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Welcome to our annual language issue. This year we present Logo, the microcomputer language perhaps best known for its turtle graphics. Mathematically minded readers may recognize the cover illustration by Robert Tinney as BYTE's own version (influenced slightly by M.C. Escher) of the classic four-bug puzzle. In this puzzle, for which a Logo program is shown on the cover, four bugs are placed at each corner of a square; each bug attempts to walk toward the bug to its immediate right. In the process they trace Archimedean spirals. The object is to calculate the length of the spirals. The answer: each is equal to the length of one side of the original square. But Logo is more than turtles, and our articles will tell you what it's all about.


Steve Ciarcia shows you how to build a graphics board for your Apple II computer using the Texas Instruments TMS9918A, and William Barden Jr. explains "A General-Purpose I/O Board for the TRS-80 Models I and III." Of course, we have Jerry Pournelle's User's Corner and more.
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August 1982 © BYTE Publications Inc

Editorial

Keeping Our Technological Edge

by Chris Morgan, Editor in Chief

This month, as we do every August, we’re devoting a portion of BYTE to a single computer language. This year’s language is Logo, and we have dedicated this issue of BYTE to Seymour Papert, who developed the language.

We chose Logo this year for many reasons, but the most important is that the first computer language you learn has a lifelong effect on how you think, computerwise. Thus, the computer language we choose for use in the schools becomes vital. I believe, for reasons detailed in various articles in this issue, that Logo is a much better language to use for introducing children to computers than, say, BASIC.

Unfortunately, Dr. Papert recently left the United States, where he spent so many years advancing the state of the computer art. He now lives in France and has become the chief scientist of the newly formed World Computer Center. We wish him well, but the circumstances that led to his departure are both disturbing and encouraging. They are related to a potential crisis in American computer research and development today. Fortunately, there’s still time to do something about the impending crisis. One way is through proposed legislation currently before Congress—I’ll say more about that later.

I may sound alarmist in using the word “crisis” to describe the current state of affairs, especially when the mainframe and microcomputer industries are doing so well. But consider this: three of America’s leading computer scientists have recently left the United States to be part of the World Computer Center under the leadership of Jean-Jacques Servan-Schreiber. In addition to Seymour Papert, they are Nicholas Negroponte, former Director of Computers and Communications at the Massachusetts Institute of Technology, who will become the new Director General of the Center, and Professor Raj Reddy, former director of the Robotics Institute at Carnegie-Mellon University.

The reason they left is simple. The French government had the foresight to see the need for and create a world computer center that will directly or indirectly benefit every world citizen. The United States lacked that foresight. As U.S. Rep. Albert Gore Jr. (D., Tenn.) said recently at a Washington briefing, “We have some serious thinking to do when scientists as distinguished as Nicholas Negroponte and Seymour Papert leave the United States in order to be part of the World Computer Center.”
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Editorial

At that same Washington briefing Jean-Jacques Servan-Schreiber showed, in a speech by turns stimulating and troubling, just how fragile our significant technological advantage in the computer field is. For example, the Japanese have made inroads into the jet engine market. Three years ago they entered into a joint venture with the ailing British Rolls-Royce jet engine division that significantly improved the company's financial position. Again and again we hear stories of Japanese companies dominating technologies pioneered in America: liquid crystals, for example, are now made almost exclusively in Japan. The same tenacity the Japanese have shown in the automobile, camera, stereo, and ship-building fields is now being directed at the personal-computing industry, and while I am not immediately concerned about a possible Japanese "threat" for reasons I detailed in my May 1982 editorial, we must still be aware of the precariousness of our position.

The World Computer Center

The World Computer Center is a new, ambitious effort to put computer power in the hands of the people. Among the Center's proposals is a project to install a personal computer in each of 500 villages (mostly in the Third World, although some sites are in developed nations including the United States). Servan-Schreiber, the Center's director, lobbied long and hard in France to short-circuit the (as Negroponte puts it) "Byzantine" maze of French bureaucracy and create the World Computer Center in Paris that has, in one sweeping gesture,
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Figure 2: With 41.4 percent of its work force engaged in information-related employment, the U.S. is the leader of the five nations represented in the graph.

provided Negroponte with twice the resources and manpower he had at MIT, which had taken 15 years to build up to its current status.

The World Computer Center has the right idea. Take a look at figure 1. It shows the astonishing growth in the percentage of U.S. workers in service-related jobs from 1860 to 1980. Figure 2 shows the current percentages of work forces in information-related jobs by country. Surprisingly, countries like Venezuela, not normally regarded as technologically advanced, already have sizable work forces in the information field.

Servan-Schreiber takes the somewhat radical view that, in several years, human beings will no longer work the production lines. All such work, he believes, will be done by robots and machines. Therefore, he warns, people will have to learn to be processors of information. Whether or not you subscribe to this view, the trend is undeniable. Robots are attractive in many ways, not the least of which is their cost of operation. Figure 3 indicates that robots currently cost less than human workers to "employ." It’s obvious to me that we must all become computer literate to survive in the future world. Yet our government is doing virtually nothing to ensure that survival.

Some Legislative Answers

One answer to the dilemma is government subsidy and encouragement of computer-literacy programs. Practically speaking, this means that personal computers must get into homes and schools. Two bills currently before Congress seek to provide financial incentives for computer manufacturers, businesses, and schools to increase their commitment to computer-literacy goals.

One of the bills, which has received a good bit of publicity, can be credited to the foresight of Steve Jobs, chairman of the board of Apple Computer Inc. The
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Technology Education Act of 1982 (HR5573 and S2281) was introduced by U.S. Rep. Pete Stark, a California Democrat. Its terms are simple: for a period of one year, computer manufacturers would be allowed to receive an increased deduction for donating computers to schools.

Built-in safeguards will assure that all manufacturers receive equal benefits. For instance, each manufacturer could give only one computer to a school. This would prevent any attempt to overpower the schools. And the computers must be state of the art. To prevent the dumping of obsolete equipment, manufacturers could not donate equipment that has been in inventory for more than two years. The manufacturer’s deduction would increase from the current 50 percent of manufacturer’s cost to the cost plus one half of its markup, not to exceed 75 percent of the list price. This is hardly a radical bill. Another bill currently on the books allows computer companies the same increased deduction for research equipment donated to universities. To my mind, HR5573 is a logical and much needed extension of the existing bill. I applaud Steve Jobs’s willingness to push computer manufacturers into action.

The other bill, The Family Opportunity Act (HR6397), was recently introduced by U.S. Rep. Newt Gingrich, a Republican from Georgia. The Family Opportunity Act would offer a $100 per year, per family member, tax credit for up to 50 percent of the cost of a home-computer hardware or software system, with five years to write off the investment. With this bill, a family of four could buy a $4000 system and, over five years, take $2000 in tax credits.

"I want every American to have access to the same opportunities that computers provide for General Electric and AT&T,” Gingrich says. “That’s why working Americans should have the same kinds of tax breaks corporations get automatically.”

Figure 3: This chart indicates that at $4.80 an hour robots cost less to employ than their human counterparts in the U.S., West Germany, and Japan (1979 figures).
New from HIPLÔT™
multi-pen plotting for as little as $1480*.

The new HIPLÔT DMP Series 6-pen option makes high performance multi-pen plotting affordable. It's available on the DMP 2, 3, and 4 models in the HIPLÔT family so you can enjoy the advantages of multi-colored plots on 8½" x 11" (DIN A4) surfaces. Of course, you also get the standard HIPLÔT range of capabilities such as intelligence, controls, interfaces and resolutions. There's a model for virtually every plotting application.

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Since it's introduction, the HIPLÔT DMP Series has been recognized as the innovative plotter line which made low-cost, high performance digital plotting a reality.

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If you need a little more capability, take a look at our new 8-pen option. It's available on the DMP 5, 6, and 7 so you can have 8-pen multi-colored plots on 11" x 17" (DIN-A3) surfaces.

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Editorial

If you can see the value of these two bills, I urge you to write to your senator and representative. Both bills must be approved by the House Ways and Means Committee before they can be voted on. The best way to make your voice heard is to contact the chairman of that committee, Dan Rostenkowski, at the House Ways and Means Committee, 1102 Longworth House Office Building, Washington, DC 20515, (202) 225-3625. If hearings are held, they will probably be before the Select Revenue Measures Subcommittee, chaired by Pete Stark. You can contact him at his office, (202) 225-5065; direct your mail to The Honorable Pete Stark, House of Representatives, 1034 Longworth House Office Building, Washington, DC 20515. Support from both Republicans and Democrats is essential if these bills are to get attention.

I cannot stress too strongly the need to make Congress aware of the urgency attached to the goal of getting computers into the hands of every American. Only then will we be able to hold our own in tomorrow's computer society.

Software Arts' TK Solver

Software Arts Inc., in case you’ve forgotten, is the company that created the immensely successful Visicalc program. Now that company, headed by Visicalc co-authors Dan Bricklin and Bob Frankston, has announced the first product to be marketed by Software Arts itself (Visicalc is marketed by Visicorp, formerly Personal Software). TK Solver (see photo 1) allows you to enter a series of formulas in a natural format (for example, “distance = time X speed”); it then compiles a list of all the variables. You can then give it a set of known values and tell it to solve for the unknown ones; it either does so or tells you why it cannot.
Never having to type the word "CATALOG," or trying to remember how to get from one part of a program to another!

If you could do these functions, and many more like them, at the STROKE of a SINGLE KEY, would you? We thought you would! So, we invented the Enhancer [] and the Function Strip. More than just another lower case adapter, the Enhancer [] is an intelligent keyboard processor. Now characters, strings of data, commands and statements can all be stored in your Enhancer [] for immediate recall by pressing JUST ONE KEY!

Features that you would expect only on larger systems now can be yours. EASILY! For instance, wouldn't you like auto-repeat, and high-speed repeat? How about a type-ahead buffer?

Even user-definable function keys are available for greater input flexibility.

The Videx Enhancer [] and Function Strip; it really is the Dawn of a New Era for Apple []™.

Suggested Prices

ENHANCER [] 149.00
FUNCTION STRIP 79.00
Package Deal 215.00

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Photo 1: The new TK Solver, from Software Arts, lets you enter a series of formulas in a natural format.

TK Solver will initially be available for the Apple II and the IBM Personal Computer. It will be on the market later this year at the price of $299. Also available will be various application packages that will supply a predefined set of rules concerned with a given specialty; these will probably be in the $50 or $100 price range.

Sound simple? Of course, but then so does Visicalc when you describe it. The basic idea has several good things going for it. First, it is extremely well human-engineered—it has to be because its potential users are not necessarily computer-oriented. Second, it automates repetitive calculations, thus giving you answers faster and more accurately than you could do yourself. Third (and most important), it allows you to do problem solving with a body of equations without your having to manipulate them algebraically.

Software Arts says that TK Solver lets the professional use the microcomputer as a problem-solving tool without having to learn programming. Will this product be as big a hit as Visicalc? Only time will tell, but look for an in-depth review of TK Solver in an upcoming issue of BYTE.

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Omission

On page 70 of the May 1982 issue of BYTE we inadvertently omitted a distributor for the NEC PC-8001A. In addition to the distributor listed, NEC Home Electronics (USA) Inc., Personal Computer Division, 1401 Estes Ave., Elk Grove Village, IL 60007 (312) 228-5900 also will provide all components in the PC-8000 series. We regret the omission and hope our readers will find this new information useful. Our thanks to Thomas L. Priestly, General Manager of the Personal Computer Division, for pointing this out to us.
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Letters

Commodore Comments

I am writing concerning the article "A Human-Factors Case Study Based on the IBM Personal Computer" by Robert G. Cooper Jr., Paul Thain Marston, John Durrett, and Theron Stimmel (April 1982 BYTE, page 56), in which a comparison of business-oriented microcomputer keyboards was included.

The Commodore keyboard used was from a PET 2001 series microcomputer, and while we appreciate being included in the comparison, certain factors must be considered: first, the PET 2001 has not been in production for about two years; second, the PET 2001 is oriented for education, not business, and our business-oriented microcomputer, the CBM 8032, was not included in the comparison.

We realize that the article and comparison were done by nonstaff authors, but we want you to know that we would be more than happy to cooperate fully with BYTE, its in-house staff, and freelancers in order to ensure that your readers get the latest and most accurate information possible about all Commodore products.

David A. Kaminer
Director of Public Relations
Computer Systems Division
Commodore Business Machines Inc.
The Meadows
487 Devon Park Rd.
Wayne, PA 19087

Unix Feedback

I find I grow tired of the Unix-versus-CP/M argument, particularly as it is phrased by people like John Lynn Roseman (April 1982 BYTE, "Letters," page 22): "Unix is a full-featured operating system which is widely regarded as the finest ever written, while CP/M is little more than a program loader." Really? I defy anybody to take a competent secretary and make him or her a useful word-processing person on the Unix EX/VI in less time than it takes to get your work done on the CP/M Wordstar system.

And I don't like the crystal-ball predictions and dogma-before-the-fact apparent in Mr. Roseman's statement: "... we can be sure that the commercial software which will eventually be available under Unix will be of higher quality than that found in the CP/M market." We can?

I direct your attention to an article by Donald Norman that appeared in Data-Add (April 1982 page 139 and following). It is titled "The Trouble with Unix," and it hits a number of nails on the head. Although I am fluent in a number of dialects of a number of languages and in a number of operating systems, I still haven't found the ultimate anything. CP/M has a number of serious limitations, but so does Unix (and so does anything else I have ever used). Allow me to paraphrase Norman's conclusions, in which he states his three most important concepts for system design: be consistent, provide the users with a clear idea of what is going on at all times, and provide mnemonics as aids to us poor humans. I would add a final imperative: remember the users' context. In other words, decide what you want to have a given system do, and for what audience. CP/M is a tremendous environment for single users doing word processing and data acquisition; BASIC is a wonderful tool for a wide range of (generally small and one-of-a-kind) programming tasks; Unix is an amazing too for some of the data-intensive work I sometimes need to do.

But please, give us all a break from the search for a perfect system for all people for all time. Provide me with information, tell me (as objectively as possible) about the tools that are available, and then leave me alone so I can get my work done.

Jeffrey L. Star
Research Geographer
Geography Remote Sensing Unit
University of California
Santa Barbara, CA 93106

More on Human Factors

Hurrah! Hallelujah! Human factors have arrived. While BYTE has occasionally published comments on the importance of making computer systems easy to use, I was overjoyed to see human factors engineering as the theme for the April 1982 BYTE. The article "Designing the Star User Interface" by Dr. David Canfield Smith, Charles Irby, Ralph Kimball, Bill Verplank, and Eric Hanslem (page 242) was particularly outstanding in showing how human factors can be incorporated into the design process.

However, several points about human
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Technical support. When you buy our tools, you get our number. If you have technical problems, call the Microsoft support staff for assistance. If we don’t have the answers now, we’ll find them and call you back.

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Better tools. Ask your Microsoft dealer about Microsoft’s family of proven tools for programmers: BASIC interpreter, BASIC compiler, FORTRAN and COBOL. Each is a specialized tool for a special programming problem. Better tools. And better tools make better programs.
factors and computer system design that do not emerge from the April issue of BYTE as a whole need to be emphasized. First, human factors need to be considered very early in design, well before the first line of code is written or the first circuit developed. Specifically, to ensure that a product will be human engineered, design from the outside in. First construct the user interface and write the user's manual. Everything else should follow. All too often the situation presented to human factors experts is: "We have built this system and are delivering it tomorrow. Isn't it wonderful? Please bless it."

Second, test, test, test. Throughout the life of a system observe user performance. Begin with simulations during the conceptual phase and conduct further tests in succeeding phases—on the documentation, on the first prototype, on the first production system, and on systems that have seen considerable operation. The focus should be on what the user does and how the system responds. While the opinions of human factors experts and user surveys provide clues about improvements, it is essential to collect time and error measures of user-computer interaction. A modicum of concrete data outweighs many opinions. Also keep in mind that computer scientists and engineers are poor critics of the friendliness of the systems they build and are not the best test subjects. They know far more about the internals of computer systems and differ in many other significant ways from ordinary users.

Third, human factors work, while sometimes costly, is money well spent. Project managers are often reluctant to spend funds for human engineering when there are more conventional projects to support (for example, developing file managers that require less memory or power supplies that run more coolly). Human factors considerations are an integral part of design and should be assigned a commensurate priority and funding. Managers need to appreciate that users don't care why a system doesn't work. To users, incomprehensible commands and error messages, inscrutable manuals, computational errors, and blown fuses are all equally bad.

Finally, one does not become a human factors expert by being appointed by one's supervisor, living with a system, or just being human. Human factors expertise is obtained primarily through experience and special training in such areas as statistics and experimental design, sensation, perception, cognition, time and motion study, safety engineering, occupational health, biomechanics, work physiology, and anthropometry. In addition, one should complete several courses specifically dealing with human factors engineering.

Paul Green, PhD
HSRI—Human Factors
University of Michigan
Ann Arbor, MI 48104

I have just finished reading the April 1982 BYTE, the issue devoted to human factors engineering. While some topics were discussed adequately, I feel the issue lacked a general discussion of the human-machine interface. It is the user interface that is the most important issue in determining how user-friendly a system is to be. Only after this subject is carefully treated can the aspects of program design be discussed. In this respect, the article "Designing the Star User Interface" presents an example of one way to implement the man-machine interface.

Currently, the most reliable low-cost man-machine interface is the touch screen. Touch screens allow the simplest touch screen. Touch screens allow the simplest user interface. Users visually see what item they're interested in, then reach out and touch it. The computer system then responds. Since it relies solely on the users' visual and tactile senses, no prior training is required.

Our experience in the creation of touch-sensitive database systems in library catalog, hospital, merchandising, publishing, and other public-use applications suggests that this technology will rapidly become dominant in environments where training of the user is not feasible or practical.

From a human factors point of view, we have learned that there are also additional considerations that improve the prospects for the success of a system in use. First of all, we have found that a combination of visual and aural responses supporting the physical sensation of touch creates a strong feeling of comfort. Using inverse video or highlighting the touched region and ringing the audible bell have proved to be helpful features. Also, if the user touches a region of the screen not relating to a valid choice, the response should be similar to that for a valid touch, but the region of the screen touched should restore to normal video almost immediately. This action tells users that the
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Letters

equipment is working and thus they have simply touched an invalid region for this particular point in their use of the system.

The design of data formats for successful touch-based systems should follow guidelines similar to those which have evolved for the design of keyboard-oriented systems; i.e., the processes should mirror and reflect the functions to be performed. One additional consideration is that menu items should be separated from each other to accommodate the accuracy of the human finger. Typically, touchable menu entries should be displayed either double the normal text size or on every other line. This spacing allows almost any user to touch the desired selection on the first try. Software products which convert the menus of already existing programs to convenient touch-screen formats are commercially available and inexpensive.

Your readers should feel free to contact us if they desire additional information about the touch-sensitive technology.

Jonathan J. Bloom, Marketing Manager
Interaction Systems Inc.
24 Munroe St.
Newtonville, MA 02160

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Your Apple computer can grow from ordinary to awesome in a matter of minutes.

The Elite disk drive Series by Rana Systems gives you that kind of magic. Quickly, easily and cost-effectively.

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Elite One, the most economical Rana drive, delivers 15% more storage capacity than Apple's drive. The top-of-the-line Elite Three will provide an astonishing four-times more storage, approaching hard disk performance. It's done through exclusive high-density single and double-sided disks and heads.

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Next to enormously increased disk space, Apple buyers are most excited about Rana's fingertip Write/Protect feature. A pushbutton on the LED-lit panel gives you a new measure of failsafe control.

While Elite drives are all plug-compatible with Apple's controller, Rana's vastly superior controller card is a must for those with growing data processing demands. With it, you control up to four floppy drives using only one slot... while still utilizing your Apple computer to achieve dramatic new heights of system flexibility and processing power.

A specially programmed Rana utility disk assures you of far-reaching compatibility, and extra dimensions of business, leisure and learning applications with your Rana-enhanced Apple computer.

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software, therefore, depends not only on the local microcomputer but also on modems, telephone lines, and a remote IBM processor running mainframe communications software. The possibilities for undetected protocol errors are enormous because all of these components normally function correctly and boundary conditions are not usually encountered in normal operation.

How, then, can we offer a warranty? By testing, testing, and testing! We have developed both hardware and software test vehicles that allow us to simulate all components of the communications path that are external to the microcomputer, including the local microcomputer operator and the remote IBM processor. Using these test harnesses we can perform functional tests that ensure that each function of the software performs as advertised and stress tests that test boundary conditions, host-generated protocol errors, and performance under high load. Any errors that slip through the test suites and are reported by customers are then incorporated into the test suites to ensure that any problem reported is never again present in a release. The software becomes more and more stable as a function of time.

From a user's viewpoint, a software warranty means that you can count on (1) getting the level of customer support needed to make the software run in your environment, (2) the software's being very stable once it is running, and (3) receiving patches and updates that correct problems found by other users.

This implies, from the vendor's viewpoint, that (1) the software must be easy to set up and run (or the vendor must have a huge customer service staff) and (2) the vendor must be prepared to expend a lot of time and money in sending out updates if the software is not stable.

We believe that the time and money spent testing, supporting our customers, and sending out updates (yes, we still find occasional bugs) is well worth it. We couldn't live with ourselves if we sent out junk that had little chance of running. Our customers deserve the best we can provide—after all, they're paying our salaries!

John A. Parsons, CDP
President
Micro-Integration Inc.
63 Maple St.
POB 335
Friendsville, MD 21531

Letters

Misrepresenting the Videotex Standard

I read with interest Chris Morgan's editorial, "Of IBM, Operating Systems, and Rosetta Stones," in the January 1982 BYTE. Of particular interest was the mention of Microsoft's device driver for the AT&T proposed videotex graphics standard. For your Canadian readers you might point out that the AT&T system is based on the Telidon coding system developed by the Federal Department of Communications in Ottawa. Mr. Morgan is in error, however, in the implication that this is a low-resolution standard. It is, on the contrary, an extremely high resolution standard, allowing up to an incredible 24 bits of data to specify each x and each y coordinate. This, admittedly, exceeds the capability of any current hardware including the printing press.

The key and the beauty of the system, however, is in the concept of the unit screen, which treats these data bits as decimal values between 0 and 1, thus achieving hardware independence and upward compatibility.

If you probe the standard further, you will see similar capability and expandability in all aspects of the code, including color, character fonts, text sizes, and the like. It is anything but a minimal standard.

It may be of interest that a Unix-based system has been written to meet the earlier Telidon standard (of which the AT&T system is essentially a superset).

Robert A. Abell, President
Alphatel Systems Ltd.
Edmonton, Alberta
Canada

We thank Mr. Abell for setting us straight about the videotex graphics standard. We are currently working on an issue, to be published in early 1983, that will be devoted in large part to the subject of standards in the microcomputer industry. . . . C. M.

The Last Laugh

I was much amused by your facetious entry in the What's New? section of the April 1982 BYTE (page 424) concerning the hard disk for the ZX81. I'm afraid the joke is on you, however, and I quote from a recent press release ("Micro Forecast," Vol. 3, No. 5):
After the first £100 computer—the ZX80—two years ago, Sinclair are looking to become the first company to market a £100 disk drive.

The project to produce a low-cost mass memory storage on hard disk for personal computing will be led by Rodime, the Glenrothes-based, all-British disk drive company, if agreement can be reached between the two companies.

The new disk drive will use 3¼-inch rather than 5¼-inch hard disks and both Sinclair and Rodime hope that users of the ZX81 will take up the disk-drive facility when it becomes available, creating a new £250 million market for the disks. At the same time it will give the ZXBl and future Sinclair computers an enormous boost as the battle for a share of the microcomputer markets heats up.

Rodime, who will develop the disks, say there are no serious technical problems preventing them from going ahead with a 3¼-inch disk and claim that with or without Sinclair they will be marketing one by 1983.

The problem of bringing the cost down, however, could confound Rodime and it would need Sinclair’s mass market as well as their gift for making a success of low-cost computing before they could seriously contemplate a £100 price tag. Sinclair meanwhile are not expected to be involved in selling the disk drives for some time yet. The first proposal came from Rodime, and Sinclair will need to overcome technical problems and plan production—possibly from the Timex plant where the ZX81 is built.

Dr. C. T. Spracklen
Department of Applied Physics and Electronics
University of Durham
Science Laboratories, South Road
Durham, DH1 3L3
United Kingdom

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The A.M. Electronics drive comes complete with an Apple-beige case and connecting cables. It’s fully tested with Apple’s disk operating system and software.

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What’s the Story, Jerry?

I have enjoyed BYTE’s “User’s Column” by Jerry Pournelle for some time now. He has presented products through the eyes of an actual user, rather than an impartial reviewer, with some amusing results (it took me three days to stop laughing at his “review” of Microproof [April 1982 BYTE, page 212]). This “actual user” view brings things down to earth.

However, I’m starting to doubt that Mr. Pournelle and I are on the same planet. He gets phone calls from Arthur C. Clarke ("Long-distance from Sri Lanka, Mr. Pournelle, . . ."); and when he has some questions about Godbout products, he calls Bill Godbout himself. To make myself feel better, I tried looking up Joe Northstar in the Osceola County phone book (I had a few questions myself), but to no avail.

I’m also getting the teensy-weeniest bit tired of Mr. Pournelle’s telling us losers about “the way to go” for his money. It would be my way to go too, if it were still his money. He proceeds to describe a system (oh, what a system) that I’ve dreamed about having (with a few minor additions) for years.

And now he sells his own software: “I’ve always liked [his program], and I’m happy to share it.” For a price, no? Why not share it in the pages of BYTE? Alas, the rich get richer.

The most comforting thing I’ve read in “User’s Column” is that Mr. Pournelle owns a TRS-80 Model I—a souped-up TRS-80, but that which we call a TRS-80, by any other name, would still run at less than 4 MHz.

I do hope all I’ve written so far just points out how envious I actually am of Mr. Pournelle, or at least of his hardware and software. But if he wants to publish Arthur Clarke’s or Bill Godbout’s home phone numbers, that’s fine with me.

One more thing: besides the fact that everyone except myself has infinitely better computer stuff, do all computer owners except myself have names for their computers? Mr. Pournelle insists on calling one of his computers “Ezekial,” or “Zeke,” instead of the more obvious “Z-2,” and I have a friend who calls his dad’s TI bubble-memory terminal “Benny.” I myself admit to calling the two lamps in my bedroom “Scott” and “Zelda,” but I call my OSI CIP “my OSI CIP,” or “the damned computer” for short. Maybe having names for one’s
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hardware is a function of the cost of it; perhaps Mr. Pournelle could speculate on this in the next "User's Column."

All in all, the "User's Columns" are the best reading I've had since The Mote in God's Eye by Larry Niven and Jerry Pournelle (Simon and Schuster, 1974), and to me they are not in different classes. (I'm as likely to be capable of purchasing Qume double-sided double-density drives as I would be capable of purchasing an Alderson Drive.)

Karim Alim
2414 Sable Drive
Kissimmee, FL 32741

Jerry Pournelle replies:
I'm glad Mr. Alim (usually) likes my columns. As to my friendships with Bill Godbout and Arthur Clarke, what am I to do? I can't believe Mr. Alim really believes that those unable to talk with everyone should speak to no one.

Regarding "dream" systems: the last time I looked, Priority One was selling the VISTA box with two Qume DT-8 drives for $1600. This isn't cheap, but I noted yesterday that my local membership discount department store sells 5¼-inch drives for Atari 800s at about $475, and I expect $500 is closer to what you'd pay at a regular store. I'd rather pay the extra $600, which is indeed what I did; I do, after all, trust my livelihood to my machines.

I make no secret that I believe the best way to go is to get a good 5-100 bus with the best disks you can buy: later on you can replace the boards in your computer. Iron's expensive, but silicon's getting cheaper all the time.

Regarding my letting Barry Workman sell my programs: I worry about that, but I've neither the time nor the ability to be a publisher, and Barry neither can nor will do it for free. It seemed to me that making the programs available is worthwhile and does no harm.

I've asked Zeke about computer names, and he tells me that his electronic friends enjoy having human appellations; it makes their humans think they are somehow the equals of computers.
I'm glad that Mr. Alim likes my other works.

Hans Strasburger
Tai 58/IV
D-8000 Munich 2
West Germany

Advice for Apple
I'm a relatively new reader of your excellent publication, but a letter from...
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<table>
<thead>
<tr>
<th>Feature</th>
<th>IBC</th>
<th>ONYX</th>
<th>ALTOS</th>
</tr>
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<tr>
<td>Oasis Operating System (Max. Users)</td>
<td>9</td>
<td>5</td>
<td>4</td>
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<tr>
<td>CPU Speed (MHz)</td>
<td>6</td>
<td>4</td>
<td>4</td>
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<td>Disk Speed I/O (MB/Sec.)</td>
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<td>.54</td>
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<td>Seek (Milli Sec.)</td>
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<td>65</td>
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<tr>
<td>Cache Disk Memory</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
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</table>

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<thead>
<tr>
<th>Product</th>
<th>Price</th>
<th>Notes</th>
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<td>Adds Multivision</td>
<td>$3,074</td>
<td>IBM Personal comp.</td>
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<tr>
<td>Alpha Micro 1030</td>
<td>12,047</td>
<td>Seattle boards</td>
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<td>Alpha Micro 1051</td>
<td>17,634</td>
<td>Davong 5 meg. H.D.</td>
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<td>Alspa AC1-2/SS</td>
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<td>IBC Cadet</td>
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<td>Altos 8000-02</td>
<td>2,629</td>
<td>Micromation</td>
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<td>Altos 8000-10</td>
<td>6,295</td>
<td>NEC 8000 64K PC system</td>
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<td>Altos 8000-15</td>
<td>3,585</td>
<td>incl. CP/M, Wordstar</td>
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<td>Altos 8600-10</td>
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<td>NorthStar Advantage</td>
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<td>Altos Series 5-150</td>
<td>2,182</td>
<td>NorthStar Adv. HD 5</td>
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<td>Altos Series 5-5D</td>
<td>4,372</td>
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<td>Vector 3005</td>
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<td>Victor</td>
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PRINTERS

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<td>Amperex GP 300</td>
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<td>Brother, parallel</td>
<td>853</td>
<td>NEC 7710 R/O</td>
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<td>C. Itoh F-10, daisy</td>
<td>1,400</td>
<td>NEC 7720 KSR</td>
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<td>C. Itoh Comet II, dot</td>
<td>799</td>
<td>NEC/ sellum 1, 16K, tractor</td>
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<td>Diablo 630, daisy</td>
<td>2,088</td>
<td>Qume 9/45 full panel</td>
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<td>IDS 560/G</td>
<td>995</td>
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<td>744</td>
<td>Smith Corona TP-1</td>
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<td>IDS Prism 132 column</td>
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<td>Tally</td>
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DISK DRIVES, MODEMS, ETC.

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<td>Amdek Color II term.</td>
<td>694</td>
<td>Houston Instr. DMP-2</td>
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<td>Ventel 212 + modem</td>
<td>765</td>
<td>Houston Instr. DMP-4</td>
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<td>Corvus 10 meg. H.D.</td>
<td>3,825</td>
<td>Houston Instr. DMP-7</td>
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<td>DEC VT-100 terminal</td>
<td>1,390</td>
<td>Morrow 20 meg. H.D.</td>
</tr>
</tbody>
</table>

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Letters

Dennis Pratt in the March 1982 BYTE (see "Apple's Decision Questioned," page 14) concerning Apple Computer Inc.'s decision to restrict mail-order and telephone sales struck a responsive chord. Having followed the development and success of the personal and small-business computer market, I'm simply amazed that Apple is attempting to justify its actions with the excuse that customers can be served properly only through the retail outlet. Because all versions of the Apple were available through the mail up until the end of last year, I suppose the company is implying that its customers are now much less intelligent than they once were. If you believe that Apple's motives are anything other than pure economics, you probably also believe that the intense competition for the personal computer market is simply a passing fad.

If I were in the Apple boardroom, however, I would worry. As I sit here typing on my non-Apple system and consider the number of personal computers that are now on the market, many available through multiple sales outlets (i.e., retail, mail, etc.), I can only suggest that the people at Apple rethink their policy. Don't they realize that Apple is not the only game in town anymore?

Mitch Che
Geothermex Inc.
Suite 201
5221 Central Ave.
Richmond, CA 94804

Stick to Computers

In addition to learning from the wealth of information contained in the various articles in each issue of BYTE, I find that I also learn a substantial amount by reading the advertisements of the latest products. I am delighted that your magazine has such a diversity of computer products presented in each issue.

This brings me to a problem, however: I really don't care to see advertisements for the Heirloom Library, Ford Motor Company, or whoever else is willing to pay for a page of BYTE.

Please, stick to computers and directly related products and services!

Dr. Alan D. Wilcox
119 Hall Ave.
Clarks Green, PA 18411

Letters------------------
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Program Generators

They’re not as easy to use as some advertising copy suggests.

George Stewart
Technical Editor

Would you like to be able to tell your computer what you want it to do without ever having to learn a programming language? Well, you can. You simply tell your computer what you want in layman's terms, and it figures out how to accomplish your wish and creates a program to do it.

The software tools that perform this feat are called program generators or application generators. (Technically, a program generator creates a stand-alone program that you can list, store, copy, and use. An application generator, on the other hand, generates a software package that is dependent on the application generator: to run your generated program, you use a run-time portion of the application generator. In this article, I'll use the term program generator to include both kinds.)

The first program generators were written for mainframe computers back in the late 1960s. Their purpose was to increase the productivity of data-processing departments. Now several have been announced for microcomputers and, for the first time, are being aimed at nonprogrammers as well as professional programmers.

Photos by Katherine Coker

The most heavily and boldly advertised package is The Last One, $600 from D. J. 'AI' Systems Ltd. One typical ad starts out with the headline "Your prayers have been answered." Understandably, the promotion has produced considerable skepticism and controversy in the computer community. Another product introduced with less fanfare is Quic-N-Easi, $395 from Standard Microsystems Inc. I'll use these two products as examples in this background report on program generators. (For more specifics on each product, see the text boxes.)

How Program Generators Work

Program generators are problem-oriented rather than procedure-oriented. In other words, because the program generators possess information about common programming problems like keyboard entry, file input/output, and data sorting, they let you concentrate on the problem you're trying to solve rather than on the special computer procedures required to solve it.

Let's say you want a program that creates a mailing-list file on a floppy disk. First, of course, you must decide exactly how you want information stored in that list—even a manual, paper-based system requires that much. Do you want to store the names in alphabetical order or by member ID? Last name first or vice versa? What's the longest name and how many lines are in the address?

You must also specify the exact steps for inputting and storing names. You would have to do much the same thing if you were explaining your wishes to another person instead of to a computer. Table 1 summarizes the
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CP/M.

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steps you might take in planning your mailing list.

Now how do you communicate all this information to a program generator? If the program generator is to be useful for nonprogrammers, most of your work should already have been done (in the planning phase just described). You'll probably communicate with the program generator in three phases: data description, screen design, and program procedure.

Data description tells the computer how many pieces of information (fields) exist in each logical file entry (record) and what kind of data goes into each. Screen design is the arrangement of headings and prompting messages that the operator will see on the screen. Program procedure tells the computer what to do with the data that is typed in. Data description and screen design are relatively straightforward, but the program design phase is where the program generator really shows its stuff (or lack of it).

After you've completed the program specification, the generator will take care of the programming details, asking you for additional information whenever necessary. Figures 1 through 4 and listings 1 and 2 show uses of The Last One and Quic-N-Easi to specify the mailing-list application.

Using an ordinary programming language, your task is far more involved. The data description, screen design, and program procedure all must be coded in computer-language statements covering a multitude of details: how to create and initialize a disk file, input each data item from the keyboard, write each completed record to disk, etc. Including steps to handle errors (keyboard mistakes or disk problems) is an especially intricate and burdensome task. Instead of focusing on your problem in layman's terms, you must convert it into technical terms.

Evaluating Program Generators

In your evaluation, you should look for capabilities in six general areas: data entry, program logic spec-
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Data entry: Getting information into the computer, as illustrated in the mailing-list application previously described, is the bread and butter of program generators. It's the simplest part of most programs and yet often the most tedious to program. A good program generator should allow easy creation of display forms, the screen layouts that prompt the operator for data. Photo 1 shows a typical display form. Ideally, you should be able to construct the display form on the screen, not on paper, and modify the screen-input form without modifying the entire application program. Checks for invalid entries should be provided automatically by the program generator.

Program logic specification: How hard is it to tell the computer what you want? That depends on how much knowledge is embedded in the program generator. To take a few minor examples, does the program generator know what alphanumeric data looks like (A-Z, a-z, 0-9, ., +, -), or do you have to make up a procedure to check the validity of each entry?

As a general rule, if an operation is generically repetitive (such as searching through a table for a specific entry), you shouldn't have to take great pains specifying the procedure to accomplish it. If you do, then you, not the program generator, are doing most of the programming work.

File storage: This is an important characteristic of program generators, and it may take some careful study. Does the program generator allow both major types of file storage—sequential and random access? Sequential access allows you to read information in the same order in which it was written, while random access allows you to access any record in the file directly. A program generator should support both types of file storage.

Photo 1: A data-entry screen created with Quic-N-Easi.

Table 1: Details of mailing list to be worked out before using the program generator. Numbers in parentheses are maximums for each item.

<table>
<thead>
<tr>
<th>Description of each member record:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Last name (15 letters)</td>
<td></td>
</tr>
<tr>
<td>First name (10 letters)</td>
<td></td>
</tr>
<tr>
<td>Member ID (5 digits)</td>
<td></td>
</tr>
<tr>
<td>Date of last contact (8 characters as mm/dd/yy)</td>
<td></td>
</tr>
<tr>
<td>Street (25 characters)</td>
<td></td>
</tr>
<tr>
<td>City (20 letters)</td>
<td></td>
</tr>
<tr>
<td>State (2 letters)</td>
<td></td>
</tr>
<tr>
<td>Zip (5 digits)</td>
<td></td>
</tr>
</tbody>
</table>

Updates mailing list:

Press (1) to update this record
Press (esc) to leave it unchanged (cancel all changes)
Press (esc) to exit from this program
OUT OF A GALAXY OF MULTIUSER SYSTEMS ARRIVES...

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it was written. Random access allows reading, writing, or updating information in any order. For applications that require frequent updates of information scattered throughout a file, random access is almost a necessity. Some program generators offer a third kind of file access called indexed sequential. In effect, your data is sorted automatically as it is entered. Instead of referring to data in terms of arbitrary record numbers, you can refer to it in terms of filing keys. The same thing can be accomplished through random-access files, but you have to provide the indexing.

Another important feature is interactivity. Do all data files have to be explicitly named during program generation, or can the end user specify files at run time? For example, suppose you have generated a sorting program. Can the operator enter the name of the file to be sorted, or does the generated program have to know about it in advance? The answer to these questions will tell you much about the flexibility of a program generator.

Equally important, what file structures are available? Can information be defined in a hierarchy? In a mailing list, can a list of family members be grouped under “member name” or a list of previous addresses be grouped under “address”? You can write powerful applications programs more simply if the program generator has built-in facilities for such hierarchical data.

Report specification: When it comes to outputting results, is it easy to explain your desired report format to the program generator? You should not have to go to great lengths to have headings and subheadings inserted at the appropriate positions. If many columns are to be printed, you
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shouldn't have to worry about squeezing them all in. The program generator should take care of that by breaking the column headings into two or more lines, etc.

