	.89
SN7408N	.25	SN7483N	.69	SN74166N	1.25
SN7409N	.25	SN7485N	.89	SN74167N	2.79
SN7410N	.25	SN7486N	.35	SN74170N	1.95
SN7411N	.25	SN7489N	1.75	SN74172N	4.95
SN7412N	.30	SN7490N	.49	SN74173N	1.29
SN7413N	.40	SN7491N	.59	SN74174N	.89
SN7414N	.49	SN7492N	.45	SN74175N	.89
SN7416N	.30	SN7493N	.45	SN74176N	.79
SN7417N	.29	SN7494N	.69	SN74177N	.79
SN7420N	.25	SN7495N	.69	SN74179N	1.49
SN7421N	.29	SN7496N	.69	SN74180N	.79
SN7422N	.45	SN7497N	1.00	SN74181N	2.25
SN7423N	.29	SN74100N	1.49	SN74182N	.79
SN7425N	.29	SN74104N	.89	SN74184N	2.49
SN7426N	.29	SN74105N	.89	SN74185N	2.49
SN7427N	.25	SN74107N	.35	SN74190N	1.25
SN7429N	.45	SN74109N	.39	SN74191N	1.25
SN7430N	.25	SN74116N	1.95	SN74192N	.89
SN7432N	.29	SN74121N	.39	SN74193N	.89
SN7437N	.25	SN74122N	.50	SN74194N	.89
SN7438N	.40	SN74123N	.59	SN74195N	.69
SN7439N	.25	SN74125N	.49	SN74196N	.89
SN7440N	.20	SN74126N	.49	SN74197N	.89
SN7441N	.89	SN74132N	.75	SN74198N	1.49
SN7442N	.49	SN74136N	.75	SN74199N	1.49
SN7443N	1.10	SN74141N	.99	SN74221N	1.25
SN7444N	1.10	SN74142N	3.25	SN74251N	.99
SN7445N	.69	SN74143N	3.49	SN74276N	1.95
SN7446N	.79	SN74144N	3.49	SN74279N	.79
SN7447N	.69	SN74145N	.79	SN74283N	1.49
SN7448N	.79	SN74147N	1.95	SN74284N	3.95
SN7450N	.20	SN74148N	1.29	SN74285N	3.95
SN7451N	.20	SN74150N	1.29	SN74365N	.69
SN7453N	.20	SN74151N	.69	SN74366N	.69
SN7454N	.20	SN74152N	.69	SN74367N	.69
SN7459A	.25	SN74153N	.79	SN74368N	.69
SN7460N	.20	SN74154N	1.29	SN74390N	1.49
SN7470N	.29	SN74155N	.79	SN74393N	1.49

74LS

74LS00	.29	74LS92	.79	74LS192	1.15
74LS01	.29	74LS93	.79	74LS193	1.15
74LS02	.29	74LS95	.99	74LS194	1.15
74LS03	.29	74LS96	1.15	74LS195	1.15
74LS04	.35	74LS107	.45	74LS197	1.19
74LS05	.35	74LS109	.45	74LS221	1.19
74LS08	.35	74LS112	.45	74LS240	1.49
74LS09	.35	74LS113	.49	74LS241	1.49
74LS10	.35	74LS114	.49	74LS242	1.49
74LS11	.39	74LS122	.49	74LS243	1.49
74LS12	.35	74LS123	1.25	74LS244	1.49
74LS13	.59	74LS125	.89	74LS245	2.95
74LS14	.99	74LS126	.89	74LS247	1.19
74LS15	.35	74LS132	.99	74LS248	1.19
74LS20	.35	74LS133	.59	74LS249	1.19
74LS21	.35	74LS136	.49	74LS251	.99
74LS22	.35	74LS138	.89	74LS253	.99
74LS26	.35	74LS139	.89	74LS257	.89
74LS27	.35	74LS151	.89	74LS258	.89
74LS28	.35	74LS153	.89	74LS260	.69
74LS30	.35	74LS154	1.75	74LS266	.69
74LS32	.35	74LS155	.89	74LS273	1.49
74LS33	.59	74LS156	.89	74LS279	.69
74LS37	.45	74LS157	.89	74LS283	.89
74LS38	.39	74LS158	.89	74LS290	.99
74LS40	.35	74LS160	1.15	74LS293	.99
74LS42	.69	74LS161	1.15	74LS298	1.25
74LS47	.89	74LS162	1.15	74LS352	1.29
74LS48	1.15	74LS163	1.15	74LS353	1.29
74LS49	1.15	74LS164	1.15	74LS365	.69
74LS51	.35	74LS165	1.15	74LS366	.69
74LS54	.35	74LS166	1.15	74LS367	.69
74LS55	.35	74LS168	1.19	74LS368	.69
74LS73	.45	74LS169	1.19	74LS373	1.95
74LS74	.45	74LS170	1.95	74LS374	1.95
74LS75	.59	74LS171	.99	74LS375	.89
74LS76	.45	74LS174	.99	74LS386	.69
74LS78	.49	74LS175	.99	74LS393	2.49
74LS83	.89	74LS181	2.95	74LS399	2.49
74LS85	1.25	74LS190	1.25	74LS670	2.49
74LS86	.49	74LS191	1.25	81LS95	1.95
74LS90	.69			81LS97	1.95

74S

74S00	.45	74S124	3.95	74S243	3.25
74S02	.45	74S133	.45	74S244	3.25
74S03	.45	74S134	.44	74S251	1.45
74S04	.58	74S135	1.19	74S253	1.45
74S05	.55	74S136	1.75	74S257	1.25
74S08	.50	74S138	1.35	74S258	1.35
74S09	.50	74S139	1.15	74S260	.75
74S10	.49	74S140	.79	74S280	2.95
74S11	.49	74S151	1.15	74S287	3.25
74S15	.45	74S153	1.15	74S288	2.75
74S20	.45	74S157	1.35	74S373	3.49
74S22	.45	74S158	1.35	74S374	3.49
74S30	.45	74S160	2.95	74S387	2.95
74S32	.55	74S174	1.59	74S471	10.95
74S37	1.25	74S175	1.59	74S472	10.95
74S40	.50	74S188	2.95	74S473	10.95
74S51	.45	74S194	1.95	74S474	12.95
74S64	.50	74S195	1.95	74S475	12.95
74S65	.50	74S196	1.95	74S570	5.95
74S74	.75	74S240	2.95	74S571	5.95
74S86	.79	74S241	2.95	74S572	9.95
74S112	.79	74S242	3.25	74S573	9.95
74S113	.79			74S940	3.15
74S114	.79			74S941	3.15

CA–LINEAR

CA3010H	.99	CA3060N	3.25	CA3089N	3.75
CA3013H	2.15	CA3080H	1.25	CA3096N	1.95
CA3023H	3.25	CA3081N	2.00	CA3130H	1.19
CA3035H	2.49	CA3082N	2.00	CA3140H	1.25
CA3039H	1.75	CA3083N	1.60	CA3160H	1.25
CA3046N	1.20	CA3086N	.85	CA3401N	.69
CA3059N	1.25			CA3600N	3.50

CD–CMOS

CD4000	.39	CD4041	1.49	CD4098	2.49
CD4001	.39	CD4042	.99	CD4506	.75
CD4002	.39	CD4043	.89	CD4507	.99
CD4006	1.19	CD4044	.89	CD4508	3.95
CD4007	.25	CD4046	1.79	CD4510	1.39
CD4009	.45	CD4047	2.50	CD4511	1.29
CD4010	.45	CD4048	1.39	CD4512	1.49
CD4011	.39	CD4049	.49	CD4514	2.95
CD4012	.25	CD4050	.49	CD4515	2.95
CD4013	.45	CD4051	1.19	CD4516	1.49
CD4014	1.39	CD4052	1.19	CD4518	1.39
CD4015	1.19	CD4053	1.19	CD4519	.89
CD4016	.59	CD4055	2.99	CD4520	1.29
CD4017	1.19	CD4056	2.95	CD4526	1.79
CD4018	.99	CD4060	1.49	CD4528	1.79
CD4019	.49	CD4066	.79	CD4529	1.95
CD4020	1.19	CD4068	.39	CD4543	2.79
CD4021	1.39	CD4069	.45	CD4562	11.95
CD4022	1.19	CD4070	.55	CD4566	2.79
CD4023	.29	CD4071	.49	CD4583	2.49
CD4024	.79	CD4072	.49	CD4584	.75
CD4025	.23	CD4073	.39	CD4723	1.95
CD4026	2.95	CD4075	.39	CD4724	1.95
CD4027	.69	CD4076	1.39	MC14409	17.95
CD4028	.89	CD4078	.55	MC14410	10.95
CD4029	1.49	CD4081	.39	MC14411	15.95
CD4030	.49	CD4082	.39	MC14412	15.95
CD4034	3.49	CD4093	.99	MC14419	7.95
CD4035	.99			MC14433	19.95
CD4040	1.49			MC14538	2.49
				MC14541	1.95

Phone Tunes

As Seen on "Good Morning America"
Replaces the Telephone Ringer Bell with a Selection of 30 Familiar Tunes

Each Unit will play any of the following tunes:

- Rule Britannia
- O Canada
- Colonel Bogey
- Westminster Chimes
- Mexican Hat Dance
- Twinkle, Twinkle Little Star
- Deutschlandlied
- God Save the Queen
- Close Encounters
- Happy Birthday
- Wedding March
- Jingle Bells
- Auld Lang Syne
- Soldiers Chorus
- Sailor's Hornpipe
- Charge!
- Greensleeves
- Lorelei
- Eyes of Texas
- Star Spangled Banner
- Oranges and Lemons
- Wilhelmus
- Mozart Sonata
- Pomp & Circumstance
- William Tell Overture
- Bach Toccata in D Minor
- Shave and a Haircut
- Blue Danube Waltz
- Beethoven's 5th
- La Marseillaise

FEATURES

Replaces monotonous telephone ringer bell. Easily connects to any standard telephone. Can be used alongside regular phone or replace a remote ringer elsewhere in building or outside. FCC approved. Can be used on any telephone system — worldwide. Use a different tune to identify extension phones. Microprocessor controlled. Adjustable volume control and variable tune speed control. Operates on two 9-volt batteries or AC Adapter (not included).

PT030 Phone Tunes $49.95
AD30 AC Adapter $8.95

DISCRETE LEDS

XC556R	.200"	red	5/$1	MV50	.085"	red	6/$1
XC556G	.200"	green	4/$1	XC209R	.125"	red	5/$1
XC556Y	.200"	yellow	4/$1	XC209G	.125"	green	4/$1
XC556C	.200"	clear	4/$1	XC209Y	.125"	yellow	4/$1
XC22R	.200"	red	5/$1	XC526R	.185"	red	5/$1
XC22G	.200"	green	4/$1	XC526G	.185"	green	4/$1
XC22Y	.200"	yellow	4/$1	XC526Y	.185"	yellow	4/$1
MV10B	.170"	red	4/$1	XC526C	.185"	clear	4/$1

.200(T1¾) Red/Green
Diffused Bi-Color LED

Part No.	1-99	100+
XC5491	.79	.69

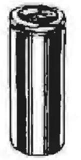
Solid red LED, metal mtg. hdw. 1/4" leads
RL-2 . . $.39 ea. or 3/$1.00

DISPLAY LEDS

C.A. — Common Anode
D.D. — Double Digit
C.C. — Common Cathode
RHD — Right Hand Decimal

Type	Polarity	Ht	Price	Type	Polarity	Ht	Price
MAN 1	C.A.—red	.270	2.95	DLG507	C.A.—green	.500	1.25
MAN 2	5x7 D.M.—red	.300	4.95	DL704	C.C.—red	.300	1.25
MAN 3	C.C.—red	.125	.25	DL707	C.A.—red	.300	1.25
MAN 52	C.A.—green	.300	.99	DL728	C.C.—red	.500	1.49
MAN 54	C.C.—green	.300	.99	DL741	C.A.—red	.600	1.25
MAN 71	C.A.—red	.300	.75	DL747	C.A.—red	.600	1.49
MAN 72	C.A.—red	.300	.75	DL750	C.C.—red	.600	1.49
MAN 74	C.C.—red	.300	1.25	DLO847	C.A.—orange	.800	1.49
MAN 82	C.A.—yellow	.300	.49	DLO850	C.C.—orange	.800	1.49
MAN 84	C.C.—yellow	.300	.99	DL338	C.C.—red	.110	.35
MAN 3620	C.A.—orange	.300	.49	FND359	C.C. ± 1	.357	.99
MAN 3630	C.A.—orange ± 1	.300	.99	FND357	C.C.	.357	.75
MAN 3640	C.C.—orange	.300	.99	FND500	C.C. (FND800)	.500	.99
MAN 4610	C.A.—orange	.400	.99	FND507	C.A. (FND510)	.500	.99
MAN 6610	C.A.—orange—DD	.560	.99	HDSP-3401	C.A.—red	.800	1.50
MAN 6630	C.A.—orange ± 1	.560	.99	HDSP-3403	C.C.—red	.800	1.50
MAN 6640	C.C.—orange—DD	.560	.99	HDSP-3406	C.C. red ± 1	.800	1.50
MAN 6650	C.C.—orange ± 1	.560	.99	5082-7751	C.A., R.H.D.—red	.430	1.25
MAN 6680	C.A.—orange	.560	.99	5082-7760	C.C., R.H.D.—red	.430	1.25
MAN 6710	C.A.—red—DD	.560	.99	5082-7300	4x7 Numeric (RHD)	.600	22.00
MAN 6740	C.C.—red—DD	.560	.99	5082-7302	4x7 Numeric (LHD)	.600	22.00
MAN 6750	C.C.—red ± 1	.560	.99	5082-7340	4x7 Hxdcl. (0-9/A-F)	.600	22.50
DLO304	C.C.—orange	.300	1.25	4N28	Photo Xsistor Opto-Isol.		.69
DLO307	C.A.—orange	.300	1.25	LIT-1	Photo Xsistor Opto-Isol.		.69
DLG500	C.C.—green	.500	1.25	MOC3010	Optically Isol. Triac Driver		1.25