Calculations: Most applications will require some calculations on the data: comparisons between names, arithmetic operations, etc. Obviously, you will need to understand the required operations fully before you can explain them to the program generator. However, you should be able to enter the necessary operations and formulas without resorting to computerese. For example, if you want to update an account balance, you should be able to accomplish this in a straightforward manner such as:

NEW BALANCE = OLD BALANCE – PAYMENT RECEIVED

You should not have to resort to formulas like this:

\[ V_1 = V_2 - V_3 \]

Editing convenience: This may be the most important aspect of a program generator, since 60 to 80 percent of programming time is usually devoted to maintenance (modification) of existing programs. Obviously,

MEMBER ID: #######

LAST NAME: ################################################################### FIRST NAME: ###################################################################

DATE OF LAST CONTACT: ##/##/##

STREET: ###################################################################

CITY: ################################################################### STATE: ## ZIP: #######.

PRESS <F1> TO UPDATE THIS RECORD
PRESS <ESC> <1> TO LEAVE IT UNCHANGED (CANCEL ALL CHANGES)
PRESS <ESC> <0> TO EXIT FROM THIS PROGRAM

Figure 3: The screen layout for the mailing-list program using Quic-N-Easi. The "#" signs show the size and position of keyboard input fields.

<table>
<thead>
<tr>
<th>OFFSET</th>
<th>FIELD</th>
<th>LEN</th>
<th>R</th>
<th>C</th>
<th>DESC</th>
<th>JUST</th>
<th>FILL</th>
<th>MY-EN</th>
<th>MU-EN</th>
<th>MU-FL</th>
<th>MU-TB</th>
<th>PROC</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>ID</td>
<td>5</td>
<td>3</td>
<td>12</td>
<td>D</td>
<td>R</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>GETRECORD</td>
</tr>
<tr>
<td>1</td>
<td>LASTNAME</td>
<td>15</td>
<td>6</td>
<td>12</td>
<td>x</td>
<td>L</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>FIRSTNAME</td>
<td>10</td>
<td>6</td>
<td>53</td>
<td>x</td>
<td>L</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>MONTH</td>
<td>2</td>
<td>9</td>
<td>23</td>
<td>D</td>
<td>R</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>DAY</td>
<td>2</td>
<td>9</td>
<td>26</td>
<td>D</td>
<td>R</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>YEAR</td>
<td>2</td>
<td>9</td>
<td>29</td>
<td>D</td>
<td>L</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>CHECKDATE</td>
</tr>
<tr>
<td>6</td>
<td>STREET</td>
<td>25</td>
<td>13</td>
<td>9</td>
<td>x</td>
<td>L</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>CITY</td>
<td>20</td>
<td>16</td>
<td>7</td>
<td>x</td>
<td>L</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>STATE</td>
<td>2</td>
<td>16</td>
<td>48</td>
<td>A</td>
<td>L</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>ZIP</td>
<td>5</td>
<td>16</td>
<td>63</td>
<td>D</td>
<td>L</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 4: The data descriptions given to Quic-N-Easi. Column abbreviations used are LEN=field length, R=display row, C=display column, DESC=data description, JUST=justification (left or right), FILL=character, MY-EN=may enter, MU-EN=must enter, MU-FL=must fill, MU-TB=must tab, and PROC=procedure associated with this field. As soon as the operator types in a member ID number, the GETRECORD procedure gets the member record, if it has been written. The CHECKDATE procedure ensures that the operator enters a valid date as mm/dd/yy.
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Listing 2: The procedures you must specify using the Quic-N-Easi language for the mailing-list application. In effect, you write this “program”; however, it is much shorter and simpler than an equivalent program written in an ordinary programming language. This application uses indexed sequential files and allows you to update existing records.

10:  * FUNCTION KEY PROCEDURE
10:  PROC KEY0
10:  CLOSE 1
10:  SYSTEM
10:  END
10:  PROC KEY1
10:  UNLOCK ID
10:  HOMECLEAR
10:  END

100:  PROC GETREC
100:  IF ID GE 1 AND ID LE 200 THEN GOTO 10010
100:  ERROR "MEMBER ID NUMBER IS OUT OF RANGE: [1 - 200]"
100:  CLEAR ID
100:  RESUME
100:  END
100:  10010 POSN 1 TO ID
100:  READ 1: 10020
100:  GET * FROM 1
100:  LOCK ID
100:  END
100:  10020 UNLOCK ID
100:  END

200:  PROC LOAD
200:  OPEN "MEMLIST", 3, 97, 1: 20010
200:  END
200:  20010 MAKE "MEMLIST", 3, 97, 10, 5, 1: 20020
200:  END
200:  20020 ERROR "CAN'T CREATE FILE"
200:  SYSTEM
200:  END

300:  PROC ENTER
300:  UNLOCK ID
300:  RESTART 1
300:  PUT * TO 1
300:  WRITE 1: 30010
300:  SECURE 1: 30020
300:  END
300:  30010 ERROR "ERROR IN WRITING RECORD"
300:  CLOSE 1
300:  SYSTEM
300:  END
300:  30020 ERROR "ERROR IN SECURING FILE"
300:  CLOSE 1
300:  SYSTEM
300:  END

400:  PROC CHECKDATE
400:  IF MONTH LT 1 OR MONTH GT 12 THEN GOTO 40010
400:  IF DAY LT 1 OR DAY GT 31 THEN 40010
400:  END
400:  40010 ERROR "ERROR IN DATE FORMAT -- USE MONTH/DAY/YEAR"
400:  CLEAR MONTH
400:  CLEAR DAY
400:  CLEAR YEAR
400:  NEXT MONTH
400:  END
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Editing convenience may be the most important aspect of a program generator.

You'd like to use the program generator to modify your generated programs, rather than deal with them directly. Can you change one part of a program—for example, the report format or the screen input format—without having to go through the entire specification procedure again? If you change the data-file structure, will this change be automatically reflected in the programs using that file? Ideally, changes in one part of a program or file should be reflected automatically throughout.

What kind of program is generated? It varies from one product to another. The Last One produces a stand-alone BASIC program. The BASIC program is intended for use with your machine's built-in BASIC interpreter. Quic-N-Easi produces format files and procedures that can be executed only by the Quic-N-Easi run-time package.

Each approach has advantages and disadvantages. When the final program is written in a standard language like BASIC, you have more flexibility in using it. If you know the programming language, you may be able to modify the program directly. On the other hand, programs such as Quic-N-Easi that use a run-time module may be considerably faster and more efficient than BASIC programs; this applies to both program development and program use.

Is a Program Generator for You?

Even though a program generator has all the features I've mentioned, it still may not be for you. For one thing, many of the program generators assume that you know programming. Some program generators require you to learn a specification language—usually quite simple. Using such a language will require that you master at least a few elementary

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The Last One

The rather grandiose idea implicit in the product’s name is that it will be the last program you ever need to buy. If that is indeed the case, the reason will probably be that you give up computing out of sheer frustration with The Last One.

The Last One is written entirely in BASIC. It consists of dozens of separate program and data files comprising more than 175,000 bytes of code (on the Model II version). In terms of sheer program size, D. J. ‘AI’ Systems is certainly giving you your money’s worth. Of course, programs can’t be rated solely in terms of cost per byte of code. Far more important is how useful the code is.

The Last One is a fully menu-driven system; that means at every stage of its operation, the screen lists currently available options. For example, when you start the program, you see the main dispersal menu:

Create program .................. <1>
Modify program .................. <2>
Modify file ...................... <3>
External files .................... <4>
Enquiry .......................... <5>
Certify new disk .................. <6>
Return to BASIC ................. <7>

Each time you select an option, The Last One must load the appropriate program and run it. This makes the system quite sluggish. Most of your time is spent watching the computer display the message “Please wait...working.” Because of a complex hierarchy of menus, skipping from one activity to another (from, for example, screen design to procedure specification) is tortuous if not impossible.

Sample Use

For generating routine data-entry applications (such as the mailing list described in the main article), The Last One is acceptable but cumbersome. You start by specifying exactly what information goes into the file. You assign a name to each field, describe the field (any characters, numeric only, or date-format data), and specify the field size. Having only three data types puts a larger burden on you to check data entries for valid information; often you will need to ensure that the data falls into a much narrower category (compare with Quic-N-Easi). If you make a mistake, you can correct it by retying all the information for the affected field.

After describing the data, you set a “file pointer,” which determines the position in the file where input/output will begin. This is probably the first place where previous computer knowledge is useful.

Next you specify the program logic in two steps. Using a “flowchart creation menu,” you select the desired sequence of operations for your program. Figure 2 shows the steps used to program the mailing-list application. When you’re done with the flowchart, you have a very general description of the program logic. However, most of the work is yet to be done.

The next phase is called “coding,” and it’s by far the most tedious. All the generalities of the flowchart must be turned into specific procedures. Wherever you have indicated a branch (change in program flow), you now specify the destination of the branch, referring back to the original flowchart. Wherever you have specified “input from keyboard” in the flowchart, you will now be prompted to design an input screen. The Last One doesn’t have a full-featured screen editor, so you must locate the prompting fields using row and column numbers. To change a completed screen, you must erase it and start all over.

Wherever you have indicated calculations, The Last One will ask you to specify them as formulas. Unfortunately, you cannot use the field names but must resort to meaningless symbols like V1, V2, V3, etc.

Outputting results is similar to keyboard input: you specify the output format by relating data fields to various rows and columns on the screen. The Last One will go through the entire list of variables in your program and ask where each one of them is to be output. Typically, only a very few of them are desired as output. This means much needless effort.

When the generalities have all been reduced to specifics, The Last One will generate a BASIC program. The final result will contain routines to handle keyboard and disk-related errors. You will be able to use the program (and associated data files) independently of The Last One.

Should you ever want to modify the program, you’ll probably want to use The Last One again, even if you know BASIC. The reason is that the generated program is completely undocumented. Variable names used have no meaning, and no explanatory remarks are embedded in the program. You can have a copy of the flowchart included at the beginning of the program, but that is too general to be really helpful in program modification. It’s easy to modify a flowchart, and generating the flowchart isn’t difficult in itself; The hard part is modifying the coded program. Rather than changing a few parts and leaving the rest of the coding unchanged, you must painstakingly repeat the entire coding procedure.

Documentation

The instruction manuals are tutorial and quite readable. One describes the package in general; the other describes specifics related to the machine you are using. The general manual takes you step by step through a simple mailing-list application, the best way to get you into the subject. However, the manual is not organized for easy reference. Information is scattered about in different sections, and much information is too abbreviated.

Summary

The Last One does contain a considerable amount of embedded knowledge. It can generate a great deal of BASIC code given a few simple commands. Unlike other program generators, The Last One doesn’t require you to learn a specification language. It’s a shame that the system isn’t faster and easier to use.

If you are willing to wade through a tedious maze of menus and specification procedures that may take hours, and if you refuse to learn BASIC or any other programming language, you can probably find a use for The Last One, especially if your application is to perform simple data storage and retrieval... G. S.
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Quic-N-Easi

The instruction manual describes Quic-N-Easi as "an applications development language that dramatically reduces development time and produces more professional, clearer screen presentations." Compared to The Last One's hyperbole, this is a refreshingly modest and accurate description.

To use this product successfully, you will need to learn some programming concepts and the Quic-N-Easi language. That's going to take a while (anywhere from a day to a week or more). But once you've learned it, you have a tool that really can speed up the programming of common business applications. (If you learn the advanced features, you can go far beyond run-of-the-mill data entry and retrieval applications.)

Quic-N-Easi consists of two programs, the "format builder" and the "run-time interpreter." The format builder lets you describe the data, set up screen formats, and specify procedures in the Quic-N-Easi language. The result of this effort is called a format file and is really your application program. The run-time program interprets the format file and, in so doing, performs the application.

The striking features of Quic-N-Easi are ease of editing and logical operation. You work with only three "modes" or activities while creating a format file: building a format background (designing the screen layout), defining the data fields, and specifying program procedures. It's simple to skip from one activity to another without losing work in either area.

Sample Use
To generate the sample mailing-list application (see main article), you start by defining the screen format. Quic-N-Easi has a screen editor that makes this easy: rather than referring to screen locations with row and column numbers, you type the desired information right onto the screen. Next you locate operator-entry fields on the screen and specify what kind of data goes in each. There are nine categories of data, including various combinations of numbers, uppercase letters, and lowercase letters. This generous selection takes much of the burden of data checking from you during the procedure specification stage: the computer will automatically ensure that valid data is entered from the keyboard.

Finally, you specify procedures to be executed immediately after each field is entered or after the entire screen form is filled. Listing 2 shows the procedures used to generate the mailing-list application.

The Quic-N-Easi language is simpler than BASIC; nevertheless, it is a computer language. If it's your first, expect some difficulty. One good thing about this language is that you can always refer to your data in terms of names you choose, like ID, STREET, etc. This is true even when you're specifying calculations to be performed on these fields. Only for internal calculations do you have to resort to names like #50, #N0, and #80.

Disk input/output is another strong point of this product. In addition to sequential and random-access files, Quic-N-Easi offers indexed sequential files, which enable your file update programs to operate with exceptional speed. (See section entitled "File Storage," page 42.) The mailing-list application was programmed using indexed sequential files.

Documentation
The instruction manual for Quic-N-Easi contains a self-teaching guide and a programmer's reference section. The self-teaching guide uses prepared format files supplied with the software distribution disk and makes an effective introduction to the system. Mastering the system is going to take quite a while, and the programmer's reference section will become useful as you begin to grasp the principles of operation. A handy reference card is also provided.

Summary
Quic-N-Easi will not free you from the task of programming. To make full use of it, you will need to understand fundamental principles of programming—as well as learn the Quic-N-Easi language. However, once you've passed these hurdles, Quic-N-Easi should help you to generate common business-application programs much faster than could be done using BASIC or other programming languages. And the level of expertise required to create a given application with Quic-N-Easi is lower than that required to create the same application in an ordinary language. . . . G. S.
A funny thing happened on my way to writing this article. Very rarely do I ever know what BYTE's monthly theme is when I am planning a project. The editors tell me, but I am always working on so many hardware projects simultaneously that I can't keep track. And I sometimes juggle my project schedule at the last minute.

This time, three weeks before my deadline, I told Senior Editor Gregg Williams that I was designing a sprite-graphics interface for August. He reminded me that the theme of the issue was Logo and that my project was a perfect enhancement to a Logo package produced by Terrapin Inc. of Cambridge, Massachusetts.

"What's Logo?" I thought to myself, but not wishing to appear completely ignorant, I took his word for it and sent my wire-wrapped prototype board to Leigh Klotz Jr. and Patrick Sobalvarro at Terrapin. It took them less than a week to devise ways to control my sprite-graphics interface using the Logo language. Their help came just at the right time. Since I was struggling with using assembly language to draw the pictures necessary for this article, I gratefully accepted a copy of the Terrapin MIT Logo language from them, along with the Logo routines they wrote to manipulate sprites. Using Terrapin's software, I quickly came to understand why Logo and a sprite-graphics interface are a natural combination.

The key component is the TMS9918A Video Display Processor.

But you don’t have to have Logo to use the sprite-graphics board. You can approach this project either as a versatile color graphics interface that you can mold to fit your requirements or as a sprite-graphics system for use with Terrapin MIT Logo. In either case, you will not be disappointed.

The TMS9918A VDP

The key component in this month's project is an integrated circuit from Texas Instruments, the TMS9918A Video Display Processor (VDP). This chip offers features that are not, to my knowledge, found in any other graphics system. A summary of its capabilities is shown in table 1.

The TMS9918A VDP is intended to be interfaced to a host microprocessor through an 8-bit bidirectional data bus and three control lines. The VDP's output is a composite color video signal, which can be fed directly into a video monitor or, with the addition of an RF (radio-frequency) modulator, to the antenna terminals of a television set.

Up to 16K bytes of dynamic RAM (random-access read/write memory) can be attached directly to the VDP. This VRAM (video RAM), which contains the data that defines the graphics image to be displayed, is automatically refreshed by the VDP. The VRAM needs no direct connection to the host computer.

The host processor interacts with the 9918A by reading from or writing to its registers or the VRAM. The interpretation of the data flow is controlled by the states of the three control lines. The timing of register and VRAM updates is asynchronous with the video output; thus the host processor can communicate with the VDP at any time.
1. display resolution of 256 by 192 pixels
2. 16 colors, including black and transparent
3. supports 16K bytes of separate video memory
4. real-time interrupt capability
5. 32 sprites for simulation of three-dimensional effects
6. composite video output
7. four display modes:
   a. graphics I (256 by 192 dots—limited color)
   b. graphics II (256 by 192 dots—extended color)
   c. text mode (24 lines of 40 user-defined characters)
   d. multicolor mode (64 by 48 low-resolution positions)
8. external video and sync inputs
9. automatic, transparent dynamic RAM refresh

Table 1: Characteristics of the Texas Instruments TMS9918A Video Display Processor integrated circuit.

Distinctive Architecture

The TMS9918A VDP displays an image on the screen that can be best envisioned as a set of overlapping display planes sandwiched together. Image objects in planes figuratively closer to the viewer (the top layers of the sandwich) seem to be in front of objects on planes further away (the bottom layers of the sandwich). The top 32 sprite planes are in front of the pattern plane, the backdrop plane, and the external VDP (video) plane, which can contain a video image from almost any compatible external source. The 9918A combines the multiple image sources to form a single composite image.

What Are Sprites?

A sprite is a graphics object of a specified pattern appearing on its plane in a position determined by a single coordinate pair specifying the
Figure 2: A possible application for sprites: displaying a graphics image of an automobile driving along a road through hilly country, past a field containing grass and a single tree, under a sky populated by clouds.

The background, comprising the hills, grass, road, and sky, is “painted” on the pattern plane. Sprites 0 and 1 are set up with patterns representing the tree’s foliage and trunk. The sections of the car are drawn using sprites 2 through 5. Finally, three clouds are drawn using sprites 6 through 8. Each of the sprites can be made to move smoothly across the screen by continuously changing a 2-byte address pointer in the sprite-attribute table.

As sprites 2 through 5 (the car sprites) are moved past the position occupied by sprites 0 and 1 (the two tree sprites), the VDP selects the displayed pixel values at each point from the highest-priority plane that is not transparent at that point; therefore our view of the car is automatically blocked out as it passes behind the tree.

Example of Sprite Use
Let’s consider a possible application: displaying a graphics image of an automobile driving along a road through hilly country, past a field containing grass and a single tree, under a sky populated by clouds (see figure 2). Starting from the foreground, we see that there is a tree between our point of view and the roadway. Naturally we expect the car to be obscured by the tree when passing behind it. And the car should obscure the background hills wherever it goes.

This scene is set up on the 9918A as follows. The background, comprising the hills, grass, road, and sky, is “painted” on the pattern plane in a way similar to the use of any conventional display.

Since the size of the sprites is limited and each sprite can be only one color, it sometimes becomes necessary to use multiple sprites to define a single entity in the picture. (When the entity is to be moved across the screen, all the sprites that form it must be moved at the same time.) So, following this plan, sprites 0 and 1 are set up with patterns representing the tree’s foliage and trunk. The sections of the body plus the two visible tires are drawn using sprites 2 through 5. Finally, three clouds (of slightly different colors) are drawn using sprites 6 through 8. Sprite planes 9 through 31 are left transparent.

Animation Comes Easy
Once the static display has been established, we can see why sprites are so useful in animating the display,
that is, causing parts of it to move. What would ordinarily be an extensive programming task is handled almost entirely in hardware by the 9918A.

Unlike spriteless systems, moving the car does not require that the software repaint the entire display pattern. Simply by continuously changing a 2-byte address pointer in the sprite-attribute table in VRAM, each of the sprites can be made to move smoothly across the screen.

In addition, as sprites 2 through 5 (the car sprites) are moved past the position occupied by sprites 0 and 1 (the two tree sprites), the VDP selects the displayed pixel values at each point from the highest-priority plane that is not transparent at that point; therefore our view of the car is automatically blocked out as it passes behind the tree. Similarly, if the clouds are different colors (perhaps white and gray) and made to pass each other, they will also appear to pass in front or behind in a pseudo-three-dimensional view. This hidden-view capability is provided in hardware and requires no special software, unlike conventional graphics systems.

Additional Examples

Photo sequences 1 and 2 are step-by-step illustrations of the use of
The turtle is obscured from view as it passes from left to right past the three boxes, beginning in photo 1b. It is not fully visible until it emerges again on the right in photo 1d. Since the three boxes reside on sprite planes of higher priority than the turtle's plane, the pixel values of the boxes take precedence in being displayed wherever the sprite shapes intersect. Also, the three boxes overlap according to their planes' priorities.

As the turtle (now sprite 1) passes from left to right, it passes in front of the red box (sprite 2) and the blue box (sprite 3), as shown in photo 2b, but it goes behind the green box (sprite 0), in photo 2c.

sprites and the concept of plane priority. Both examples use four sprites, but the priorities of the planes used for each sprite shape are changed to demonstrate different effects. Three of the sprites are solid-color boxes, and one is a shape described as a turtle. The turtle is programmed to pass from left to right past the boxes.

In photos 1a through 1d, the green box is sprite 0, the blue box is sprite 1, and the red box is sprite 2. The yellow turtle is sprite 3. No other sprites are involved, and the pattern plane and backdrop are transparent, resulting in a black background.

You'll notice that the turtle is obscured from view as it passes from left to right past the three boxes, beginning in photo 1b. Since the three boxes reside on sprite planes of higher priority than the turtle's plane, the pixel values of the boxes take precedence in being displayed wherever the sprite shapes intersect. Observe also that the three boxes overlap according to their planes' priorities. The green covers the blue, and the blue covers the red. As for the turtle, it has the lowest priority and is not fully visible until it emerges again on the right in photo 1d.

In photos 2a through 2d, some priorities are exchanged; the shapes have been set up on a new permutation of planes. The green and red boxes re-
Figure 3: The binary coding for an 8-by-8-pixel sprite pattern is stored in VRAM in the sprite-generator table in 8 bytes. Each bit in the pattern coding corresponds to one pixel in the displayed pattern. Wherever a 1 is stored in a pixel’s pattern bit, the sprite will be colored; where the bit is a 0, the sprite will be transparent. Each sprite can be only a single color.

Each sprite’s attributes are stored in the 128-byte sprite-attribute table. Each set of attributes takes up 4 bytes. In each set of attributes, the first two bytes set the x,y coordinates of the sprite on the screen, referenced from the screen’s upper left corner. The third attribute byte contains the sprite’s “name” (actually the low-order bits of the address of its segment of the sprite-generator table), and the fourth byte defines the sprite’s color, according to the 4-bit color values given in table 2.

<table>
<thead>
<tr>
<th>Hexadecimal Value</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>transparent</td>
</tr>
<tr>
<td>1</td>
<td>black</td>
</tr>
<tr>
<td>2</td>
<td>medium green</td>
</tr>
<tr>
<td>3</td>
<td>light green</td>
</tr>
<tr>
<td>4</td>
<td>dark blue</td>
</tr>
<tr>
<td>5</td>
<td>light blue</td>
</tr>
<tr>
<td>6</td>
<td>dark red</td>
</tr>
<tr>
<td>7</td>
<td>cyan</td>
</tr>
<tr>
<td>8</td>
<td>medium red</td>
</tr>
<tr>
<td>9</td>
<td>light red</td>
</tr>
<tr>
<td>A</td>
<td>dark yellow</td>
</tr>
<tr>
<td>B</td>
<td>light yellow</td>
</tr>
<tr>
<td>C</td>
<td>dark green</td>
</tr>
<tr>
<td>D</td>
<td>magenta</td>
</tr>
<tr>
<td>E</td>
<td>gray</td>
</tr>
<tr>
<td>F</td>
<td>white</td>
</tr>
</tbody>
</table>

Table 2: Four-bit binary codes used by the 9918A to specify the color of a picture element or color pattern.

main sprites 0 and 2, respectively, but the turtle is now sprite 1 and the blue box is sprite 3. The first feature of note is the reordering of the overlapping boxes. Instead of the sequence green, blue, red, we now have green, red, blue.

As the turtle (now sprite 1) passes from left to right, it passes in front of the red box (sprite 2) and the blue box (sprite 3), as shown in photo 2b, but it goes behind the green box (sprite 0), as we see in photo 2c. The appearance is that it is passing among rather than behind the boxes.

Boxes and turtles may not impress you very much in themselves, but remember that no complicated hidden-line algorithms are needed to determine pixel precedence. Everything I’ve demonstrated is done completely in hardware on the 9918A. The only software computation (other than initially generating the sprites) is to change a 2-byte x,y coordinate pair to move the turtle.

There is a restriction, however, on the number of sprites that may occupy a single horizontal scan line in the video display raster: only four may do so simultaneously. If a fifth sprite is moved into a position such that part of its pattern is on the same line with parts of four other sprites, the conflicting parts of the lowest priority sprite of the five will be made transparent on the display. Also, the number of the fifth sprite will appear in the 9918A’s status register.

Structure of Sprites

There are two basic sizes of sprites: 8 by 8 pixels and 16 by 16 pixels. The 8-by-8-pixel sprite is more often used;
the binary coding for its pattern is stored in VRAM in the sprite-generator table (SGT) in 8 bytes, as shown in figure 3. The larger 16- by 16-pixel sprite requires 32 bytes for storage of its pattern coding.

Each bit in the SGT pattern coding corresponds to one pixel in the displayed pattern. Wherever a 1 is stored in a pixel's pattern bit, the sprite will be colored; where the bit is a 0, the sprite will be transparent. Each sprite can be only a single color.

Either size sprite may be enlarged (magnified) by a factor of 2 under software control; the magnification factor (1 or 2) is global, affecting all sprites. The display produced for the priority demonstration of photo sequences 1 and 2 consisted of 16- by 16-pixel sprite shapes made from 8- by 8-pixel sprites magnified to be twice as big as normal.

Each sprite's attributes (values that determine the characteristics of color, coordinate position, and SGT pattern location) are stored in the sprite-attribute table, or SAT, in VRAM. Each set of attributes takes up 4 bytes; to support 32 sprites, the table must be 128 bytes long. To find the storage location of a particular sprite's attributes, we merely take the sprite's number, multiply it by 4, and add the result to the base address of the sprite-attribute table, which is stored in the 9918A's register 5.

In each set of attributes, the first two bytes set the x, y coordinates of the sprite on the screen, referenced from the screen's upper left corner. The third attribute byte contains the sprite's "name" (actually the low-order bits of the address of the sprite's SGT segment), and the fourth byte defines the sprite's color, according to the 4-bit color values given in table 2.

Not Only Sprites

In addition to sprites, the TMS9918A VDP is capable of considerable graphic feats using only the pattern plane, which operates in any of four display modes. Not all modes use the full 16K-byte memory capacity that the 9918A is capable of supporting. The display mode and memory allocation are selected by setting bits in the VDP's registers. Let's look at some of these other methods of display.

Graphics I Mode

In the Graphics I mode, the screen is divided up into a grid of pattern positions arranged in 24 rows of 32 columns: a total of 768 positions. Each pattern position contains 64 pixels arranged in 8 rows of 8 columns. The contents of the pattern-generator table (PGT) in VRAM determine what is displayed in these pattern positions, and the pattern-color table (PCT) defines the colors associated with them.

In Graphics I mode, up to 256 different patterns can be stored; any one of these can be used in any of the 768 pattern positions, and each pattern can contain two of fifteen possible colors. The patterns can be alphanumeric characters or small sections of a large display picture, disassembled as if it were a jigsaw puzzle.

The pattern definition in the pattern-generator table consists of an 8-byte segment of memory; each bit in the segment corresponds to one pixel in the 8 by 8 matrix; the first byte is the top row of the matrix, and the second byte is the second row, etc. The colors to be used in a given pattern are determined by the two 4-bit values stored in the pattern's color byte in the pattern-color table; binary 1s and 0s are set in the pattern-generator table to turn on one color or the other for each pixel in the pattern.

Graphics II Mode

The Graphics II mode is similar to the Graphics I mode except that it allows 768 separate pattern definitions instead of only 256. In addition, instead of only two colors within each 8- by 8-pixel pattern block, Graphics II mode allows two colors to be defined separately for each byte in the pattern block, so potentially sixteen colors could appear in a single
Figure 4: A schematic diagram of the E-Z Color Graphics Interface. Very few components are needed to connect the TMS9918A to the computer's electrical bus; most of the integrated circuits are simply memory components used as the 9918A's VRAM.

block. As you might expect, this mode uses more memory, potentially as much as 12K bytes of VRAM.

By allowing 768 distinct patterns for the 768 available pattern locations, the Graphics II mode equals the image capacity of the widely used conventional 256- by 192-pixel displays. Virtually any scene pictured in the Apple II high-resolution graphics mode, for example, can be recreated on the pattern plane of the 9918A. With a little additional application programming to set register pointers and load the pattern and color tables, the Graphics II mode can exactly synthesize the point- and line-plotting functions of conventional graphics interfaces. And you still can use the sprites.

Photo 3 is an example of a Graphics-II-mode display combined with sprites, showing a simulation of some analog sensor meters. The pattern plane contains the meter scales and alphanumeric labeling, while the pointers within the meter scales are sprites, which are easily moved to represent changes in the measured quantities. Since there is no screen rewriting required to move the dial pointers, there is absolutely no flicker, and the pointer placement is an easily calculated x displacement.

Multicolor Mode

The Multicolor mode is essentially a low-resolution graphics mode. In it, the screen is divided into 3072 blocks, each measuring 4 by 4 pixels, in a 48-line by 64-column format. The color of each block can be any of the fifteen colors or transparent.

Text Mode

In the Text mode, the screen is divided into a grid measuring 24 lines by 40 columns of pattern positions,
The circuit shown is intended for use with an Apple II computer, with the circuit board plugged into a slot on the motherboard (usually slot 4), but other versions of the circuit for S-100-bus computers and the IBM Personal Computer are under development. The E-Z Color Graphics Interface may also be adapted for use with other computers.

each of which measures 6 by 8 pixels. The Text mode is intended for display of alphanumeric characters rather than graphics patterns. There can be up to 256 unique character patterns defined at a single time to fill the 960 pattern positions. The sprite planes are not available in Text mode. (If you need both sprites and text simultaneously, you can generate character patterns in the Graphics I mode if you don’t mind a slightly shorter line length than in the Text mode.)

The character set is stored in the pattern table in VRAM. Since the cells measure 6 by 8 pixels, the characters should occupy a 5- by 7-pixel format to allow some space between characters. By properly setting the register pointers, it is possible to have the table addresses for the character patterns equal the characters’ ASCII (American Standard Code for Information Interchange) values, which makes character generation easy.

Use of Memory

While the 9918A project I built has 16K bytes of VRAM, not all modes use that much. A typical application that uses only two colors with 256 unique 8- by 8-pixel patterns and 32 sprites would take less than 4K bytes of VRAM. By providing 16K bytes of VRAM with the 9918A, I found that I often had room to store four complete displays; the VDP can switch between them by simply changing pointers in the registers.

E-Z Color Graphics Interface

Figure 4 is the schematic diagram of my project for this month, which I call the Circuit Cellar E-Z Color Graphics Interface. The design is a typical 9918A color graphics interface in that it is interfaced to a microcomputer bus with a minimum of compo-
A prototype printed-circuit board is shown in photo 4. This particular design has been configured for use with an Apple II, yet its signals are compatible with those used in many other computer systems. If you are willing to add a 40-pin connector and do some hand-wiring, you can use this board with some other kind of microcomputer.

The circuit requires an 8-bit bi-directional data bus, one address line (typically A0), and the two control signals Read Enable (CSR) and Write Enable (CSW). For operation with the Apple II, these signals are formed by logically combining the Apple’s DS (Device Select) and R/W (Read/Write) lines. The two control signals are known by different names in other computer systems, but their functions are generally compatible. Two additional lines, INT (Interrupt) and Reset/Sync, are shown as jumper connections. They are available for various optional enhancements, such as interrupt-driven animation or synchronization with external video sources.

By the time you read this article, I shall have completed the designs for S-100-bus and IBM Personal Computer versions of the E-Z Color Interface. Check with the parts source given at the end of the article for availability.

Assembly-Language Sprite Use

Listing 1 on page 68 is a program that demonstrates the routines needed to display and move sprites. The program is written in 6502 assembly language to run on an Apple II computer equipped with the E-Z Color Graphics Interface, installed in motherboard slot 4 at hexadecimal address C0C0.

The first requirement is to initialize the eight registers and clear the VRAM. In this example the 9918A is set to the following operating specifications: Graphics II mode, external video input disabled, and 16- by 16-pixel sprites, with selectable magnification to twice the normal size (32 by 32 pixels) under keyboard control.

When the program starts, four different sprites are displayed, as shown in photo 5. You can change the display as follows. When you press the M key, the sprites’ position coor-
ordinates are incremented and the sprites move. Pressing the O key and then a hexadecimal digit 1 through F will set one of the fifteen background colors or transparency (shown). Pressing the left- or right-arrow keys will vary the sprites’ size between 16 by 16 and 32 by 32 pixels.

If you are ambitious, one possible exercise is to add more sprites to this program. Photo 6 shows how complicated things get when we have 24 sprites.

**Logo Sprite Use**

If you don’t care to concern yourself with the intricacies of assembly language, you may choose to use routines written in Terrapin’s version of MIT Logo to control the E-Z Color graphics.

Terrapin Logo normally uses a single video monitor for all its display functions: text listings and line drawing. The colors available are limited to the six supported by the Apple’s high-resolution graphics mode. When the E-Z Color Graphics Interface is installed, the regular display screen is still used for text display and the regular turtle graphics; the E-Z Color board must be connected to a second color video monitor for its display to be simultaneously visible. Photo 7 on page 68 shows the two-monitor set-up. (If you don’t need to see both displays at once, you could set up a switch to select the video output of one source or the other for display on a single monitor.)

The Logo procedures developed by Leigh and Pat implement user commands to specify the characteristics of each sprite; these commands include SETSHAPE, SETCOLOR, and SXY (for “set x,y position”). If you like, you can map out your own sprite shapes and incorporate them into the routines, but some predefined patterns, shown in photo 8, are provided. (People from Terrapin seem to like turtle shapes.)

The photo sequences 1 and 2 used earlier to demonstrate sprite planes were done using a Logo program. For example, the three boxes (shown in photo 9) are drawn in Logo using the following groups of simple statements:

Text continued on page 80
When the E-Z Color Graphics Interface is installed in the Apple II, the regular display screen is still used for Terrapin MIT Logo's text display and turtle graphics; the E-Z Color board must be connected to a second color video monitor for its display to be simultaneously visible.

Listing 1: Program written in 6502 assembly language to run on an Apple II computer equipped with an E-Z Color Graphics Interface installed in motherboard slot 4.

<table>
<thead>
<tr>
<th>LINE#</th>
<th>LOC</th>
<th>CODE</th>
<th>LINE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0002</td>
<td>0000</td>
<td>;</td>
<td>;</td>
</tr>
<tr>
<td>0003</td>
<td>0000</td>
<td>;</td>
<td>;</td>
</tr>
<tr>
<td>0004</td>
<td>0000</td>
<td>;</td>
<td>;</td>
</tr>
<tr>
<td>0005</td>
<td>0000</td>
<td>;</td>
<td>;</td>
</tr>
<tr>
<td>0006</td>
<td>0000</td>
<td>;</td>
<td>;</td>
</tr>
<tr>
<td>0007</td>
<td>0000</td>
<td>;</td>
<td>;</td>
</tr>
<tr>
<td>0008</td>
<td>0000</td>
<td>SLOT = $40 ;SLOT = NO. X 10 HEX</td>
<td></td>
</tr>
<tr>
<td>0009</td>
<td>0000</td>
<td>KBD = $C000 ;APPLE KEYBOARD DATA</td>
<td></td>
</tr>
<tr>
<td>0010</td>
<td>0000</td>
<td>KSTRB = $C010 ;KEYBOARD DATA CLEAR</td>
<td></td>
</tr>
<tr>
<td>0011</td>
<td>0000</td>
<td>VREG = $C081+SLOT ;VDP REGISTER</td>
<td></td>
</tr>
<tr>
<td>0012</td>
<td>0000</td>
<td>VDATA = $C080+SLOT ;VDP RAM</td>
<td></td>
</tr>
<tr>
<td>0013</td>
<td>0000</td>
<td>;</td>
<td>;</td>
</tr>
<tr>
<td>0014</td>
<td>0000</td>
<td>*= $1000 ;PROGRAM STARTING ADDRESS</td>
<td></td>
</tr>
<tr>
<td>0015</td>
<td>1000</td>
<td>;</td>
<td>;</td>
</tr>
<tr>
<td>0016</td>
<td>1000</td>
<td>;************ INITIALIZE VDG ************</td>
<td></td>
</tr>
<tr>
<td>0017</td>
<td>1000</td>
<td>;</td>
<td>;</td>
</tr>
<tr>
<td>0018</td>
<td>1000</td>
<td>A087 LDY #$87 ;REGISTER SELECT</td>
<td></td>
</tr>
<tr>
<td>0019</td>
<td>1002</td>
<td>A207 LDX #$07 ;INITIALIZE COUNTER</td>
<td></td>
</tr>
<tr>
<td>0020</td>
<td>1004</td>
<td>BDC610 INIT1 LDA ITAB,X ;LOAD INIT TABLE</td>
<td></td>
</tr>
</tbody>
</table>

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The Logo procedures developed at Terrapin Inc. provide you with commands such as SETSHAPE, SETCOLOR, and SXY. You can map out your own sprite shapes and incorporate them into the routines, but some predefined patterns are provided, including a box, a rocket, a turtle, and a block.

Listing 1 continued:

0021 1007 209F10 JSR SREG ;WRITE TO VDP
0022 100A 88 DEY ;DECREMENT REGISTER
0023 100B CA DEX ;DECREMENT COUNTER
0024 100C D0F6 BNE INIT1 ;DONE?
0025 100E
0026 100E ;*************** CLEAR ALL MEMORY .............................
0027 100E
0028 100E A040 LDY #$40 ;BYTE2 ADDRESS SET UP
0029 1010 A900 LDA #$00 ;BYTE1 ADDRESS SET UP
0030 1012 209F10 JSR SREG ;WRITE TO VDP
0031 1015 A200 LDX #$00 ;INITIALIZE COUNTER
0032 1017 A2C0 LDX #$C0 ;COUNTER HIGH BYTE
0033 1019 8DC0C0 FILL STA VDATA ;WRITE TO VDP RAM
0034 101C C8 INY ;INCREMENT LOW COUNTER
0035 101D D0FA BNE FILL ;LOW COUNTER FULL?
0036 101F E8 INX ;INCREMENT HIGH COUNTER
0037 1020 D0F5 BNE NEXF ;HIGH COUNTER FULL?
0038 1022
0039 1022 ;******** LOad SPRITE Attributes .................................
0040 1022
0041 1022 A047 LOOP LDY #$47 ;BYTE2 AT 0700 HEX
0042 1024 A900 LDA #$00 ;BYTE1 ADDRESS SET UP
0043 1026 209F10 JSR SREG ;WRITE TO VDP
0044 1029 A200 LDX #$00 ;INITIALIZE COUNTER

Listing 1 continued on page 70
Listing 1 continued:

LINE#  LOC  CODE  LINE

0045  102B  BDCE10  NEXA  LDA  ATAB,X  ;LOAD  ATTRIBUTE
0046  102E  8DC0C0  STA  VDATA  ;STORE  TO  VDP  RAM
0047  1031  E8  INX  ;INCREMENT  COUNTER
0048  1032  8A  TXA
0049  1033  C910  CMP  #$10  ;TEST  COUNTER
0050  1035  D0F4  BNE  NEXA  ;DONE?
0051  1037  
0052  1037  A040  LDY  #$40  ;BYTE2  AT  0000  HEX
0053  1037  A04F  C9CF  CMP  #$80  ;BYTE1  ADDRESS  SET  UP
0054  1037  20F910  JSR  SREG  ;WRITE  TO  VDP
0055  1037  20A610  LDY  #$80  ;INITIALIZE  COUNTER
0056  1040  BDDE10  NEXTS  LDA  PTAB,X  ;LOAD  PATTERN  BYTE
0057  1043  8DC0C0  STA  VDATA  ;STORE  TO  VDP  RAM
0058  1046  E8  INX  ;INCREMENT  COUNTER
0059  1047  8A  TXA
0060  1048  C980  CMP  #$80  ;TEST  COUNTER
0061  104A  D0F4  BNE  NEXTS  ;DONE?
0062  104C  
0063  104C  AD00C0  CBACK  LDA  KBD  ;TEST  FOR
0064  104C  C988  CMP  #$88  ;"O"  KEY  INPUT
0065  104F  20F910  JSR  SREG  ;BYTE1  REGISTER  7
0066  1050  20A610  LDY  #$81  ;STORE  TO  VDP
0067  1053  20A610  JSR  LOADN  ;INITIALIZE  COUNTER
0068  1056  A087  LDY  #$87  ;LOAD  PATTERN  BYTE
0069  1058  20F910  JSR  SREG  ;STORE  TO  VDP
0070  105B  
0071  105B  AD00C0  CSIZE  LDA  KBD  ;TEST  FOR  LEFT  ARROW
0072  105E  C988  CMP  #$88  ;MAGNIFICATION  X  1
0073  1060  D00A  BNE  ONE
0074  1062  ADC710  LDA  ITAB+1  ;LOAD  REGISTER  1
0075  1065  29FE  AND  #$FE  ;MASK  0  ON  LSB
0076  1067  A081  LDY  #$81  ;BYTE1  REGISTER  1
0077  1069  20F910  JSR  SREG  ;STORE  TO  VDP
0078  106C  C995  ONE  CMP  #$95  ;TEST  FOR  RIGHT  ARROW
0079  106E  D00A  BNE  MOVE  ;MAGNIFICATION  X  2
0080  1070  ADC710  LDA  ITAB+1  ;LOAD  REGISTER  1
0081  1073  0901  ORA  #$01  ;MASK  1  ON  LSB
0082  1075  A081  LDY  #$81  ;BYTE1  REGISTER  1
0083  1077  20F910  JSR  SREG  ;STORE  TO  VDP
0084  107A  
0085  107A  AD00C0  MOVE  LDA  KBD  ;MOVE?
0086  107D  C9CD  CMP  #$CD  ;TEST  FOR  "M"  KEY
0087  107F  D018  BNE  JUMP
0088  1081  EECE10  INC  ATAB  ;SPRITE0  UP
0089  1084  CECE10  DEC  ATAB+1  ;SPRITE0  LEFT
0090  1087  EDE210  INC  ATAB+4  ;SPRITE1  UP
0091  108A  EED310  INC  ATAB+5  ;SPRITE1  RIGHT
0092  108D  CED610  DEC  ATAB+8  ;SPRITE2  DOWN
0093  1090  CED710  DEC  ATAB+9  ;SPRITE2  LEFT
0094  1093  CEDA10  DEC  ATAB+2C  ;SPRITE3  DOWN
0095  1096  EEDB10  INC  ATAB+&D  ;SPRITE3  RIGHT
0096  1099  2C10C0  JUMP  BIT  KSTRB  ;CLEAR  KEYBOARD

Listing 1 continued on page 72

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5 Year Warranty
### Listing 1 continued:

<table>
<thead>
<tr>
<th>LINE#</th>
<th>LOC</th>
<th>CODE</th>
<th>LINE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0104</td>
<td>109C</td>
<td>4C2210</td>
<td>JMP LOOP ;JUMP TO START</td>
</tr>
<tr>
<td>0105</td>
<td>109F</td>
<td>;</td>
<td></td>
</tr>
<tr>
<td>0106</td>
<td>109F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0107</td>
<td>109F</td>
<td>;********** STORE VIDEO REGISTERS **************</td>
<td></td>
</tr>
<tr>
<td>0108</td>
<td>109F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0109</td>
<td>109F</td>
<td>8DC1C0</td>
<td>SREG STA VREG ;STORE BYTE1</td>
</tr>
<tr>
<td>0110</td>
<td>10A2</td>
<td>8CC1C0</td>
<td>STY VREG ;STORE BYTE2</td>
</tr>
<tr>
<td>0111</td>
<td>10A5</td>
<td>60</td>
<td>RTS ;RETURN</td>
</tr>
<tr>
<td>0112</td>
<td>10A6</td>
<td>;</td>
<td></td>
</tr>
<tr>
<td>0113</td>
<td>10A6</td>
<td>;********** LOAD KEYBOARD INPUT **************</td>
<td></td>
</tr>
<tr>
<td>0114</td>
<td>10A6</td>
<td>;</td>
<td></td>
</tr>
<tr>
<td>0115</td>
<td>10A6</td>
<td>2C10C0</td>
<td>LOADN BIT KSTRB ;CLEAR KEYBOARD</td>
</tr>
<tr>
<td>0116</td>
<td>10A9</td>
<td>2C00C0</td>
<td>WAIT BIT KBD ;TEST KEYBOARD</td>
</tr>
<tr>
<td>0117</td>
<td>10AC</td>
<td>10FB</td>
<td>BPL WAIT ;IS KEY PRESSED ?</td>
</tr>
<tr>
<td>0118</td>
<td>10AE</td>
<td>AD00C0</td>
<td>LDA KBD</td>
</tr>
<tr>
<td>0119</td>
<td>10B1</td>
<td>29F0</td>
<td>AND #$F0 ;TEST IF NUMERICAL INPUT</td>
</tr>
<tr>
<td>0120</td>
<td>10B3</td>
<td>9C0</td>
<td>CMP #$C0</td>
</tr>
<tr>
<td>0121</td>
<td>10B5</td>
<td>F006</td>
<td>BEQ LETER</td>
</tr>
<tr>
<td>0122</td>
<td>10B7</td>
<td>AD00C0</td>
<td>LDA KBD</td>
</tr>
<tr>
<td>0123</td>
<td>10BA</td>
<td>290F</td>
<td>AND #$0F ;MASK OFF HIGH NIBBLE</td>
</tr>
<tr>
<td>0124</td>
<td>10BC</td>
<td>60</td>
<td>RTS ;RETURN</td>
</tr>
<tr>
<td>0125</td>
<td>10BD</td>
<td>AD00C0</td>
<td>LETER LDA KBD</td>
</tr>
<tr>
<td>0126</td>
<td>10C0</td>
<td>18</td>
<td>CLC</td>
</tr>
<tr>
<td>0127</td>
<td>10C1</td>
<td>6909</td>
<td>ADC #$09 ;CONVERT INPUT TO HEX VALUE</td>
</tr>
<tr>
<td>0128</td>
<td>10C3</td>
<td>290F</td>
<td>AND #$0F ;MASK OFF HIGH NIBBLE</td>
</tr>
<tr>
<td>0129</td>
<td>10C5</td>
<td>60</td>
<td>RTS ;RETURN</td>
</tr>
<tr>
<td>0130</td>
<td>10C6</td>
<td>;</td>
<td></td>
</tr>
<tr>
<td>0131</td>
<td>10C6</td>
<td>;*************** TABLES ***</td>
<td></td>
</tr>
<tr>
<td>0132</td>
<td>10C6</td>
<td>;</td>
<td></td>
</tr>
<tr>
<td>0133</td>
<td>10C6</td>
<td>02</td>
<td>ITAB .BYT $02,$C2,$01,$80 ;INITIALIZE TABLE</td>
</tr>
<tr>
<td>0134</td>
<td>10CA</td>
<td>01</td>
<td>.BYT $01,$0E,$00,$01</td>
</tr>
<tr>
<td>0135</td>
<td>10CE</td>
<td>;</td>
<td></td>
</tr>
<tr>
<td>0136</td>
<td>10CE</td>
<td>40</td>
<td>ATAB .BYT $40,$60,$00,$03 ;SPRITE 0 ATTRIBUTE</td>
</tr>
<tr>
<td>0137</td>
<td>10CF</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>0138</td>
<td>10D0</td>
<td>00</td>
<td></td>
</tr>
<tr>
<td>0139</td>
<td>10D1</td>
<td>03</td>
<td></td>
</tr>
<tr>
<td>0140</td>
<td>10D2</td>
<td>60</td>
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</tbody>
</table>

Listing 1 continued on page 76
Write 100 percent of your code—including I/O control statements—in high-level language for most applications.

These six languages have been tailored especially for RCA CMOS microprocessors and Microboards.

**BASIC 1.**
- Compiler/interpreter.
- Develop program using interpreter and compile for code compactness in target system.

**BASIC 2.**
- Extended BASIC interpreter with µP I/O control statements.
- Floating point math, string variables, multi-dimensional arrays.
- ROM-BASIC interpreter runs on low-cost Microboard Development Systems.
- Run-time, auto-start interpreter ROM option available (also for BASIC 2).

**Micro Concurrent PASCAL.**
- For real-time multi-tasking 1802 and Microboard applications.
- Cross-compilers available for most computers.
- ROM-able 1802 p-code interpreters, with and without floating point.
- Also available on CompuServe time-sharing service.
- Micro Concurrent PASCAL:
- 1802 microprocessor dialect of PL-1.

**PLM-1800.**
- 1802 microprocessor dialect of PL-1.

**Structured language.**
- Runs on RCA development systems.
- MACROASSEMBLER.
- Nested macro capability lets you define your own instructions.
- Parameter substitution.
- Conditional and repetitive assembly.

In plain English: whatever your µP or Microboard application, we've made it easier than ever to program. You can get started now with one of our development systems. The price of the low-cost system is only $499**.

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*Trade name of Ener rect, Inc.
**Optional U.S. distributor resale.
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Increased Productivity
Innovative features which dramatically increase productivity include built-in horizontal scrolling for up to 254 columns and screen line editing, which lets you extensively edit or re-enter any command line on the screen for CP/M-86 and application programs. Previously only available on mainframe computers, this greatly reduces the amount of re-typing necessary due to mis-typed or repeated commands. Long strings of commands can also be repeated with a few keystrokes. It’s almost like having a built-in full screen editor for every program you use. And with 25% more disk capacity you will be swapping disks a lot less.

We Don’t Lock You In
We can read and write not only IBM CP/M-86 disks, but also IBM MS-DOS and many other CP/M double density disks. And files may be transferred with other CP/M and CP/M-86 computers via the serial port. The screen driver with status line and horizontal scrolling faithfully emulates many popular terminals. Of course we’re software compatible with IBM and have a superset of their features. And you may even find our manual to be better than IBM’s.

No Software Shortage
Most CBASIC programs will run perfectly with our CP/M-86 and CBASIC-86. Even most programs compiled with CBASIC 8080 will run with CBASIC-86. And Pascal-MT is available too. Remember, we emulate most CRT terminals.

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Labels, ASCII, Exceptional Speed
No other Z80 CP/M disassembler produces understandable source code as quickly as V-COM. It is INTEL and ZILOG compatible, and features easy to read code with a cross reference table. Best of all, it can create source code with user defined labels, storage areas and ASCII strings. V-COM is exceptionally fast and can disassemble a typical 12K.COM file into a 76K.ASM file, containing 7500 lines of source code, and a 33K cross reference file in under two minutes with 8” SD floppies. (About five times faster than others).

The unique user created information files let you specify labels for 8 and 16 bit values and the location of storage areas, tables and ASCII strings. The disassembled code can be sent to the console, the disk and the printer, or any combination at once.

Each package includes a 30 page manual, sample program files and variations of V-COM compatible with TDL, MAC and ZILOG assemblers. Feature for feature, no other disassembler at any price even comes close. ............... $80
Manual Only ........................................ $12

8086 SOFTWARE
VEDIT full screen editor for CP/M-86, MS-DOS, IBM Personal Computer and IBM Displaywriter .................. $195
CP/M-86 BIOS for popular S-100 disk controllers and SCP 8086 computer. Source Code ...................... $90
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The newest generation VEDIT combines sophisticated program development editing with useful word processing features and new powerful 'TECO' like macros.

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Fast and easy editing for program development and word processing. Includes automatic screen scrolling, a status line with the cursor's line and column positions, an 'Undo' key, and recovery from full disk conditions (you can delete files or change disks). Fully adapts to your system with a menu driven customization for keyboard layout, CRT selection and more. Since VEDIT receives major enhancements twice a year, you're assured that VEDIT will always be 'state of the art' with our inexpensive update option and support you can really count on.

Performance
Exceptional speed and true 'what you see is what you get' full screen editing with a convenient array of cursor movements and editing functions. Edits files up to one disk in length, and holds up to 45K of a file entirely in memory. You can insert a specified line range of another file anywhere in the text, and change disks in the middle of an edit session. Includes search and replace, text move and copy, complete file handling and flexible macros. Unique automatic indenting for use with structured languages such as Pascal, 'C' and PL/I. Other features for assembly language, Fortran and Cobol.

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Features include word wrap, adjustable left margin, reformatting of paragraphs, word and paragraph oriented cursor movement and deleting, and printing with embedding of printer control characters. May be used stand-alone or in conjunction with most text output processors.

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CRT version supports over 40 terminals, including ANSI standard and all screen sizes. Utilizes 'smart' terminal features for fast screen updating. Your keyboard layout can use any available function and cursor keys. Memory mapped version offer high speed, flexibility, supports bank select and the SSM VB3. Versions for Fulcrum VIO-X, P1CEON and TDL video boards.

New Macros
Ten buffers can hold macro command strings. These may be executed, edited, saved and loaded from disk. Macros can perform complex editing operations. (For example, a macro could automatically perform a series of global search and replace on many files). The buffers may also hold text, allowing extensive text 'cut and paste', including portions from multiple files. New startup command file can also setup VEDIT parameters, initialize a terminal's programmable function keys and more.

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Manual Only .................................. $18

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Circle 110 on inquiry card.
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Listing 1 continued on page 78
A GALAXY of features makes the LNW80 a remarkable computer. As you explore the LNW80, you will find the most complete, powerful, ready to run, feature-packed personal and business computer ever made into one compact solid unit.

QUALITY CONSTRUCTION — Instrumentation quality construction sets LNW80 computers apart from all the rest. Integrated into the sleek solid steel case of the LNW80 is a professional 74-key expanded keyboard that includes a twelve key numeric keypad.

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Our down to earth price won't send you into orbit.
Listing 1 continued:

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**SYMBOL TABLE**

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<td>MOVE</td>
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<tr>
<td>VREG</td>
<td>C0C1</td>
</tr>
</tbody>
</table>

END OF ASSEMBLY

---

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(800) 423-3886

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**THE FIRST ACE — A2**
The new A2 is the price/compatibility substitute for the Disk II* intended as the second drive on an existing controller, or as a full A2 subsystem. The A2 drive or A2 subsystem is an ideal choice when the drives will be primarily used for entertainment or prepackaged software programs.

**THE SECOND ACE — A40**
The A40 is a price/performance alternative to the Disk II. With 40 tracks, you get an additional 20K bytes, and faster track-to-track access. The A40 is intended for use in dedicated DOS, CP/M and Pascal applications, and as a companion drive for the A70. The A40 is Micro-Sci's most cost-effective disk subsystem for the Apple II.

**THE THIRD ACE — A70**
The A70 is the price/capacity alternative. At over a quarter million bytes per drive, the A70 has the capacity of two Disk II's or an eight-inch floppy, but costs only slightly more than a single Disk II. One A70 supports a DOS file as large as 270K, a CP/M file up to 560 blocks in Pascal.

**THE PAIR — MICRO-SCI's CONTROLLERS**
The A2 comes with a unique new controller. This controller supports any combination of A2s or Disk IIs and you have complete flexibility. The A40 and A70 share a common controller. Mix A40s and A70s in any fashion, one A40 with one A70, two A40s or two A70s — all on the same controller. You can have a Disk II or A2 controller with Disk II or A2 drives and still add A40 or A70 subsystem. That's full system-level compatibility.

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*APPLE II, APPLE II PLUS, **DISK II, ***APPLE, APPLE II AND DISK III ARE REGISTERED TRADEMARKS OF APPLE COMPUTERS, CUPERTINO, CALIFORNIA.
The first command specifies that sprite 0 is being addressed. The second tells Logo to use the predefined box pattern, while the third says that the sprite is to be colored green (remember, the rest of the sprite plane will be transparent). Then the fourth command states that the sprite is to be drawn at coordinate 20,20.

Now, to add the blue box as sprite 1 at $x,y$ coordinates 12,12:

TELL 1
SETSHAPE :BOX
SETCOLOR :BLUE
SXY 12 12

Finally, to draw the red box as sprite 2 at position 5,5:

TELL 2
SETSHAPE :BOX
SETCOLOR :RED
SXY 5 5

A turtle can be drawn simply by using a similar procedure substituting the command SETSHAPE :TURTLE.

At this writing, Terrapin MIT Logo does not support turtle velocity (automatic constant movement actuated by the commands SETSPEED and SETHEADING) as does the Logo package available for the Texas Instruments TI 99/4A microcomputer, but a future version of Terrapin's product may do so.

In Conclusion

The TMS9918A Video Display Processor has many more capabilities than I have room to write about here, and my examples of a few boxes and turtles are an inadequate demonstration of the powerful combination of the E-Z Color Graphics Interface and Terrapin MIT Logo. I am certain that you can fully appreciate them only by observing a dynamic display and seeing how few commands are needed to create it.

I don't usually get excited over mega-bit-width processors or super-high-level languages. What does excite me, however, is taking one of my projects hot off the soldering iron and seeing it operate so easily in synergism with someone else's work. After seeing the graceful mating of the E-Z Color Graphics Interface with Terrapin MIT Logo, I can't help but be excited about other sprite-graphics applications.

Next Month:

Build the MicroVox text-to-speech voice synthesizer.

References


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For those of you breathlessly awaiting the results of BYTE's Game Contest (see the December 1981 BYTE for details), direct your attention to the display before you. Although it was difficult to convince the judges to abandon their everyday routine and spend hours playing games, everyone eventually made that ultimate sacrifice. With bloodshot eyes fixed on the displays and nervous fingers manipulating keyboards and joysticks, these tireless individuals toiled day and night. And when the chairs were finally pushed away from the table . . .

**Cosmic Conquest**  
Apple II  
Alan Sartori-Angus  
Grahamstown, Republic of South Africa  
A real-time space strategy game.

**CHARGE!**  
Apple II  
C. Anthony Ray  
Urbana, Illinois  
A trajectory game that shoots electrons through stationary ions.

**The Game of Rat and Dragon**  
Apple II  
Truck Smith  
Fullerton, California  
A chase with a rat, some cheese, and a dragon.
A Few Details

A detailed description and complete listing of each of the winning games will be published in future issues of BYTE. Beginning in September, two entries will be featured each month, culminating with the first and second place winners in the December 1982 BYTE games issue. Overall, the games submitted were original, playable, and enjoyable. Fifty-one entries were received from 21 states and 6 foreign countries. Other statistics about the entries include:

Machines Used
- 19 Apples
- 13 TRS-80 Models III
- 9 TRS-80 Color Computers
- 4 Commodore VICs
- 3 CP/M machines
- 2 TRS-80 Model IIs
- 1 Atari 400/800

Types of Games Received
- 26 arcade games
- 8 simulations
- 7 adventures
- 5 board games
- 5 puzzle games

Programming Languages Employed
- 40 BASIC games
- 5 BASIC/machine-language games
- 3 machine-language games
- 2 Pascal games
- 1 FORTH game

Special thanks goes to Jon Swanson who administered the Game Contest and kept everything under control.

Think you have a better idea? . . . then read on
Some Fortune, Some Fame
First Prize: $500 Second Prize: $300
Third, Fourth, and Fifth Prizes: a custom-embroidered BYTE jacket.
Several Honorable Mention certificates will also be awarded for other noteworthy games. All winning games (including Honorable Mention games) will be published in BYTE.

* A Game Is A Game Is A Game Is A Game Is A... *

What kinds of games are we looking for? Anything that's fun! Graphic arcade-style games, strategy games, puzzle games, text-only adventures, single- or multiplayer simulations, abstract games, and historical games. A game doesn't need to occupy 48K bytes of memory to be fun—it's the concept that counts! (For example, see Quinti-Maze and Three Dee Tee, the games to be published in the September 1982 BYTE.) We aren't interested in computer versions of games that already exist—we want to see something original!

* All The Rules Fit To Print *

• This contest will be judged by the BYTE editorial staff. Factors influencing the decision will be the originality and playability of the game, as well as the quality of the accompanying manuscript. The judges' decision is final.
• All entries should be marked on the outside: "MAGNETIC MATERIALS—DO NOT X-RAY."
• Game submissions cannot be returned unless they are accompanied by a return envelope stamped with sufficient postage.
• This contest is open to anyone except employees or immediate family of McGraw-Hill and its subsidiaries. Void where prohibited by law.
• Prizewinners will give all rights to the article to BYTE in exchange for the designated prizes. In all cases, the author retains all commercial rights to the software written, and BYTE readers may not distribute and/or sell the software without the author's permission. All prizewinners will receive the standard payment for a BYTE article ($50 per published magazine page).
• Only one entry per contestant is permitted.
• Games must be in the format specified.
* Computers and Formats *

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 by those to which we have access.) Games must be submitted on the appropriate media.

Apple II, Atari 800, Commodore PET/CBM, IBM Personal Computer, Radio Shack TRS-80 Model I or III: 5¼-inch disk

Commodore VIC, Radio Shack TRS-80 Color Computer: cassette tape

Radio Shack TRS-80 Model II: 8-inch disk

CP/M with “plain vanilla” terminal (i.e., no special features of the terminal are used): single-density 8-inch disk

Note: All disks (except for CP/M systems) must contain the operating system used and two copies of the game you are submitting. If your game is on cassette tape, be sure to record several copies of the game on a high-quality tape recorder.

Submit your game on the magnetic media listed for your computer. Include whatever documentation may be necessary to play your game: a clear listing on unlined paper, a brief introduction to the game, how it was designed, and how it works. All written materials should be typed double-space for possible publication in BYTE. (Send a stamped, self-addressed legal-size envelope for a copy of our author’s guide.)

* DEADLINE *

Entries must be sent to:

BYTE Game Contest
POB 372
Hancock, NH 03449

Entries will not be accepted before January 1, 1983, and must be postmarked no later than February 15, 1983. Results will be published in the July 1983 BYTE.

* Hints, Clues, Tricks, and Other Helpful Info *

Four words are your passport to success in the Second BYTE Game Contest: Imagination, Playability, Presentation, and Simplicity

Imagination: What the gaming community has seen very rarely is a game that fully exploits the unique strengths of the computer (and avoids its weaknesses). Ask yourself, “What is my computer good at? How can I design a game around it? What kind of game can I create that has never been seen before?”

Playability: A technically perfect game that isn’t fun to play has no chance in the Second BYTE Game Contest. Be sure that your game appeals to the player(s): action games should have variation, pacing, and increasing levels of difficulty; strategy games should give the players a “rich” set of moves that allow them to exercise their ingenuity and cunning in the face of victory or defeat; adventures should be self-consistent and clever. All games should make user input easy to understand by including error-trapping and other user-friendly features.

Presentation: You should pay as much attention to your presentation as you do to your game. In the next four months, look over BYTE’s publication of winning entries (from the First Game Contest) to see which presentations caught our eye!

Simplicity: This quality is such an important component of playability that it deserves special mention. Games, like short stories or vintage automobiles, require polishing to look their best—and much of that polishing is cutting out extraneous or confusing details and refining the game design to a sleek final version. Remember the adage, “Less is more.”
A Beginner's Guide to Logo

Logo is not just for kids.

Harold Abelson
Laboratory for Computer Science
MIT NE43-805
Cambridge, MA 02139

In the 1960s, computers were very expensive and didn't have much memory. A computer such as the IBM 1620 could store a maximum of 24K bytes (or 60,000 decimal digits). Even the largest research computers could manage only six times that much. Since programs had to use memory sparingly, computer languages were designed to reflect this concern.

Languages had to be simple for the computer, even at the expense of being cumbersome for the programmer. For example, to help the compiler keep track of memory, most programming languages insisted on a close tie between the names used in a program and the storage cells in the computer memory. As a consequence, the only kinds of data objects that could be directly named and manipulated by program operations were those that could be stored in a single cell. The only data structures available were those whose size could be prespecified at compile time. Most languages also required the programmer to include bookkeeping "declaration" statements, or adhere to other restrictions on the use of names, to make it easy for the compiler to determine what kind of storage each variable required. (For example, some languages required names beginning with I or J to refer to integers, arrays had to be declared together with their size, and defined functions had to have a name beginning with FN, followed by a digit.)

The concern for conserving memory permeated not only the language, but the computer system as a whole. For instance, if the system included a program editor, editing a line of code required the programmer to abort the program, load the editor, read a file, perform the edit, write a new file, exit the editor, recompile the edited code, and reload the program. All this because the editor and the language could not fit into main memory at the same time.

The languages of the 1960s flourished with the personal computers of the 1970s, which, although no longer very expensive, still did not have much memory. As personal computers became more popular, people began to confuse the idea that a language that is simple for a computer would also be simple for people. ("BASIC has only a few primitives; therefore, it must be easy to learn.") Some people even rationalized that the cumbersome features of such languages were actually advantages. ("Having to declare the data types of variables makes you organize your programs better." "If it's too easy to edit programs, you won't write them carefully in the first place.") And when educators explored the potential uses of computers, they often accepted the drawbacks of these languages as an integral part of programming.

Over the past 12 years, the Logo Group at MIT under the direction of Seymour Papert, along with colleagues at a few universities and research centers around the world, has taken a different approach to educational computing. Rather than accept the limitations of affordable computers (by the standards of those days), we worked with the largest research computers available. The system we used, called Logo, is essentially a dialect of LISP, a powerful language developed for research in artificial intelligence, and used a great deal of memory compared to standards of the 1960s. (Some of the important linguistic aspects of Logo are discussed in "Why Logo?" by Brian Harvey in this issue on page 163. For a more general perspective on LISP, see "An Overview of Lisp" by John Allen in the August 1979 BYTE, page 10.)

In working with Logo, we've discovered some important things. A computer language can be both sim-
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Drawing with the Turtle

Let's begin with a look at some turtle graphics. The turtle is a small triangular pointer on the screen that responds to a few simple commands. FORWARD moves the turtle in the direction it is facing a given number of units. If you type the Logo command FORWARD 50, the turtle will respond by moving forward 50 turtle steps (about 1/4 the height of the screen). RIGHT rotates the turtle clockwise a given number of degrees. BACK and LEFT cause the movements opposite to FORWARD and RIGHT. The turtle also carries a pen, which leaves a trace of its path on the screen as it moves while the pen is down. The commands PENUP and PENDOWN make the turtle raise and lower the pen. Figure 1 shows the result of a simple sequence of Logo commands.

It's lots of fun to make drawings by using these commands (together with a few others, such as CLEARSCREEN, which erases the screen). But in order to really make progress, you have to teach the computer some new words. For instance, you can teach the computer that the turtle can draw a square by repeating this sequence four times: go FORWARD 50 steps, turn RIGHT 90 degrees. The Logo commands would be:

```
TO SQUARE
  REPEAT 4 [FORWARD 50 RIGHT 90]
END
```

SQUARE is an example of a Logo procedure. The first line (signaled by TO) specifies the name of the procedure. This procedure happens to be called SQUARE (since that's what it draws), but you could have called it anything. The rest of the procedure (the procedure's body) specifies the list of instructions to be carried out in response to the command SQUARE; the word END indicates the end of the definition.

Once defined in this way, SQUARE becomes part of the computer's vocabulary. Whenever you give the command SQUARE, the turtle will draw a square.

Procedures with Inputs

An important difference exists between SQUARE and FORWARD. SQUARE always draws a square 50 steps on a side, but FORWARD is more versatile; it takes an input that determines how far the turtle should
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A design created by a simple one-line Logo program that makes the turtle repeat these steps six times: go FORWARD 20 units, turn RIGHT 60 degrees, and draw a square of size 75 units.

You can change the SQUARE procedure so that it also takes an input that determines the size of the square to be drawn. For example:

```
TO SQUARE :SIZE
REPEAT 4 [FORWARD :SIZE RIGHT 90]
END
```

You use SQUARE just as you would any Logo command that takes an input. That is, to draw a square with 100-step sides, you type:

```
SQUARE 100
```

To draw a square with 50-step sides, you type:

```
SQUARE 50
```

The definition of SQUARE illustrates the general rule for defining procedures that take inputs. You choose a name for the input and include it in the procedure title line preceded by a colon. Then you use the input name (with the colon) in the procedure body wherever you would normally use the value of the input.

Since a procedure, once defined, becomes just another word the computer "knows," you can use procedures as parts of the definitions of other procedures. Here's a procedure that produces a design by repeatedly going forward, turning, and drawing a square (see photo 1):

```
TO DESIGN
REPEAT 6 [FORWARD 20 RIGHT 60 SQUARE 75]
END
```

Simple Recursive Procedures

This next procedure also draws a square of a specified size:

```
TO SQ :SIZE
FORWARD :SIZE RIGHT 90 SQ :SIZE END
```

Although SQ and SQUARE both draw squares, they behave very differently.

Instead of drawing a square and then stopping, SQ makes the square retrace the same path over and over, or until you tell the computer to stop. Here is why this happens. When you give the command:

```
SQ 100
```

the turtle must go FORWARD 100, RIGHT 90, and then do SQ 100 again, and so on, and so on.

Add a second input to SQ and you obtain a procedure called POLY, which repeats over and over the sequence: go FORWARD some fixed distance, and turn RIGHT some fixed angle. The procedure takes as inputs the size of each FORWARD step and the amount of each turn:

```
TO POLY :SIZE :ANGLE
FORWARD :SIZE
RIGHT :ANGLE
POLY :SIZE :ANGLE
END
```

To use the POLY procedure, type the word POLY, followed by specific values for the inputs:

```
POLY 60 144
```

Figure 2 shows some of the many different shapes obtained by calling POLY with various inputs.

Recursion is the programming word to describe the ability to use a procedure as part of its own definition. SQ and POLY are recursive procedures of a very simple form—they merely repeat an unchangeable cycle over and over. But recursion is a much more powerful idea and can be used to obtain much more complicated effects. To take just a small step beyond the purely repetitive kind of recursion, consider:

```
TO POLYSPI :SIZE :ANGLE
FORWARD :SIZE
RIGHT :ANGLE
POLYSPI :SIZE + 3 :ANGLE
END
```

Giving the command

```
POLYSPI 1 120
```

leads to this sequence of turtle moves:
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Figure 2: These shapes are all drawn by the three-line Logo program POLY, which has the turtle go FORWARD some fixed amount, turn RIGHT some fixed angle, and repeat this over and over. The figures drawn by POLY always close, but the number of sides that must be drawn before the figure closes depends upon the ANGLE input to the procedure.

Figure 3: Figures created using POLYSPI. A variant of POLY (see figure 2), the program takes advantage of recursion to increase the turtle’s FORWARD step each time the procedure calls itself. The result is a polygonal spiral. As with POLY, varying the ANGLE input changes the symmetry of the pattern.

which produces a triangular spiral in which each of the sides is three steps larger than the previous side. Figure 3 shows some of the shapes generated by the POLYSPI procedure. As a variant, you can replace the FORWARD step in POLYSPI by a command that draws a square:

```
TO SPINSQUARE :SIZE :ANGLE
  SQUARE :SIZE
  RIGHT :ANGLE
  SPINSQUARE :SIZE+3 :ANGLE
END
```

The result of running SPINSQUARE 1 10 as shown in figure 4 is a sequence of squares of increasing size starting with a square of one-step size. Each square is three units larger than the previous one and rotated from it by 10 degrees. The procedure keeps running and the squares keep growing until you tell Logo to stop. You can also modify the procedure so that it stops when the squares become larger than a certain size (e.g., 100 steps) by including a stop rule:

```
TO SPINSQUARE :SIZE :ANGLE
  IF :SIZE > 100 THEN STOP
  SQUARE :SIZE
  RIGHT :ANGLE
  SPINSQUARE :SIZE+3 :ANGLE
END
```

Part of the power of recursion is the fact that such simple programs can lead to such varied results.

An Environment for Exploring

As you can see from the examples presented so far, it is very easy to get started programming with turtle graphics. This is partly because of the subject matter of turtle graphics. The basic commands have simple, visible effects. At the same time, turtle graphics is an incredibly rich area for
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exploration in which even simple programs can have unexpected, often beautiful results. The small amount of Logo we’ve seen so far is enough to support weeks of activities in programming and mathematics, exploring such questions as “How does the shape of a POLY figure depend on the angle input?” or “Why do so many repeated programs produce symmetric designs?” or simply creating beautiful patterns. Andrea diSessa and I describe some of the mathematics that arises from investigating this computer-based approach to geometry in the book Turtle Geometry: The Computer as a Medium for Exploring Mathematics (Cambridge, MA: MIT Press, 1981).

In addition to the subject matter, the system interaction also plays a crucial role. When people explore using Logo, they are continually defining new procedures and modifying old ones. A typical compiler-oriented system, in which changing a definition requires switching back and forth among separate editors, compilers, and linking loaders, is inappropriate for this kind of activity. Much of the effort in implementing Logo has gone into providing a programming environment that makes it easy to define and modify procedures. The Texas Instruments and Apple implementations of Logo include integrated screen editors. Giv-
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**Outputs**

We've already seen how to define procedures that require inputs. You can also make a procedure output a value. For instance, the following procedure takes two numbers as inputs and outputs their average:

```
TO AVERAGE :X :Y
OUTPUT (:X + :Y) / 2
END
```

The result returned by `AVERAGE` can be examined directly (using `PRINT`) or used in turn as an input for other operations:

```
PRINT (AVERAGE 2 3)
2.5
```

```
PRINT (AVERAGE 1 2) + (AVERAGE 3 4)
5.0
```

```
PRINT (AVERAGE (AVERAGE 1 2) 3)
2.25
```

Note the Logo convention of using parentheses to group a procedure with its inputs. Although parentheses are almost always optional in simple Logo lines, it is a good idea to include them because they make the lines easier to read.

**Programming with Procedures**

A Logo program is typically structured as a cluster of procedures. These procedures pass information among themselves by means of inputs and outputs. The advantage of this kind of organization is that it separates the program into manageable pieces, as each procedure can be simple in itself. Even in a complex program, it is unusual to have an individual procedure that is more than a few lines long. In addition, the integrated Logo editor and the general interactive nature of the Logo system enable you to define and test individual procedures separately.

To illustrate procedural organization, let's design a simple game that's played as follows. The computer chooses at random a "mystery point" on the screen, and asks the player to make successive `LEFT` and `FORWARD` moves with the turtle. Before each move, the computer prints the turtle's distance from the mystery point. The goal is to get the turtle very close to the point in as few moves as possible. Here's a transcript of the game in action. The computer's responses are printed in italics to distinguish them from what the player types:

```
DISTANCE TO POINT IS 67.6
TURN LEFT HOW MUCH? 0
GO FORWARD HOW MUCH? 25
DISTANCE TO POINT IS 90.25
TURN LEFT HOW MUCH? 180
GO FORWARD HOW MUCH? 50
DISTANCE TO POINT IS 47.38
```

And finally:

```
DISTANCE TO POINT IS 12.08
YOU WON IN 11 MOVES!
```

The heart of the program is a procedure called `PLAY`. This takes as input a number `M`, which indicates the number of moves so far. `PLAY` first checks to see if the player has won. If so, it prints a message saying how many moves have occurred, and stops. Otherwise, it asks the player to make a move, and goes on to the next round, with `M` increased by 1:

```
TO PLAY :M
TEST CHECKWIN?
[IFTRUE (PRINT [YOU WON IN] :M [MOVES]!)]
[IFTRUE STOP]
MAKEMOVE
PLAY :M + 1
END
```

The `PLAY` procedure is simple in itself...
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Circle 267 on inquiry card.
because it delegates the problems of testing for wins and making moves to the procedures CHECKWIN? and MAKEMOVE.

Here's MAKEMOVE, which prompts the user for angles and distances, and moves the turtle correspondingly. It uses a subprocess procedure READNUMBER, which returns a number typed in at the keyboard:

```
TO MAKEMOVE
  PRINT [TURN LEFT HOW MUCH?)
  FORWARD READNUMBER
  PRINT [GO FORWARD HOW MUCH?)
END
```

To check for a win, the program must test whether the turtle's position is close to some predetermined point (e.g., 20 steps). The Logo primitive operations XCOR and YCOR return the turtle's x and y coordinates. We'll suppose that the x and y coordinates of the hidden point are given by variables XPT and YPT. If you assume there is a procedure DISTANCE that returns the distance between two points, the CHECKWIN? procedure can be written as follows:

```
TO CHECKWIN?
  MAKE *D DISTANCE XCOR YCOR XPT YPT
  IF :D < 20 OUTPUT "TRUE"
  OUTPUT "FALSE"
END
```

CHECKWIN? returns as its value either TRUE or FALSE, which is the result that is tested by PLAY to determine whether the game is over. Observe also the use of the MAKE statement to assign values to variables. In this case, D is used to designate the distance.

Here is the procedure for computing the distance between two points, as the square root of the sum of the squares of the coordinate differences:

```
TO DISTANCE :A :B :X :Y
  MAKE *DX :A - :X
  MAKE *DY :B - :Y
  OUTPUT SQRT (:DX*:DX + :DY*:DY)
END
```

Now you need a procedure to start the game:

```
TO GAME
  CLEARSCREEN
  MAKE "XPT RANDOMCOORD
  MAKE "YPT RANDOMCOORD
  PLAY 0
END
```

This clears the screen, assigns values (chosen at random) to the mystery-point coordinates XPT and YPT, and calls PLAY with an initial M equal to zero.

The following procedure, used to select random coordinates, returns a random number between -75 and +75. It works by calling the Logo primitive RANDOM to obtain a random number between 0 and 150, and subtracts 75 from the result:

```
TO RANDOMCOORD
  OUTPUT (RANDOM 150) - 75
END
```

The only thing needed to complete the program is READNUMBER, which returns a number input from the keyboard:

```
TO READNUMBER
  OUTPUT FIRST REQUEST
END
```

READNUMBER uses the Logo primitive REQUEST, which waits for the user to type a line, and then returns a list of all the items in that line. The desired number is extracted as the first item of the input list. (We'll talk about lists below.)

Actually, it might be better to design READNUMBER so that it checks to see if the item to be returned is indeed a number, and to complain otherwise:

```
TO READNUMBER
  MAKE "TYPEIN FIRST REQUEST
  IF NUMBER? :TYPEIN OUTPUT :TYPEIN
  PRINT [PLEASE TYPE A NUMBER]
  OUTPUT READNUMBER
END
```

Notice the final line of the procedure. Its effect is to make READNUMBER try again for an input until it gets a number, as many times as necessary.
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<th>Atari® 400**</th>
<th>TI* 99/4A</th>
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<td>$299.95</td>
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<td>$454.00</td>
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<td>16K</td>
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<tr>
<td>Upper/Lower Case Characters</td>
<td>YES</td>
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<td>YES</td>
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</tr>
<tr>
<td>Operates with all Peripherals (Disk, Printer and Modem)</td>
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<tr>
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1 April '81 issue 2 May '81 issue 3 November '81 issue 4 Fall '81 issue
This makes the game behave as follows:

```
GO FORWARD HOW MUCH?
FJKSL
PLEASE TYPE A NUMBER
FIFTY
PLEASE TYPE A NUMBER
50
```

Lists

We've seen that Logo's procedural organization makes it an easy and convenient language for writing programs. Most modern programming languages are, in fact, procedurally organized, although few languages make it so easy to interactively define and modify procedures as does Logo.