COMPUTER GRADE CAPACITORS



MFD	WVDC	PRICE	MFD	WVDC	PRICE	MFD	WVDC	PRICE
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

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LOW PROFILE (TIN) SOCKETS

	1-24	25-49	50-100
8 pin LP	.17	.16	.15
14 pin LP	.20	.19	.18
16 pin LP	.22	.21	.20
18 pin LP	.29	.28	.27
20 pin LP	.34	.32	.30
22 pin LP	.37	.36	.35
24 pin LP	.38	.37	.36
28 pin LP	.45	.44	.43
36 pin LP	.60	.59	.58
40 pin LP	.63	.62	.61

SOLDERTAIL STANDARD (TIN)

	1-24	25-49	50-100
14 pin ST	.27	.25	.24
16 pin ST	.30	.27	.25
18 pin ST	.35	.32	.30
24 pin ST	.49	.45	.42
28 pin ST	.99	.90	.81
36 pin ST	1.39	1.26	1.15
40 pin ST	1.49	1.45	1.30

SOLDERTAIL (GOLD) STANDARD

	1-24	25-49	50-100
8 pin SG	.39	.35	.31
14 pin SG	.49	.45	.41
16 pin SG	.54	.49	.44
18 pin SG	.59	.53	.48
24 pin SG	.79	.75	.69
28 pin SG	1.10	1.00	.90
36 pin SG	1.65	1.40	1.26
40 pin SG	1.75	1.53	1.45

WIRE WRAP SOCKETS (GOLD) LEVEL #3

	1-24	25-49	50-100
8 pin WW	.59	.54	.49
14 pin WW	.79	.73	.67
16 pin WW	.86	.77	.70
18 pin WW	.99	.90	.81
20 pin WW	1.19	1.08	.99
22 pin WW	1.49	1.35	1.23
24 pin WW	1.39	1.26	1.14
28 pin WW	1.69	1.53	1.38
36 pin WW	2.19	1.99	1.79
40 pin WW	2.39	2.09	1.89

1/4 WATT RESISTOR ASSORTMENTS – 5%

ASST. 1	5ea.	10 Ohm 12 Ohm 15 Ohm 18 Ohm 22 Ohm / 27 Ohm 33 Ohm 39 Ohm 47 Ohm 56 Ohm	50pcs.	$1.95
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ASST. 3	5ea.	470 Ohm 560 Ohm 680 Ohm 820 Ohm 1K / 1.2K 1.5K 1.8K 2.2K 2.7K	50pcs.	$1.95
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ASST. 6	5ea.	150K 180K 220K 270K 330K / 390K 470K 560K 680K 820K	50pcs.	$1.95
ASST. 7	5ea.	1M 1.2M 1.5M 1.8M 2.2M / 2.7M 3.3M 3.9M 4.7M 5.6M	50pcs.	$1.95
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7106EV/Kit*	IC, Circuit Board, Display		34.95
7107CPL	3½ Digit A/D (LED Drive)		15.95
7107EV/Kit*	IC, Circuit Board, Display		29.95
7116CPL	3½ Digit A/D LCD Dis. HLD.		19.95
7117CPL	3½ Digit A/D LED Dis. HLD.		17.95
7201IDR	Low Battery Volt Indicator		2.25
7205IPG	CMOS LED Stopwatch/Timer		12.95
7205EV/Kit*	Stopwatch Chip, XTL		19.95
7206CJPE	Tone Generator		5.15
7206CEV/Kit*	Tone Generator Chip, XTL		12.95
7207AIPD	Oscillator Controller		5.50
7207AEV/Kit*	Freq. Counter Chip, XTL		13.95
7208IPI	Seven Decade Counter		17.50
7209IPA	Clock Generator		4.95
7215IPG	4 Func. CMOS Stopwatch CKT		11.95
7215EV/Kit*	4 Func. Stopwatch Chip, XTL		19.95
7216AIJI	8-Digit Univ. Counter C.A.		32.00
7216CIJI	8-Digit Freq. Counter C.A.		26.95
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7218CIJI	8-Digit Univ. LED Drive		10.95
7224IPL	LCD 4½ Digit Up Counter DRI		11.25
7226AIJL	8-Digit Univ. Counter		31.95
7226AEV/Kit*	5 Function Counter Chip, XTL		34.95
7240IJE	CMOS Bin Prog. Timer/Counter		4.95
7242IJA	CMOS Divide-by-256 RC Timer		2.05
7250IJE	CMOS BCD Prog. Timer/Counter		6.80
7260IJE	CMOS BCD Prog. Timer/Counter		5.25
7555IPA	CMOS 555 Timer (8 pin)		1.45
7556IPD	CMOS 556 Timer (14 pin)		2.20
7611BCPA	CMOS Op Amp Comparator	5MV	2.35
7612BCPA	CMOS Op Amp Ext. Cmvr.	5MV	2.95
7621BCPA	CMOS Dual Op Amp Comp.	5MV	3.95
7631CCPE	CMOS Tri Op Amp Comp.	10MV	5.35
7641CCPD	CMOS Quad Op Amp Comp.	10MV	7.50
7642CCPD	CMOS Quad Op Amp Comp.	10MV	7.50
7660CPA	Voltage Converter		2.95
8038CCPD	Waveform Generator		4.95
8048CCPE	Monolithic Logarithmic Amp		21.60
8069CCQ	50ppm Band—GAP Volt Ref. Diode		2.50
8211CPA	Volt Ref/Indicator		2.95
8212CPA	Volt Ref/Indicator		3.95

74C

74C00	.39	74C95	1.50	74C221	1.89
74C02	.39	74C107	1.25	74C240	2.29
74C04	.39	74C151	2.95	74C244	2.25
74C08	.39	74C154	1.98	74C373	2.49
74C10	.39	74C157	2.25	74C374	2.50
74C14	.75	74C160	1.59	74C901	.39
74C20	.39	74C161	1.59	74C903	.59
74C30	.39	74C162	1.49	74C911	10.95
74C42	1.29	74C163	1.69	74C912	10.95
74C48	1.95	74C164	1.59	74C915	1.59
74C73	.79	74C173	1.29	74C917	10.95
74C74	.79	74C174	1.35	74C922	5.49
74C85	1.95	74C175	1.19	74C923	5.75
74C86	.39	74C192	1.49	74C925	7.50
74C89	4.95	74C193	1.49	74C926	7.50
74C90	1.29	74C195	1.34	80C95	.79
74C93	1.29			80C97	.79