A much more special aspect of Logo is the way it handles collections of data. This is done using lists. A list is a sequence of data objects. For example:

```
[ 1 2 BUCKLE MY SHOE]
```

is a list of five things. The items in a list can themselves be lists, as in:

```
[ [PETER PAN] WENDY JOHN]
```

which is a list of three items, the first of which is itself a list of two items. Similarly, we can have lists whose items are lists, and so on. Lists, therefore, are a natural way to represent hierarchical structures, that is, structures composed of parts that themselves are composed of parts.

Logo includes a number of operations for manipulating lists. FIRST extracts the first item of the list. In this example:

```
FIRST [ 1 2 BUCKLE MY SHOE]
```

it is 1, and in the next example:

```
FIRST [ [PETER PAN] WENDY JOHN]
```

it is [PETER PAN].

The BUTFIRST operation takes the two objects x and y and constructs a list whose FIRST is x and whose BUTFIRST is y. For example:

```
FPUT 5 [ 2 BUCKLE MY SHOE]
```

produces the list [ 5 2 BUCKLE MY SHOE], and

```
FPUT [PETER PAN] [BUCKLE MY SHOE]
```

produces the list [PETER PAN BUCKLE MY SHOE].

The significant thing about lists in Logo is that they can be manipulated as what computer scientists call "first-class data objects." That is to say, Logo lists (as opposed, for example, to arrays in BASIC) can be:

- assigned as the values of variables
- passed as inputs to procedures
- returned as the outputs of procedures

For instance, you can assign names to lists:

```
MAKE "X [OOM PAH]
MAKE "Y [HEIGH HO]
```

and then refer to the values of these variables, so that BUTFIRST :X is the list [PAH]. You can also combine operations on lists to produce more complex operations. For example:

```
FIRST FIRST [PETER PAN] WENDY JOHN
```

returns the word PETER.
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You can also write procedures that manipulate lists:

TO DOUBLE :L
OUTPUT SENTENCE :L :L
END
PRINT DOUBLE [OOM PAH]
OOM PAH OOM PAH
PRINT DOUBLE DOUBLE
[OOD OOM PAH]
OOM PAH OOM PAH
OOM PAH OOM PAH

The implication of this is that you can combine operations on lists, much as you combine operations on numbers in ordinary languages. For example, one very useful list operation is PICKRANDOM, which chooses an item at random from an input list. PICKRANDOM is not provided as a primitive operation, but is easily constructed out of simpler operations, such as finding the length of a list, selecting a random number in a given range, and extracting the nth item of a list.

Playing with Text
To illustrate how lists are used, let's examine a program that composes vacation postcards, such as:

DEAR DOROTHY
WISH YOU WERE HERE.
LOVE -- JOHN
DEAR MARY
EVERYONE'S FINE.
WRITE SOON -- AUNT EM

You begin by setting up lists of names and phrases from which the elements of the postcard will be chosen:

MAKE "NAMES
[JOHN]
[DOORTHY]
[THE AUNT EM]
[OCCUPANT]

MAKE "PHRASES
[I WISH YOU WERE HERE]".
[WEATHER'S GREATI]
[Surf'S Up.]
[EVERYONE'S FINE.]"

MAKE "CLOSINGS"
[LOVE]
[SEE YOU SOON]
[WRITE SOON]

Here's the main postcard program:

TO POSTCARD
PRINT SENTENCE [DEAR] NAME
PRINT BODY
PRINT (SENTENCE CLOSING
[-] NAME)
POSTCARD
END

The recursive call in the last line makes the procedure keep printing new postcards over and over. (Compare the SQ and POLY procedures.)

The procedures NAME, BODY, and CLOSING generate the elements of the postcard by selecting items from the appropriate lists:

TO NAME
OUTPUT PICKRANDOM :NAMES
END
TO BODY
OUTPUT PICKRANDOM :PHRASES
END
TO CLOSING
OUTPUT PICKRANDOM :CLOSINGS
END

You can change the postcard program so that it automatically augments its repertoire of phrases by every so often (say, one chance in three) asking the user to type in a new phrase and adding that to the PHRASES. To do this, add to the POSTCARD procedure the line:

IF 1.IN.3 LEARN.NEW.PHRASE

The 1.IN.3 procedure returns TRUE with odds of one chance in three and FALSE otherwise. One possible way to write this procedure is:

TO 1.IN.3
IF (RANDOM 3) = 0 OUTPUT "TRUE"
OUTPUT "FALSE"
END

Here's how the program learns a new phrase:

TO LEARN.NEW.PHRASE
OUTPUT PICKRANDOM :PHRASES
END

The idea is that REQUEST returns (as a list) the phrase that the user types in response to the message. This is added to PHRASES (by means of FPUT), so that the program will be able to use this phrase in future postcards, like:

PLEASE TYPE IN A NEW PHRASE
DON'T FORGET TO FEED THE DOG.
DEAR OCCUPANT
DON'T FORGET TO FEED THE DOG.
LOVE -- JOHN

Another change you can make is to generate longer postcards, whose BODY consists of one or more phrases. One way to do this is to alter the BODY procedure as follows:

TO BODY
IF 1.IN.2 OUTPUT SINGLE.PHRASE
OUTPUT SENTENCE BODY
SINGLE.PHRASE
END
TO SINGLE.PHRASE
OUTPUT PICKRANDOM :PHRASES
END

This uses recursion in a devious way. Half the time you call BODY, it will output a single phrase, just as before. (The procedure 1.IN.2 is analogous to the 1.IN.3 procedure above.) But the other half of the time, it recursively generates a new BODY and combines this (using SENTENCE) with a single phrase. The new (recursively called) BODY will itself generate a single phrase only half the time. Otherwise, it will call a third BODY. The result is that a call to BODY will generate a single phrase about half the time, two phrases about one-fourth of the time, three phrases about one-eight of the time, and so on.

Here's the final postcard program in action:

DEAR AUNT EM
SURF'S UP. DON'T FORGET TO FEED THE DOG.
WRITE SOON -- DOROTHY

PLEASE TYPE IN A NEW PHRASE
GET THE MONEY IN SMALL BILLS.

DEAR OCCUPANT
WEATHER'S GREATI WISH YOU WERE HERE. GET THE MONEY IN SMALL BILLS.

SEE YOU SOON -- JOHN

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Text-generation procedures are fun to write and to play with and also easy to modify. You can make them as elaborate or as simple as you like and apply the same ideas to producing essays, poems, love letters, and so on. The idea of generating a random postcard program is based on work done at MIT by Neil Rowe, whose article “Grammar as a Programming Language” (Creative Computing, January/February 1978) contains many other examples of text-generation procedures. It also shows how to implement, in Logo, a special-purpose “sublanguage” for creating such programs.

**Recursive Tiling**

The success of Logo as a catalyst for learning involves much more than the Logo language itself, although the language does play a crucial role. The best kind of Logo activity is a synthesis of programming, mathematics, aesthetics, and, above all, the opportunity to explore. One particularly striking example of this is the “recursive tiling” program invented by Andrea diSessa and Doug Hill. This scheme enables you to write simple procedures that draw patterns such as the ones shown in photos 2 and 3, giving you literally billions of possibilities to examine and explore.

The idea is as follows. Suppose you have a program that draws a pattern inside a square of some given size. By scaling the pattern size in half and gluing together four copies, you obtain a more complex pattern in the a square of the original size, as shown in figure 5a on page 108. In fact, you can generate many different patterns from a single pattern because each copy of the original pattern that you place in each corner square can be rotated through an arbitrary multiple of 90 degrees, as shown in figure 5b.

To convert this idea into a computer program, suppose you have a procedure called PROC that draws a pattern in a square. Assume that PROC takes an input $S$ that specifies the size of the square, scaled so that $S$ is equal to half the diagonal of the square. Assume also that PROC is designed to begin drawing with the turtle at the center of the square pointing...
at a vertex, and to end with the turtle in the same state.

Now suppose you have a square of size S divided into four “corner squares” each of size S/2. The following process is designed to start with the turtle at the center of the square, facing one of the corners. It draws a copy of the PROC design in that corner square and returns the turtle to the center of the larger square. Then it turns the turtle 90 degrees to point at the next corner square. The steps in the process are:

1. Move the turtle FORWARD a distance of S/2. This brings the turtle to the center of the small square, pointing at a vertex of that square.
2. Run the procedure PROC with an input of S/2 (half the diagonal of the smaller square). This draws the pattern and leaves the turtle at the center of the small square.
3. Move the turtle BACK a distance of S/2 to return it to the center of the larger square.
4. Rotate the turtle 90 degrees.

In addition, before performing step 2, you can rotate the pattern through a multiple of 90 degrees. If you do this, you should perform the opposite rotation at the end of step 2, so that the turtle will end up facing in the same direction from which it started.

The following CORNER procedure implements this strategy. CORNER takes three inputs. The first, A, is a multiple of 90 degrees to be turned before drawing the pattern (A is an integer from 0 to 3). The next input, PROC, is the name of the procedure that draws the pattern. PROC is assumed to take one input that specifies the size of the pattern. The third input to CORNER is a number S that specifies the size of the square. The procedure is used as follows:

```
TO CORNER :A :PROC :S
  FORWARD :S/2
  RIGHT 90 * :A
  DRAWFIGURE :PROC :S/2
  LEFT 90 * :A
  BACK :S/2
  RIGHT 90
END
```

**Photos 3a and 3b:** Two tiling patterns constructed on the same basic triangle as in photos 2a and 2b. All four patterns use the gluing scheme shown in figures 5a and 5b, and photos 4a, 4b, and 4c, extended to four levels.
Figure 5: Given a design that lies inside a square, four copies of the same design (each scaled to half the size of the original) will produce a more complex pattern in the same square. Varying the relative orientations of the four copies produces different overall designs. This is the basic gluing scheme used to produce the patterns in photos 2a, 2b, 3a, and 3b, starting with a triangle, and repeating the gluing process four times (i.e., working with a final pattern element scaled to 1/16 times the size of the original square).

The CORNER procedure uses a subprocedure DRAWFIGURE, which takes as inputs a procedure name and a number and runs the procedure with the number as input. DRAWFIGURE is implemented in terms of the Logo primitive operation RUN, which executes a list as if it were a typed-in command line:

```
TO DRAWFIGURE :PROC ;INPUT
  RUN SENTENCE :PROC ;INPUT
END
```

For example, if you execute:

```
DRAWFIGURE [SQUARE] 100
```
this combines [SQUARE] and 100 to obtain the list [SQUARE 100] and executes this list as if it were a typed-in Logo command line, which is to say, it executes the command SQUARE 100.

The CORNER procedure begins with the turtle pointing at one corner of the large square; it ends with the turtle pointing at the next corner. This means that you can obtain a complete gluing design by running CORNER four times. Each of the four calls to CORNER can specify a different 90-degree multiple of A, through which the design in that corner should be rotated. Since each gluing has four corners, and each corner can have any of four rotations, there are $4^4$ or 256 possible gluings for any given pattern. Here are two possible gluings:

```
TO GLUE1 :PROC ;S
  REPEAT 4 [CORNER 0 :PROC ;S] ;
END
```

Photo 4b shows the result of entering

```
GLUE1 [TRI] 100
```
where TRI is a procedure that draws a small triangle inside a square, as

---

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Photo 4: Photo 4a shows a triangle inside a square, as drawn by the procedure TRI. (The square, shown here in color, is not drawn by TRI. Photos 4b and 4c show two different one-level gluings of the TRI procedure to form a more complicated figure inside a square. The complex designs in photos 2a, 2b, 3a, and 3b are four-level gluings based on the same TRI figure.)

GLUE2 [TRI] 100

Now comes the clever idea. The GLUE procedures enable you to glue together four copies of any pattern. On the other hand, entering

GLUE1 [TRI] 100

is also a command that draws a pattern in a square. In fact, the list [GLUE1 [TRI]], when combined with a size (via the DRAWFIGURE procedure), produces a command that draws a pattern in a square of the specified size. Therefore, you can use a GLUE procedure to glue together four of these patterns, for example:

GLUE1 [GLUE1 [TRI]] 100

or

GLUE2 [GLUE1 [TRI]] 100

But again, each of these “two-level” gluings is itself something that can be glued, so you can make three-level patterns such as

GLUE2 [GLUE1 [GLUE2 [TRI]]] 100

and so on and so one. The patterns shown in photos 2a, 2b, 3a and 3b are, in fact, all four-level gluings based on the same TRI procedure, using different rotations at the various levels.

There’s an enormous range of possibilities to investigate here. Four levels of gluings with 256 orientation choices at each level give $256^4$ or more than 4 billion possible four-level gluings, all from a single base pattern! (The number of distinct patterns is reduced by various symmetries in the gluing process, which is itself an interesting phenomenon to explore.) For more variety, you can try different base patterns, or even develop different gluing schemes, such as the one derived from dividing an equilateral triangle into four smaller equilateral triangles. (See Turtle Geometry
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The Computational Perspective

Logo is often described as a programming language. Those of us who designed Logo tend to think of it rather as a computer-based learning environment, where the activities (exploring the symmetry of POLY) are just as integral as the programming tools used (recursion and lists). Logo is also a continually evolving environment, and the microcomputer implementations of Logo that have appeared during the past year are only the first to be widely available. We plan to extend Logo to incorporate new linguistic features, such as the "message passing" facilities found in Smalltalk and recent implementations of LISP (see the August 1981 issue of BYTE for an overview of Smalltalk), as well as new activities, such as a computer-based physics curriculum that builds upon turtle geometry. At the MIT Laboratory for Computer Science, the Educational Computing Group is designing a follow-on system to Logo suitable for the new generation of personal computers that will be coming into use during the latter half of the 1980s.

The next few years will be exciting ones in educational computing because personal computers are becoming powerful enough to support systems that are designed for the convenience of people rather than for the convenience of compilers. If we can dispel the delusion that learning about computers should be an activity of fiddling with array indexes and worrying about whether \( X \) is an integer or a real number, we can begin to focus on programming as a source of ideas. For programming is an activity of describing things. The descriptions are phrased so that they can be interpreted by a computer, but that is not really so important. Computational descriptions, like those of science or mathematics, provide a perspective, a collection of "tools of thought," such as procedural organization, hierarchical structure, and recursive formulations. Logo, and languages like it, will help make these tools available to everyone.
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Logo in the Schools

Putting Logo in the classroom has led to some interesting results.

In the 15 years since its development, the Logo computer language has been used in a variety of research and educational settings. Students from preschool to graduate school; those with severe physical, mental, and emotional handicaps; and students with outstanding ability in science and mathematics have been involved with Logo. It has been used in educational settings to:

- provide an environment for experiential learning of mathematics
- promote the development of problem-solving abilities
- serve as an introductory programming language that helps students learn principles of structured programming
- serve as a vehicle for computer literacy, helping students develop a sense of personal control of a computer
- support the learning of students who, for one reason or another, have not been successful in traditional classrooms
- provide the basis for learning environments in a number of subject areas, including music, language arts, fine arts, physics, biology, and mathematics
- form a foundation for an entirely new kind of school based on Piagetian approaches to teaching and learning, using computers as all-purpose tools to facilitate learning

Each time Logo has been introduced into a school, certain objectives have been emphasized at the expense of others. This article deals with four different Logo projects and describes the settings, the goals of each project, and some of the known results. In some cases, I have drawn on the published reports listed in the references. Where published reports are not available, I have relied on visits and interviews with people directly involved. Each of the projects has had many dimensions that are not included here because of space limitations. For further information, read the reports cited in the references or contact the projects.

Each project had a different type of student population, different choice of goals, and different kinds of results.

The Edinburgh Logo Project, Department of Artificial Intelligence, University of Edinburgh, Edinburgh, Scotland, dealt with 12- and 13-year-old boys attending a private school adjacent to the university. It focused on the use of Logo to create an environment for learning to think mathematically and on developing new methods to teach the content of conventional school mathematics. The Brookline Logo Project, conducted as a collaboration between the MIT Logo Group and the public
schools of Brookline, Massachusetts, had two very different phases. In the first, a laboratory was set up with four computers. The emphasis of the research was to observe and document what a group of sixth-grade students actually learned, rather than assess whether they had achieved a set of preplanned objectives.

The second phase of the Brookline Logo Project involved placing computers in fourth- through eighth-grade classrooms for several weeks at a time. This project emphasized the development of curriculum materials to support the learning of Logo as one activity in a multifocused classroom. The Computers in Schools Project, conducted by the New York Academy of Sciences in conjunction with the New York Public Schools, provided training for elementary and junior high school teachers to use Logo as a permanent feature of their classrooms. The major focus of this project has been implementation in the school, training and supporting teachers to ensure successful use of Logo in the classroom.

The Lamplighter School Logo Project, conducted at a private school in Dallas, Texas, for students aged 3 to 9, is the most ambitious Logo project to date. Conducted as a joint effort with the school, the MIT Logo Group, and Texas Instruments, the project was intended to provide the school with enough computer hardware that access to computers would not be a limitation on what the students could learn. Logo would be taught to all students and teachers, from nursery school through grade four. Eventually, the project was expected to enhance learning in many areas as it facilitated the use of the computer as a multipurpose learning tool throughout the curriculum. The Lamplighter School also served as the primary test site for the development of the Texas Instruments implementation of Logo.

The Edinburgh Logo Project

The objective of the Edinburgh Logo Project was to discover whether the students’ “...ability to do mathematics and to talk about their mathematics was changed by exploring mathematical problems through [Logo] programming.” The quotes in this section are taken from Teaching Mathematics Through Logo Programming: An Evaluation Study, by Howe, O'Shea, and Plane (see references section 1). The students were a group of 11 sixth-grade boys from the George Herriot School, a private school near the university. They were selected from the school's lowest-level math group.

The project lasted for two years, during which the students attended a Logo lab at the university. For the first year, the students worked through a set of graded worksheets to learn the basic elements of Logo. For the second year, they did special Logo exercises designed to teach topics
selected from their regular mathematics curriculum.

The project was highly structured in several respects. The students' learning experiences were structured by means of assigned worksheets that they worked through in order, each at his own rate. In this way, researchers could effectively monitor the progress of each student. During the second year of the project, Logo activities were drawn from mathematical topics such as areas of rectangles, factors and multiples, positive and negative numbers, and plotting coordinates on graphs.

The research aspect of the project was also carefully structured. Students were given standardized tests in mathematics before and after the project. Their progress was compared with that of a control group (drawn from boys in the second lowest-level math group). Both groups of boys, as well as their teachers, were also given a series of questionnaires designed to measure their attitudes toward mathematics.

Great care was taken to see that the research design was carefully carried out.

The published results of the project on student achievement were not very dramatic. Over the two years, the experimental group improved a bit more than the control group on a "basic maths" test. The reverse was true on a "maths attainment" test. The most interesting finding had to do with the teachers' perceptions of the students in both groups. Teachers found that students who had taken part in the Logo classes were more willing to "argue sensibly about mathematical issues" and to explain their "mathematical difficulties clearly."

Teachers found that students who had taken part in the Logo classes were more willing to "argue sensibly about mathematical issues" and to explain their "mathematical difficulties clearly."

Conversations with some of the people involved indicate that a lot of interesting data about what and how the students learned was collected during this project. Unfortunately, little of that information has been analyzed or published. For people interested in teaching Logo, the most tangible results of the project may be the sets of worksheets developed to teach Logo concepts and mathematical applications. These represent a useful set of Logo teaching ideas—even if they are not used in the strictly...
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sequential format for which they were originally designed. Copies of student worksheets used in both years of the project are available from the Edinburgh Logo Group.

The Edinburgh Logo Group has also been involved in several other educational projects. In one project, student teachers who were not math specialists were taught Logo to see how it would affect their teaching of mathematics. In another project presently under way, computers have been installed in several schools so that the Logo curriculum can be taught by classroom teachers who have taken a Logo training course. This project is intended to give clearer results about the impact of Logo on the improvement of classroom performance in mathematics.

In order to carry out the current study, the Edinburgh Logo Group implemented a version of Logo on the Terak computer system, an LSI-11-based system with high-resolution graphics. Disks for this version of Logo are available from the Edinburgh Logo Group. Other Logo implementation projects are under way for microcomputer systems widely available in Great Britain.

**The Brookline Logo Project**

The first Brookline Logo Project, funded by the National Science Foundation and conducted by the MIT Logo Group in collaboration with a public school in Brookline, Massachusetts, had a very different set of goals and results. In this case, 50 sixth-grade students were given the opportunity to learn Logo in a computer lab established within the school. The work of 16 of these students, representing a full range of academic abilities and interests, was selected for study.

The entire Logo learning experience of these students was carefully monitored and analyzed, documenting what the students learned, what learning styles they used, and what types of choices they made. Some common material and ideas were presented to all the students and intro-

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The problem of developing objective data about learning gains made by the students. Standardized tests had been rejected as irrelevant to the goals of the project (the ability to use turtle geometry is not measured by sixth-grade math tests). The problem-solving tests and mathematical tests devised and administered by the project staff had inconclusive results. The problem of developing objective tests in such areas as problem solving or procedural thinking is still an open question for educational researchers.

Another limitation of the project was that it required an extremely sensitive and knowledgeable teacher, with a great deal of time to consider the needs of each student. It was the
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hope of the project staff that the two-volume report, with its analysis of student learning and many examples of student projects, could be an effective resource for teachers working in less ideal settings. The report was also intended as the basis of a Logo curriculum to be developed in subsequent projects.

The second Brookline Logo Project was also funded by the National Science Foundation to develop a curriculum supporting classroom use of Logo. Computers were placed in classrooms from grades four through eight. Teachers were provided with a small amount of training, and the project developed curriculum materials to be used by students and teachers. During the project, two computers circulated among several classrooms. Each classroom had exclusive use of a computer for 8 to 12 weeks. During this time, students worked on their own at the computer, individually or in pairs, while the rest of the class went on with its regular work. About once a week, the entire class met for a lesson at which ideas would be shared, new concepts introduced, and assignments given.

The curriculum materials developed by the project are at two different levels: an introductory Logo curriculum for grades four through six, and a set of advanced Logo projects based on playing and modifying a set of “dynaturtle” games. The introductory curriculum includes step-by-step instructions for students, as well as a number of different types of project ideas. Teachers are given information about everything from the physical arrangement of the computer in the classroom to the concepts the students will be learning, suggestions for whole class lessons, and a checklist to help them monitor student progress.

The advanced activities focus on a series of dynaturtle games that can be used in two different ways. The games provide a microworld in which students can explore the behavior of the dynaturtle—a Logo turtle that has been programmed to follow Newton’s Laws of Motion. Each game introduces a new factor to be considered.

The first game involves making the dynaturtle hit a target, which forces a student to learn to control its momentum and understand something about how the vector quantities of force and momentum are combined. The second game involves driving the dynaturtle around a circular racetrack, introducing some of the concepts involved in orbital motion. The third game, a version of the familiar Lunar Lander, introduces the effect of gravity. The booklet accompanying the games contains many suggestions and challenges for the students that are designed to help them understand the physics concepts embedded in the games. (Also, see R. W. Lawler’s “Designing Computer-Based Microworlds,” in this issue on page 138.)

Another method for using the dynaturtle games is as a programming project. The games are deliberately designed to be simple so that they lend themselves to many obvious improvements. Every student who has played them has had ideas for making them better and more interesting. A student booklet
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provides detailed suggestions for making a series of changes in each game. Students who have already learned simple Logo programming can learn some of the intermediate features of the programming language while using these games as models for the construction of elaborate programs from small modules. Students who have gone through these projects are ready to tackle any number of interactive programming projects of their own devising.

Curriculum materials developed during the project are not yet publicly available. The MIT Logo Group is seeking a commercial publisher for them in accordance with the requirements of the National Science Foundation.

One of the most interesting aspects of the second Brookline Logo Project was the way in which students emerged as Logo teachers. Because there was a group of "student experts" at the beginning of the project, seventh graders who had participated in the first project, teachers incorporated these students as tutors into their planning from the start.

As the project went on, certain students from this group (and others) became known as experts at Logo programming and at managing the computer systems. Teachers throughout the school routinely began to ask these students for help when necessary. When the youngest students in the school, the fourth graders, were introduced to Logo, each student was assigned an upper-grade tutor for the first few weeks. Thus, the fourth graders developed a quick proficiency with the mechanics of the system and were able to begin their own projects very quickly.

A related aspect of the project was the way that students in the same classroom worked together on Logo activities. During the first Brookline Project, student interaction had been limited by the arbitrary manner in which groups were assigned to the laboratory. In the classrooms, students formed natural groupings to share ideas and help each other. Project ideas and "secret knowledge" of how to do certain things were passed among the students by word of mouth. The result of using students as teachers and working partners was a reduction in the teachers' role as source and authority, and the creation of a student-based Logo culture.

It had been assumed at the start that teacher knowledge would be a major limiting factor in what the students could achieve. It turned out that this was not the case. The limitations on student knowledge were what limited what other students could learn. A strategy was devised to support the transfer of knowledge from student to student. Once a week, an after-school student interest group met to work on projects and share ideas. This gave the students involved an opportunity to further their own Logo knowledge, to increase their store of project ideas, and to develop more consistent ways of thinking about how Logo works. All this made them much more effective in their informal role as spreaders of the Logo culture.

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primarily on curriculum development, there was no opportunity for a study of the role of students as teachers and the impact of this on the roles of classroom teachers as traditional authority figures and sources of all school learning. This type of situation is becoming quite common; students know more about the computers than their teachers because they have more time to develop and share their expertise. The use of computers involves students in grades two through nine from a full range of socioeconomic backgrounds. Like the second Brookline Project, the computers are located in elementary and middle school classrooms. A major difference is that the teachers have had an extensive training period and each classroom is assigned a computer for the entire year.

The project began in the summer of 1980 with a three-week training program for 11 teachers and a principal. An expanded training program in the summer of 1981 included eight more teachers from each of the three school districts. During the year, project staff members made weekly visits to each participating classroom. Teachers also attend a monthly seminar held at the New York Academy of Sciences.

Although the project has not yet published any progress reports, the staff believes it has been successful in

Computers in the Schools—New York City

The Computers in the Schools Project, conducted by the New York Academy of Sciences in collaboration with New York City School Districts 2, 3, and 9, provides teachers with training and support to teach Logo in their own classrooms. The project involves students in grades two through nine from a full range of socioeconomic backgrounds. Like the second Brookline Project, the computers are located in elementary and middle school classrooms. A major difference is that the teachers have had an extensive training period and each classroom is assigned a computer for the entire year.

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90 to 95 percent of the classrooms involved. In a conversation with project coordinator Michael Tempel, he defined “success” in the following terms: “The positive educational benefit was obvious! Kids were engaged in valid intellectual and social processes. You could see them developing. . . . We have seen striking changes in kids’ relationships to schools and learning; kids who had not been successful in school got turned on.”

Like the second Brookline project, the Computers in the Schools Project found that interaction among students has been a major positive consequence of having Logo in classrooms. Although Tempel stressed that to remain effective the Logo environment requires “measured and periodic input from the teacher,” he has been struck by how much work the students do without teacher intervention. The activity “has a real quality of self-sufficiency” for the students.

One important condition of the project has been the insistence that each classroom have at least one computer for an entire year. Tempel believes that access to computers has been a major element in the success of the project. Another condition was that all the teachers involved had to volunteer for the project and take the summer training without additional pay. This helped ensure that teachers had a direct personal stake in the project. Such factors should not be underestimated when comparing this to other Logo projects or considering it as a model for implementing Logo in other school districts.

When the formal project ends this year, the teachers who have already been trained are expected to carry out future training and support activities on their own. Teachers in each of the three districts will have the responsibility for training and support in their own district. The Logo Learning Center, established by Logo Computer Systems Inc., will function as an informal meeting place, providing a mechanism for teachers to stay in touch, share ideas, and receive additional training.

The future of the Computers in the Schools Project itself involves an ambitious proposal to create a “magnet school” for the three districts in which the students would have access to computers from the earliest grades. With specially trained volunteer teachers, the school would be a focus for Logo-related research and curriculum development. This project has received the support of the three school districts involved and is presently in the proposal-development stage. Since costs for equipment, research, and curriculum development will be far beyond what can be provided by the school system, the New York Academy of Sciences is seeking support from a number of different groups. It hopes to be able to start with a small number of students this fall.

The Lamplighter School Logo Project

The most ambitious Logo project to date was carried out jointly by the MIT Logo Group, Texas Instruments, and the Lamplighter School, a private school in Dallas, Texas. Lamplighter School has 400 students between the ages of 3 and 9. The school has been provided with 50 Texas Instruments Logo systems that are used throughout the grades. The goal of the project is to establish a setting in which student access to computers would not be a limiting factor and to see what students could learn in such circumstances.

The project is now in its third year. A half-time teacher/coordinator oversees the day-to-day workings of the project and provides individual Logo tutorials for every teacher in the school on a biweekly basis. Computers are in every classroom from the nursery school through fourth grade. Every teacher and child is involved to some extent.

On a recent visit to the school, I was struck by just how comfortable the children are with the computers. Two 4-year-old girls were using a computer to construct geometric designs on a screen with square-shaped sprites. (A sprite is a hardware implementation of a turtle, to allow multiple moving objects on the screen.) Nearby, classmates were engaged in more conventional activities: building with blocks, putting together a puzzle, playing with toy...
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cars, playing house, and finger painting. Computers for these young students are just another way of exploring their world.

The typing ability of the first and second graders is amazing. The students are already writing simple programs, using the keyboard and the Logo screen editor with great dexterity. One second-grade "hacker" had just invented a procedure that simulated the effect of the reset key, clearing the screen and printing "Welcome to Logo!" He also proudly pointed out, "It doesn't erase your procedures!"

In the third grade, several children were clustered around two computers. One of them had made a "secret" animation program that made a number of sprites move continuously in a dynamically unfolding spiral. Three boys were trying to duplicate the procedure on the adjoining computer. Another child was designing a sprite shape for the center of the screen that would look as if it were emitting the spiraling sprites.

Competition, cooperation, communication, problem solving, programming, geometry, and artistry were all happening at once. Meanwhile, the teacher who had introduced the basic idea that all the students were building on was helping another student figure out how to make a sprite move in a circle.

These vignettes should give a sense of the flavor of the school. While some children are occupied with computers, regular school life goes on for others. The class next door may have five computers sitting idle while a geography or reading lesson is being presented much as it would be in any other school. Computers are accepted by the teachers and students as an integral part of the school, but they are not allowed to dominate it.

Some of the anticipated results of the Lamplighter Project have never happened. For example, the students have not used computers for creative writing, despite the availability of a simple screen editor as part of the Logo system. The equipment provided to the school in the first three years of the project has not included printers, which would be needed to make creative writing a realistic activity. Nor has Logo been integrated into as much of the school's curriculum as had been planned. According to Lamplighter's headmistress Pat Mattingly, "The teachers just don't have enough time for curriculum development in addition to all their other duties." With a few minor exceptions, the research studies that were expected to be part of the project have not materialized. Some unique, exciting, and wonderful things have been happening at the Lamplighter School, but except for the school staff, who usually are too busy to write, study, and reflect on the situation, one gets the feeling that "nobody's watching."

Other Interesting Projects
To round out the picture, I want to mention some other schools at which Logo is being used for research and development. The Cotting School for the physically handicapped in Boston has been the site of a series of projects conducted by Dr. Sylvia Weir of MIT. In these projects, Logo has enabled students with cerebral palsy, previously unable to communicate effectively, to begin to realize their intellectual potential. Of all the Logo projects, this has been the most dramatic in demonstrating Logo's effectiveness for students who previously had not been successful in academic settings. It has also made the most significant progress toward the goal of finding objective ways of determining just what students learn as they engage in Logo activities.

Another Logo project aimed at discovering what students are learning is being conducted by the Center for Children and Technology of Bank Street College in New York City. In this project, students in grades three through six have extensive access to Logo. The research is focusing on students learning problem-solving techniques and on social interaction among students as they work on Logo activities—two areas that have been highlighted, but not carefully studied by other projects.
A third interesting Logo school project is not a research project at all. At Lincoln-Sudbury Regional High School in Sudbury, Massachusetts, students learn Logo as the introductory computer programming language. Experiences at Lincoln-Sudbury may show the way to those seeking to use Logo with older students.

Conclusions

I will take the risk of drawing a few general conclusions from these very diverse projects.

Logo can be effective for all students in a school setting. In fact, a regular theme of all the projects cited is the success of students who previously had been unsuccessful in school.

Teacher training is critical. At the very least, teachers need to understand the value of exploratory learning and student interaction. Further, at all sites involving Logo in classrooms, teachers have felt the need for continued support and training. While this need may diminish as teachers become more familiar with computers and Logo, it seems to be a reality for the present.

Teachers and students need resource materials, guidebooks, project suggestions, etc. The more specific the goals, as in the Edinburgh Logo Project or in the physics activities of the Brookline Logo Project, the more specialized and extensive the materials needed.

Student interaction has been a critical and positive element of all classroom-based Logo projects. In each case, students have taken on significant roles as teachers of other students, even as teachers of their own teachers.

In no case has the “full potential of what might be possible” with Logo been realized. It will probably take a lot of time, and many diverse efforts, before the learning potential of Logo can be fully understood and utilized. Whether the goal is to integrate Logo into existing school subjects or to use

### Logo Information Sources

Here is a partial listing of organizations that offer Logo training and information:

1. Logo Training Courses and Workshops:
   - Austin College, Sherman, TX 75090. Contact Prof. Henry Gorman.
   - Bank Street College, 610 West 112th St., New York, NY 10025. Contact Karen Scheingold.
   - Lesley College, 29 Everett St., Cambridge, MA 02138. Contact Nancy Roberts.
   - Teachers College, Columbia University, Microcomputer Resource Center, 525 West 120th St., New York, NY 10027. Contact Karen Billings.
   - Technical Education Research Centers, 8 Eliot St., Cambridge, MA 02138. Contact Robert Tinker.
   - University of Wisconsin—Oshkosh, Microcomputer Applications Group, Oshkosh, WI 54901. Contact Don Voils.
   - Boston Computer Society Logo Users Group, One Center Plaza, Boston, MA 02108.
   - FOLLK, Friends of LISP/Logo and Kids, 436 Arballo Dr., San Francisco, CA 94132.
   - Friends of the Turtle, POB 1317, Los Altos, CA 94022.
   - Logo Times, included in 99'er Magazine, POB 5537, Eugene, OR 97405.
   - LOGOPHILE, Logo Special Interest Group, c/o Higginson, Faculty of Education, Queens University, London, Ontario, K7L 3N6 Canada.
   - Monadnock Area Logo User's Group, c/o Dan and Molly Watt, Gregg Lake Rd., Antrim, NH 03440.
   - Young People's Logo Association, 1208 Hillsdale Dr., Richardson, TX 75081.

2. Organizations, Users' Groups, and Newsletters:
   - Boston Computer Society Logo Users Group
   - FOLLK, Friends of LISP/Logo and Kids
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References
1. The Edinburgh Logo Project, Department of Artificial Intelligence, University of Edinburgh, Forrest Hill, Edinburgh, EH1 2QL Scotland.
2. The Brookline Logo Project, MIT Logo Group, Building 20C, Room 109, Massachusetts Institute of Technology, Cambridge, MA 02139.
   Bibliography of Logo Memos. MIT Logo Group.
4. Lamplighter School, Headmistress Pat Mattingly, 11611 Inwood Rd., Dallas, TX 75229.
6. Center for Children and Technology, Bank Street College, Karen Scheingold, Director, 610 West 112th St., New York, NY 10025.

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Designing computer applications for education might be called cognitive engineering, for its objective is to shape children's minds. That lofty goal must carry with it a commitment to cognitive science, the study of how knowledge functions and changes in the mind. In light of the profound influence of computers in the schools, designing educational applications without such a commitment would be irresponsible.

I believe that Jean Piaget, the Swiss student of knowledge, formulated the general solution to the problem of how intelligence develops. Although the field of cognitive science has advanced beyond Piaget's innovative theories by revising and extending them, his insights into the nature of learning continue to influence teaching methods. The union of computer microworlds and Piagetian theory is the subject of this article.

Piaget and Education

Central to the work of Piaget is constructivism, the view that the mind incorporates a natural growth of knowledge and that the mind's structure and organization are shaped by interactions among the mind's parts. In The Science of Education and the Psychology of the Child (The Viking Press, 1971), Piaget challenges educators to answer two questions: How does instruction affect what is in the mind? and What remains in the mind from the process of instruction long after the time of instruction has passed? In the same work, Piaget disputes both the effectiveness and the ethical correctness of many of the practices of modern education:

If we desire to form individuals capable of inventive thought and of helping the society of tomorrow to achieve progress, then it is clear that an education which is an active discovery of reality is superior to one that consists merely in providing the young with ready-made wills to will with and ready-made truths to know with.

The Dilemma of Instruction

Given Piaget's view that learning is a primary, natural function of the healthy mind, we might consider instruction in any narrow sense unnecessary. Children (and older students of life as well) learn the lessons of the world, effectively if not cheerfully, because reality is the medium through which important objectives are reached. Nevertheless, in certain situations children often rebel against the lessons society says they must learn. Thus the educator's ideal of inspiring and nurturing the love of learning frequently is reduced to motivating indifferent or reluctant students to learn what full functioning in our society requires.

Teachers face a dilemma when they try to move children to do schoolwork that is not intrinsically interesting. Children must be induced to undertake the work either by promise of reward or threat of punishment, and in neither case do they focus on the material to be learned. In this sense the work is construed as a bad thing, an obstacle blocking the way to reward or a reason for punishment. Kurt Lewin explores this dilemma in "The Psychological Situations of Reward and Punishment" (A Dynamic Theory of Personality: Selected Papers of Kurt Lewin, McGraw-Hill, 1935). The ideas of Piaget and Lewin have led me to state the central problem of education thus: How can we instruct while respecting the self-constructive character of mind?

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BYTE August 1982 139

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<td>SHUGART 85TR Dbl Dens Dbl sided 8'</td>
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<td>APPLE COMPATIBLE MICRO-SCI A2 35 track drive</td>
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<td>APPLE COMPATIBLE MICRO-SCI Controller for above</td>
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**APPLE PRODUCTS**

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<td>NOVATION D CAT Modem (direct RS-232 connection)</td>
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<td>EPSON GRAFTRAX 80</td>
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**MICROCOMPUTER & MONITORS**

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<td>NEC 8012A I/O Unit w/32K, expansion slots</td>
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<td>NEC 8031A Dual Mini-disk drive unit</td>
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<td>AMDEK Video 100 (12&quot; B/W)</td>
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<tr>
<td>SANYO 13&quot; Color</td>
<td>490</td>
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Figures 1a–lf: Polyspiral designs generated by changing one variable of the three in the POLYSPI procedure (shown in listing 1). The procedure's variables are DISTANCE, ANGLE, and CHANGE (in distance). The procedure draws a design by going forward the specified distance, turning at the specified angle, then increasing the distance by the specified change, going forward for the incremented distance at the specified angle, and so on. In this example, the distance variable and the change in distance are held constant. The angle variable is stepped up by one degree in each design. The strikingly different designs show the power of the concept of stepping variables.

The POLYSPI microworld reveals the powerful idea of stepping variables. The stepping of variables means identifying one variable as a dimension of examination and holding all other variables constant while the chosen one is varied incrementally. In short, this microworld provides a clear model of how particular things may be generated through their intersecting dimensions of variation. Piaget judged variable-stepping to be an essential component of formal operational thought. The idea is a powerful one because it is almost universally useful; it is crucial to the process of scientific investigation.

Within the microworlds of turtle geometry, the insights achieved with POLYSPI exploration are easily extended to a related microworld of INSPI designs. The INSPI procedure differs from POLYSPI only in that the

signs produced by different executions of that procedure. Figures 1a–lf show some examples of POLYSPI designs. The POLYSPI procedure is stated in listing 1. Some of the designs are pretty, mainly because surprising spiral patterns emerge under certain conditions. The general appeal of POLYSPI designs largely accounts for the adoption of turtle graphics as a subsystem of languages such as Smalltalk, Pascal, and even some implementations of PILOT. The variability of the POLYSPI procedure sometimes permits even a beginner to surprise more expert users (as well as himself) with the discovery of beautiful designs.

The procedure in listing 1 and its designs comprise a microworld. The objects of the microworld are all the designs that the procedure can generate, an engaging and extensive domain for exploration. More important, the designs are a class of "neat phenomena" whose generation can be made comprehensible with the following small set of ideas. First, the POLYSPI procedure provides a crisp model of variable separation: the three variables DISTANCE, ANGLE, and CHANGE are each used once, and used differently, in a simple procedure text. Second, the difference in relative potency of the variables (the impact of a unit change on the produced design) is obvious and striking. (ANGLE and then CHANGE are much more potent than DISTANCE.)

The POLYSPI microworld reveals the stepping of variables as a powerful idea. By stepping variables I mean identifying one variable as a dimension of examination and holding all other variables constant while the chosen one is varied incrementally. In short, this microworld provides a clear model of how particular things may be generated through their intersecting dimensions of variation. Piaget judged variable-stepping to be an essential component of formal operational thought. The idea is a powerful one because it is almost universally useful; it is crucial to the process of scientific investigation.
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Listing 1: The POLYSPI procedure, written in Logo. From only three variables—distance, angle, and change in distance—this procedure can generate a remarkable variety of polyspiral designs. The procedure draws by going forward the specified distance, turning at the specified angle, then increasing the distance by the specified change, going forward for the newly incremented distance at the same specified angle, and so on. Some designs drawn by POLYSPI appear in figures 1a–1f.

```
TO POLYSPI :DISTANCE :ANGLE :CHANGE
  FORWARD :DISTANCE
  RIGHT :ANGLE
  MAKE "DISTANCE :DISTANCE + :CHANGE
  POLYSPI :DISTANCE :ANGLE :CHANGE
END
```

change value is applied to the ANGLE variable instead of to the DISTANCE variable. (For a case study of a child’s ability to grasp and extend this idea, see my article “Extending a Powerful Idea,” in a forthcoming issue of The Journal of Mathematical Behavior.)

The BEACH Microworld

The adolescent’s initiation to formal thought differs greatly from the preschooler’s introduction to reading, yet both learning experiences involve grasping central representations. What the prereader learns in an alphabetic language is a serial symbolic representation for words that signify the names of objects, actions, and so on. Let me here describe a Logo microworld for learning the alphabetic language. This microworld helped my 3-year-old daughter learn to read with minimal direct instruction.

While previous Logo implementations focused on a single, all-important agent—the turtle—TI Logo also has sprites. A sprite is a video-display object that has a location, a heading, and a velocity, but no drawing capability. It may be associated with a shape (which it “carries” and which assumes one of 16 colors). The shapes can be easily defined and changed by the Logo user. There may be a maximum of 25 shapes. The importance of a multitude of easily discriminated objects for early language applications cannot be overestimated. TI Logo has a second graphics system, “tile graphics,” that is compatible with the sprite graphics system. The static tiles, which may also assume 16 different colors and exhibit modifiable shapes, provide a suitable “background” for the movements of the dynamic sprites. The result is the opportunity to create scenarios that have many moving objects with different shapes and different colors and a static but vivid backdrop. The BEACH microworld permits the creation of such scenarios, as the scenes in photos 1a and 1b illustrate.

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Photos la–lb: Two scenes from the BEACH microworld. Photo la shows a scene with many objects. Photo lb shows a scene typical of those drawn by a 3-year-old child. The author’s daughter learned to read 30 words by exploring the BEACH microworld, which the author and his children created using TI Logo with the Texas Instruments 99/4A microcomputer.

Meaningful Names Ease Learning
Because Logo gives the user great freedom to define and name procedures, appropriate descriptive English words can be used. For example, SUN can be the name of the procedure that creates a yellow ball on the display. The word UP can name the command that increases the value of a sprite’s y coordinate. Repeated often enough, UP puts the SUN in the sky above the BEACH. Another word, such as SLOW or FAST, can set the SUN in motion. Because new procedures are easily defined, the child, a family member, friend, or teacher could even make the SUN ZOOM if the child wishes. Such flexibility permits the microworld to be tailor-made to suit any child. To the extent that the child participates in defining the objects to be part of the world, their attributes, and the actions they are to perform, the microworld is also constructed by the child herself. My 3-year-old, Peggy, her older siblings, and I chose about 20 objects to populate her world, designed and made shapes to represent them, and wrote the procedures to create and manipulate them. The vocabulary of her BEACH world includes the following:

**OBJECTS**
BEACH, BIRD, BOAT, BOY, CAR, DOG, FISH, GIRL, HOUSE, JET, KID, MAN, MOON, OAK, PINE, PLANE, PONY, STAR, SUN, TRUCK, VAN, WAGON

**ACTIONS**
UP, DOWN, MOVE, BACKWARD, FAST, FLY, HALT, SAIL, SHOW, SWIM, TURN, WALK, ZAP, ZOOM, PAINT BLACK, PAINT GREEN, etc.

When Peggy began to play with this computer microworld, she did not recognize any words except “by,” and she had no idea what that meant. Her ability to discriminate between letters and name them was undependable and idiosyncratic. She began keying words, copying them letter by letter from a set of 4- by 6-inch cards I had made. Soon she began keying her favorite or most-used words from memory, and later she was able to read those individual words in other contexts. Now she deals with the written language one word at a time (as infants begin to speak with specific signification). To handle sentences (other than “paint some-color-name”) or begin phonetic decoding of words, she will need more complex microworlds.

For Peggy, the learning of reading and the learning of writing have been synchronized (as speaking and interpreting speech are for the toddler); she learned to read her 30-word vocabulary by learning first to “write,” i.e., key the words on the computer terminal. Writing was an essential part of controlling the computer microworld that engaged her. My role as teacher changed from taskmaster to occasional consultant. I would answer questions Peggy brought me after she had tried to work with the constructed reality of the BEACH microworld, and I helped her when she had problems, but I offered her no lessons beyond the rule that words are keyed letter by letter,
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<td>EPSON MX 850</td>
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<td>100K VIGICAL</td>
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<td>SCRIBE TENDER (Two Serial Ports and One Parallel Port)</td>
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<td>SCRIBE MASTER (Three Serial and Three Parallel Ports)</td>
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<td>AMDEX COLOR</td>
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I make no claim that computer microworlds can teach all reading skills, nor that this specific BEACH world would appeal to other children in different circumstances. I do, however, see the BEACH microworld as a prototype of the various worlds that others may fashion for small children.

Design Heuristics: Powerful Ideas

A computer microworld should be constructed around a powerful idea, one worth the instructor's time to develop or the student's time to explore. Who decides if an idea is sufficiently powerful? You do, at first, when you design a microworld. Next, the students determine the worth of the microworld as they incorporate the idea into their minds or reject it.

If you need a little guidance when you design a computer-based microworld, Papert (in Mindstorms) offers four criteria for powerful ideas: they should be simple, general, useful, and syntonic. The idea behind a microworld must be formulated as simply as possible; an idea can be powerful only when understood. Even if an idea is embodied in a specific microworld, it will not be useful through extension unless it is general.

Reality dictates the candidates for powerful ideas. Society also declares what ideas are important: if you can't read, for example, a technological society relegates you to subhuman status. But it is your own mind, more than any advice, that can tell you what ideas are powerful. Your own insights enable you to integrate important experiences. An idea is powerful, then, if it gives form to your understanding of life. It follows that you cannot inspire others with an idea unless it has first inspired you.

Interconnection of Knowledge

What Papert labels the "syntonic" characteristic focuses on how an idea assumes power within the mind of an individual. An idea is powerful for a person if it relates and unifies knowledge gained in diverse experiences.

An idea gains power if it can be reduced to a concrete model that serves as a metaphor for the interpretation of subsequent problems. Such a model helps explain which aspects of new problems must be considered, which may be neglected, and which anomalies must be explained away on a basis of local evidence. Models prove more or less powerful depending on the individual's interests and experiences.

The most essential characteristic of powerful ideas is their relation to the individual's previous knowledge. You can tell students that one situation resembles another, but recognition of such comparisons is more powerful if it is the students' own discovery. They will make the connections between the structures of one idea and another at a level of detail appropriate to their specific prior knowledge and feelings. This internalization is the basis of an idea's power for the individual.

An analogy may help here. If you solder a connection at too low a temperature, you can get mechanical binding but undependable electrical contact. Ideas imposed by instruction are like badly soldered joints. Only the individual has the power to fuse connections between new ideas and his or her own most personal thoughts and feelings. These connections alone can make an idea an important part of how the person sees the world and behaves in it.

Paradoxically, an excellent way to harness the students' understanding for engagement with ideas is to liberate their expressiveness. Because Logo is a vehicle for free exploration, knowledge built from Logo is syntonic, appropriate to the person, and experienced as an authentic, intimate part of the self. Such is the power of an approach to learning that frees the individual to create within a social context that makes our culture's most powerful ideas accessible.

I/O and Applications Design

An application design negotiates between a specific objective and the potential of the equipment. Computers are general-purpose symbol manipulators, so they can deal
abstractly with an idea. What any computer system can do in an interesting way, however, depends on its input/output (I/O) devices. Look for something special about a machine's I/O to suggest the kinds of neat phenomena the system could exhibit. Consider these examples from previously implemented Logo systems:

- The accessibility of the robot floor-turtle world to a child's physical intervention can lead even a small child into simulating the turtle's actions and into debugging procedures (after fixing a procedure "manually," a child can become more engaged in fixing it symbolically).
- Turtle graphics—whose appeal depends largely on the emergence of patterns from simple procedures that command the drawing of many lines—came into its own only with the general availability of bit-map-based displays.
- Logo on the GTI-3500 had a significant potential for engineering and physics simulations because a hardware-implemented "spin" primitive extended the forward and right primitives of "classical" Logo.
- The TI 99/4A joins together a general-purpose microprocessor (where TI Logo is implemented) with a special-purpose graphics processor that manipulates the sprites that give TI Logo its most striking effects.

As increasingly powerful microprocessors become affordable, the special quality of each will bring new potential for creating engaging microworlds. More powerful microprocessors and graphics slave processors may, for example, bring molecule modeling within reach. Local networks of small machines may permit group simulation of economic and political situations (as in games) that are now too abstract, rule-driven, and theoretical to interest many young people. There will continue to be opportunities for creating microworlds around the most powerful ideas of contemporary science and technology.

Objects in Microworlds

Logo procedures can serve as a bridge between less precise and more formal systems. The commands of Logo are designed to communicate with a computer and its output devices, but the extension of Logo through procedures whose names are natural-language words can make the objects and actions more comprehensible. This ability to be extended is a key feature for young children.

But Logo is only a quasi-natural language; a Logo procedure must run on a machine. Further, the objects of a Logo microworld are formal; they can be completely defined by a specification of their state variables. One of the simplest of these objects is the Logo screen turtle. Once you have specified the turtle's location, heading, and pen position, there is no more to say about it. The operations of a microworld are also completely specifiable in terms of the effects they have on state variables. The RIGHT and LEFT commands, for example, modify the heading of the turtle but do not affect its location. Given the object orientation of Logo and the ease of specifying the interaction of state-change operations with state variables, a first criterion for the quality of any Logo implementation (an application microworld or the interpreter itself) is the clear presentation of the state variables to someone using the system. Two examples of representation inadequacies in TI Logo can clarify the point: although the heading of a sprite is a significant state variable, it cannot be determined by inspecting the object's appearance (the shape carried by the sprite) when its velocity is zero; it is impossible to determine visually which sprite is the "current" object, i.e., the one or ones that will respond to the next Logo command. Ideally, the equivalent of a SHOWTURTLE/HIDETURTLE set of commands would show which is the active sprite. Whatever the limitations of a specific Logo implementation, anyone who designs a computer-based microworld should strive to represent all the state vari-

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Comments on a New Microworld

One of the objectives of Logo is to put power in the hands of beginning users. Even powerful ideas usually come from striving to reach a simple, down-to-earth objective. To demystify designing a microworld, I would like to present a few comments on some work in process. I wanted to develop an effective way to present some ideas of algebra to a 12-year-old. I remembered a casual comment of a former MIT Logo colleague, Andy diSessa, that one of the most powerful ideas accessible through Logo was embodied in “procedures that output.” At the time, I was mystified, even though Andy had explained that his comment was based on the fact that such a procedure was equivalent to a mathematical function. That observation came back to me. Algebra is about mathematical functions. Although I couldn’t fully appreciate Andy’s comment, it focused my attention on a personally comprehensible way of expressing mathematical functions in Logo.

Common mathematical functions assign the value of one variable (call it \( y \)) to the value of some expression based on another variable (call it \( x \)). Assigning values is just what the MAKE command does. If a superprocedure controlled assigning to \( y \) the value of an \( x \)-based expression for the domain of possible values of \( x \), it would generate any function expressible in the Logo language. When given two inputs \((x,y)\), the DOT primitive of Apple Logo draws a dot at the screen location of those coordinate values. If the value of \( x \) is incremented across the domain of possible \( x \)-coordinate values, and \( y \) is specified in terms of the value of \( x \), DOT can be used to plot discrete sketches of mathematical functions. A second method of drawing functions is possible. If those “dotted” locations are used as the position coordinates of a SETTURTLE (SETPOSITION) command, the screen turtle will draw a line-segment approximation to a mathematical function. These are the ideas around which the PLOTTING microworld is constructed. Photos 2a and 2b show examples from the PLOTTING microworld.

How can a person go from common experiences to a new idea by doing something only slightly unusual—but with that small difference providing access to a range of significant phenomena? Think about what kinds of experiences younger students might have had that could support learning about mathematical functions. Any child who uses Logo for a while learns to define specific variable values using the MAKE primitive; for example:

\[
\text{MAKE "MY.NAME "BOB}
\]

\[
\text{MAKE "MY.AGE 42}
\]

The minimal significant complication possible in the specification of a variable is to make its value depend on something else, such as keyboard input. It is common for beginners to write routines such as the greeting below for inclusion in some more ambitious program:

```
TO GREET
PRINT [WHAT’S YOUR NAME ?]
MAKE "WHO READWORD
;accept keyboard input
PRINT [SENTENCE
[GLAD TO MEET YOU,] :WHO)
END
```

We can start with nonarithmetic examples of variables as functions of other variables. They can be simple or complex. Graphs of equations can be viewed as another, more specific form of a familiar kind of relation—a new representation for a familiar idea. The algebraic formulas with which we usually associate the graphs of equations are seen as another description of a correspondence relation, a description that is specific and limited, but very powerful.

Making clear the connection between concrete uses of programming variables and mathematical functions is one justification of a PLOTTING microworld. This idea is one I judge to be powerful. The programming needed to make a Logo PLOTTING subsystem is nearly trivial (see listing 2), but that is precisely the virtue of a powerful language: its expressiveness makes ideas and functions stand clear of accidental complications.

Extending the PLOTTING World

If we look beyond the simple plotting of functions, the intellectual extensions of such a microworld can be simple and striking. Consider these two possibilities. First, when the domain of \( x \) is specified with beginning, end, and increment or step-size (to control the grain of the plotted function), the slogan through which continuity is often expressed becomes an almost obvious consequence of the “dotted” representation: “you give me an epsilon, and I can give you a delta such that whenever the difference between successive values of \( x \)
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Listing 2: The DOTPLOT procedure, written in Logo. The procedure plots \( y \) as a function of \( x \) for values of \( x \) incremented by CHANGE. Resulting plots appear in photos 2a–2b.

TO DOTPLOT :CHANGE
MAKE "X :X - 135
PRINT MAKE "Y A FUNCTION OF :X
MAKE "FUNCTION READLIST
LABEL "AGAIN IF :X > 135 [STOP]
RUN :FUNCTION
MAKE "FUNCTION MAKE "ANGLE :ANGLE + :CHANGE
SETPOS(SENTENCE :X:Y)
LABEL "AGAIN MAKE "ANGLE :ANGLE + :CHANGE
GO "AGAIN
END

Listing 3: The LJ1 procedure, written in Logo. Using the variables COEFF1, COEFF2, and CHANGE, the procedure draws Lissajous figures like those shown in photos 3b, 3c, and 3e.

TO LJ1 :COEFF1 :COEFF2 :CHANGE
RUN :FUN1 RUN :FUN2
PENUP RUN :FUN1 RUN :FUN2 SETPOS(SENTENCE :X:Y)
PENDOWN
MAKE "FUN1 (SENTENCE [MAKE "X 100 * SIN :COEFF1 * :ANGLE]
MAKE "FUN2 (SENTENCE [MAKE "Y 100 * COS :COEFF2 * :ANGLE]
LABEL "AGAIN MAKE "ANGLE :ANGLE + :CHANGE
SETPOS(SENTENCE :X:Y)
GO "AGAIN
END

is less than \(\delta\), the difference between successive values of \( y \) will be less than \(\epsilon\)." Second, consider the implications for understanding the differential calculus. When plotting the value of a function, it is simple to save the value of the prior point-couple and calculate the slope of the function. This is an empirical form of differentiation. A micro­world of plotting tools (whose activities could include plotting functions, the empirical derivation of slopes of those functions, and curve fitting—with the plotting tools—to those empirically derived slopes) could provide a body of practical experience about the relations between functions and their slopes. This experience, for which differential calculus will later provide a theory, will make the calculus easier to appreciate and assimilate.

These ideas may interest a math teacher or a psychologist, but would any child be interested in plotting mathematical functions? Are there any accessible neat phenomena? This is the most important final question the creator of every microworld must face. The concrete appeal of this microworld must be the creation of appealing (and possibly puzzling) graphic designs. The beauty of turtle-geometry designs derives from the use of repetition and variables in simple procedures. This observation suggests that we look at repeating functions such as those produced by the sine and cosine primitives. Photos 3a–3f show six designs made from combinations of sine and cosine functions. These designs, generally known as Lissajous figures, are my candidates for neat phenomena of the PLOTTING microworld. [Editor’s Note: Named for French physicist Jules Lissajous, each of these figures consists of the series of plane curves traced by an object that executes two mutually perpendicular harmonic motions. . . . P.L.] The method of the procedure shown in listing 3 is to calculate a screen location with \( x \) as a sine function of an angle value and \( y \) as a cosine function of the same angle. The design is made when the turtle draws a line as it moves from one calculated location to the next one. The procedure is stopped manually.

Lissajous figures are similar to POLYSPI designs in general character because they are made of line segments that show natural classes or families of shapes and occasionally emerge as surprisingly beautiful. Like INSPI designs, they are somewhat mysterious to those who think more concretely than formally. Are they...
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Photos 3a-3f: Six more designs from the PLOTTING microworld. The author regards designs made from sine and cosine functions as neat phenomena; i.e., phenomena inherently interesting to observe or interact with. In each design, a procedure calculates a screen location with $x$ as a sine function of an angle value, and $y$ as a cosine function of the same angle. The turtle draws a line by moving from one calculated location to the next.

Photo 3a shows a plot of $y = \sin x$ and $x = \cos y$. The designs in photos 3b, 3c, and 3e were plotted using the `LJ1` procedure shown in listing 3, with the following respective sets of values for the three variables (COEFF1, COEFF2, and CHANGE) in the procedure: 1, 1, 1; 77, 23, 9; 1, 2, 84. The design in photo 3d was plotted by a similar procedure that plots cosine against sine, using the values 13, 26, 6. Photo 3f resulted from another similar procedure that plots cosine against cosine, in this case using the values 7, 28, 43.

"neat" enough? Will their appeal be universal? Such questions are clearly impossible for me to answer. If this microworld is of limited interest, perhaps you will have a better idea. More power to you!

The Challenge to Educators

If Piaget's vision that education should involve active discovery of reality is correct and Papert is right in saying that computer-based microworlds provide a solution to the central problem of education, the challenge of education will be more technical in nature than theoretical or ideological.

Clearly, the computer revolution is having a significant impact on education. But that revolution is only worthwhile if it liberates people, which it can by offering educators two remarkable opportunities: with computer technology, teachers will be able to help children expand their love of learning; in turn, teachers will achieve a kind of professional status long denied them. Teachers, programmers, and other microworld designers will be the architects of inner space, proposing ideas and creating tools that will enrich our minds.

Acknowledgments

Many people in the extended Logo community have contributed to the ideas of this paper. Seymour Papert's influence is central and obvious. Conversations with people who have worked for or visited Logo Computer Systems in Boston and New York have inspired observations or explanations. Dan Watt's editorial comments have been helpful. The article was revised for publication while the author was a consultant to Le Centre Mondial L'Informatique et Resources Humaine. Thanks to Guy Montpetit for use of the text processor and to the Spencer Foundation for support during a period when these ideas were developing.

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Logo is a language for learning. That sentence, one of the slogans of the Logo movement, contains a subtle pun. The obvious meaning is that Logo is a language for learning programming; it is designed to make computer programming as easy as possible to understand. But Logo is also a language for learning in general. To put it somewhat grandly, Logo is a language for learning how to think. Its history is rooted strongly in computer-science research, especially in artificial intelligence. But it is also rooted in Jean Piaget’s research into how children develop thinking skills.

In a certain sense, all programming languages are the same. That is, if you can solve a problem in one language, you can solve it in another—somehow. What makes languages different is that some types of problems are easier to solve in one language than in another. Language designers decide what kinds of problems their language should do best. They then make design choices in terms of those goals.

Logo as a Programming Language

Let’s postpone for a while the broader educational issues. First, we’ll consider Logo simply as a programming language. How is it similar to other languages; how is it different? Syntactic details aside, there are several substantial points of language design through which Logo can be compared to other languages.

Logo is procedural. A programming project in Logo is not written as one huge program. Instead, the problem is divided into small pieces, and a separate procedure is written for each piece. In this respect, Logo is like most modern languages. Pascal, APL, LISP, C, and even FORTRAN permit the division of a program into independent procedures. Among the popular general-purpose languages, only BASIC lacks this capability. (The sample Logo programs in this article are written in Apple Logo, a dialect written by Logo Computer Systems Inc. Other versions of Logo will be slightly different in details.)

Consider the Logo program in listing 1a. Even if you don’t know anything about Logo, it’s probably obvious what this pair of procedures does. Compare it to the BASIC version in listing 1b.

The GOSUB construct in BASIC is weaker than a true procedure capability in several ways. For one thing, the BASIC subroutine is not an independent program; if line 100 were omitted, the program would “fall into” the subroutine. More important, there is no concept in BASIC of inputs to procedures, like QUESTION and ANSWER in the Logo program. Instead, extra statements must be used to assign values to the variables Q$ and A$.

This explicit assignment is not simply an inconvenience. It means that the main part of the program has to “know” about the inner workings of the subroutine. In the Logo version, the procedure named QUIZ knows only that the procedure QA has two inputs, a question and an answer. If QA were modified to use different names for the variables, QUIZ would still work. Similarly, although this particular example doesn’t show it, Logo procedures can have an output that is communicated to the calling procedure. (The DEF statement in BASIC provides a limited version of procedures with outputs; the limitations are that the inputs and outputs must be numbers, and the definition must be a single line without conditional branching.)

Logo is interactive. Like BASIC, but unlike Pascal, Logo lets you type in a command to be carried out right away. It’s also quick and easy to change one line of a program. Other interactive languages are LISP and...
Listing 1: Comparison of Logo and BASIC. Each program asks the same set of three questions and compares the user's response to the author's answer. In the BASIC version (listing 1b), the "questioning" subroutine (lines 1000-1110) is not an independent program. In the Logo version (listing 1a), the procedure QA could stand alone, and might conceivably be used by other programs.

(1a)

TO QUIZ
QA [WHAT'S THE BEST MOVIE EVER?] [CASABLANCA]
QA [HOW MUCH IS 2 + 2?] [5]
QA [WHO WROTE "COMPULSORY MISLEDUCATION"?] [PAUL GOODMAN]
END

TO QA :QUESTION :ANSWER
TYPE :QUESTION
TEST EQUALP :ANSWER READLIST
IFTRUE [PRINT [YOU'RE RIGHT!]]
IFFALSE [PRINT SENTENCE [NO, DUMMY, IT'S] :ANSWER]
END

(1b)

10 Q$ = "WHAT'S THE BEST MOVIE EVER?"
20 A$ = "CASABLANCA"
30 GOSUB 1000
40 Q$ = "HOW MUCH IS 2 + 2?"
50 A$ = "5"
60 GOSUB 1000
70 Q$ = "WHO WROTE 'COMPULSORY MISLEDUCATION'?"
80 A$ = "PAUL GOODMAN"
90 GOSUB 1000
100 GOTO 9999
1000 PRINT Q$;
1010 INPUT R$;
1020 IF R$ = A$ THEN GOTO 1100
1030 PRINT "NO, DUMMY, IT'S"; A$;
1040 RETURN
1100 PRINT "YOU'RE RIGHT!"
1110 RETURN
9999 END.

APL; other noninteractive languages are C and FORTRAN.

Whether or not a language is interactive has an effect on its efficiency. In brief, program development is generally faster with an interactive language, but already-written programs generally run faster in a language that is not interactive. The difference has to do with the mechanism by which the computer "understands" your program.

Every computer is built to understand one particular language. This machine language is different for each type of computer. Since machine-language instructions are represented as numbers, they're not easy for people to read. For example, the number 23147265 might mean "add the number in memory location number 147 to the number in memory location 265." Programs written in a high-level language, including Logo and the other languages mentioned here, must be translated into machine language before the computer can carry them out. This translation is done by another computer program that comes in one of two flavors: compiler or interpreter.

A Pascal compiler, for example, takes a program written in Pascal and translates (compiles) it into the machine language of whatever computer you're using. The translated program is permanently saved as machine language (probably as a file on your floppy disk). Thereafter, the machine-language program can be executed directly. The compiling process takes a long time. But once it's finished, running the compiled program is very fast because it never be compiled again.

A Logo interpreter, on the other hand, does not create a permanent machine-language version of your program. Instead, each Logo statement is translated and executed every time the statement is supposed to be executed. The interpreter does not produce a machine-language representation of your program, but simply carries out the machine-language steps itself. If a Logo statement is to be executed six times, it's translated six times. (Actually, some interpreters, including Apple Logo, save a partial translation of each procedure, so that the second execution is somewhat faster than the first; this process is too complicated to explain in this article.)

Interpreted languages can be interactive. Suppose you want to find the value of 2 + 2 in Pascal. First, you must use the text-editor part of your Pascal system to write a disk file containing a Pascal program. Then, you run the Pascal compiler, which will translate the program into machine language. Finally, you run the compiled program and your computer types out 4. In an interpreted language like Logo, you can simply type PRINT 2 + 2 to see the same result.

The situation in which interaction is most important is program development. If you are writing a complicated program, it probably won't work right the first time you try it. You'll have to try it, see what goes wrong, change the program, and try again. In order to see what went wrong, you'd like to be able to use interactive debugging. (You stop the program where the error happens and type in commands to examine the values of variables at that moment.) This debugging cycle may be repeated many times before the program finally works completely. Even though a compiler might make the program run faster, an interpreter is likely to make the entire debugging process faster because it's so much easier to find and fix your mistakes. It's only after the program works, and you want to use it every day without modification, that the compiled version is really faster.
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The flexibility and ease of use of an interactive language is particularly valuable in an educational setting. For a student of programming, there often is no production phase — the program is of interest only as long as it doesn't work. When it does work, the student goes on to the next problem. In that sort of environment, the speed advantage of the compiler never materializes. In a business environment, on the other hand, the actual production use of a program is likely to be more important, which makes a compiler more desirable.

Some languages use mixed schemes. BASIC (normally an interpreted language) has compilers that allow the user to give up interaction for efficiency. Some LISP compilers can coexist with interpreters, so that some procedures can be compiled while others are being debugged interactively. Some versions of Pascal are compiled into an intermediate language called p-code, which is then interpreted. FORTH uses a similar system of partial compilation, but the compiler is part of the run-time environment, so single statements can be compiled and run interactively.

Logo is recursive. In a procedural language, one procedure can use another procedure as a subprocedure to do part of its work. A language is recursive if a procedure can be a subprocedure of itself.

All modern procedural languages allow recursion. Among widely used languages, only FORTRAN allows procedures but not recursion. (BASIC, as was mentioned earlier, has neither.) It may seem as though recursion isn't too important. Why should it be any different from any other use of subprocedures? It's hard to explain in a simple way why recursion is important. The idea behind recursion, though, has profound mathematical importance. By allowing a complicated problem to be described in terms of simpler versions of itself, recursion allows very large problems to be stated in a very compact form.

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Figure 1: Typical moves in the Tower of Hanoi puzzle. Figure 1a shows the initial position, figure 1b the first move, and figure 1c the position after several moves. Figure 1d shows an illegal situation with a larger disk on a smaller one.

has a number of different-size disks piled initially on one of three pegs, with the smallest at the top. The problem is to move the disks onto a different peg, moving one disk at a time and never moving a disk onto a smaller disk (see figure 1).

To solve this problem, first notice that it’s very easy with only two disks, with the smallest at the top. The problem is to move the disks onto a different peg, moving one disk at a time and never moving a disk onto a smaller disk (see figure 1).

Now suppose there are six disks (see figure 2b). Again, we have to begin by getting disk 6, the largest one, from peg A to peg B. But now there are five disks in the way, not just one. This provides us with a subproblem: move five disks from peg A to peg C. But this is exactly the Tower of Hanoi puzzle itself with five disks instead of six! The subproblem is a simpler version of the main problem. This calls for the recursive solution shown in listing 2.

In working through this program, bear in mind that each use of the HANOI procedure has its own, private variables; the value of NUMBER, for example, remains constant throughout any particular use of the procedure, even though there is another use of HANOI with a different value for NUMBER in the middle.

In addition to Logo, many other languages allow recursion (these include Pascal, C, LISP, and APL). The style of Logo, however, encourages the use of recursion more than some other languages. C and Pascal allow recursion but encourage iteration. (Iteration means telling the computer to execute something repeatedly. The FOR...NEXT construct in BASIC is an example.) Logo is the other way around: iteration is possible, but recursion is preferred. For many purposes, neither approach is clearly right. Iteration is somewhat simpler for the situations in which it works at all; in some cases like the Tower of Hanoi puzzle, however, nothing but recursion will do.

Until recently, iteration was much more efficient than recursion, both in speed and in the use of memory. A major advance in recent implementations of Logo, including the versions available for the Apple II and the Texas Instruments TI-99/4A microcomputers, is that tail recursion is recognized by the interpreter and treated as if it were written as iteration. Tail recursion is the situation in which the recursive use of a procedure is the last thing done in the procedure. In general, it is only tail-recursive programs that could just as easily be done iteratively. The HANOI procedure, for example, is not tail recursive because two recursive procedure calls are in it, only one of which is at the end.

Logo has list processing. Every major programming language has some way to group several pieces of information (numbers, for example) into one large unit. In FORTRAN and BASIC, this mechanism is the array. In Pascal and C, arrays are also used, along with a more complicated grouping called a record in Pascal or a structure in C. In Logo, the main grouping mechanism is called the list.

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Figure 2: How the puzzle breaks down into simpler subproblems with similar solutions. Figure 2a shows the simplest solution to a puzzle involving only two disks. Figure 2b shows the situation when the same procedure is used on more disks.

Listing 2: General solution to the Tower of Hanoi puzzle in Logo. The program requires four inputs. The variable NUMBER tells the program how many disks to the puzzle; the other three inputs are the names of the pegs. The IF statement detects the trivial subproblem of moving zero disks, for which there is nothing to do.

The solution is found by dividing the problem into a series of simpler subproblems, all of which can be solved by repeating a simple series of moves. First, move all but the bottom disk to the third peg; then, move the bottom disk to the destination peg; and finally, move all but the bottom disk to the destination peg (see figure 2).

TO HANOI :NUMBER :FROM :TO :OTHER
IF :NUMBER = 0 [STOP]
HANOI :NUMBER - 1 :FROM :OTHER :TO
HANOI :NUMBER - 1 :OTHER :TO :FROM
END

HANOI 6 "A" "B" "C
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more efficient to deal with. The restrictions on arrays mean that if the computer knows where the beginning of some array is located in memory, the location of the nth element of the array can be calculated easily, no matter what values the elements actually have.

With a list, the size of each element is variable. Therefore, lists are stored in a more complicated way. As a result, to find the fourteenth element, you have to start with the first one, figure out where the second one is, then figure out where the third one is, etc. Since this is all done automatically by the Logo interpreter, lists aren't hard for the programmer to use, but it's somewhat slower than finding something inside an array.

Among major languages, LISP uses lists much like those in Logo. (In fact, the data structures in Logo are based on those of LISP. LISP's name stands for LISt Processing.) APL uses a data structure that is like lists in that it is not fixed in size, but is like arrays in that it is uniform in composition. In other words, an APL vector can grow or shrink, but it has to be all numbers or all characters. Pascal and C don't have lists, but they have pointer variables that can be used along with records or structures to build the equivalent of lists. FORTRAN and BASIC don't have dynamic storage allocation—you can't make something bigger in the middle of the program—so there is no way to create lists in them.

Logo is not typed. In BASIC, if you want a variable to contain a character string, you put a dollar sign at the end of its name. If you don't use the dollar sign, the variable must contain a number, not a string. (Some versions of BASIC have a third type: a variable whose name ends with a percent sign contains an integer, or whole number.) In Pascal and C, the type of a variable must be given explicitly in a declaration. In FORTRAN, variables can be declared as in Pascal; if a variable isn't declared, its type depends on the first letter of its name. The letters I through N indicate integer variables.

In Logo, as in LISP and APL, variables are not typed. Any variable can take on any value. The same variable can be an integer at one point in the program and a character string (called a word in Logo) later on.

Originally, variable typing wasn't a matter of language-design philosophy. Variables were typed to make life easier for the people who wrote compilers. Since different machine-language instructions are used, for example, to add integers and to add numbers with fractional parts, it's easier to translate "A+B" into machine language if you know ahead of time whether or not A and B are integers.

More recently, some language designers have taken the position that variable typing is a good thing, apart from implementation issues, because it disciplines the programmer to use a variable for only one purpose. In re-
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Listing 3: Logo variables are nontyped. The variable NUMBERS contains whatever the user enters. First, it is examined as a list of words and tested to see if it contains the value DONE; next, it is used as a list of numbers and added.

TO ADDLOOP
PRINT [TYPE TWO NUMBERS TO ADD.]
MAKE "NUMBERS READLIST
IF FIRST :NUMBERS = "DONE [STOP]
PRINT SENTENCE [THE SUM IS] (FIRST :NUMBERS) + (LAST :NUMBERS)
ADDLOOP
END

jecting typing, the designers of Logo did not mean to encourage the hap­
hazard use of variables for different purposes; rather, they built a pro­
cedural language in which variables are attached to a particular pro­
cedure, rather than being available to the entire program. This encourages the same discipline in a different way.

As an example in which typed vari­

ables are awkward to use, listing 3 il­

lustrates the common problem of writing a program that reads some numbers entered by the user, per­
forms some calculation with them, and repeats the process until the user signals that there are no more prob­lems to do.

This program has been written so that the user can enter the word DONE when no more numbers are left to add. In a typed language, the numbers would have to be read into a numeric-type variable, not a string-type variable. Entering a nonnumeric word would be an error. FORTRAN programs used to be full of instruc­
tions to the user like "type 9999 to in­
dicate that you're done." Pascal pro­
grams face the same difficulty.

Logo is extensible. Every computer language has certain built-in, or primitive, operations. Most lan­
guages, for example, include arith­
etic operations on numbers, and some way to print the results. Pro­
cedural languages allow the program­
mer to create new operations, extend­
ing the capability of the language. In that sense, most languages are exten­sible. But "extensible" is used by lan­
guage designers in a special sense.

An extensible language is one in which user-defined procedures "look like" primitive procedures. This is partly a matter of notation and partly a matter of real power. In most lan­
guages, the primitive arithmetic opera­
tions can be applied to several dif­
ferent types of variables (integer and real, for example) with appropriate results for each type. In most lan­
guages, however, user-defined pro­
cedures must specify in their defini­
tion one particular type of variable to which they apply. This restriction violates the principle of extensibility.

Extensible languages are particular­ly valuable for teaching because a teacher can provide language exten­
sions and teach them as if they were primitives. LISP, Logo, APL, and FORTH are extensible, with some minor restrictions in some cases. Logo violates pure extensibility, for example, in that some of the primitive arithmetic operations are represented in infix form (with the operation sym­bol between the two operands, as in 3 + 2 ), while user-defined pro­
cedures can be represented only in prefix form (with the operation sym­bol before the operands, as in SUM 3 2). Almost all Logo primitives are used in prefix form.

As an example of the use of exten­sibility in Logo, most versions do not have primitive procedures for iter­
ative looping, like the FOR, DO, or WHILE constructs in other languages. But it is very easy to define these pro­
cedures, if you want them, so that they look syntactically similar to the IF command that is a Logo primitive.

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Logo, LISP, and APL are interpreted, list-oriented, and untyped. Pascal and C are compiled, array-oriented, and typed. (All respectable languages are procedural, by definition.) These groupings reflect historical accidents, implementation convenience, and language-design philosophy. For example, C and Pascal are very similar because they are both derived from an earlier language, ALGOL, that established a style followed by many newer languages.

Compilers have a much easier time with typed languages, while interpreters are just as happy with untyped ones. The list-oriented languages were all invented by people who are primarily mathematicians, rather than computer programmers.

Within each group, though, the differences tend to reflect the particular use each designer had in mind. For example, C is different from Pascal largely because C was designed as a language for systems programming.

In the list-oriented group, LISP was developed for use in artificial-intelligence research, and APL was developed to teach algebra and the mathematical topics, like calculus, that depend on algebra. Logo, though, was developed as a learning language, not for a specific branch of mathematics, but for problem-solving behavior. Logo is meant to appeal particularly to younger students than APL does, although Logo has also been used successfully with college physics students at MIT.

From the point of view of the “pure” computer scientist, Logo is LISP. The developers of Logo, in fact, have been artificial-intelligence researchers for whom LISP is second nature. The differences between the two languages are all based on the specific intent to make Logo particularly useful as a learning language. Logo’s special properties from this point of view will be described next.

Logo is “tuned” for interesting applications. Probably the most famous aspect of Logo is the idea of turtle geometry. This approach to computer graphics has been added to other languages, such as Pascal and PILOT, but it originated with Logo.

Most approaches to computer graphics are based on Cartesian coordinates (the “x,y” system you learned for graphing equations in high school—see figure 3). In this approach, each line you want to draw is specified in terms of the specific positions of the endpoints, relative to a fixed-coordinate system. Using Cartesian coordinates, it’s not too hard to draw an upright square in a known position, but if the square is tilted, its coordinates must be calculated using trigonometry. The power of turtle geometry is that lines are described not in terms of absolute position in a coordinate system, but relative to the position and direction of the turtle, a conceptual animal that moves around the TV screen. In this system, you don’t say where the turtle starts or ends, just how far it moves and in what direction:

```
TO SQUARE :LENGTH
    REPEAT 4 [FORWARD :LENGTH RIGHT 90]
END
```

Other articles in this issue of BYTE explain more about how turtle geometry works (see “A Beginner’s Guide to Logo” by Harold Abelson on page 88 and “Introducing Logo to Children” by Cynthia Solomon on page 196). For our purposes, what’s important is that the use of this powerful approach makes graphics programming possible for beginners the first time they use the computer.