LINEAR

LH0002CN	4.85	LM340T-5	1.25	LM702H	.79
LM10CLH	4.50	LM340T-12	1.25	LM703CN	.89
LM11CLH	4.75	LM340T-15	1.25	LM709N	.29
LH0070-0H	4.95	LM341P-5	.75	LM710N	.79
TL071CP	.79	LM341P-12	.75	LM711N	.79
TL072CP	1.29	LM341P-15	.75	LM723N	.49
TL074CN	2.49	LM342P-5	.69	LM733N	1.00
LH0082CD	35.00	LM342P-12	.69	LM739N	1.19
TL082CP	1.19	LM342P-15	.69	LM741CN	.35
TL084CN	2.19	LM348N	1.25	MC1741SCG	3.00
LH0094CD	35.80	LM350K	5.75	LM747N	.79
LM300H	.99	LF351N	.60	LM748N	.39
LM301CN	.35	LF353N	1.00	LM1014N	2.79
LM302H	1.95	LF355N	1.10	LM1310N	1.95
LM304H	1.95	LF356N	1.10	LM1458CN	.59
LM305H	.99	LM358N	1.00	LM1488N	1.25
LM307CN	.45	LM359N	1.79	LM1489N	1.25
LM308CN	1.00	LM370N	4.49	LM1496N	1.95
LM309H	1.95	LM373N	3.25	LM1556V	1.75
LM309K	1.25	LM377N	2.95	LM1800N	2.95
LM310CN	1.75	LM380N	1.25	LM1871N	5.49
LM311/CN	.90	LM381N	1.95	LM1872N	5.49
LM312H	2.49	LM382N	1.79	LM1877N-9	3.25
LM317MP	1.15	LM384N	1.95	LM1889N	3.20
LM317T	1.75	LM386N-3	1.29	LM1896N	1.75
LM317K	3.95	LM387N	1.45	LM2002T	1.49
LM318CN	1.95	LM389N	1.35	LM2877P	2.05
LM319N	1.95	LM392N	.69	LM2878P	2.25
LM320K-5	1.35	LF398N	4.00	LM2896P-1	2.25
LM320K-12	1.35	LM399H	5.00	LM3189N	2.95
LM320K-15	1.35	TL494CN	4.49	LM3900N	.59
LM320T-5	1.25	TL496CP	1.75	LM3905CN	1.79
LM320T-12	1.25	NE510A	6.00	LM3909N	1.15
LM320T-15	1.25	NE529A	4.95	LM3914N	3.95
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LM335Z	1.40	NE555V	.39	RC4195TK	5.95
LM336Z	1.75	LM556N	.79	LM4500A	3.25
LM337T	1.95	NE564N	3.95	ICL8038B	4.95
LM337MP	1.15	LM565N	1.25	LM13080N	1.29
LM338K	6.95	LM566CN	1.95	LM13600N	1.49
LM339N	.99	LM567V	1.25	75138N	1.95
LM340K-5	1.35	NE570N	4.95	75450N	.59
LM340K-12	1.35			75451CN	.39
LM340K-15	1.35			75492	.59

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Value	1-9	10-99	100+	Value	1-9	10-99	100+
10 pf	.05	.04	.03	.001µF	.05	.04	.03
22 pf	.05	.04	.03	.0047µF	.05	.04	.03
47 pf	.05	.04	.03	.01µF	.05	.04	.03
100 pf	.05	.04	.03	.022µF	.06	.05	.04
220 pf	.05	.04	.03	.047µF	.06	.05	.04
470 pf	.05	.04	.03	.1µF	.15	.12	.10

100 VOLT MYLAR FILM CAPACITORS

.001mf	.12	.10	.07	.022mf	.13	.11	.08
.0022mf	.12	.10	.07	.047mf	.21	.17	.13
.0047mf	.12	.10	.07	.1mf	.27	.23	.17
.01mf	.12	.10	.07	.22mf	.33	.27	.22

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.15/35V	.28	.24	.20	2.2/25V	.51	.45	.34
.22/35V	.28	.24	.20	3.3/25V	.63	.47	.37
.33/35V	.28	.24	.20	4.7/25V	.63	.56	.48
.47/35V	.28	.24	.20	6.8/25V	.79	.69	.54
.68/35V	.28	.24	.20	15/25V	1.39	1.26	.95
1.0/35V	.28	.24	.20	22/6V	.79	.69	.56

MINI. ALUMINUM ELECTROLYTIC CAPACITORS

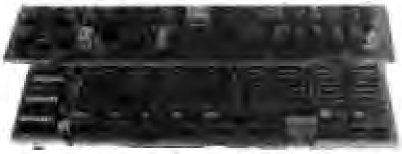
Axial	1-99	100-499	500+	Radial	1-99	100-499	500+
.47/50V	.16	.14	.10	.47/25V	.15	.13	.12
1.0/50V	.16	.14	.11	.47/50V	.16	.14	.12
3.3/50V	.17	.15	.11	1.0/16V	.15	.13	.12
4.7/25V	.18	.15	.11	1.0/25V	.16	.14	.12
10/25V	.18	.15	.11	1.0/50V	.17	.15	.14
10/50V	.19	.16	.12	4.7/16V	.16	.13	.12
22/25V	.19	.16	.12	4.7/25V	.16	.14	.13
22/50V	.24	.20	.15	4.7/50V	.17	.15	.14
47/25V	.25	.21	.19	10/16V	.15	.13	.12
47/50V	.29	.25	.23	10/25V	.16	.14	.13
100/25V	.28	.24	.22	10/50V	.17	.15	.14
100/50V	.41	.37	.34	47/50V	.25	.21	.19
220/25V	.39	.34	.33	100/16V	.21	.17	.14
220/50V	.49	.45	.41	100/25V	.25	.23	.21
470/25V	.54	.49	.45	100/50V	.37	.34	.31
1000/16V	.79	.69	.61	220/16V	.25	.21	.19
2200/16V	.89	.79	.69	470/25V	.35	.31	.27

Circle 207 on inquiry card.

PRIORITY ONE ELECTRONICS

ONE

CompuPro™ from Godbout



"LITTLE 8" Z80 SYSTEM STARTER SET

CPU Z: A 4MHz Z80A-based 8-bit workhorse CPU board that includes all the standard features plus many of the convenience options. Meets all IEEE 696/S-100 specifications, including timing.

DISK 1 DMA High Performance Disk Controller: disk controllers don't have to be your system's bottleneck! The DISK 1 is lightning fast thanks to properly implemented DMA (with arbitration) and data transfer that is independent of CPU speed.

RAM 20 32K High Speed Static RAM. This board has it all. Operates at speeds up to 10MHz, ultra-low power consumption, IEEE 696/S-100 extended addressing protocol, bank select and flawless DMA.

CP/M 2.2: The de facto standard of 8-bit operating systems ready to load and go!

ANOTHER *PRIORITY 1* EXCLUSIVE!

We went to GODBOUT and made a special buy on the nucleous of the best S-100 Z80A* systems ever.

LOOK AT WHAT YOU GET:

1 GBT160A 2/4 MHz Z80 CPU	$295.00
1 GBT164A32 32K 10MHz Static Ram	$425.00
1 GBT171A DMA Disk Controllers	$495.00
1 GBTCPM80 CP/M 2.2	$175.00
IT ALL ADDS UP TO	$1390.00

TOTAL PACKAGE PRICE Reg. Sale $1095.00

*Combined With 10% Discount Coupon, You Pay Only **$985.50**

YOU SAVE $404.50

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Don't forget you can save an additional 10% on Mainframes, I/O, Terminals, and Printers when purchased simultaneously with system using discount coupon.

TAKE A DEEP BREATH! SIT DOWN!

We made a special buy on a quantity of REMEX 4000 Double Density, Double Sided 8" disk drives. The REMEX drives are high speed - 3ms" Just what you need to take full advantage of yourlightning fast DMA disk controller from Godbout. We supply two of these high speed drives, a DTCDDC88 Dual Drive Cabinet with power supply, data cable, and documentation to make an incredibly powerful and versatile Z80 system.