In the past, computer programming has appealed to only a small number of people because there has been a real lack of problems that are both interesting and easy enough for beginners. Traditional programming courses have been heavy in algebraic problems (“Write a program to solve quadratic equations.”). Therefore, they have not attracted people who...
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Listing 4: Pig Latin translation via Logo.

TO PIGLATIN :SENT
    IF EMPTYP :SENT [OUTPUT []]
    OUTPUT SENTENCE (PLWORD FIRST :SENT) (PIGLATIN BUTFIRST :SENT)
END

TO PLWORD :WORD
    IF VOWELP FIRST :WORD [OUTPUT WORD :WORD "AY"]
    OUTPUT PLWORD WORD BUTFIRST :WORD FIRST :WORD
END

TO VOWELP :LETTER
    OUTPUT MEMBERP :LETTER [A E I O U Y]
END

don’t like the traditional mathematics curriculum.

Turtle geometry is not the only special application built into Logo. Another one is language processing. Letters, words, and sentences are a natural hierarchy of Logo objects. (In most programming languages, by contrast, a sentence is not a list of words, but a string of characters. If you want to deal with the words in the sentence, you have to write a complicated program just to look for spaces in the string to divide the words.) As a simple example, listing 4 is a Logo program to translate a sentence into pig Latin. PLWORD is used as a subprocedure to translate a single word based on this rule: if the word starts with a vowel, add AY at the end. If not, move the first letter to the end and try again.

In the program, WORD and SENTENCE are procedures for joining two objects into a larger object; FIRST and BUTFIRST separate an object into its component parts. The primitive procedure FIRST, when applied to a sentence, produces the first word of the sentence. When applied to a word, it produces the first letter. No other programming language deals so neatly with this hierarchy of objects in human language.

Logo is user-friendly. A language for learners has to be designed to deal with problems that are less important in a language meant for experienced programmers. For example, when you make a mistake, you should get a detailed, helpful error message. Languages that say things like SYNTAX ERROR or ERROR NUMBER 259 are not encouraging to a beginner. Logo has messages like:

+ DOESN’T LIKE HELLO AS INPUT

This means that you tried to add a nonnumber, the word HELLO, to something. When you see the message

I DON'T KNOW HOW TO FRIST

you have used a procedure, FIRST, that you haven't defined. The message

NOT ENOUGH INPUTS TO MAKE

means that the procedure MAKE needs two inputs, and you gave only one. If the error happens during the execution of a procedure, Logo also prints the name of the procedure and the line containing the error.

Since the beginning of time (in 1954), programming students have been getting confused about common programming statements such as \( X = X + 1 \), a frequently used assignment construct that seems to go against one's algebraic intuition. Pascal’s use of \( : = \) instead of the unadorned equal sign is somewhat of an improvement, and APL’s \( - \) is even better. Even so, the notation doesn’t make it obvious that \( X - 3 \) has an effect very different from \( X + 3 \) or \( X - 3 \), which look very similar. In Logo, the assignment is done this way: MAKE "X :X + 1. Although less terse than a single-character symbol for assignment, the word MAKE con-
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C treats all procedures as operations, but allows an operation to be used as if it were a command; the result of the operation is ignored in that case. In LISP and APL, the result of such a "top-level" operation is printed. (In LISP, every procedure has an output and every top-level command prints something. In APL, some procedures don't have output and, therefore, don't print anything.) In Logo, using an operation without a command is considered an error; if you want something printed, you must use the PRINT command.

The use of infix arithmetic in Logo is a concession to the habits of the users. All other Logo procedures are used in prefix form, with the procedure name before the inputs. Arithmetic can also be expressed in prefix form. The two Logo expressions 3 + 2 and SUM 3 2 are equivalent.

The infix form seems more natural to people accustomed to doing arithmetic outside of the Logo environment. The prefix form, however, is better in some ways. For example, it eliminates the need for precedence of operations (i.e., where division is always done before addition, etc.). Also, it eliminates the need for parentheses to indicate grouping. In LISP, only the prefix forms are used.

Another user-friendly aspect of Logo is its facility for interactive definition of procedures. Early versions of Logo used a line-numbering technique: within each procedure, lines were numbered and could be replaced much as the lines of a BASIC program can be replaced. Current implementations of Logo use a display editor in which special control characters are used to move the cursor around the display screen to change individual characters anywhere in a procedure definition.

Logo has no threshold and no ceiling. This means that Logo is easy enough for anyone to use, but it is powerful enough for any project; it's not a "toy" language. Logo is best known as a language for elementary school children, but it's designed for learners of any age and any level of sophistication.

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Well, very young children might have trouble with typewriter keys and with the spelling of procedure names. Several years ago, however, Radia Perlman at MIT built a series of special keyboards with large buttons labeled with pictures instead of words. With this special hardware, she taught the ideas of turtle geometry to 4-year-olds. This project even included the idea of procedures, with buttons called "start remembering" and "stop remembering" to delimit a procedure definition, and one called "do it" to execute the procedure. Multiple procedures could be named by using buttons in different colors.

How old can a Logo learner be? Professors Harold Abelson and Andrea diSessa have been using Logo to teach physics to MIT undergraduates. They use Logo simulation programs to demonstrate not only simple Newtonian mechanics but even the general theory of relativity. Their book, *Turtle Geometry: The Computer as a Medium for Exploring Mathematics* (Cambridge, MA: MIT Press, 1981), demonstrates their approach, which has also been used successfully with high school students.

Logo has also been used for a special group of learners, those with severe handicaps. In the past, many children of normal or superior intelligence, but with impaired ability to communicate, have been diagnosed as retarded. Computers can be used with such children both as a communication prosthesis and as a field of interest in which the handicapped learner can exhibit autonomy in pursuing goals. The use of Logo in education for the handicapped is explored in Dr. E. Paul Goldenberg's book *Special Technology for Special Children* (Baltimore: University Park Press, 1979).

Other languages designed with students in mind are BASIC, Pascal, and APL. (I omit PILOT, which was designed not so much for students as for teachers; in its original design, students were supposed to use computer-aided-instruction programs written in PILOT, rather than PILOT itself.) How do these languages compare with Logo in their applicability to education?

BASIC was designed as a modification of FORTRAN for beginners. By far the most important advance in BASIC was its interactive approach. This was much more of a pioneering step than it now seems because people are now accustomed to inexpensive personal computers with this feature. In the early days of BASIC, the only computers were huge, expensive ones. Although timesharing, which allowed several people to use the big computer at once, had recently been invented, many people objected to it because it used the precious time of the huge computers inefficiently. (The response of timesharing advocates was that it was more efficient in the use of human time.) An interactive language was even more time-consuming than timeshared use of the old, compiled languages. For John Kemeny and his colleagues at Dartmouth to move against the general worship of efficiency was very brave.

Besides adding interaction, BASIC removed some of the most difficult parts of FORTRAN. For example, the INPUT and PRINT statements in BASIC don't require a detailed specification of the format in which infor-
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mation is presented, as FORTRAN does with its FORMAT statement. (As an example, FORTRAN requires the user to specify the number of digits before and after the decimal point in the printed form of a number.) Of the modern languages, only C uses primarily format-directed input and output. Unfortunately, the important ideas of procedures and local variables were also left out of BASIC.

This means that easy problems are very easy to solve in BASIC, but hard problems are close to impossible. Any large BASIC program is bound to be an unreadable maze of GOTOs. The designers of BASIC, after all, intended it as a language for beginners (i.e., Beginner's All-purpose Symbolic Instruction Code). FORTRAN was supposed to be used for more difficult programs.

The advent of personal computers has pushed BASIC into a more extended role, not because it's easy for the programmer, but because it's easy for the computer! The Logo interpreter, like the Pascal compiler, barely fits in an Apple II computer with 64K bytes of memory. BASIC interpreters are used with 8K-byte machines at a much lower cost. The result is that computer magazines are filled with long, complicated BASIC programs that are far from basic in their readability.

Pascal, on the other hand, was designed to include the most advanced ideas of computer science in recent years. Although intended as a first language, it was meant primarily for college students, particularly those interested in computer science as a career. That helps to explain why it is compiled and typed, two strong barriers to the unsophisticated student. Even the simplest Pascal program is rather complicated to write, enter into the computer, and run. That's why, in practice, Pascal is often taught to students who have already used BASIC and FORTRAN.

BASIC and Pascal were both designed to teach computer programming per se. APL was designed to teach mathematics, especially at the high school level. Its inventor, Kenneth Iverson, used it for several years as a blackboard language without any intention of actually implementing it on a computer. That helps explain his willingness to use special symbols not then found on any actual computer printer. Anything can be drawn on the blackboard!

In its intended use, APL is very powerful. Many computations that require iterative loops and auxiliary variables in other languages can be done in one step in APL. Most people see this power mainly as a matter of terseness; APL is famous (or notorious) for its one-line programs. The real virtue of APL's approach is that it allows the student's attention to be focused on the mathematics of a problem, rather than on the needs of the computer. APL was designed to be used not in a special programming course or a special unit stuck into another math course, but casually throughout an algebra course, just as you'd use a calculator.

Logo's goal is different from all these. It isn't supposed to be an easy introduction to something else, it's not specifically for computer-science majors, and it isn't a tool for teaching the same math curriculum people are already teaching. Instead, it's a door into the territory of the computer as an object for intellectual exploration. To return to the theme stated at the beginning of this article, Logo is for learning learning.

Why Logo?
In his book Mindstorms: Children, Computers, & Powerful Ideas (New York: Basic Books, 1980), Seymour Papert says, "It is not true to say that the image of a child's relationship with a computer I shall develop here goes far beyond what is common in today's schools. My image does not go beyond: It goes in the opposite direction." Logo isn't just a programming language; it's also a philosophy of education. Papert's book is the best explanation of that philosophy, but what follows is a briefer summary.

A child learns partly by picking up specific facts and skills. Much of existing formal education is about facts and skills: reading, spelling, and the multiplication table. But a more profound kind of learning is the skill
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of learning itself, which involves the building of mental models of the world, of oneself, and of the learning process. These models are developed through intellectual exploration. That exploration may begin in a weak, haphazard way, but a good learner develops strategies for purposeful exploration. The more one learns, the better the model of learning, and the more able one becomes as a learner.

In this process of growth, it doesn’t really matter what particular aspect of the world you explore. In the introduction to Mindstorms, Papert mentions that at age 2 he fell in love with automobile gearboxes. When I was in junior high school, I fell in love with hypnotism. The point about using computers in education is not that everyone must know something about computers, but simply that for many people, computer programming can be the arena for this general process of learning to learn. Because the computer is such a general-purpose machine, it can appeal to many different interests. It can draw pictures, make music, write stories, or move robots.

“I want a job as a computer programmer. Why should I learn Logo, and not something useful like COBOL?” This is a common question. There are two possible answers to it. The first is that Logo, as explained earlier, is designed to make explicit many of the fundamental ideas of computer programming. Someone who learns Logo is likely to have a very clear idea of the nature of variables, procedures, and most other programming constructs. So Logo may be a better basis even for learning COBOL than simply starting with COBOL itself. But the second answer is that Logo’s purpose isn’t to train computer programmers. Logo isn’t meant to replace all other programming languages.

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children because most people have a model of the learning process in which children learn and adults don't. This model is unfortunate. Logo can be useful to people of any age, but it will be most useful to you if you approach it in a playful, exploratory way.

It's important to distinguish between the Logo language and any particular implementation of Logo. Some things can't be done in the Apple and Texas instruments versions of Logo simply because the machines aren't big or fast enough or because the implementation doesn't include some capabilities. For example, no microcomputer version of Logo has a good way of storing data on disk, although all versions can store procedures on disk.

The Logo interpreter barely fits in a 64K-byte Apple II, and the implementation favors the features needed for education, not those needed for practical data processing. But in principle, Logo is a good language in which to develop any application because of its interactive debugging and its procedural style.

Do you want to write a video-game program? It'll probably run too slowly in Apple Logo, unless it's a simple one. But it might be worthwhile to develop it in Logo, playing around with different ideas for your game in an environment that permits quick, easy modification of your program, and then rewrite it later in some other language. The advantage of Logo can be described partly in purely technical terms like "interactive." Another way of looking at it, however, is that Logo encourages the playfulness you need to design the best possible game. If all you want to do is make an exact copy of Asteroids, the benefits of Logo are less important.

In summary: Logo is a LISP-like language, and a laboratory for loose, lifelong learning about learning.

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Introducing Logo to Children

Teaching Logo requires an awareness of different learning styles.

Cynthia Solomon
80 Ellery St.
Cambridge, MA 02138

As computers continue to enter schools and homes, parents, teachers, and children face the problem of integrating the machines into their lives. For many, computers serve as powerful instruments for personal use and intellectual development. Many Logo researchers see the potential of computers to serve as personal instruments for everyone and have been working toward that goal. In the process, they have focused on developing not only the Logo language, but things to do with the language and ways of thinking and talking about these activities. How people talk about what they are doing, the way they interact with one another, and the way they interact with the computer give rise to a new kind of culture, a computer culture.

Seymour Papert has been the guiding influence in the development of this kind of computer culture. (See Mindstorms: Children, Computers, & Powerful Ideas [New York: Basic Books, 1980] for a fuller discussion of Logo and computer cultures.) Papert created the Logo language for children. Although it had to be simple to learn, it needed a rich and easily expandable vocabulary. It had to reflect some of the important ideas in computer science, such as proceduralization, local and global variables, naming, self-referential programming, etc. These are attributes that a language such as BASIC does not possess. BASIC has a reputation for being easy to learn; it has a small vocabulary of key words. But this initial set of key words is not easily expandable; the programmer cannot create new key words. This sets BASIC apart and makes it easy to learn but hard to use. The programmer cannot build procedures, name them, and then use them to build other procedures. The powerful problem-solving strategy of breaking problems into smaller and smaller parts can only be a paper-and-pencil strategy in a BASIC programming environment. The structure of BASIC does not support this important problem-solving strategy.

Once Logo was developed for children, Papert and his collaborators looked to the computer to provide an environment in which a person could learn by doing and thinking about what they did. A person would actively explore the capabilities of both Logo and the computer by constructing objects and debugging them. The computer would serve as a source or tool for creating interesting mathematical objects that would draw upon a person's intuitive knowledge and that could be used in constructing other objects. One of these objects is the computer-controllable geometric entity, now widely known as a turtle. Exploring the turtle's behavior leads people to draw upon their intuitive geometric knowledge. This knowledge does have a formal aspect as expressed in the area of mathematics known as computational geometry. (See Turtle Geometry: The Computer as a Medium for Exploring Mathematics by Harold Abelson and Andrea diSessa [Cambridge, MA: MIT Press, 1981] for an excellent presentation of...
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the formal aspects of turtle geometry.) In this kind of a computer culture, people draw upon knowledge acquired in other activities; and they apply what they learn in the Logo culture to many different areas.

My personal contributions toward this goal focus on what is required to encourage the development of computer cultures in the Logo spirit. One of the questions I have considered is: What does a teacher of Logo have to know? There is no one answer to this question. I have seen children teach other children about Logo. Although their knowledge is quite different from the adults who taught them, the children were very successful at sharing with each other a way of thinking and talking about computers. Perhaps I should pose a different question and ask: What are some of the things I think about as I teach people to program?

I see much of my own development as a teacher as acquiring (1) a collection of programming projects that make the power of programming techniques and concepts apparent to beginners; (2) a vocabulary for talking about programming; (3) an awareness of different learning styles and strategies for building on them; and (4) a sensitivity to the kinds of resistances that keep many adults and children from experimenting with mathematical ideas.

A Model for Introducing People to Computers

When I enter a new teaching situation, I have in mind several models of how to introduce people to Logo. I also maintain a willingness to switch from one model to another or even diverge from all of them. My primary goal is for people to do something they could not have done without a computer, but something that is familiar to them (e.g., draw a square or print their name all over the screen). I also want to think toward a next step and how the beginning programmer can build on what happened in the first session in the following one. Flexibility is one of the most powerful ideas in this culture, but to be flexible implies having a model to
Mr. Holmes, Dr. Watson, I’m really glad you made it,” said the office manager who had enlisted the services of my friend. “Last night, a big chunk of data disappeared from our computer system. My boss wants to know who was responsible…and fast!”

Holmes began to investigate.

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“But how, dear man,” I interjected, “did you deduce that a power glitch was to blame for last night’s loss of data?”

“Elementary, my dear Watson,” he said, puffing contentedly on his pipe. “Elementary.”

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Example of a First Session

Usually, a beginner starts by communicating with a turtle. The student specifies an algorithm in Logo that causes the turtle to draw a geometric design (e.g., a square). This is done relying on intuitive mathematics instead of formula-driven mathematics. That is, the description to the computer is based on how the student would trace out the path of a square if the student had the same limited understanding as the turtle does (e.g., knowing how to move FORWARD or BACK, and turn LEFT or RIGHT). The sequence in figure 1 illustrates the effect of such commands on the turtle. These commands can be named and turned into a procedure that then becomes a part of Logo’s working vocabulary:

```
TO SQUARE
  FORWARD 50
  RIGHT 90
  FORWARD 50
  RIGHT 90
  FORWARD 50
  RIGHT 90
END
```

The TO informs Logo that a procedure is being created. SQUARE is the name of the procedure. END marks the end of the text of the procedure. Now the programmer might use the SQUARE procedure to produce a new design like the one in figure 2, created by PANES, which follows:

```
TO PANES
  SQUARE
  SQUARE
  SQUARE
  SQUARE
END
```
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The beginner gets an immediate sense of the relationship between program and goal and rapidly elaborates this into an understanding of the relationships among goals and subgoals, procedures and subprocedures (e.g., the programmer learns that PANS is made by running the SQUARE procedure four times). The beginner is involved in debugging, in learning by doing and thinking about the process. (For example, the programer may create a square that doesn't close. Listing the procedure, the student catches a bug in the input to FORWARD when drawing the last side of SQUARE; it should be FORWARD 63, not 36.) The programmer may use anthropomorphism or identification as a debugging aid (e.g., pretending to be the turtle causes a person to walk in the same path as the turtle would, and it also helps to understand the turtle's behavior). Thus, in a first session, a programmer writes a procedure that then becomes part of Logo's working vocabulary. In doing this, the programmer achieves a sense of the power available to influence the environment and a sense of accomplishment and creativity.

A Model of Learning Styles
I have observed that children take over the computer in different ways. They show different learning styles, different paths into the computer work. Undoubtedly, this bare statement is true for all learning. What is special here is that the flexibility of the computer allows the process to go further and become more explicit. In working with computers, many paths lead to the same goal. Moreover, many equally great goals can be pursued.

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Janet, a 6-year-old, had previously made a square. In constructing CB (see figure 3), she used similar techniques. She made the turtle draw BALLOON and then turn RIGHT 90 repeatedly until it had walked in a complete path and returned to the position and heading it started from.

Janet was not aware of this as a generalization, but her specific experiences led her to believe that these two actions repeated over and over resulted in the turtle making a complete trip, i.e., return to its starting state.

Next, FLOWER (see figure 4) was made by running CB, turning the turtle 51 degrees, and repeating these two actions six more times. Why 51 degrees? Well, Janet just happened to pick that number. Why did 51 have that effect on CB? The answer lies in the fact that turning the turtle 51 degrees seven times results in a total turning of 357 degrees, which is very close to a complete rotation of 360 degrees. In this situation, Janet was satisfied; for her purposes, the design was complete.

A more interesting question is: How did she know to probe the turtle environment in this way? She knew certain facts about turtles and turtle-directed procedures that she had gained from her experiences with the turtle. For example, if the turtle draws something and doesn’t return to its starting state, repeat the procedure. Something interesting will happen and eventually the turtle will come back to where it was initially. On the other hand, if the turtle does return to its starting state when it makes a design, change the turtle’s heading and run the program again.

Using Procedures
Janet’s learning style in this project rather than starting out with a specific goal. In this case, the learner is intent on exploring the effect of the particular building block. Therefore, the result is open-ended.

Finally, some learners have to explore their environment on a micro-level before they can establish patterns of planning or directed exploration. These micro-explorers are often the most timid learners, doing such things as assuring themselves that FORWARD 100 is the same as FORWARD 1, FORWARD 9, FORWARD 11, FORWARD 23, and FORWARD 56. Others might exhibit this conservative, gradual exploration by using the same numbers as inputs to FORWARD and RIGHT, or by repeating the same commands over and over.

Any child might use all three of these learning styles. In an initial session, I might try to “plant seeds” for all three. For example, I would encourage a beginning student to drive the turtle around the screen in a series of direct commands with no goal other than to understand the turtle’s behavior. But in the same initial session, I would suggest some concrete goal, such as making the turtle walk in a square or, perhaps, having placed some squares on the screen, I would ask the child to make the turtle touch them. In this, I elicit primarily a micro-explorer style with some hint at a planner style.

I facilitate a macro-explorer style by seizing on something interesting the child has just done and suggesting “teaching” it to the computer. Thus, I encourage the child to form procedures, thereby turning the turtle meanderings into repeatable procedures or building blocks. Using these procedures, the child can create more unanticipated designs.

I would encourage children to follow a planner style of learning by asking them to choose a design from a collection of procedures already familiar to them or by asking them to make a design of their own and use these as procedures. Being sensitive to these styles of learning and their natural intermixing helps to develop strategies for guiding the children. These styles of learning are exhibited by novices to programming in Logo regardless of their age.

Using Procedures
Janet, a 6-year-old, had previously made a square. In constructing CB (see figure 3), she used similar techniques. She made the turtle draw BALLOON and then turn RIGHT 90 repeatedly until it had walked in a complete path and returned to the position and heading it started from.

Janet was not aware of this as a generalization, but her specific experiences led her to believe that these two actions repeated over and over resulted in the turtle making a complete trip, i.e., return to its starting state.

Next, FLOWER (see figure 4) was made by running CB, turning the turtle 51 degrees, and repeating these two actions six more times. Why 51 degrees? Well, Janet just happened to pick that number. Why did 51 have that effect on CB? The answer lies in the fact that turning the turtle 51 degrees seven times results in a total turning of 357 degrees, which is very close to a complete rotation of 360 degrees. In this situation, Janet was satisfied; for her purposes, the design was complete.

A more interesting question is: How did she know to probe the turtle environment in this way? She knew certain facts about turtles and turtle-directed procedures that she had gained from her experiences with the turtle. For example, if the turtle draws something and doesn’t return to its starting state, repeat the procedure. Something interesting will happen and eventually the turtle will come back to where it was initially. On the other hand, if the turtle does return to its starting state when it makes a design, change the turtle’s heading and run the program again.

In other words, Janet did not need the teacher’s knowledge about the power of 360 degrees. Rather, she needed the idea of the total turtle trip that, translated into intuitive knowledge, told her to keep repeating an action until the turtle returned to its starting state. Janet’s learning style in this project
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and many others was that of a macro-explorer.

The BEAR project was initiated by Lisa, an 11-year-old from an inner-city school close to MIT. Lisa approached the project as a micro-explorer. Although she had previously written several procedures, Lisa showed great resistance to using them as building blocks. For example, after constructing a square procedure, she tried to reconstruct a square, as other micro-explorers might, by telling the turtle to move in incremental steps, e.g., \texttt{FORWARD 11, FORWARD 9, etc.}

I asked her to play with circles using \texttt{CIRCLER} or \texttt{CIRCLEL} procedures, which require the radius as input. I encouraged her to try using circles of different sizes. She made the circles shown at the top of figure 5. I then encouraged her to do the same thing on the other side of the larger circle, as shown at the bottom of figure 5. When asked what it reminded her of, she thought it looked like a bear’s head. She then added the eyes and used the head for the body (see figure 6). In so doing, I helped her shift modes from micro-explorer to planner.

This project illustrates clearly that many ways can be used to arrive at a particular goal. Picking a starting state for the turtle influences the construction of the procedure. Whether the job is thought of in terms of sub-procedures or whether the design is first created by the student (whether by the mind’s eye or on paper) and the turtle is made to trace the path etched on paper has important consequences in how the project is developed.

If the design is to be taught to the turtle by breaking it up into parts, the programmer has to decide what building blocks are needed. This BEAR has several interesting features. It is made entirely of circles. The head and the body are identical. The project is easily changed to focus only on the head or to create, with minor modifications, a different animal (see figure 7).

Both Lisa and I benefited from this project. She became a more confident problem-solver and tended to move away from her micro-explorer style of probing. She used a powerful mathematical idea, symmetry, in a playful but personally meaningful way, and used it throughout her project. I, on the other hand, added to my collection of programming projects. We both followed our intuition.
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Figure 7: Other animals created by modifying the BEAR procedure.

Figure 8: Other designs created by Lisa using Logo.

hopeful that when Lisa used circles as building blocks she would discover some lovely thing to make with them, and she did.

A Model of Teaching and Learning as Debugging

Turtle geometry is but one part of the Logo computer culture. Other areas of activity have been explored and many more are waiting to be explored. Turtle geometry, however, serves to illustrate key characteristics of the culture, in particular, the idea of exploring an environment and the objects in it by manipulating them through a complex of interactions based on procedural descriptions. By elaborating the descriptions through debugging (testing procedures in real situations), getting concrete feedback on these actions, and adjusting the initial descriptions to take into account these results, a person's exploration in Logo will be furthered. The process of procedural description and debugging might be seen as a dynamic process of assimilation and accommodation, of making theories and revising them as a result of experience and knowledge, but doing this playfully as an enjoyable activity involving one's whole self.

Conclusions

Sharing in this learning process is a self-empowering experience for all participants. A different way of looking at learning and teaching emerges, one based on the Piagetian idea that even very young children have theories. Thus, teaching and learning are not a matter of being wrong or right, but rather a process of debugging. Learning and teaching are intertwined and become a process of developing debugging aids as knowledge gaps are discovered and filled in. The persons using computers are cast in the role of both student and teacher as they actively participate in development of the computer culture. They contribute to its richness and enrich their own lives. 

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<thead>
<tr>
<th>MODEL</th>
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<th>MODEL</th>
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### TRIPLE OUTPUT MODELS

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### SINGLE OUTPUT MODELS

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### DISK DRIVE MODELS

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</table>
For easy access, the terms in this glossary are arranged alphabetically, but this arrangement hides the complex interrelationships of the ideas in the definitions. The groupings on this page were developed to make obvious the relationships between important Logo concepts. You can use it as a map to guide you through the glossary.

The groupings do not represent a true tree structure because some of the terms appear under several different headings. The main concepts are organized into broad categories, with more detailed information listed in outline form under each main heading.
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This glossary is more cultural than technical partly because the learning philosophy behind Logo is more of a culture than a technique. The Logo technical vocabulary consists, for the most part, of familiar words adopted from general usage to refer to specific Logo metaphors, images, and ideas. Many of the terms and definitions presented here are derived from three books: Seymour Papert's Mindstorms: Children, Computers, & Powerful Ideas (New York: Basic Books, 1980); Harold Abelson and Andrea diSessa's Turtle Geometry: The Computer as a Medium for Exploring Mathematics (Cambridge, MA: MIT Press, 1981); and my own Special Technology for Special Children (Baltimore: University Park Press, 1979). Reference is also made to Brian Harvey's article "Why Logo?" on page 163 in this issue of BYTE.

anthropomorphic images: metaphors in which computers, computer procedures, and objects controlled by computers are thought of as if they were persons. "Anthropomorphic images facilitate the transfer of knowledge from familiar settings to new contexts. For example, the metaphor for what is usually called programming computers is teaching the turtle a new word." (See Papert, page 59.) Thinking of the machines as (limited) people—and even modeling people's behavior through analogies to machine processes—does not involve treating people like machines. (On this latter point, see the entry on computer-aided instruction.)

artificial intelligence (AI): the branch of computer science from which Logo grew. The name of this science derives from its attempts to simulate, using machines, the behavior that is regarded as intelligent in people or animals. If this narrow view of the field was ever true, it no longer is. Cognitive psychology and artificial intelligence together are sometimes referred to as cognitive science. They study such disparate processes as natural-language understanding, visual perception, and knowledge acquisition. Good studies of human information processing frequently require both a careful study of how people perform tasks and serious attempts to build models based on a theory and observations to test the theory. The complexity of these models requires computer simulation.

command: a Logo procedure that performs in some particular way, but does not return a value to its calling procedure. It's analogous to a procedure in Pascal. See also operation.

computer-aided instruction (CAI): in the broadest sense, any educational endeavor that is aided by computers. In general, however, CAI means automated worksheets (drill and practice) or electronic tutors (frame-oriented CAI or automated programmed texts). This is very different from the Logo philosophy of using the computer not as the supplier or exerciser/tester of knowledge, but rather as a context within which to use thinking to solve problems of genuine interest.

Programming learning explicitly models the human as a machine in that the student is being programmed by the computer. Logo learning sees the learner as the agent—actively constructing knowledge. The student takes the teacher's role—teaching the turtle a new word.

computer literacy: often seen as a general (and superficial) experience with computers. This concept is tied to a transitional stage in the spreading of computer technology. When computers were rarer and more specialized, computer literacy was not an issue (just as no one now worries about electron-microscope literacy). When computers become as common as cars, computer literacy will cease to be an issue.

Literacy has two conventional meanings. The first—being well-read and articulate in one's language—suggests fluency in a particular computer language. Programming is having the ability to express a novel idea in that language. Letting children be programmers, helping them to become fluent at expressing mathematical and logical ideas, is the Logo sense of a thoughtful literacy. (This idea, however, doesn't fit in with the image that the word 'literacy' is generally used to convey, a skill that every child must learn in order to be able to cope. It's more like learning a foreign language: a valuable skill for those who choose to learn it, but not an absolute requirement for life or for employability.)

The other conventional meaning of literacy—having minimal reading skills—makes little sense in a society replete with computers. With many computer languages to choose from, what could be considered minimal communication skills? Teaching general familiarity with computers without providing an opportunity to develop good communication skill is a little like having a course teaching people the names of the features of a car without allowing them to learn to drive.

controlling the computer: the issue is one of locus of control. Whereas computers have conventionally been used in education to program the kids—in effect, to control their behavior—the Logo philosophy stresses kids programming computers. It is often said that teaching is the best way to learn. The computer is a highly responsive student and rigidly faithful to its teacher. For students who have had little sense of control in school, this, even apart from the content of the subject they are studying,
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is a valuable experience. (The importance of being in control is particularly apparent in the Logo work of students with special needs. For more, see Special Technology for Special Children.

dynamiturtle: a dynamic (rather than static) turtle. Whereas a static turtle has a fixed spatial position and heading, a dynaturtle may have a fixed velocity or acceleration. Whereas commands (state-change operators) to a static turtle specify a change in position (e.g., FORWARD 100) or heading (e.g., LEFT 90), a command to a velocity turtle specifies a change in velocity and has an analogy to force. Dynamic turtles can be a flexible laboratory tool for experimentation in physics and mathematics and, like their static cousins, for aesthetics as well.

FORWARD: Logo command to the turtle telling it to move forward in the direction it is heading. This state-change operator takes a single input that says how far (in turtle-steps) forward to move. For example, FORWARD 100 says move forward 100 units; FORWARD :SIDE + 10 says move forward the distance 10 + :SIDE (whatever value the variable :SIDE happens to have at the moment). The only other turtle-geometric state-change operator dealing with the turtle's position is called BACK. Neither of these change the turtle's heading. See also LEFT.

global: something pertaining to the entire environment being considered. Among variables, global variables are those that can be accessed and changed from any place in a program. Logo encourages the use of local variables—variables that belong to a particular procedure—because they make for more orderly and more debuggable programs.

Another kind of global reference is the Cartesian coordinate system. It is global in that each point is specified in relation to a standard referent (the origin). Points are not specified in relation to each other. For a discussion of the difficulties caused by such a global perspective for graphics representation, see the section of Brian Harvey's article "Why Logo?" on page 178 in this issue of BYTE. Logo's orientation is, in general, toward local references. See local.

input and output: within the Logo culture, we pay more attention to the inputs and outputs of procedures than to traditional issues of hardware. The input to a procedure is thought of as a message that the procedure needs in order to do its job. As an example, FORWARD needs an input telling it how far to move the turtle; PRINT needs to know what to print. Some procedures need more than one input message in order to know what to do. A procedure to draw arbitrary polygons, for example, needs two inputs, one telling it the size of its forward step, and the other telling it the angle to turn at each corner.

The output of a procedure is a message sent back to the procedure that called it. For example, SUM outputs a message that is the sum of its two inputs. A procedure that produces output (see operation) must send its message to a procedure expecting an input. (In this way, output and input are closely linked in Logo.) Hardware aspects of I/O are handled conveniently for the programmer so she can concentrate on the behavior of the conceptual building blocks (procedures) she is creating without wasting attention on the machine.

interest worlds: areas of special interest in which the computer can be a useful tool, servant, or laboratory. Art, music, geometry, physics, and language have all been extensively developed as interest worlds by various Logo investigators. See also micro-worlds.

iteration: telling the computer to execute something repeatedly. See recursion, which Logo favors as a control structure.

learning: the focus of the Logo environment. What one does for oneself. See teaching.

LEFT: Logo command to the turtle telling it to turn left while remaining in the same location. This state-change operator takes a single input that says how many degrees to turn. For example, LEFT :ANG says turn left :ANG degrees (whatever value the variable :ANG happens to have at the moment). The only other turtle-geometric state-change operator dealing with the turtle's heading is RIGHT. See also FORWARD.

LISP: acronym for LISt Processing. A programming language widely used in artificial-intelligence research, the basis for many of the ideas in Logo.

list: Logo's fundamental data structure. A list is an ordered sequence of arbitrary Logo objects (see object). Since its elements may be either words or other lists (which may themselves contain yet other lists, nested to any level), lists can be used to create very complex data structures. They can represent information trees (decision trees, binary trees, etc.) and unordered sets. Lists are sometimes used in Logo to accomplish the same purposes for which arrays might be used in other languages. (Logo also has other ways of providing access to information that is indexed numerically or with alpha-
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Most variables used in Logo are local. The simplest elements of lists are words.

**local**: something that has meaning only in the specific context in which it is being used. A local variable is one whose name has a value only within the procedure in which it is defined. Most variables used in Logo are local. The turtle’s perspective on its turtle-moves is also a strictly local one. It does not know where it is (with respect, say, to a globally defined origin). In the grand scheme of things, it doesn’t need to know where it is. It only needs to know how to move with respect to itself. “The turtle can forget about the rest of the plane when drawing a circle and deal only with the small part of the plane that surrounds its current position.

“By contrast, \( x^2 + y^2 = r^2 \) relies on a large-scale, global coordinate system to define its properties. And defining a circle to be the set of points equidistant from some fixed point is just as global. … The turtle representation does not need to make reference to that ‘faraway’ special point, the center.” (See Abelson and diSessa, page 14.) This local view of movement in space is not only easier to use for simple mathematical ideas, but lends itself quite beautifully to extensions into very fancy math; calculus and limits immediately come to mind. See **global**.

**Logo**: not an acronym. Derived from the Greek word for “word” or “thought.” The name was coined by Wallace Feurzeig at Bolt Beranek and Newman Inc., one of the collaborators in the development of the language.

**metaphor**: Logo learning makes considerable use of metaphor and pays particular attention to which metaphors are chosen. Is a computer a tutor, a student, a pair of eyeglasses, or a screwdriver? Is a variable name the name by which we refer to a particular value, or the name of a box in which we find whatever we find? Are procedures little folks with specific jobs to do? Are robot turtles literate but literal-minded pets? It is not that Logo learners have particular metaphors that are different from those of others—some people find the little-people model of procedures useful, while others find it irritating—but that the use of metaphor is such a natural part of Logo learning.

**microworlds**: as used by Logophiles, a microworld is a well-defined, but limited, learning environment in which interesting things happen and in which there are important ideas to be learned. A microworld can have other microworlds within it. For example, within the microworld of turtle graphics, one can define a smaller microworld consisting of all the designs that can be drawn with a POLYSPI procedure. (See R. W. Lawler’s “Designing Computer-Based Microworlds” on page 138 in this issue.)

The concept of microworlds is borrowed from artificial-intelligence research. It’s very difficult to simulate intelligent behavior in general, but by restricting our attention to a very small area we can begin to find elements that can be modeled. Thus, the concept of microworlds is a useful source of interesting programming projects.

The most famous AI microworld is the blocks world, in which the computer controls a robot arm that can manipulate small blocks. You can tell the computer things like “Put the red block on top of the small green block,” or ask questions like “Are any green blocks under a red block?” This is a microworld of the English language (among other things) in that it must understand the vocabulary, syntax, and semantics of sentences pertaining to the moving of blocks. It is also a microworld of structural stability, in that it must understand what physical maneuvers are possible with stackable blocks. One cannot, for example, realistically pick up the bottom block in a stack of eight without dropping others. Similarly, one can place a pyramidal block on a
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cube, but not a cube on a pointy block.

object: the naturalness with which Logo passes data messages back and forth among procedures (see input and output), and the ubiquity of anthropomorphic images for those procedures, makes the metaphor of object manipulation very appealing for what tends to be called data processing elsewhere. Logo has two kinds of data objects, words and lists. (Some implementations also provide arrays.) Though procedures are generally known as the active elements in a workspace, they can also be manipulated (created, edited, destroyed, or passed back and forth) by other procedures. Therefore, Logo’s procedures are also frequently referred to as objects, especially when one is referring to the contents of the workspace. Finally, “object” retains all of its conventional meanings in addition to the technical sense mentioned already. Thus, we speak of procedures as manipulating objects, whether the objects are words printed on the screen or turtles doing a dance on the floor.

operation: A Logo procedure that computes a value and returns that value to the calling procedure. (It is analogous to what Pascal calls a function.) The value can be any Logo object—a number, word, or list. See also command.

Piaget: Jean Piaget, one of the great thinkers of our time, realized that children and recognized that every learner (in particular, each infant and child) knows an active role in his or her own development. For each wrong answer a child came up with (e.g., the 4-year-old stating confidently that trees make the wind blow), he asked the question: Why that particular wrong answer? What is the logic in the child's thinking that leads to that kind of explanation?

In this sense, he saw these wrong answers not as random movements in the absence of the right answer, but as the result of bugs in a program that does give mostly the right answer. The frequent focus of attention on Piaget’s stages is a bit of a red herring. Although he has described these stages discretely, it is their contents—the form that thinking takes at various developmental levels, the logic of it—and not the stages themselves, or the age at which they appear, that are the real importance of Piaget’s theory.

Evidence of the influence of Piagetian thinking (if not each of Piaget’s specific notions about thinking) pervades the Logo culture. Our interest in debugging, the metaphor of objects, and the assimilation of computer technical ideas into familiar contexts (e.g., anthropomorphization or playing turtle) all reflect that influence.

playing turtle: pretending to be the turtle and walking through a turtle-graphics procedure as the turtle might see it. This process can make fairly difficult geometric constructions transparent to young children with little or no formal training in geometry. Playing turtle, though, refers as much to the thinking through of a procedure before programming it as to walking through an existing procedure.

By way of example, some 10-year-olds were trying to figure out how to teach the turtle to make a circle. I suggested they play turtle. They concluded that if all they could tell the turtle was to go forward and to turn, it would have to go just a little bit forward, turn a little, go a little bit forward again, turn a little again, and so on. After one kid had made it around the circle (one of the instructions was “keep doing that until you get back to the beginning”), they were convinced they had the right idea. To help them with the details, I reminded them of the Total Turtle Trip Theorem and again encouraged them to play turtle. They began to reason out the details of how much to turn, how many times to repeat the process, and how big they wanted to make each step.

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problem solving: a skill that is at the core of Logo's "curriculum." Most traditional math instruction is about already-solved problems; the student memorizes someone else's techniques. Only recently have people understood that real mathematicians do something very different; they don't just study old problems, they solve new ones. Professor George Polya at Stanford University has been a pioneer in studying the techniques that good mathematicians bring to bear on new problems. Many ideas that are part of the Logo programming style parallel Polya's mathematical ideas. Most important, the use of procedures as building blocks for more complex procedures (as opposed to writing one huge program without a layered structure) parallels Polya's strategy of dividing a large problem into smaller pieces.

procedures: the conceptual building blocks of Logo programs. Logo users start with a vocabulary of primitive (built-in) procedures, and use them to teach Logo new vocabulary that can then be used in all the ways that primitives are used.

program: the Logo use of "program" is much more like the television use of it than of the usual computer use. A program is the whole show and may consist of a host of songs and dances, skits, acts, and routines. (But the word "routine" is not routinely used by Logophiles to mean a part of a computer program.) A person writes procedures. The top-level procedure runs a program that may be quite simple or may involve the use of several subprocedures. If it makes use of subprocedures, this top-level procedure may be referred to as a superprocedure.

programming: consider the following metaphors for programming: teaching turtle a new word; communicating with the turtle; translating from English to French or Logo; or being fluent enough in a language to express oneself easily.

prosthetic: one metaphor for the computer. As an artificial arm may help an amputee manipulate objects, so may an artificial piano player help one manipulate music. Because it is a versatile tool it can provide access to a large variety of inaccessible spaces and activities. The computer's use in musical composition and performance, graphics production (e.g., the special effects in a slew of recent television advertisements and in movies like Star Wars), and other areas are all extensions of human abilities—but extensions without which we are severely disabled in areas we now take for granted. It is merely a sociological and technological artifact that we regard as handicapped people who lack certain other abilities we take for granted. (For more on computers as aids to communication and autonomy for special education or rehabilitation, see Special Technology for Special Children.)

QWERTY phenomenon: Papert uses this term to refer to traditions that dig
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themselves in after their original purpose, presumably a good one, has become obsolete. The name derives from the six top left-hand letters on a standard typewriter keyboard. This arrangement of keys was chosen to slow down a typist so that the early manual typewriters would not readily jam. Attempts to convert to a more optimal arrangement of keys have routinely failed as people were used to doing things the old way. So, too, much of the curriculum survives primarily because it is familiar and not because it makes much current sense.

recursion: a recursive definition defines a procedure or function in terms of itself. For example, a recursive definition of "factorial" states that 0! = 1 and that n! = n*(n-1)! (See recursion.) A Logo program based on this definition might look like this:

```
TO FACTORIAL :N
IF :N = 0 OUTPUT 1
OUTPUT :N * FACTORIAL (:N - 1)
```

A nonrecursive definition might say something like:

\[ n! = n \times (n-1) \times (n-2) \times \ldots \times 3 \times 2 \times 1. \]

(Compare the structures by writing the latter in BASIC.) Both definitions and programs work, of course, but which definition one chooses affects how one programs. In the case of "factorial," both definitions are easy to implement, but sometimes recursion is the only way. For more on recursion, see the section of Brian Harvey's article on page 166 in this issue of BYTE.

sentence: in Logo, a sentence is a list of words. Logo provides tools to manipulate the words of a sentence. In most programming languages, one uses character strings instead of sentences; an English sentence becomes simply a bunch of symbols, some of which are letters and some of which are spaces. But those computer languages don't help the programmer divide this uniform character string into words. Logo's approach is an example of the microworld influence in programming.

sprite: animation of graphics has long been a high priority in Logo implementations, but only recently have small computers gained the power to handle animations well (except, of course, for animations written efficiently in assembly language). Sprites may be thought of as screen objects with a defined appearance (color, shape, size, etc.) and a velocity. Both of these can be changed according to the wishes of the programmer. They "live" on different layers of the screen, as if they are on plastic overlays. Thus, a sprite defined as a picture of an elephant may roam through a forest of trees, passing behind some and in front of others. The Logo programmer does not have to attend to the hiding of lines when one sprite is partially occluded by another—that is handled automatically. In this way, complex animations involving three-dimensional interactions of several screen objects can be as simple as drawing the objects and instructing each on how it should move.

state: the relevant properties of something. For example, the state of the turtle includes its position and the direction in which it's pointing, but doesn't include any of its past history (such as the distance it has traveled). The criterion of relevance here is that the turtle's future behavior, in response to some Logo program, depends on its current state and not on its past. (Of course, the turtle's state does reflect where it has been, but tells only part of the history and not all of it.) The isolation of only the important aspects of a situation is a valuable debugging tool.

subprocedures: Logo encourages students to deal with large problems by dividing them into subprocedures. In a "long, featureless set of instructions it is hard to see and trap a bug. By working with small parts, however, bugs can be confined and more easily trapped, figured out." (See Papert,
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The simplest form in which Logo stores data, a word is an unbroken string of characters (typically alphanumericics, but capable of being constructed to contain any characters including spaces or control characters, when that is desired). Words can be concatenated into larger words, dissected into parts, and used as elements of lists. Numbers, single characters, and character strings are all treated as words by Logo.

Total Turtle Trip Theorem: when a turtle wanders over a path and ends up heading in the same direction as when it started, its total turning is an integer multiple of 360 degrees. Some special cases follow. If it wanders over a simple closed curve (a closed path that does not cross itself, like a polygon, a circle, or the outline of a pond), it turns through exactly 360 degrees. To figure out how much to turn at each point of a five-pointed star, play turtle (remember to end up heading the same way you started). How many full rotations do you make while walking over the star shape? (Two.) Therefore, you have turned 2*360 degrees in all. How much at each corner? (A fifth of that.) Repeating [FORWARD 100 LEFT 200] enough times makes another kind of star. How many points does it have? What about the star made by turning 80 degrees at each corner? See also turtle geometry.

turtle: (1) a computer-controlled robot that has position and heading, each of which can be changed independently of the other. It is significant that these two components of the turtle's state are independent. Cars and trucks (and their remote-control toy versions) do not have independent control of heading and motion. Their inability to make sharp corners (no matter how good the turning radius) limits their usefulness in artistic and mathematical realms. Also, because the interaction complicates thinking about their behavior, it is difficult to write programs to control them in any realms; (2) a graphic representation (typically, a pointy isosceles triangle) of such a physical robot; (3) a creature that lots of people love even though the beast rarely does anything in anyone's presence.

turtle graphics: the graphics you know and love—the graphics command system that has crept into several other computer languages (I've seen it in some Pascal implementations and even a version of BASIC) originated with Logo. See FORWARD, Logo, and turtle.

workspace: a Logo workspace may be thought of quite concretely as if it were a kitchen, basement, or artist-studio workspace: a place where one can set out one's materials and begin to work. The Logo workspace contains all the procedures and data objects the programmer is currently using, which can be saved in whole or in part on files for use at a later date. Retrieving the contents of a file places its contents into the workspace, as does defining a new procedure or data object. Pictures or text that are on the screen are not part of the computer's internal workspace any more than pictures drawn by a robot turtle on the floor are part of that workspace. (Nevertheless, many implementations of Logo make it possible to save screen graphics on a file and retrieve that file to the screen.)
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Logo for the Apple II, the TI-99/4A, and the TRS-80 Color Computer

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Gregg Williams
Senior Editor

Of all the languages we have covered in our annual August language issues, Logo is the only one you could probably find in computer stores along with the corresponding issue of BYTE. Versions of APL, Pascal, LISP, and FORTH have become available in the time since those language issues were published (we’re still waiting for Smalltalk), but Logo is available now. Better still, the versions of Logo available now are probably better implementations than were their counterparts when they came out.

In this article I will compare four versions of Logo: TI Logo for the Texas Instruments TI-99/4 and TI-99/4A and Apple Logo, Krell Logo, and Terrapin Logo, all for the Apple II and Apple II Plus computers. A fifth version of Logo, Color Logo from Radio Shack for the TRS-80 Color Computer, was released just as I finished writing this article. It is reviewed separately in the text box on page 247. For the sake of convenience throughout this article, TI-99/4A will also refer to the TI-99/4, and Apple II will refer to both that and the Apple II Plus. And because Terrapin and Krell Logos are basically the same implementation, I will usually refer to them both at the same time as Terrapin/Krell. I will review the products in alphabetical order.

### At a Glance

**Name**
Apple Logo

**Type**
Programming language

**Distributor**
Apple Computer Inc. 20525 Mariani Ave. Cupertino, CA 95014 (408) 996-1010

**Manufacturer**
Logo Computer Systems Inc. 222 Brunswick Blvd. Pointe Claire, Quebec Canada H9R 1A6 (514) 694-2885

**Price**
$175

**Authors**
Jim Davis, Gary Drescher, Ed Hardebeck, Stephen Hare, Tom Polucci, Brian Silverman, and other members of the LCSJ staff

**Format**
5¼-inch floppy disk

**Language Used**
6502 machine language

**Computer Needed**
Apple II or Apple II Plus with a 16K-byte memory card

**Software Included**
Two Logo disks (copy protected)

**Documentation**

**Audience**
Anyone interested in Logo

### Common Features

I won’t presume to write any kind of tutorial on elementary Logo programming (for that, see the other Logo articles in this issue), but I thought I’d start this review by looking at some of the features common to Apple, Terrapin/Krell, and TI Logo.

The cornerstone of Logo is the concept of the turtle. The turtle is a triangular object on the video display that can be given simple commands (like FORWARD 50, PENUP, RIGHT 90). Since it carries a “pen” that can draw lines when in PENDOWN mode, commands given to the turtle result in line drawings on the video display.
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Apple Logo and the P6A Problem

In an unusual combination of circumstances, Apple Logo may not work on your Apple. Here's why, and here's what you can do about it.

When the Apple Language System with Apple Pascal was first introduced, everyone had to replace the P5 and P6 ROMs (read-only memory chips) on their Apple disk-controller cards with the new P5A and P6A ROMs (this is what allows the Apple disk to store information in the denser 16-sector format). There was actually a bug in the P6A ROM so small that no software ran incorrectly because of it. Apple started supplying the corrected P6A and didn't worry about the few people who had the older P6A ROM. This was a reasonable thing to do since the change didn't make any difference, right?

(Terrapin Inc. also sells an actual robot turtle that can be controlled from the Apple II and Terrapin Logo—it's a two-wheeled object about half the size of a basketball, and it can draw on large sheets of paper placed under it.)

Wrong. Some two years later, the company that did the copy-protection scheme for Apple Logo found that the protected Logo disk wouldn't boot on some Apples. It eventually discovered that the bug in the older P6A ROM was the culprit.

When Apple Computer Inc. was told, it decided to solve the problem by instructing all its authorized dealers to give, free of charge, a P6A ROM to anyone who can prove he has an Apple disk drive. (The easiest way to prove that is to take the disk-controller card in to the dealer.) Dealers will be reimbursed by Apple, so they should be glad to give you the P6A ROM even if you didn't buy your computer there. If you have any trouble doing this, contact Apple Computer Inc. at (408) 996-1010.

(Terrapin/Krell and Apple Logo use the Apple high-resolution graphics screen to display the turtle and its drawings. Both can draw in the six Apple II colors (black, white, green, violet, orange, and blue) and in a "color" called "reverse," which reverses the part of the high-resolution screen it passes over according to a fixed set of rules known to most Apple users. The Apple Logo turtle can also be given an erasing pen that draws in the color of the video-display background. Because the Apple II maintains separate text and graphics screens, you can switch between the two at any time with control keys that display text only, split text and graphics, and graphics only (the keys used are different for the two Apple Logos, but they perform the same function). An example of a program that uses turtle graphics is given in listing 1; the drawing it produces is shown in photo 1.

The TI turtle is, in contrast, rather limited in that its implementation restricts the amount of drawing it can do before it "runs out of ink." The TI-99/4A does not have a graphics mode...
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TO MOVEBUG :N

; [THIS MOVES BUG IN TOWARD THE NEXT BUG CLOCKWISE]
; [FROM BUG N, IT ALSO DRAWS A LINE FROM]
; [THE BUG'S STARTING CORNER TO ITS CURRENT]
; [POSITION TO ADD COLOR TO THE DRAWING]
; []
; [PUT TURTLE TO CURRENT BUG POSITION]
PENUP
SETPOS (GPROP :BUG.N "XVAL") (GPROP :BUG.N "YVAL")
PENDOWN
; []
; [POINT TURTLE TOWARD NEXT BUG'S PRESENT POSITION]
MAKE "M (:N + 1)
IF :M > 4 [MAKE "M 1]
MAKE "BUG.M (WORD "BUG :M)
SETHEADING TOWARDS (GPROP :BUG.M "XVAU") (GPROP :BUG.M "YVAU")
; []
; [MOVE TURTLE AND RECORD NEW POSITION AS] [BELONGING TO BUG N]
FORWARD : LEN; [LEN IS A GLOBAL VARIABLE]
PPROP :BUG.N "XVAL" XCOR
PPROP :BUG.N "YVAL" YCOR
; []
; [MOVE TURTLE TO STARTING CORNER, DRAWING LINE]
MAKE "CORNER.N (WORD "CORNER : N)
SETPOS (GPROP :CORNER.N "XVAU") (GPROP :CORNER.N "YVAU")
END

TO BIGSQ :SZ

; [THIS DRAWS A SQUARE OF LENGTH :SZ WITH THE] [CURRENT TURTLE POSITION AS CENTER. AT THE] [END, THE TURTLE'S POSITION IS UNCHANGED,]
; [BUT THE PEN IS DOWN]
; []
PENUP
HALFSQ :SZ / 2
PENDOWN
REPEAT 4 [FORWARD :SZ RIGHT 90]
PENUP
HALFSQ :SZ / 2
PENDOWN
; []
END

TO HALFSQ :SZ

; [THIS DRAWS TWO SIDES OF A SQUARE -- THE PEN] [MAY BE UP OR DOWN],
; []
REPEAT 2 [FORWARD :SZ RIGHT 90]
END

Listing 1 continued on page 238
**Software Breakthrough...**

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Technical Review by Wayne Hepburn

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I interviewed him to find out more about QUIKPRO + PLUS and pass this valuable information to you. He told me "The best part of this software is that it gives you a separate custom program every time you use it. The resulting program is produced, error-free, in BASIC (Microsoft Basic /MBasic /Basic 80 /Oasis Basic, as appropriate to your system) for you by QUIKPRO + PLUS. What's more, you can list your new program, look at it, see what makes it tick, and modify it as you wish."

You can also, customize, enhance, alter, and even copy the programs you create with QUIKPRO + PLUS. This is because programs created by QUIKPRO + PLUS are structured, easy to follow, and include many REMARKS statements right in the program listing. I don't know of any other software with the flexibility and ease of use I found in QUIKPRO + PLUS.

HUNDREDS OF APPLICATIONS...

For Education, Business, Hobby, Home, Science, Personal, etc. a partial list includes programs like these: Financial Forecasting, Expense Planning, Data Access and Retrieval, Modeling, Record Keeping of all kinds, Statistical Data Banks, and much, much more. QUIKPRO + PLUS cuts the time it takes to generate a new custom program down to a few minutes. That's true. I saw a letter from a user who created a separate program in Basic within fifteen minutes after reading the clear, simple, complete Documentation & Operating Manual for QUIKPRO + PLUS. The software will generate File Handling and Data Entry Programs in a file format, drawn right on the screen by user. Programs created by QUIKPRO + PLUS produce standard ASCII Data Files allowing data to be easily accessed by other programs, other micro's, and even main frames.

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Listing 1 continued:

TO ADDPROPS :N :LIST ;
  [:]
  [:THIS SETS UP THE WORDS BUG1 THROUGH BUG4]
  [:AND CORNER1 THROUGH CORNER4 WITH TWO]
  [:PROPERTIES EACH -- XVAL AND YVAL]
  [:]
  LOCAL "NAME1
  LOCAL "NAME2
  MAKE "NAME1 WORD "BUG :N
  MAKE "NAME2 WORD "CORNER :N
  PPROP :NAME1 "XVAL FIRST :LIST
  PPROP :NAME2 "XVAL FIRST :LIST
  PPROP :NAME1 "YVAL LAST :LIST
  PPROP :NAME2 "YVAL LAST :LIST
  [:]
END

TO :N END

TO SETPROPS ;
  [:]
  [:FILL PROPERTY LISTS OF BUG1 - BUG4, CORNER1 - CORNER4]
  ADDPROPS 1 LIST ( -1 * :BIGUNIT) :BIGUNIT
  ADDPROPS 2 LIST :BIGUNIT :BIGUNIT
  ADDPROPS 3 LIST :BIGUNIT ( -1 * :BIGUNIT)
  ADDPROPS 4 LIST ( -1 * :BIGUNIT) ( -1 * :BIGUNIT)
  [:]
END

TO 4.BUGS :LEN :TIMES ;
  [:]
  [:THIS DRAWS THE CLASSIC SPIRAL CREATED BY]
  [:THE MOTION OF 4 BUGS, EACH STARTING AT ONE CORNER]
  [:OF A SQUARE AND FOLLOWING THE BUG CLOCKWISE]
  [:TO IT]
  [:]
  FULLSCREEN
  HIDETURTLE
  MAKE "BIGUNIT 100
  BIGSQ (2 * :BIGUNIT)
  [:]
  SETPROPS Repeat :TIMES [MOVEBUG 1 MOVEBUG 2 MOVEBUG 3 MOVEBUG 4] END

of video display, but it does have re­ definable characters called tiles (more on them later). The lines drawn by the turtle are actually redefined tiles. Because only 192 of the 256 tiles are available for redefinition (64 store the TI-99/4A character set) and there are far more than 192 characters on the graphics part of the video display, a design can easily cover more tiles than are available. The limitation of the TI turtle is offset by the availability of colorful sprites on the TI-99/4A computer. All three Logos have a full complement of turtle commands; see reference list on page 280 for details.

Another traditional feature of Logo is a set of list-manipulating words. Although most of the publicity about Logo emphasizes its graphics and its suitability for education, Logo is also a fairly powerful list-manipulation language with distinct similarities to LISP (the granddaddy of artificial­intelligence languages). As an exam­ ple, listing 2 shows a set of Logo pro­cedures that sorts a list of words. Apple Logo and Terrapin/Krell Logo are roughly equal in their list-processing abilities, but TI Logo has some definite deficiencies; these will be discussed in a later section.

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Apple® Logo is a product of Logo Computer Systems, Inc., 222 Brunswick Boulevard, Point-Claire, Quebec, Canada H9RIA6.

Circle 29 on inquiry card.
Photo 1: A drawing made using turtle graphics and an Apple II computer. The procedure, called 4.BUGS, is given in listing 1. Each curved line is the actual path of the bug; the straight lines to the corner were drawn to add color to the photo.

At a Glance

Name
Krell Logo

Type
Programming language

Manufacturer
Krell Software Corporation
1320 Stony Brook Rd.
Stony Brook, NY 11790
(516) 751-5139

Price
$149.95

Authors
Leigh Klotz Jr., Patrick Sobalvarro, and Stephen Hain

Format
5¼-inch floppy disk

Language Used
6502 machine language

Computer Needed
Apple II or Apple II Plus with 16K-byte memory card (will not work on Apple III)

Software Included
Two copies of MIT Logo (copy protected), Utilities Disk (with utilities from MIT and Krell), Alice in Logoland disk

Documentation

Audience
Anyone interested in Logo

* refers to materials stated as part of the package but not seen by the reviewer; Krell says it will send all missing materials to earlier purchasers of Krell Logo.

TI Logo and Radio Shack Color Logo are both limited to integer arithmetic, while Apple Logo and Terrapin/Krell Logo use floating-point arithmetic.

and Radio Shack Color Logo are limited to integers between −32,768 and 32,767, while Apple Logo and Terrapin/Krell Logo use both integers and floating-point numbers. The Apple-based Logos are as useful for arithmetic computation as any BASIC. In addition to the four basic arithmetic operators, the Apple-based versions offer the sine, cosine, and arctangent functions, rounding and truncating (to integer) functions, and a square root function.

All five Logos have editors that allow Logo procedures to be created and edited. The Apple Logo and Terrapin/Krell Logo editors are very similar, although I like the Terrapin/Krell version a little more because of a slightly more convenient arrangement of function keys. Apple Logo gives you a simple line-at-a-time, no-editing way to type in procedures; this is probably intended for young children who might get confused by the power of the regular editor. (Terrapin/Krell Logo offers a similar procedure on its Utility Disk.) The TI and Radio Shack versions have less sophisticated editors. All the editors except the Radio Shack one work in a way that is somewhat annoying to experienced users. For example, you are always in a kind of insert mode—when you type characters, they are inserted at the cursor location and all other characters on that line are moved to the right. You must use a specific keystroke to delete a character or a line. In any case, the editors in each Logo are easy to learn and are not, in themselves, worthy of more discussion here.

(One additional editing feature of the Apple-based Logos is the ability to reproduce the last line typed in when not in the editor. The line ap-
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1 TM of Digital Research
Listing 2: A set of Logo procedures that will sort a list of words. This version is written in Terrapin/Krell Logo and is used as a benchmark. The empty brackets on several lines were placed there automatically by the Terrapin/Krell Logo editor. Due to space limitations, the slightly different versions that run on the Apple and TI-99/4 will not be given here.

TO STR.GR.THAN :FIRST :SECOND
; []
; (READ THIS NAME AS "STRING-GREATER-THAN")
; []
; THIS RETURNS A TRUE OR FALSE VALUE DEPENDING
; ON WHICH OF TWO WORDS, :FIRST OR :SECOND
; ALPHABETICALLY PRECEDES THE OTHER
; []
IF :FIRST = :SECOND OUTPUT "FALSE
IF :FIRST = " OUTPUT "FALSE
IF :SECOND = " OUTPUT "TRUE
MAKE "CHAR1 FIRST :FIRST
MAKE "CHAR2 FIRST :SECOND
IF ASCII :CHAR1 > ASCII :CHAR2 OUTPUT "TRUE
IF ASCII :CHAR1 < ASCII :CHAR2 OUTPUT "FALSE
OUTPUT STR.GR.THAN BUTFIRST :FIRST BUTFIRST :SECOND
END

TO INSERT :WORD :LIST
; []
; THIS INSERTS :WORD ALPHABETICALLY INTO
; AN ALREADY SORTED :LIST; THIS RETURNS
; A NEW LIST THAT CONTAINS ALL OF :WORD
; AND :LIST, NEITHER OF WHICH IS CHANGED.
; []
IF NOT STR.GR.THAN :WORD FIRST :LIST THEN OUTPUT FPUT :WORD :LIST
IF STR.GR.THAN :WORD LAST :LIST THEN OUTPUT LPUT :WORD :LIST
OUTPUT FPUT FIRST :LIST INSERT :WORD BUTFIRST :LIST
END

TO SORT :LIST
; []
; THIS RETURNS A SORTED LIST THAT HAS THE
; SAME CONTENTS AS THE UNSORTED :LIST
; []
IF :LIST = [] OUTPUT []
TEST BUTFIRST :LIST = []
IFTRUE OUTPUT :LIST
IFFALSE OUTPUT INSERT FIRST :LIST SORT BUTFIRST :LIST
END

One feature common to all the Logo implementations covered here has to do with Logo source code. Although Logo is supposed to make using the computer as easy as possible, none of the implementations discussed here allows Logo procedures to be typed in (or printed out) with the indentations and statement groupings that make a structured language more readable. For example, a REPEAT statement with several statements in the body of the repeat loop must put all the statements on one line. They cannot be placed one statement per line (as can be done in Pascal, for example) because these implementations use a carriage return to denote the end of a completed Logo command. This is an unfortunate fact we will have to live with for now; perhaps later versions of Logo will remedy the situation.

Two final notes concern the Apple-based versions of Logo. Because the language uses the 16K-byte memory card (the Apple Language Card or its equivalent), neither Apple Logo nor Terrapin/Krell Logo will run on an Apple III under Apple II emulation mode. In addition, Apple Logo may not load on a few Apple IIs. See the text box Apple Logo and the P6A Problem on page 234 for more details.

Apple Logo
Apple Logo’s greatest strength is its advanced programming commands. Package-related commands allow you to group together selected procedures and variables and manipulate them by a given name; among other things, the package of items can be saved, erased, or hidden from view (or buried) in Logo. For example:

PACKAGE "PKG1 [PROC1 PROC2 PROC3]

defines the package PKG1 to be the three procedures named above. You can then save just these items to a disk file named GWPKG1 with:

SAVE "GWPKG1 "PKG1

You can erase all the above items from the workspace with:

ERALL "PKG1

In addition, you can hide them from view with:

BURY "PKG1

After they are buried, the procedures are available for use, but they do not show up in any list of the workspace contents and they cannot be erased accidentally. The availability of packages makes workspace manipulation much easier (especially when you want to save, delete, or otherwise manipulate only part of the workspace), and the BURY feature allows you to customize the Logo workspace for a particular application and “lock” those features into Logo where they cannot be seen or altered by the nontechnical user.

Another Apple Logo feature, the STARTUP file, allows you to create a
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*C = Compiler; I = Interpreter. Times (except for Seattle Computer) taken from August 1981 issue of Interface Age.

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Radio Shack Color Logo

A spiral drawn with Color Logo turtle graphics. Note that text and graphics can be mixed on the same screen. The oblong object at the end of the spiral trail is the Color Logo turtle.

Multiple turtles in Color Logo. Here, multiple turtles are simultaneously drawing the branches of a tree shape. (Some turtle shapes are smeared because they were in motion when the photo was taken.)

As this review was going to press, we received a preliminary version of Color Logo for the TRS-80 Color Computer. Although it would be unwise to do an in-depth review of a product before it is entirely finished, I will give you an overview of the product in its current form. (The language itself is finished, but the authors, Larry Kheriaty and George Gerhold of Micro Pi, are changing it where possible in response to the reactions of people who are critiquing it.)

Two factors influence the structure of Color Logo, which is radically different from the other Logos being reviewed here. The first factor is the absence of any connection to MIT, which had a direct hand in the other Logos. The second factor is the limited memory size of the TRS-80 Color Computer—it has a maximum of 32K bytes, which must accommodate both the Logo language and a usable workspace. (The version that we received is on a 5 1/4-inch floppy disk. The language will also be available on cassette and ROM cartridge. Since the cartridge version does not occupy any of the memory space, it will give Color Logo a larger workspace than is otherwise possible. The cartridge version will run on either a 16K-byte or a 32K-byte machine.)

Because of the influences mentioned above, Color Logo is quite different from the other Logos reviewed here. It is intended for use by children, which is reflected in its limitation to turtle graphics. In other words, Color Logo supports turtle graphics (more on this later) but does not include any string- or list-manipulating words. In fact, all you can do outside turtle graphics is print a character string or number at the current location of the turtle.

The turtle graphics of Color Logo are on a 192 by 256 grid, although the actual resolution of the graphics is 192 by 128. The turtle and background can be one of four colors, and you can choose one of two 4-color sets (you cannot, however, mix the sets). This seems to be equivalent to medium-resolution graphics PMODE 3 in TRS-80 Color Computer Extended BASIC.

Color Logo has four modes: break, doodle, edit, and run. Break mode is a "central" mode from which you read and save files and go to the edit and run modes; all modes return to the break mode when the red Break button is pressed. All Logo statements and procedures are run from the run mode, through which turtle graphics appear (see above right photo). Edit mode allows you to create or change all the procedures in the workspace (all the procedures are in one workspace). Doodle mode, entered from run mode with a name that later becomes the name of the pattern about to be drawn, allows you to create turtle graphics with predefined one-key commands (Color Logo provides a keyboard overlay that identifies the keys). When doodle mode is exited, the pattern can be redrawn in run mode by executing the name given earlier.

The most interesting feature of Color Logo is its ability to create multiple (up to 255) turtles and have them send messages to each other (see above right photo). A new turtle is created by a HATCH command and then given an identification number, a procedure name to start executing, and an optional list of parameters to the procedure. The newly created turtle has the same shape, heading, and location as the turtle that created it, and it exists until the procedure calling it finishes or until a

Continued on page 250
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<table>
<thead>
<tr>
<th>Name</th>
<th>TRS-80 Color Logo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Programming language</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>Radio Shack, Education Division</td>
</tr>
<tr>
<td></td>
<td>400 Atrium, One Tandy Center</td>
</tr>
<tr>
<td></td>
<td>Fort Worth, TX 76102</td>
</tr>
<tr>
<td></td>
<td>(817) 390-3302</td>
</tr>
<tr>
<td>Price</td>
<td>Disk version, 599</td>
</tr>
<tr>
<td></td>
<td>Program pack version (not yet available)</td>
</tr>
<tr>
<td>Authors</td>
<td>George Gerhold and Larry Kheriaty</td>
</tr>
<tr>
<td>Format</td>
<td>Disk (available third quarter, 1982)</td>
</tr>
<tr>
<td></td>
<td>Program pack (read-only memory cartridge, available January, 1983)</td>
</tr>
</tbody>
</table>

The disk version of Color Logo saves a maximum of 16 Logo workspaces, each of which is referred to by a letter from A to P. While this seems quite simplistic to most of us, it is exactly right for its intended audience, young children. I assume that the cartridge and cassette versions will use a similar mechanism.

Two more Color Logo features deserve mention. One is the inclusion of a WHILE statement that allows a list of items to be done as long as a given condition evaluates to a nonzero (“true”) value. The other is the ability to redefine the turtle’s shape under program control. This can be used to change the turtle’s default shape (an odd, elongated capsule shape) or even to perform some limited animation by rapidly redefining the turtle shape.

Although some bugs will be fixed in the next version of Color Logo, like other Logos, Color Logo does not remember where the theoretical point is in relation to the plotted point. The result is that executing FORWARD 1 twenty times will force the turtle to draw a line on one of the eight points of the compass (depending on the true heading of the turtle and which point it’s nearest to). This property of the preliminary version of Color Logo I looked at is unfortunate, since it creates a discrepancy between what you think Logo should do and what it actually does. Still, such a simplification is understandable given the complexity of Logo and the limited memory space of the TRS-80 Color Computer; if this behavior is in the finished product, I’ll certainly understand.

In general, this looks like a nice Logo for children. As always, you should check the product’s capabilities against its intended use and audience. Radio Shack plans to have Color Logo in its stores by September 1982.

---

The VANISH statement is called with its number. Color Logo processes one statement from each turtle, then repeats the process, thus giving the illusion that all the turtles are executing their programs simultaneously. Turtles can send and receive “mail,” but the mail is limited to a single integer value between −32,768 and 32,767. Radio Shack claims in a press release that, with Color Logo, “Anyone from the preschool child to the computer scientist can investigate the principles of structured thinking (and programming), multitasking, interprocess communications, modular programming, parameter passing, local and global variables, and looping and recursion.” Although about half of the above subjects can be taught with the language, I think that some of the claims are extravagant for a Logo that can only pass single-integer “messages.”

Property lists are lists of characteristics that can be associated with a given Logo variable. For example, you may have a number of words that describe geometric shapes: TRIANGLE, SQUARE, PENTAGON. You can then give each of these words two properties, NUM.OF.SIDES and INTERIOR.ANGLE, and assign values to them. Using the name SQUARE as an example, you would first add the properties and their values to the property list associated with SQUARE:

```plaintext```
PPROP "SQUARE "NUM.OF.SIDES 4
PPROP "SQUARE "INTERIOR.ANGLE 90
```

You can then print out the property list of SQUARE (the computer’s responses are in italics):

```plaintext```
SHOW PLIST "SQUARE
[INTERIOR.ANGLE 90 NUM.OF.SIDES 4]```

---

Text continued from page 242:

“turnkey” system. If a Logo file named STARTUP is on your data disk when you first boot up Logo, that file is automatically loaded into the Logo workspace. If a Logo variable named STARTUP has a value that is a list, that list is executed after loading the startup file. In this way, a nontechnical user can follow the standard Logo booting procedure and end up with a customized workspace running a certain program.)
or you can get the value of a given
property:

SHOW GPROP "SQUARE
"NUM.OF.SIDES

4

Note that the word SQUARE can be
either a variable with a value or a
procedure with a definition; its prop­
ty list is connected to but not the
same as the word itself. Property lists
can be useful in certain list-manipu­
lation applications. (By the way, it
would not be very hard to make a set
of Logo procedures that do the same
thing for most of the other Logos;
Harold Abelson does this—he calls
them association—in his two books, Apple Logo and Logo for the Apple II.)

CATCH and THROW are two
unlikely Logo commands that allow a
given condition to cause the execu­
tion of a list of commands. Normally,
there's nothing special about that—an
IF statement will do the same thing—but in this case, the triggering
condition may be a Logo error. If so,
a Logo program can intercept the
usual Logo response to that error and
substitute a user-specified response;
this allows a program to recover from
specified errors instead of ending.

Apple Logo contains a number of
useful commands that are not in the
other Logos reviewed here. Although
most of them can be defined by the
user, it is nice to have them available
automatically. Examples of such
commands are COUNT (which returns
the number of items in a list), ITEM
(which returns the nth item of a list),
and numerous predicate words that
return a value of "TRUE" or "FALSE" depending on the logical value of
whatever is being tested (EMPTY,
KEYP, WORDP, and others). Apple
Logo also lets you redefine the
primitive operations supplied with
the language; although most people
won't need to do this, it's nice to be
able to.

Several other features are worth
mentioning. One characteristic of all
Logos is that any named variable be­
gins global to the workspace (and
so has the same value within any
procedure in it) unless the name is an
argument to a procedure (these are
called dummy arguments in other
computer languages). Apple Logo has
added a LOCAL statement that
restricts the domain of any variable
named by it to the procedure that
uses the LOCAL statement and any
procedures it calls. This often helps
prevent hard-to-find program errors
resulting from unsuspected interac­
tion between variables.

Users of Apple Logo will probably
be able to buy a peripheral board for
the Apple that will give it sprites (col­
ored, moving images of varying
shapes—see the discussion on sprites
in the section on TI Logo, below).
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Logo Computer Systems Inc. (which created Apple Logo) showed me a prototype of a sprite board that the company plans to market by the end of 1982. Multiple sprites will be able to move on screen at a time, and they will be able to draw lines, just as a turtle can. (TI Logo sprites do not draw lines.) Once this happens, TI Logo will lose one of its main advantages over the versions of Logo for the Apple II. (At this writing, we have no details on availability or price.)

Apple Logo: Problems

I found one bug in Apple Logo and several things I didn't like. The bug occurred as follows:

SHOW SENTENCE -5 3
-/5 3/
SHOW SENTENCE +5 3
/[8/]

Apple Logo should have returned /5 3/. The error occurs in the parsing of the phrase +5 3 and has nothing to do with the SENTENCE command itself. Apple Logo shows a certain resemblance to LISP in allowing an operator-number-number construct for the operations of addition, subtraction, multiplication, and division. So Apple Logo behaves as follows:

PRINT + 5 3
8
PRINT / 12 4
3

It seems that something in the parsing algorithm cannot distinguish between +5 3 and + 5 3. Although this is definitely an error, it probably will not occur in normal programming because people do not usually place plus signs before positive numbers.

A command I don't like is the Apple Logo IF statement. In Terrapin/Krell Logo, an IF statement looks like this:

IF :RES0 THEN MAKE "RES :RES -1 ELSE MAKE "RES :RES +1

In Apple Logo, this becomes:

IF :RES0 [MAKE "RES :RES -1] [MAKE "RES :RES +1]
In Apple Logo, both the THEN and the ELSE clauses of the IF statements are actually lists. If the expression evaluated is true, the first list is executed; if it is false, the second list is executed. This particular syntax seems arbitrary to me, and it might seem rather cryptic to someone who has not dealt with computers before. In addition, if you write an IF statement without the brackets, you get an error message that is unrelated to the expression evaluated is true, the first list is executed; if it is false, the second list is executed. This particular syntax seems arbitrary to me, and it might seem rather cryptic to someone who has not dealt with computers before.

For example, the commands

\[ \text{TOWARDS, IFTRUE, SETHEADING TOWARDS :XVAL :YVAL} \]

In addition, if you write an IF statement without the brackets, you get an error message that is unrelated to the IF statement or the absence of brackets. This makes the debugging process longer. Given the apparent Apple Logo philosophy of tailoring the system to the nontechnical user, I'm surprised the IF statement was implemented this way.

Apple Logo seems to enjoy making inputs to certain commands into lists. For example, the commands SETPOS, TOWARDS, IFFALSE, and IFFALSE require their arguments to be made into lists. Given, say, variables XVAL and YVAL that have numeric values, in Terrapin/Krell Logo, you would say:

\[ \text{SETHEADING TOWARDS :XVAL :YVAL} \]

However, Apple Logo requires you to make a list of the :XVAL :YVAL pair. So the Apple Logo version has to be:

\[ \text{SETHEADING TOWARDS LIST :XVAL :YVAL} \]

The word LIST has to precede the values of XVAL and YVAL because the TOWARDS command requires as input a list with two numbers in it. (You can't simply say [:XVAL :YVAL] because brackets prevent the evaluation of :XVAL and :YVAL.) Like the use of the IF statement, the use of brackets (or any other list-making words) seems to me arbitrary, cryptic, and error inducing.

Finally, there is an omission in the Apple Logo system that I find quite inexcusable—Apple Logo has no provision for putting comments in Logo programs. According to someone at Logo Computer Systems Inc., comments were not allowed because they caused procedures to take up too much space. I find this a rather weak excuse for a language that purports to teach good programming habits and make programming easy for beginners. Making comments in programs, regardless of the language used, is one of the cornerstones of good programming practice, and I am amazed and horrified to find that Apple Logo does not provide for them (all the other Logos except the TRS-80 Logo do).

There is, however, a way around the lack of comments in Apple Logo. Simply define a short procedure that takes a list as an input and does nothing with it:

\[ \text{TO ; :ARG END} \]

This defines the Logo procedure ";," which will "eat" any list that comes directly after it. You can now add comments to a program by putting brackets around them and a semicolon and a space just before the opening bracket:

\[ \text{TO DUMMY.PROGRAM ; [THIS COMMENT WILL BE IGNORED} \]

\[ \text{END} \]

This method, however, may have speed and program-size side effects because the comments are actually a part of the procedure and are executed every time the procedure is executed. As for the necessity of putting brackets around things—you're getting used to that by now, aren't you?

### Terrapin/Krell Logo

Both Terrapin Inc. and Krell Software Corporation are licensed to distribute MIT Logo, a version of Logo developed by the Logo Group of the Massachusetts Institute of Technology. (This implementation was created by Leigh Klotz Jr., Patrick Sobalvarro, and Stephen Hain under the direction of Harold Abelson.) Though the language is the same for both companies' versions, the materials supplied with each version differ. The main differences are as follows: Krell Logo includes a second (copy-protected) Logo disk, a set of introductory programs called "Alice in Logoland," a program called INSTANT.LOGO.TUTOR, a nice reference-guide wall poster, and a copy of Logo for the Apple II, by Harold Abelson. Terrapin Logo includes only one Logo disk (you can buy an extra one for $15), a copy of Logo for the Apple II: Technical
Listing 3: An example of the TRACE function tracing the execution of the Logo phrase STR.GR.THAN "IT "IS.