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GBT1612A 6 MHz 8085/8088 Dual Processor Board
GBT171A High Speed DMA Disk Controller
GBT162A System Support 1 Multi Function Board
GBT133A Interfacer 1 Dual Serial I/O
128K 10MHz Low Power Static Ram
CP/M 2.2 De facto Standard 8 Bit Operating System
CP/M 86 16 Bit Operating System Ready to Load & Go
Cables andDocumentation Three interfacer cables, one disk I/O cable, complete documentation for all hardware, and manuals for both CP/M operating systems
Compu Pro's famous **1 Year** limited warranty

Now the best part of all. If urchased separately these quality components would list for $4,344.00. But Super Sixteen's low package price is **$3495.00**, an excellent deal!

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Super Sixteen is also available qualified under the Certified System Component high reliability program - with 2 year warranty, 200 hour burn-in and 8MHz processors. That brings the package price to $4095.00.

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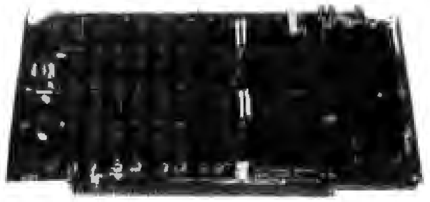

THE UNIVERSAL IEEE-S100 DYNAMIC MEMORY CARD

THE EXPANDABLE 1 TM 64K Dynamic Ram board provides your S-100 system with 64K of reliable, high-speed dynamic RAM. Compatible with most of the major S-100 systems on the market, including those with front panels, it supports DMA operations and requires no Wait states with current microprocessors.

- *User expandable from 16 to 64 K*
- *2 or 4 MHz operation*
- *North Star compatible*
- *Cromemco Compatible*
- *Designed to IEEE proposed S-100 bus standards*
- *Supports IMSAI-type front panels*
- *Operates with either an 8080 or Z-80 based S-100 system, providing processor-transparent refreshes with both*
- *Bank-select system allows system memory expansion and is compatible with Cromemco products*
- *Bank select port's address is jumper selectable*
- *Any 16K block can be made bank-independent*
- *All 64K can be made bank-enabled on power-on and reset*
- *Configuration as a 16K, 32K, or 48K board without the removal of RAMs*
- *Fully buffered address and data lines*
- *Fail-safe refresh circuitry for extended Wait states*
- *Board configuration with reliable, easy-to-configure Berg jumpers*
- *Supports DMA*
- *Jumper-selectable Phantom input*
- *Uses Popular 4116 RAMS*
- *Assembled & tested*
- *All ICs in sockets*
- *Power supply: Unregulated +8, +16, and −16 volts*
  Maximum power draw: 400 mA at +8 volts
  175 mA at +16 volts
  5 mA at −16 volts
  Dissipation: less than 8 watts
- *Temperature: 0 to 70 degrees Celsius*
- *Humidity: 0 to 90% noncondensing*
- *PC Board*
- *FR-4 glass epoxy*
- *Solder mask on both sides*
- *Gold-plated connector fingers*
- *Silk screen component outlines, reference numbers, and part designations*

PRIEXP116	16K Assembled & Tested	$299.00
PRIEXP132	32K Assembled & Tested	$339.00
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WITH FRICTION AND TRACTOR FEED

- Bi-DIRECTIONAL - 120 CPS
- 9 x 9 Matrix (Alphanumeric)
- 9 x 9 or 12 Matrix for Graphics
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- 6 or 8 Lines Per Inch
- 80 CPL @10 CPI for 82A
- 132 CPL @ 10 CPI for 83A
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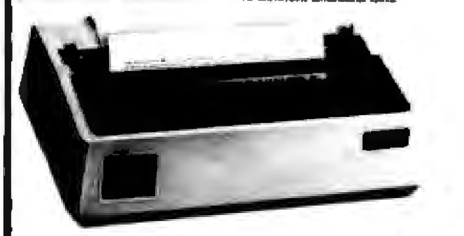
- 110 Through 1200 Baud
- Self Test
- Out of Paper Switch
- Friction or Tractor Feed
- 3" to 14" Top of Form (Switch Selectable)
- 10 Different Character Sets



Part No	Description	List Price	Our Price
OKIDAT82AT	80CPL@10CPI	$799.00	$575.00
OKIDAT83AT	132CPL@10CPI	$1195.00	$775.00

LIST PRICE: $2495.00

SPECIAL PRICE $1595.00

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Electronics Corporation

10 x 9 DOT MATRIX WITH TRUE DECENDERS ALPHANUMERICS/GRAPHICS PRINTER

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SPECIFICATIONS: 165 CPS ● 132 char per line ● Graphics res 60HX 72V ● Adj. tractor feed 3" to 16" width ● 10 character per inch or 5 expanded lines per inch 2, 3, 4, 5, 6, 8, 10 for alpha numerics 12 for graphics ● paper load front or bottom ● complete self test mode ● self-contained intelligent controller card handles both serial and parallel interfaces ● audible signaling ● out of paper detection ● bidirectional w/logic seeking.

MALIBU165	Serial/Parallel Interface	$1595.00
MALIBU1652	Parallel only Interface	$1450.00

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- Dual 5¼" Floppy
- 315K Per Drive 630K Total
- S100 Controller (8080, 8085, Z80 Compatable)
- Handles Up to 4 Drives
- Comes With MDOS, Basic, Assembler, and Text Editor

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74C04	.35	74C902	.85	4021	.95	14409	8.95
74C08	.35	74C903	.85	4022	1.15	14410	8.95
74C10	.35	74C905	10.95	4023	.35	14411	9.95
74C14	1.50	74C906	.95	4024	.75	14412	12.95
74C20	.35	74C907	1.00	4025	.35	14419	2.95
74C30	.35	74C908	2.00	4026	1.65	4502	.95
74C32	.50	74C909	2.75	4027	.65	4503	.65
74C42	1.75	74C910	9.95	4028	.80	4508	1.95
74C48	2.10	74C911	10.00	4029	.95	4510	.95
74C73	.65	74C912	10.00	4030	.45	4511	.95
74C74	.65	74C914	1.95	4034	2.95	4512	.95
74C76	.80	74C915	2.00	4035	.85	4514	1.25
74C83	1.95	74C918	2.75	4040	.95	4515	2.25
74C85	1.95	74C920	17.95	4041	1.25	4516	1.55
74C86	.95	74C921	15.95	4042	.75	4518	1.25
74C89	4.50	74C922	5.95	4043	.85	4519	1.25
74C90	1.75	74C923	5.95	4044	.85	4520	1.25
74C93	1.75	74C925	6.75	4046	.95	4522	1.25
74C95	1.75	74C926	7.95	4047	.95	4526	1.25
74C107	1.00	74C927	7.95	4049	.55	4527	1.95
74C150	5.75	74C928	7.95	4050	.55	4528	1.25
74C151	2.25	74C929	19.95	4051	.95	4531	.95
74C154	3.25	74C930	19.95	4053	.95	4532	1.95
74C157	1.75	4000	.35	4060	1.45	4538	1.95
74C160	2.00	4001	.35	4066	.75	4539	1.95
74C161	2.00	4002	.25	4068	.40	4543	2.70
74C162	2.00	4006	.95	4069	.35	4555	.95
74C163	2.00	4007	.29	4070	.35	4556	.95
74C164	2.00	4008	.95	4071	.30	4581	1.95
74C165	2.00	4009	.45	4072	.30	4582	1.95
74C173	2.00	4010	.45	4073	.30	4584	.95
74C174	2.25	4011	.35	4075	.30	4585	.95
74C175	2.25	4012	.25	4076	.95	4702	12.95
74C192	2.25	4013	.45	4078	.30	4724	1.50
74C193	2.25	4014	.95	4081	.30	80C07	.95
74C195	2.25	4015	.95	4082	.30	80C95	.85
74C200	5.75	4016	.45	4085	.95	80C96	.95
74C221	2.25	4017	1.15	4086	.95	80C97	.95
74C373	2.75	4018	.95	4093	.95	80C98	1.20

7400 SERIES

7400	.19	74128	.55
7401	.19	74132	.45
7402	.19	74136	.50
7403	.19	74141	.65
7404	.19	74142	2.95
7405	.22	74143	2.95
7406	.22	74144	2.95
7407	.22	74145	.60
7408	.24	74147	1.75
7409	.19	74148	1.20
7410	.19	74150	1.35
7411	.25	74151	.65
7412	.30	74152	.65
7413	.35	74153	.55
7414	.55	74154	1.40
7416	.25	74155	.75
7417	.25	74156	.65
7420	.19	74157	.55
7421	.35	74159	1.65
7422	.29	74160	.85
7423	.29	74161	.70
7425	.29	74162	.85
7426	.29	74163	.85
7427	.29	74164	.85
7428	.45	74165	.85
7430	.19	74166	1.00
7432	.29	74167	1.95
7433	.45	74170	1.65
7437	.29	74172	5.95
7438	.29	74173	.75
7440	.19	74174	.89
7442	.49	74175	.89
7443	.65	74176	.89
7444	.69	74177	.75
7445	.69	74178	1.15
7446	.59	74179	1.75
7447	.69	74180	.75
7448	.69	74181	2.25
7450	.19	74182	.75
7451	.23	74184	2.00
7453	.23	74185	2.00
7454	.23	74186	18.50
7460	.23	74190	1.15
7464	.39	74191	1.15
7465	.39	74192	.79
7470	.35	74193	.79
7472	.29	74194	.85
7473	.34	74195	.85
7474	.35	74196	.79
7475	.49	74197	.75
7476	.35	74198	1.35
7480	.59	74199	1.35
7481	1.10	74221	1.35
7482	.95	74246	1.35
7483	.50	74247	1.25
7484	.90	74248	1.85
7485	.65	74249	1.95
7486	.35	74251	.75
7489	4.95	74259	2.25
7490	.35	74265	1.35
7491	.40	74273	1.95
7492	.50	74276	1.25
7493	.49	74279	.75
7494	.65	74283	2.00
7495	.55	74284	3.75
7496	.70	74285	3.75
7497	2.75	74290	.95
74100	1.00	74293	.75
74107	.30	74298	.85
74109	.45	74351	2.25
74110	.45	74365	.65
74111	.55	74366	.65
74116	1.55	74367	.65
74120	1.20	74368	.65
74121	.29	74376	2.20
74122	.45	74390	1.75
74123	.55	74393	1.35
74125	.45	74425	3.15
74126	.45	74426	.85
		74490	2.55

December Specials

EPROMS

2708	(450 ns)	2.99	8/2.75
2716	(450 ns)(5V)	5.50	8/4.95
2716-1	(350 ns)(5V)	9.00	8/8.50

MPU's

Z80A	CPU	6.00
Z80A	PIO	6.00
Z80A	SIO/1	15.00
6821		4.25
6850		3.75

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7805T	.65	7905T	.89
7812T	.65	7912T	.89

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74S00	.44	74S74	.69	74S163	3.75	74S258	1.49
74S02	.48	74S85	2.39	74S168	4.65	74S260	1.83
74S03	.48	74S86	1.44	74S169	5.44	74S274	19.95
74S04	.79	74S112	1.59	74S174	1.09	74S275	19.95
74S05	.79	74S113	1.98	74S175	1.09	74S280	2.90
74S08	.48	74S114	1.50	74S181	4.47	74S287	4.75
74S09	.98	74S124	2.77	74S182	2.95	74S288	4.45
74S10	.69	74S132	1.24	74S188	3.95	74S289	6.98
74S11	.88	74S133	.98	74S189	14.95	74S301	6.95
74S15	.70	74S134	.69	74S194	2.95	74S373	3.45
74S20	.68	74S135	1.48	74S195	1.89	74S374	3.45
74S22	.98	74S136	1.09	74S196	4.90	74S381	7.95
74S30	.48	74S139	1.25	74S197	4.25	74S387	5.75
74S32	.98	74S140	1.45	74S201	14.95	74S412	2.98
74S37	1.87	74S151	1.19	74S225	8.95	74S471	9.95
74S38	1.88	74S153	1.19	74S240	3.98	74S472	16.85
74S40	.44	74S157	1.19	74S241	3.75	74S474	17.85
74S51	.78	74S158	1.45	74S251	1.90	74S482	15.60
74S64	.79	74S161	2.65	74S253	7.45	74S570	7.80
74S65	1.25	74S162	3.70	74S257	1.39	74S571	7.80

PROMS

74S188	(82S23)	OC	32 x 8	3.95
74S287	(82S129)	TS	256 x 4	4.75
74S288	(82S123)	TS	32 x 8	4.45
74S387	(82S126)	OC	256 x 4	5.75
74S471		TS	256 x 8	9.95
74S472	(82S147)	TS	512 x 8	16.85
74S474	(82S141)	TS	512 x 8	17.85
74S570	(82S130)	OC	512 x 4	7.80
74S571	(82S131)	TS	512 x 4	7.80

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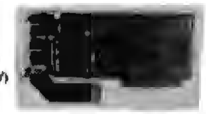
EXPAND YOUR 48K COMPUTER TO 64K
APPLE RAM



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- INCLUDES 5 JUMPER OPTIONS
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- THOSE EXTRA PLUG-IN CARDS CAN CAUSE EXTRA HEAT

HOW TO HOOK IT UP

1. Clip it on your APPLE
2. Unplug your 120V cable (you won't need it)
3. Plug short 120V cable from Super Fan II to the back of your computer
4. Plug the supply cable from Super Fan II to your 120V power source
5. Turn on the rocker switch and a built-in red ready light comes on
6. You are all set "COOL IT"

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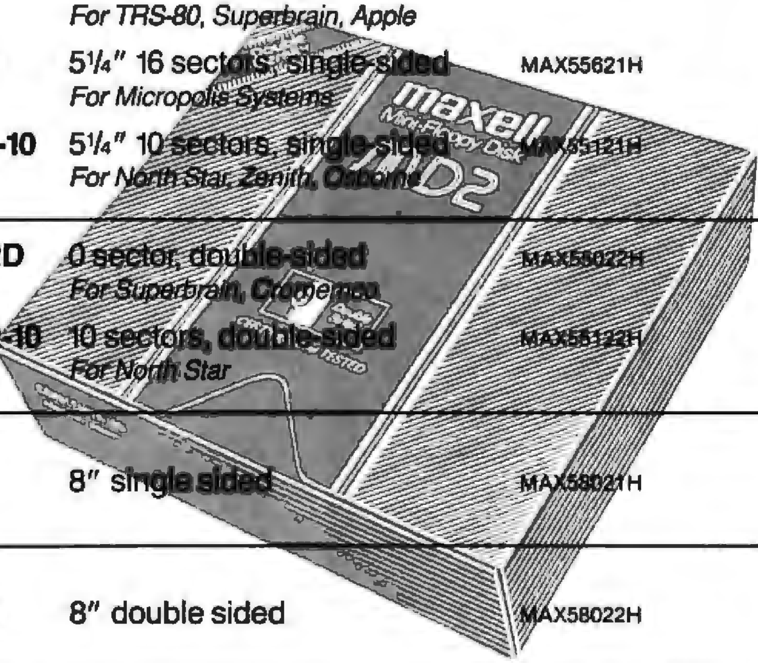

		Order Number	
MD1	5¼″ 0 sector, single-sided *For TRS-80, Superbrain, Apple*	MAX55021H	$29.95
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MD2D	0 sector, double-sided *For Superbrain, Cromemco*	MAX56022H	$44.95
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HAZELTINE 1410, List $900	749
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704-9, RS232C, List $1795	1595
TI 810 Basic, RS232C, List $1645	1349
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820 RO, Basic, List $1995	1645
820 KSR, Basic, List $2165	1839
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CONDUCTOR, DD, A&T, List $325	269
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NORTH STAR Z80A (ZPB-A/A), List $325	$ 269
CROMEMCO 4MHz (ZPU-W), List $395	335
CROMEMCO 4MHz (SCC-W), List $495	382
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SSM CB1 8080, A&T, List $252	214
CB2, Z-80, A&T, List $344	289
CB2, Z-80, Kit, List $260	219
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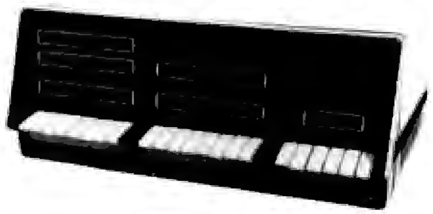

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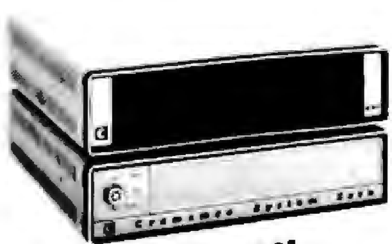

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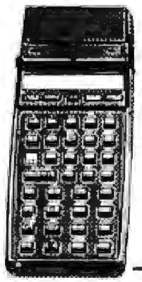

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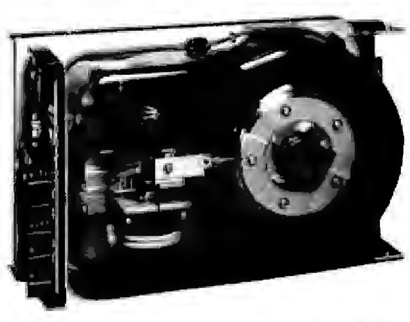

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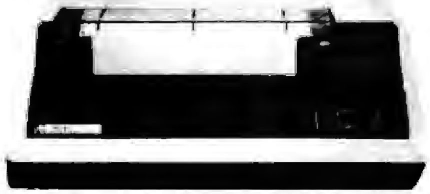

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WANTED: Have five systems in market timing (stock and commodity). Will exchange with you on your systems. Peter Peters, POB 407, Flushing NY 11363.

FOR SALE: TRS-80 disk system. $1400. Model I, Level II, keyboard, MPI drive, LNN Research expansion interface with 32 K, and Heath H-14 printer. All items in good working order. Murray Foster, c/o Ritam Corp, POB 921, Fairfield IA 52556, (515) 472-8262 days, 472-9417 evenings.

FOR SALE: Vadic modems VA-3403P/VA-3405C. Vadic modems are asynchronous and can run 300, 600, or 1200 bps, based on switch settings. We have boards, as well as a remote chassis for sale. The boards can be used in the Vadic cabinet VA-1601. Armand Marricco, Yale University, ADS, 155 Whitney Ave, New Haven CT 06511, (203) 432-4230.

FOR SALE: Pascal Microengine, Western Digital desk-top computer with 16-bit microprocessor and 32 K words (64 K bytes) of programmable memory. Recently updated to accommodate memory expansion to 128 K bytes. Floppy-disk controller, two RS-232C asynchronous/synchronous parts, and the latest issue of HO software (UCSD Pascal). $2800. W McKinney, 2506 Don Juan Dr, Rancho Cordova CA 95670, (916) 453-2500.

FOR SALE: 8-inch DSDD drives. Two add-on, double-sided, double-density (1.2 megabyte) disk drives, with separate enclosures and power supplies. QUME DT-8 in CDC cabinet: $750. Morrow 2+2: $795. Both for $1495, UPS freight paid. Both new and in use. You need cable, controller, and system support software. CP/M sysgen assistance available to purchaser. Also, Hayes Micromodem 100: $295. Dave Crane, POB 402614, Dallas TX 75240, (214) 931-2669, 931-8272.

FOR SALE: Logix teammate game computer with manual. Has a 2-digit display and a 4 by 4 lamp array. Has four special function keys, ten numbers, and five letters. There are no pieces missing and it is in excellent working order. Send check or money order for $40. Maurice Yanney, 508 Margin Rd, Lebanon PA 17042.

FOR SALE: 8 K Commodore PET 2001. Stacks of documentation and mail-order offers. Light pen. Over fifteen cassettes with 100 programs, including Microchess 2.0, Battleship, and many others (mostly games). Also have assembler and machine-language monitor. Everything in excellent condition. Will sell all for $500 or best offer. Will also consider a trade. Lee Grey, 250 Bruton Way, Atlanta GA 30342, (404) 257-9106.

WANTED: Fifteen-year-old needs start in computers. Will buy and/or pay shipping for surplus, used or damaged computers, and related equipment that would be otherwise discarded. I will accept collect calls. Jason Bender, 23855 SE 162nd, Issaquah WA 98027, (206) 392-2698.

WANTED: PC-100C printer. Also, the first four issues of BYTE from September through December 1975. Please give price, including shipping. Ken Hamel, Rte 5 Box 162, Watertown WI 53094.

FOR SALE: Heath H-8 computer, H-9 video terminal, H-17-1 floppy disk, various hand tools (Pana Vise vacuum base, vertical vise head, circuit board holder), and soldering iron (25 W). H-8 includes two WH-16K programmable memories and WH-8-5 serial/cassette interface. All documentation is included, plus other books. $1100. Good condition. SSG Percy Davis, Jr, 622 Bishop Rd Apt M16, Lawton OK 73501, (405) 357-3309.

HELP: Operator of CPT8000 word processor who knows nothing about computers would like to hear from anyone who can tell me how to play games or do other interesting or useful things on it. Also, interested in purchasing any software I can use on it. Adam Starchild, POB 1608, Tarpon Springs FL 33589.

FOR SALE: Complete Heathkit H-8 based 32 K system. Includes: H-9 terminal, H-17 dual disk drives (204.8 K), H-8-5 serial I/O card, H-8-4 parallel I/O card, H-8-7 interface card, and complete system software, including BASIC, ASM, EDIT, and DBUG. Full documentation provided. $1800 or best offer. J Trivisonno, John Carroll University, Cleveland OH 44118, (216) 491-4301.

FOR SALE: Altair 8800 with 51 K, Dutronics Z80, Thinker Toys Discus 2-D with two drives, ADM3A video display, Heath H-14 printer, CP/M 2.2, and Meca dual-digital tape. $6000. Stan Stewart, 5208 S Lewis #2013, Tulsa OK 74105, (918) 743-4344 home, 744-0331 office.

FOR SALE: Centronics Model 779 dot-matrix printer. Apple interface card and all cables included. Nearly new, excellent condition. $500 or best offer. Dennis Simms, 5232 N Lowell Blvd, Denver CO 80221, (303) 458-1833.

WANTED: Student experimenter needs any of the following items: resistors, transistors, capacitors, ICs, diodes, books, magazines, condensers, amplifiers, old computer parts, wire-wrapped sockets, LEDs, toggle switches, dip switches, small motors, nuts, bolts, wire, crystals, keyboards, knobs, small color TV, push-button switches, small wheels, springs, PC boards, victor pins, small speakers, TV circuits, heat sinks, small fans, wire-wrapped connectors, potentiometers, sockets, and small ball bearings. Please write. Judy Stapleton, POB 536, Pine Lake GA 30072.

WANTED: Has anyone implemented MP/M on North Star Horizons (DD)? Advice, comments, and possible sources urgently required by nonprofit publicly owned college without access to Intel MDS. Assistance gratefully acknowledged. Stuart Bell, Plymouth CFE, Kings Rd, Plymouth, Devon United Kingdom.

WANTED: Software interface between CP/M and Processor Technology CUTER cassette interface for backing up CP/M-compatible program on cassette tape. Faber Tan, 3630 El Camino Real, Palo Alto CA 94306, (415) 493-6500.

FOR SALE: Datasouth DS120 terminal controller—converts DECwriter II (LA35/LA36) to high-speed printer. See Datasouth ad in BYTE (April 1981, page 126) for description. Like-new condition. Asking $450 (it costs $750 when new); manual included. GSI, 245 Nassau St, Princeton NJ 08540, (609) 924-1155.

FOR SALE: Four SwTPC 4 K memory boards, $40 each or $150 for all four postpaid, PR-40 printer; $200 postpaid. S Brown, 35 Kettle Pond Rd, Amherst MA 01002, (413) 253-3183.

FOR SALE: Apple II with 48 K, Autostart read-only memory, Applesoft card, Programmer's Aid read-only memory, 3.3 disk, Apple parallel card, and Dan Paymar LCA. All for $1875 or separately for 75% of list. Centronics P1 printer: $195. Unused Memorex diskettes: $2.50 each. Computer books, magazines, and software: 25 to 75% (including VisiCalc, S-C assembler, Sargon II, Adventure, Star Cruiser, and more—original only, no copies). Send SASE for list. W Bollinger, 8210 Gannon, St Louis MO 63132, (314) 991-0357.

WANTED: I'm interested in getting together with other people involved in optical computing (I don't mean the use of fiber-optic communication, but true optical processors, memories, modulators, etc.) If you work or play in these areas, please write. James A Lisowski, 902 Willow Ln, S Milwaukee WI 53172.

FOR SALE: Typagraph computer terminal with 110/300 bps, full uppercase/lowercase capability, numeric keypad, pin feed with adjustable tractors to full 132 columns, forms control, modem included for remote connect via telephone, and RS-232 for direct connect. $995 or best offer. Ron McCarty, 4031 Station Rd, Erie PA 16510, (814) 898-2847.

FOR SALE: Apple II Plus with 48 K programmable memory, the Apple II BASIC Programming Manual, and the Applesoft BASIC Programming Reference Manual. Price negotiable. Daniel L Martin, 9801 Portside Dr, Seminole FL 33542, (813) 595-1412.

FOR SALE: Antique computer system. Friden 5610 Computyper (serial number 1365), Friden 2205-1-A Flexowriter, Friden 2315 tape punch, and Friden 2314 SelectaData. The entire system weighs approximately 800 lbs. The Computyper and Flexowriter are built into a desk unit. Excellent condition, everything works perfectly. Best offer. Steven Chabotte, 21 Garfield Ave, New London CT 06320.

FOR SALE: Comprint 912-GP printer. 9 by 12 dot-matrix characters, uppercase/lowercase with descenders. Quiet, fast electrostatic printing at 170 lpm on 8½-inch paper rolls. No ribbons to purchase, paper costs less than three cents a page. Including manual, about 400 feet of paper, and cable for plug-in operation with TRS-80 expansion interface or Apple parallel printer interface card. $225 plus shipping. Delmer D Hinrichs, 2116 SE 377th Ave, Washougal WA 98671, (206) 835-2983.

FOR SALE: Several new and unused Penril 212A modems. These are 300 or 1200 bps modems and I will sell them for $500 each. Mike Hayes, POB 29000, San Antonio TX 78229, (512) 340-6507.

FOR SALE: Complete set of BYTE from first issue through the December 1980 issue. All in excellent condition. Best offer. Robert Greengrove, 162 Grant Ave, Nutley NJ 07110, (201) 667-7425.

FOR SALE: For Apple II owners: DS-65 digisector card plus advanced video television camera. Applications in computer portraits, home security, and robotics. All software and documentation included. New: $500. Prices negotiable. Scott Anderson, (206) 454-6053.

FOR SALE: DEC PDP-11/05 minicomputer with 8 K words of core memory. Has 9-slot chassis with power supply and full front panel. No interfaces or documentation. Works OK. $1000/offer. John Wanoblew, 1168 B Redman St, Orlando FL 32809.

WANTED: Minifloppy system for Processor Technology SOL-20 computer (Hercules). I need the S-100 floppy-controller board and one drive, working or broken. I also need the schematics, manual, and any software you can give up. Send description and price. Geoffrey Placious, 13340 Bondy Way, Gaithersburg MD 20760.

FOR SALE: Five SwTPC 4 K memory boards, two with write protect added. $60 each. Mark Dean, 2575 Three Bar Ln, Norco CA 91760.

FOR SALE: Texas Instruments TI-99/4 computer console with 72 K memory capacity and all original documentation. Unit is one month old. Will sell for $650 or best offer. Also, ten 5-inch diskettes for $2.50 each plus postage. Bill Efron, 1369 Murray St, St Paul MN 55116.

FOR SALE: 48 K Apple II with integer and floating-point BASIC. One Apple disk drive and controller. Base II printer and 9600 bps interface. Black-and-white television. Assorted software on disk. All manuals, etc. May buy as set for $1500 or best offer. May buy pieces at best offer. Must sell. David A Schultz, Concordia College, Moorhead MN 56560.

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September BOMB Speaks Up

Steve Ciarcia's article, "Build an Unlimited-Vocabulary Speech Synthesizer," has captured first place in the September BOMB. Steve will receive the $100 prize. Second place goes to senior editor Gregg Williams for his article "Tree Searching, Part 1: Basic Techniques." Gregg is a staff editor and not entitled to the prize money. Third place goes to David Thompson for his review, "The Big Board: A Z80 System in Kit Form."