```
TRACE ON
EXECUTING STR.GR.THAN IT IS
IF :FIRST = :SECOND OUTPUT "FALSE"
IF :FIRST = " " OUTPUT "FALSE"
IF :SECOND = " " OUTPUT "TRUE"
MAKE "CHAR1 FIRST :FIRST"
MAKE "CHAR2 FIRST :SECOND"
IF ASCII :CHAR1 > ASCII :CHAR2 OUTPUT "TRUE"
IF ASCII :CHAR1 < ASCII :CHAR2 OUTPUT "FALSE"
OUTPUT STR.GR.THAN BUTFIRST :FIRST BUTFIRST :SECOND
EXECUTING STR.GR.THAN TS
IF :FIRST = :SECOND OUTPUT "FALSE"
IF :FIRST = " " OUTPUT "FALSE"
IF :SECOND = " " OUTPUT "TRUE"
MAKE "CHAR1 FIRST :FIRST"
MAKE "CHAR2 FIRST :SECOND"
IF ASCII :CHAR1 > ASCII :CHAR2 OUTPUT "TRUE"
ENDING STR.GR.THAN
ENDING STR.GR.THAN
RESULT: TRUE
```

Manual, and a copy of the Terrapin Logo Language Tutorial, by Deborah Tater and Patrick Sobalvarro.

Your choice of the Krell or Terrapin version of MIT Logo will depend on your own preferences. On one hand, Terrapin now employs one of the persons who implemented MIT Logo and consults with another (Leigh Klotz Jr. and Patrick Sobalvarro, respectively). Terrapin will offer revised versions of Terrapin Logo for $20; also, if you find an error in Terrapin Logo during the 90-day warranty period and Terrapin has corrected it, you will receive the revision containing the correction free. The tutorial book by Tater and Sobalvarro is very good. Although it is geared for the novice, it does a very good job of introducing some advanced Logo concepts. Finally, Terrapin may be offering a version of its Logo that implements sprites (more on that below).

I found the programs supplied by Krell competent but simplistic; however, the "Alice" programs might be of interest to children. Krell also offers more support materials, though many of them were not available at press time and so could not be evaluated. Abelson's excellent tutorial book is geared to the beginning, non-technical user. I prefer the Terrapin version, largely because of its superior technical support and the availability of a sprite version. However, the Krell version offers slightly more materials for the money.

Although both Terrapin/Krell Logo and Apple Logo can be used easily by any prospective user, adult and child alike, the differences between them seem to indicate different company perceptions of the intended Logo user. Each version makes a certain class of things easier to do. Although Apple Logo has a richer set of commands, it is delivered to the user as a sealed "black box" that you can't tinker with; in addition, certain features (like the STARTUP file, buried packages, and the necessity of deleting a disk file before it can be resaved under the same name) seem to point toward making the finished application as user-proof as possible. On the other hand, Terrapin/Krell Logo seems to be oriented toward the more knowledgeable user, who doesn't need that extra level of protection. The following paragraphs describe the features of Terrapin/Krell Logo that support this point of view.

The pair of program debugging commands TRACE and NOTRACE is easily the most important feature of Terrapin/Krell Logo. After TRACE has been executed, Logo executes a procedure one line at a time (showing each line as it executes) and waits for...
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as a keypress before executing the next statement. Listing 3 shows an example of executing a Logo statement when the TRACE function is active. In preparing for this review, I wrote several programs and transferred them to all three Logo systems; I can't tell you how much I missed the TRACE function on the three systems that don't have it.

Another convenient feature of Terrapin/Krell Logo is the DOS command, which lets you interact with the Apple DOS (disk operating system). For example, you can rename a file from Logo like this:

```
DOS (RENAME GERBIL.LOGO, GERBILWARS.LOGO)
```

The DOS commands this works with are BLOAD, BRUN, BSAVE, CATALOG, DELETE, LOCK, MON, NOMON, RENAME, UNLOCK, and VERIFY.

Terrapin/Krell Logo includes a Logo 6502 assembly-language assembler and sufficient information on the Logo internal structure to make it useful. This is the single feature of Terrapin/Krell Logo that best illustrates its "open-software" as opposed to Apple Logo's "closed-software" philosophy. With the Terrapin/Krell Logo Assembler, you can do a lot of things that can't be done with Apple Logo—anything that requires assembly language or interfacing to the outside world. For example, an assembly-language program to generate a variable-pitched tone through the Apple speaker can be interfaced to Logo and used to create a music-playing program written in Logo.

Assembly-language routines can also be used to connect Logo to, say, a nonstandard printer card, a real-time clock, or a tone generator connected through the Apple game paddles. (Logo for the Apple II: Technical Manual also includes a two-page list of useful memory addresses and routine entry points as part of an entire chapter on how to write assembly-language routines for Terrapin/Krell Logo and how to use the Logo Assembler.)

The Utilities Disk is another important feature of Terrapin/Krell Logo. It contains the assembler as well as several other useful sets of procedures. Table 1 gives a list of the major files on that floppy disk. Both Terrapin and Krell have put on their Utilities Disks several files that have been created by members of their staffs; each are not, of course, available on the Utilities Disk supplied by the other company.

A special variable called SAVEMOD can be changed to allow using the Terrapin/Krell Logo editor as a text editor. (Without this change, the editor would try to execute the contents of the file.) Some procedures on the Utilities Disk make reading, writing, and printing arbitrary text files easier. The SAVEMOD variable is also useful in making self-starting files (files that, after being loaded into the Logo workspace, automatically execute one or more phrases of Logo).

Terrapin/Krell Logo will work with Steve Ciarcia's sprite board for the Apple (see Ciarcia's column in this issue for details). It is possible that Terrapin will also create a new version of Logo that will integrate sprite and turtle graphics on the same screen and allow sprites to be given movement that is independent of the executing procedure; however, this had not been decided at the time this was written. As with the sprite board for Apple Logo, the availability of one from Terrapin would negate the presence of sprites as one of the primary advantages of TI Logo.

**Sprites are easily the most important feature of TI Logo.**

**TI Logo: Features**

Although people at Texas Instruments worked with people at MIT to create TI Logo, this Logo is not as...
similar to the Apple-based Logos as they are to each other. Some of the differences will make TI Logo the best system for some people, but most of them, in my opinion, will severely limit TI Logo's usefulness. I'll consider the features of TI Logo first, then its limitations.

Sprites are easily the most important feature of TI Logo. They are colored video images (up to 16 dots wide by 16 dots high) that are an inherent part of the TI-99/4A. The TI-99/4A has 32 sprites built into it, and each sprite can be given a shape, color, and position on the video display (independent of the text being displayed); in addition, the sprites have an inherent priority of display among themselves, so that when two sprite images intersect, one sprite appears to be on top of the other (see photo 2). This priority is automatically maintained by video circuitry inside the TI-99/4A.

TI Logo adds some features to the hardware-inherent features of sprites. Sprites (like turtles) can be given a heading, but, unlike turtles, they can also be given a velocity. In other words, sprites move in a straight line at a given speed without slowing down the running program until they are told to change their behavior; in fact, they also move even when no program is running. The reference list, which includes all the sprite commands, shows TI Logo's superiority over the Apple-based Logos in this respect. However, sprites are unlike turtles in that they cannot draw lines.

Closely related to sprites are sprite shapes. Five are defined by name: PLANE, TRUCK, ROCKET, BALL, and BOX. (Because sprite shapes are called by number, these are actually variables with the values 1 through 5.) Sprites can also be given one of 16 colors, and the attributes of shape, color, heading, and speed can be assigned to a sprite by the following Logo commands.

```
TELL SPRITE 2
(makes sprite 2 "listen" to the commands that follow)
CARRY :BALL
(gives it the predefined "ball" shape)
CARRY 4
(does the same as CARRY :BALL)
SETCOLOR :RUST
(gives it an orange-brown color)
SETCOLOR 8
(does the same as SETCOLOR :RUST)
SETHEADING 90
(makes it point to the right)
SETSPEED 48
(starts it moving at a speed of 48)
```

Note that the number of the sprite (in this case, sprite 2) and the shape of

---

**Photo 2:** Priority in TI Logo sprites. The sprite with the lower number (a truck) appears to be on top of the sprite with the higher number (a box).
The MAKESHAPE procedure in TI Logo. When MAKESHAPE \( n \) is executed, sprite shape \( n \) is displayed in enlarged form and is available for editing. The graphics cursor, a blinking box, can be moved to any box with arrow keys; when the cursor leaves a box, the box can be left either filled in or empty. Any sprites carrying that shape immediately assume that shape, as can be seen by the small sprite of the same shape on screen.

Tiles are TI's nontechnical name for characters, which are patterns in an 8 by 8 grid. (Interestingly enough, certain TI Logo commands like MAKECHAR and PRINTCHAR refer to them as characters, while the documentation and some other commands—TELL TILE \( n \) and PUTTILE—refer to them as tiles.) There are 256 tiles available in the system, 64 of which are used for the TI Logo character set. Any tile can be redefined with the MAKECHAR command, which works like the MAKESHAPE command described above.

Tiles can also, to a certain extent, be given a different color. Tiles are grouped by ascending tile number in sets of 8, and a tile can be given one of 16 colors by using the SETCOLOR command:

```
TELL TILE 78
SETCOLOR :LEMON
```

These commands will cause the letter \( \text{N} \) (which is tile 78) to change to a cer-
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- Apple II Plus with 48K bytes of memory
- Apple Language Card
- Disk controller card and one floppy disk
- RF modulator (approximate price)
- Terrapin/Krell Logo

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40.00
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- PHP2200 Memory Expansion
cassette recorder (approximate price)
- PHM3040 TI Logo cartridge

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Table 2: Comparative prices of Logo systems. The table shows the list prices of Logo systems based on Apple Logo, Terrapin/Krell Logo, TI Logo with a floppy disk, and TI Logo with a cassette recorder, respectively. These comparisons assume that a color television (not included in the prices) will be used for video display.

TI Logo: Problems
Unfortunately, there are several things wrong with TI Logo. Most of these problems won't matter for cer-
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tain users, but they will be very important to others. You should ask yourself how important these problems are to you.

One problem I want to mention, keyboard layout, should be attributed to the TI-99/4A computer rather than TI Logo itself; and two others, turtle drawing behavior and slowness of execution, are probably attributable to the computer as well. The poor layout of the TI-99/4 and TI-99/4A keyboards is well known and does not need to be amplified here. The latter keyboard is improved in that it has true typewriter keys instead of button-type keys, but one knowledgeable TI Logo observer says that the TI-99/4A keyboard is more difficult to use for Logo than the TI-99/4's.

In any case, the TI-99/4A keyboard still infuriates anyone with any keyboard skills. (This was less of a problem for children who do not know how to type, but it would put them at a disadvantage when using other keyboards.) Two often-used keys, the backspace and double-quotes (";') keys, use a poorly placed FCTN key. The FCTN key is below the right shift key; backspace is FCTN-3 and the double-quotes key is FCTN-P. In addition, some FCTN keys that are active within the TI Logo editor are inactive outside it, while others are active in both places. This leads you to try certain FCTN keys to see if they accomplish a given editing task; not only do they not, but they aren't truly inactive, either—they leave funny-shaped graphics characters (FCTN-4, when used outside the editor, is an example of this).

I also blame the slowness of TI Logo (see the section on benchmarks later) on the computer itself, although I am not completely sure of this. All I know is that TI BASIC is also very slow. I also blame the slowness of TI Logo: Undocumented Features

Through experimentation and conversations with various people in the TI Logo community, I found several Logo commands that are in TI Logo but are not documented. The fundamental list-manipulating commands FPUT and LPUT work, as do several predicate words—NUMBER?, THING?, and WORD? (for definitions, see the words NUMBERP, THINGP, and WORDP in the reference list).

Another command that I was told about and later confirmed, DEBUG, toggles an internal trace mode between on and off states. When the trace mode is on and a procedure is executed, any error condition causes the procedure to pause (rather than simply end) with a prompt telling you what level you are at. You can then execute statements from the keyboard to determine (and perhaps correct) what is wrong, then type CONTINUE to continue execution.

TI Logo: Implementation Errors and Poor Design Decisions

In this section, I am going to cover some of the more serious errors in TI Log
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Listing 4: Two memory-filling procedures. FILLMEMORY fills memory by creating an infinitely nesting procedure that prints out its current depth. FILLPROC creates short empty procedures of equal length under program control. Listing 4a shows the version used by Terrapin/Krell Logo, while listing 4b shows the version used by TI Logo. The procedure MAKEQQ must be executed once before the TI Logo memory-filling procedures will work.

(4a)
TO FILLMEMORY :N
    PRINT1 [AT LEVEL) PRINT :N
    FILLMEMORY :N + 1
    PRINT1 [SECOND TIME AT LEVEL] PRINT :N
END

TO FILLPROC :N
    PRINT1 [AT LEVELi PRINT :N
    MAKE "PROCNAME WORD "P :N
    DEFINE :PROCNAME [[])
    FILLPROC : N + 1
END

(4b)
TO MAKEQQ
    MAKE "QQ "1234567890ABCDEFGHIJKLMNOPQRSTUVWXYZ
END

TO FILLMEMORY :N
    TYPE IA T LEVELi PRINT :N
    FILLMEMORY :N + 1
    TYPE [SECOND TIME AT LEVELi PRINT :N
END

TO PICK :N :WORD
    IF :N = 1 THEN OUTPUT FIRST :WORD
    OUTPUT PICK :N − 1 BUTFIRST :WORD
END

TO FILLPROC :N
    TYPE [AT LEVEL) PRINT :N
    MAKE "PROCNAME WORD "P PICK :N :QQ
    DEFINE :PROCNAME [[])
    FILLPROC :N + 1
END

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Logo itself. Some of these can be called poor design decisions—in other words, the people who designed TI Logo decided to implement a feature in a way that resulted in an awkward situation that could have been averted. At least one of these is an implementation error—a “bug” in the program that shouldn’t be there. Several errors that I discuss below could be called either poor design decisions or implementation errors, depending on your point of view.

The word/number dichotomy: TI Logo regards words and numbers as noninterchangeable items (in the Apple-based Logos, numbers are words). This changes the behavior of several Logo words. For example, the Apple-based Logo will behave as follows:

MAKE "NUM1 14
(make NUM1 equal to 14)
MAKE "VAR1 WORD "XXX :NUM 1
(make VAR1 equal to the string XXX followed by the value of NUM1)
PRINT :VAR1
(print the value of VAR1)
XXX14

However, TI Logo will not do this. Instead, it returns the message:

WORD DOESN’T LIKE 14 AS INPUT

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Several TI Logo commands—WORD, FIRST, BUTFIRST, LAST, and BUTLAST—behave as shown above. This causes a lot of problems when you are trying to create words during program execution. In the benchmark program FILLPROC, I wanted to create a series of procedures, P1, P2, P3, and so on. I did this easily in the Apple-based Logos (see listing 4a), but I had to create the procedure names differently in the TI Logo version (listing 4b).

A “hole” in the instruction set: The TI Logo version of the FILLPROC procedure is also different from the Apple-based Logo versions in that TI Logo has a “hole” in its instruction set. Like the Apple versions, TI Logo has a command to convert a character to its numeric equivalent (CHARNUM in TI Logo), but (unlike the Apple versions’ CHAR) there is no command to convert a number to its character equivalent. If there had been, I could have replaced the phrase

WORD “P PICK :N :QQ

in the TI Logo version with the phrase

WORD “P CHAR :N

and deleted the procedure PICK and the variable QQ.

An unexplained irregularity in the evaluation of Logo phrases: Another design decision is an odd algorithm for evaluating Logo phrases. This results in a bug I found when transferring the STR.GR.THAN procedure (see listing 2) from Terrapin/Krell Logo to TI Logo. Using a slightly different example, the Apple-based Logos had no problem with the phrase

PRINT ASCII “B > ASCII “A TRUE

The TI Logo version (which uses CHARNUM in place of ASCII) acts as follows:

PRINT CHARNUM “B > CHARNUM “A >DOESN’T LIKE B AS INPUT

After some experimentation, I found that TI Logo returns the correct value of TRUE given the command

PRINT (CHARNUM “B ) > CHARNUM “A

It seems that TI Logo scans an expression from right to left (which is okay in itself) and evaluates CHARNUM “A to a value of 66. It then tries to make the comparison “B > 66 and returns the above error message. The parentheses in the corrected version force the evaluation of CHARNUM “B before the greater-than comparison is made. I am at a loss to explain why this happens. At first, I thought TI Logo evaluates expressions strictly right to left without any idea of operator precedence, but several experiments with the arithmetic operators FIRST, BUTFIRST, and WORD showed that TI Logo does evaluate certain operations before others.

Now we get to a realm in which the problems can be blamed on either poor design decisions or implementation errors. I think they are outright errors because they are different from the internal models I (and most people) have of Logo. Another reason for calling them errors is that they are not pointed out in the documentation.

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You find out about them when programs don't work, and it takes a long time to find the error because your internal model of Logo behavior suggests you look elsewhere for the error.

The absence of an empty string: I found this decision/error while debugging the TI Logo version of the procedure STR.GR.THAN, which determines whether one string is alphabetically greater than another (see listing 2). The procedure is recursive, and one ending condition is the empty string—a string (word) with zero characters in it. In other words, the Apple-based Logos work like this:

MAKE "STRING "AD
(makes the variable STRING equal to AD)
PRINT :STRING
AD
(print the value of STRING)
MAKE "STRING BUTFIRST :STRING
(makes the variable STRING equal to all the characters but the first of the value of STRING)
PRINT :STRING
D
(STRING is now one character long)
MAKE "STRING BUTFIRST :STRING
PRINT :STRING
(null is printed because STRING is zero characters long)
PRINT :STRING = 
(is the value of STRING the empty string?)
TRUE
(yes, it is)

TI Logo works the same as above, with the following exception:

PRINT :STRING
BUTFIRST :STRING
D
(what's wrong here?)
PRINT :STRING = "D
TRUE
PRINT (BUTFIRST "D") = "D
TRUE
(BUTFIRST of a single-letter word is the word itself.)

The odd behavior of numbers enclosed by brackets: Another decision/error is that TI Logo, unlike the Apple-based Logos, incorrectly parses lists that include negative numbers. Apple Logo does the following:

PRINT FIRST [-2 4 -3] 
-2
PRINT LAST [-2 4 -3]
-3

TI Logo does the following:

PRINT FIRST [-2 4 -3] 
-2
PRINT LAST [-2 4 -3]
-3

Again, you have to know about this kind of behavior before you program in TI Logo, and it's not documented in the reference material. What's more, this situation makes programming in TI Logo more difficult. To create a list with negative numbers in it, you have to use the commands SENTENCE, FPUT, and LPUT and place the negative numbers inside parentheses.

MAKE "NUMLIST (SENTENCE 
(-2) 4 (-3))
PRINT :NUMLIST 
-2
PRINT LAST :NUMLIST 
-3

Problems with the TI Logo editor: One of the things I don't like about the TI Logo editor (the same applies to the sprite- and tile-making procedures) is that there is no way to exit the editor while leaving the procedure as it was before editing started. The Apple-based Logos have this ability (Control-C to exit with the changed procedure, Control-G to exit with the unchanged procedure), but TI Logo has one key only—the Back key. The contents of the editor at that time, like it or not, become the definition of that procedure.

Two other undocumented problems in the TI Logo editor may cause you to make errors. First, if you hit the Back key and the procedure being
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- 9x9 ASCII Character Set
- Cartridge Ribbon
- 5 3/4 Character Print Width
- Double Feed (Front or Bottom)
- Non Volatile Form Retention
- Top of Form
- Horizontal Tabs
- Vertical Tabs
- Post- logout Skip Over
- Auto Line Feed
- Auto End of Line Carriage Return
- 6 IPS Paper Show
- Parallel and Serial Interfaces
- 10 PPO/CO Bead Communications
- Terminal Status Indicators
- Audio Alarm
- Self Test
- X, Y, Xoff
- Paper Out Detection
- Compressed Print – 10, 12, 16.5 cpi
- High Resolution Dot Addressable Graphics
- 2K Expanded Print Buffer
- APL/ASCII Character Set

The DS180 is available nationwide through our network of sales/service distributors.
## TI Logo: Perspective

Before I finished this article, I talked with Mr. Donald P. Bynum, Division Manager of the Personal Computer Division of Texas Instruments. He was very receptive to the criticisms I made, and he told me how TI is improving its Logo. He was aware of the documentation problem and said that TI was in the process of writing a more complete tutorial book about TI Logo that would be supplied with later versions of the product. In addition, TI is publishing a book/software combination called the *TI Logo Curriculum Guide*, which should be available separately by the time you read this. The price of this product is steep ($49.95), but it contains extensive teacher-oriented material on using Logo at various grade levels as well as a disk and two cassettes of Logo programs for preschool children. The book also contains an 84-page appendix called the *TI Logo Reference Guide*, which should be available separately by the time you read this. The price of this product is steep ($49.95), but it contains extensive teacher-oriented material on using Logo at various grade levels as well as a disk and two cassettes of Logo programs for preschool children. The book also contains an 84-page appendix called the *TI Logo Reference Guide*, which should be available separately by the time you read this.

Mr. Bynum also told me about a second version of TI Logo that will be available before the end of the year. This version will include such enhancements as music capability, double-size sprites, a workspace almost twice as large as that of the first version, more extensive documentation, and the ability to print procedures via the RS-232C port. In addition, the new version will no longer "hang up" when it runs out of memory (OUT OF SPACE), the Logos give you messages like *YOU TRIED TO EXECUTE AN UNDEFINED PROCEDURE*, and the price differential between a TI Logo and an Apple-based Logo system may make you willing to work around the idiosyncrasies of the TI Logo system.

### Error Handling

One of the most impressive things about all five Logos is the clarity of their error messages. Unlike the usual vague or cryptic error messages (like SYNTAX ERROR or OM ERROR or ERROR 24), the Logos give you messages like *TELL ME HOW TO xxxxx* (when you try to execute an undefined procedure), *YOU TRIED TO DIVIDE BY ZERO, FILE IS THE WRONG TYPE, and xxxxx DOESN'T LIKE yyyy AS INPUT*. Such error messages are made easier by the interpreted nature of Logo (compiled languages usually give less specific error messages). People used to working with computers can get by with poorer error messages, but good error messages are especially important in systems that will be used by beginners and nontechnical people.

However, the Logo systems give different levels of information with the error messages. I created the same error situations in the Apple- and TI-based Logos and recorded the error messages given; see listing 5. Terapin/Krell Logo gives more detailed error messages than Apple Logo (again, a reflection of the intended user). TI Logo error messages are...
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complete but not as easy to use because they give the number of the line in error instead of displaying the line itself.

Documentation

Taking the Logos in alphabetical order again, we start with Apple Logo. The documentation for Apple Logo is in two volumes, both in the half-page spiral-bound format of all the Apple Computer Inc. documentation. (Instead of the metal spiral binding used in all Apple documentation to date, the spiral binding here is plastic; perhaps this is just new packaging, but it might be in deference to young children using the documentation—a nice change, in any case.) The first book, *Apple Logo: Introduction to Programming through Turtle Graphics*, by Cynthia J. Solomon, is the kind of step-by-step, gentle introduction to Logo needed by anyone using a computer for the first time. The book, which is 153 pages long, uses turtle-related projects to cover procedures, file storage and retrieval, the Logo editor, variables, recursion, and most of the graphics-related commands. The subjects covered are explained in an easily understandable way. The book is laid out in a pleasing format that includes many screen shots (to illustrate the turtle’s behavior in the examples given); most pages have a wide left margin that gives you a place to write notes (if you’re the kind of person who writes in books).

*Apple Logo: Reference Manual*, by Laurence J. Davidson, is the one book I read cover to cover. It’s 186 pages long and covers all aspects of the Apple Logo package. I found it to be comprehensive, well organized, and easy to read.

Terrapin Logo is documented by two books, *The Terrapin Logo Language Tutorial*, by Deborah Tater and Patrick Sobalvarro, and *Logo for the Apple II: Technical Manual*, by Harold Abelson and Leigh Klotz Jr. These two books roughly correspond to the Apple Logo counterparts; the former is the tutorial book, and the latter is the reference manual. In comparison to the Apple Logo manuals, what the Terrapin manuals lack in “polish,” they make up for in content. The writing style of the tutorial book is not as calculatedly simple as its Apple Logo counterpart, but it is written in a friendly, conversational way. I think that, again, this is because Apple Logo is intended for a less technical (perhaps younger) audience. In contrast to the Apple Logo tutorial book, *The Terrapin Logo Language Tutorial* covers a larger subset of the Logo world; it includes sections on words, lists, and debugging. Appendix III, which explains rather well the concept of tail recursion, is particularly well done. (Tail recursion usually occurs when the last thing a recursive procedure does is call itself. When this occurs, Logo can treat the procedure as iterative instead of recursive, thus saving a lot of memory and allowing Logo to function more efficiently.)

*Logo for the Apple II*, by Harold Abelson (published by BYTE Books), is supplied with Krell Logo in place of the Terrapin tutorial book. It is easily the best tutorial book (for people who don’t need the gentle approach of the Apple Logo tutorial book) of the three Apple-based tutorial books. It comes the closest of the three to covering the entire Logo instruction set in a tutorial manner. It also has plenty of drawings and charts as well as spiral binding and wide margins on each page.

*Logo for the Apple II: Technical Manual* is the reference work for both Terrapin and Krell Logos. Its description of individual Logo commands is very terse (as opposed to the Apple Logo documentation, which gives a longer definition and several examples for each word), which may be a problem for some users. However, the manual does devote an entire chapter to the assembler and its use with Terrapin/Krell Logo; this chapter includes a lot of information on the internal structure of Terrapin/Krell Logo, something that Apple Logo does not do.

An 83-page book called the *TI Logo User's Manual* (by Diane R. Musha and other members of the TI Learning Center) is the only documentation available for TI Logo. The first 64 pages are tutorial and cover the TI Logo editor, saving and loading files to cassette or floppy disk, procedures, variables, the turtle, and the special features of TI Logo—sprites and tiles. A 9-page appendix lists and briefly defines all the predefined words in TI Logo; however, I found the definitions of HOME and SETSPEED to be incorrect and also found several basic Logo words (see page 262) that work in TI Logo but that are missing from the appendix. I think it is safe to say that any user will have to buy a supplementary textbook on Logo to get full use of TI Logo; the TI Logo documentation just doesn’t tell you all you need to know about the language.

A Few Benchmarks

I don’t want to give the impression that I have conducted an exhaustive set of benchmarks for the five Logos—I haven’t. At first, the idea of doing Logo benchmarks seemed almost sacrilegious, like trying to benchmark sunsets. Still, old habits die hard. . . .

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At first, the idea of doing Logo benchmarks seemed almost sacrilegious, like trying to benchmark sunsets. Still, old habits die hard. . . .
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the Apple-based Logos are within 20 percent of each other in workspace size.

It is more difficult to compare the Apple-based Logos to TI Logo because the latter does not have a command that returns the workspace size. So I created and ran two procedures that filled memory, thinking that the numbers they returned would be proportional to the relative sizes of the workspaces. (I chose to do a second procedure to confirm the results of the first; with only one procedure, I would have no way of telling whether the assumption that the numbers are proportional to the workspace sizes is valid.) The first procedure, FILLMEMORY (see listing 4a and 4b), fills memory by running an infinitely deep recursive procedure and printing out its current recursion level; the level at which the procedure runs out of memory should be proportional to the workspace size. (The second PRINT statement in FILLMEMORY is used to keep tail recursion, which would prevent true recursion, from happening.)

The second procedure, FILLPROC (see listings 4a and 4b), fills memory by creating a series of empty procedures, P1, P2, P3, and so on; the Logo word DEFINE is used to create new procedures under program control. As described in the last section on TI Logo, the version of FILLPROC had to be implemented differently because of the TI Logo instruction set.

The results of these two tests are given in table 3. The performance of all the Logos on FILLPROC is rather puzzling. Terrapin/Krell Logo (in comparison to Apple Logo) seems to do worse on FILLMEMORY and better on FILLPROC. These numbers should be discarded in favor of the node figures discussed above. In both cases, though, TI Logo did much more poorly than the Apple-based Logos, although I would hesitate to give a percentage figure based on these figures. TI Logo requires 48K bytes of memory (16K bytes in the TI-99/4A itself and 32K bytes in an expansion box), and according to a source at TI, the TI Logo cartridge takes up only a small area of memory itself. Thus the amount of free memory available to TI Logo is roughly equal to that of the Apple-based Logos; I don't think we can attribute the reduced TI Logo capacity to the available memory in the machine.

The other set of benchmarks tests the Logos' overall speed performance running a program that relies heavily on recursion (which most Logo programs do) and list manipulation. I used the SORT procedure of listing 2 to sort two lists: first, the list "LOGO IS AN INTERESTING LANGUAGE FOR PICTURE DRAWING, LIST MANIPULATION, AND EDUCATION); and second, [Z Y X W V U T R Q P O N M L K J I H G F E D C B A]. The timing results of these benchmark programs, given in table 4, show that Apple Logo is about 10 percent faster than Terrapin/Krell Logo, which will not be noticeable in most situations. TI Logo, however, is slower than the Apple-based Logos by a factor of two.

Which Logo Is Right for You?

If you skipped the rest of this article to read this section, you're out of luck—the answer to the above question is more in the body of this article.

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Table 3: Workspace size of the three implementations of Logo as indicated by the FILLMEMORY and FILLPROC procedures. See the section on benchmarks for details (see listings 4a and 4b on page 264).
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**Reference list:** A comparison of Apple, Terrapin/Krell, and TI Logo nongraphics and graphics-related commands.

**Notes**
1. This list does not include the 16 color names (RED, BLUE, ORANGE, and so on) used by TI Logo, nor does it include the two-letter abbreviations available for some Logo commands.
2. Words that perform the same function but have different names are listed alphabetically by first name.
3. An asterisk beside a command denotes that, in Apple Logo, the action of the word can be limited by inclusion of an optional package name; in this case, only objects "contained" in that package are affected.
4. These descriptions are not intended to be complete definitions of individual commands. A thorough understanding of Logo is necessary to understand some of them.

### Nongraphics Commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>+, -, */</td>
<td>adds, subtracts, multiplies, divides two numbers (integers only in TI Logo)</td>
</tr>
<tr>
<td>=</td>
<td>returns true value if two objects are equal to each other</td>
</tr>
<tr>
<td>&lt;, &gt;</td>
<td>does less-than or greater-than comparison on two numbers (integers only in TI Logo)</td>
</tr>
<tr>
<td>;</td>
<td>used to get the value of a variable name</td>
</tr>
<tr>
<td>;</td>
<td>used to mark the rest of the line as comments</td>
</tr>
<tr>
<td>;</td>
<td>used to prevent evaluation of the word that follows</td>
</tr>
<tr>
<td>ALLOF</td>
<td>returns a value of true if all inputs are true (Apple Logo uses AND; TI Logo uses BOTH)</td>
</tr>
<tr>
<td>ANYOF</td>
<td>returns true value if any of its inputs is true (Apple Logo uses OR; TI Logo uses EITHER)</td>
</tr>
<tr>
<td>ARCTAN</td>
<td>returns the arctangent of its input (Terrapin/Krell uses ATAN)</td>
</tr>
<tr>
<td>ASCII</td>
<td>returns the ASCII value of the character input (TI Logo uses CHARNUM)</td>
</tr>
<tr>
<td>BEEP</td>
<td>starts a tone</td>
</tr>
<tr>
<td>BURY</td>
<td>isolates a group of procedures from the rest of the Logo workspace</td>
</tr>
<tr>
<td>BUTFIRST</td>
<td>returns all but first letter/item of a word/list</td>
</tr>
<tr>
<td>BUTLAST</td>
<td>returns all but last letter/item of a word/list</td>
</tr>
<tr>
<td>BUTTONP</td>
<td>returns true value if specified paddle button is depressed (Terrapin/Krell Logo uses PADDLEBUTTON)</td>
</tr>
<tr>
<td>BYE</td>
<td>leaves Logo</td>
</tr>
<tr>
<td>CALL</td>
<td>assigns a value to a name (Apple Logo uses NAME)</td>
</tr>
<tr>
<td>CATALOG</td>
<td>displays names of all files on current disk</td>
</tr>
<tr>
<td>CATCH</td>
<td>user-defined error-trapping word</td>
</tr>
<tr>
<td>CHAR</td>
<td>returns character with a given numeric value</td>
</tr>
<tr>
<td>CLEARTEXT</td>
<td>clears all text from screen and puts cursor at beginning of first text line</td>
</tr>
<tr>
<td>CLEARINPUT</td>
<td>clears character buffer</td>
</tr>
<tr>
<td>CONTINUE</td>
<td>continues a procedure that has been paused</td>
</tr>
<tr>
<td>COPYDEF</td>
<td>copies a procedure definition into a new name</td>
</tr>
<tr>
<td>COS</td>
<td>returns the cosine of a given input (in degrees)</td>
</tr>
<tr>
<td>COUNT</td>
<td>returns the number of elements in a list</td>
</tr>
<tr>
<td>DEBUG</td>
<td>foggy debug state of computer; when on, the computer does an automatic pause when an error condition occurs</td>
</tr>
<tr>
<td>DEFINE</td>
<td>allows a new procedure to be defined under program control (without entering Edit mode)</td>
</tr>
<tr>
<td>DEFINEDP</td>
<td>returns true value if its input is the name of a defined procedure</td>
</tr>
<tr>
<td>DISK</td>
<td>returns drive, slot, and volume number of current disk</td>
</tr>
<tr>
<td>DIFFERENCE</td>
<td>returns the difference of two numbers</td>
</tr>
<tr>
<td>DOS</td>
<td>allows Logo to execute an Apple DOS command</td>
</tr>
<tr>
<td>EDIT</td>
<td>allows editing of an existing procedure</td>
</tr>
<tr>
<td>EDNS *</td>
<td>allows editing of a group of variable definitions (stands for &quot;edit names&quot;)</td>
</tr>
<tr>
<td>ELSE</td>
<td>marks action taken if the conditional expression of an IF statement is false (Apple Logo uses brackets in place of ELSE keyword)</td>
</tr>
<tr>
<td>EMPTYP</td>
<td>returns true value if object named is an empty list or word</td>
</tr>
<tr>
<td>END</td>
<td>signals the end of a procedure</td>
</tr>
<tr>
<td>EQUALP</td>
<td>returns true value if two objects are equal (TI Logo uses IS)</td>
</tr>
<tr>
<td>ERALL *</td>
<td>erases all objects (Terrapin/Krell Logo uses ERASE ALL)</td>
</tr>
<tr>
<td>ERASE</td>
<td>deletes the named procedure from the workspace (Apple Logo can delete multiple procedures)</td>
</tr>
<tr>
<td>ERASEFILE</td>
<td>erased a file from the disk</td>
</tr>
<tr>
<td>ERASEPICT</td>
<td>erases a graphics image from the disk</td>
</tr>
<tr>
<td>ERN</td>
<td>erases a list of variables from the workspace (Terrapin/Krell Logo uses ERNAME, which erases only one variable; ERN stands for &quot;erase name&quot;)</td>
</tr>
</tbody>
</table>
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in a VT103 video terminal with LSI 11/2 and
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DON'T ASK WHY WE CHARGE SO LITTLE, ASK WHY THEY CHARGE SO MUCH.
### Nongraphics Commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
<th>Apple Logo</th>
<th>Terrapin/Krell Logo</th>
<th>Ti Logo</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERNS *</td>
<td>erases a list of variables from the workspace (stands for &quot;erase names&quot;)</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>ERPS *</td>
<td>erases a list of procedures from the workspace (stands for &quot;erase procedures&quot;)</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>ERROR</td>
<td>prints out information explaining the most recent error</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>FIRST</td>
<td>returns the first letter/item of a word/list</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>FPUT</td>
<td>makes an object the new first element of an existing list</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>GOODBYE</td>
<td>reinitializes Logo, all previous work is lost</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>GO</td>
<td>goto statement for use within a Logo procedure</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GPROP</td>
<td>returns the value of a certain property of a variable</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>GREATER</td>
<td>returns true value if the first of the two numbers is greater than the other</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>IF</td>
<td>signals the beginning of an if...then...else construct in Logo</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>IFF</td>
<td>states the action to be taken if a previous test is false (Apple and Terrapin/Krell Logo also use IFFALSE)</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>IFT</td>
<td>states the action to be taken if a previous test is true (Apple and Terrapin/Krell Logo also use IFTTRUE)</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>INT</td>
<td>returns the integer portion of a number (Terrapin/Krell Logo uses INTEGER)</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>IS</td>
<td>returns true value if two items are equal</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>ITEM</td>
<td>returns the nth item in a list</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>KEYP</td>
<td>returns true value if a key has been pressed but not yet read (Terrapin/Krell and TI Logos use RC)</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>LABEL</td>
<td>within a procedure, used to mark the destination of a goto statement (TI and Terrapin/Krell Logo use the label name and a colon only)</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>LAST</td>
<td>returns the last letter/item of a word/list</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>LESS</td>
<td>returns true value if the first of two numbers is less than the second</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>LIST</td>
<td>makes a list from a series of items</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>LSTP</td>
<td>returns true value if the variable named is a defined list (Terrapin/Krell Logo uses LISTT)</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>LOAD</td>
<td>loads the contents of a disk file into the Logo workspace (TI Logo uses RECALL, Terrapin/Krell Logo uses READ)</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>LOCAL</td>
<td>declares a variable as local to the enclosing procedure without making it the argument of the procedure</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LPUT</td>
<td>makes an object the new last element of an existing list</td>
<td></td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>MAKE</td>
<td>assigns a name to a value</td>
<td></td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>MEMBERP</td>
<td>returns true value if the given object is an element of the given list</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>NAMEP</td>
<td>returns true value if the given name has a value</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>NOBEEP</td>
<td>turns off the tone started by BEEP</td>
<td></td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>NODES</td>
<td>returns the number of free nodes in the system (Terrapin/Krell Logo uses .NODES)</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>NOT</td>
<td>inverts a logical value</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>NOTRACE</td>
<td>turns off tracing feature</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>NUMBER</td>
<td>returns true value if its input is a number (Terrapin/Krell and TI Logo use NUMBER?)</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>OUTDEV</td>
<td>directs output to a device connected to Logo through an Apple peripheral card (Apple Logo uses .PRINTER)</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OUTPUT</td>
<td>causes a procedure to end and return a value to its caller</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>PA *</td>
<td>prints all procedures and names in the workspace (Apple Logo uses POALL; Terrapin/Krell Logo uses PRINTOUT ALL)</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>PACKAGE</td>
<td>puts a list of procedures into a named package</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PADDLE</td>
<td>returns the numeric value associated with a paddle (TI Logo uses JOY)</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PAUSE</td>
<td>suspends execution of an executing procedure and allows user to interact with Logo from the keyboard (TI Logo uses the Aid key)</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>PKGALL</td>
<td>puts everything not already in a package into a named package</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>PLIST</td>
<td>returns the property list of an object</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PN *</td>
<td>prints all the names in the workspace (Apple Logo uses PONS; Terrapin/Krell Logo uses PRINTOUT NAMES)</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>PO</td>
<td>prints a given procedure (Apple Logo can print several procedures; Terrapin/Krell Logo also uses PRINTOUT)</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>POPS *</td>
<td>prints the definitions of all procedures (Terrapin/Krell Logo uses PRINTOUT PROCEDURES)</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>POTS *</td>
<td>prints all the procedure names in the workspace (TI Logo uses PP; POTS stands for &quot;print out titles&quot;)</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>PPS *</td>
<td>prints all the property lists (stands for &quot;print out properties&quot;)</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>PRIMITIVEP</td>
<td>returns true value if the object is a Logo primitive</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PRINT</td>
<td>prints what follows and begins a new line</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>PRINT1</td>
<td>prints what follows without beginning a new line (TI and Apple Logos use TYPE)</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>PRINTCHAR</td>
<td>prints the character with a given number value</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>PRODUCT</td>
<td>calculates the product of two numbers</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>QUOTIENT</td>
<td>calculates the integer portion of the quotient of two numbers</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>RANDOM</td>
<td>generates a random number between 0 and n (TI Logo always generates an integer between 0 and 9)</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>
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<table>
<thead>
<tr>
<th>Command</th>
<th>Apple Logo</th>
<th>Terrapin/Krell Logo</th>
<th>TI Logo</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RANDOMIZE</strong></td>
<td>randomizes the values of all future calls to RANDOM; RANDOMIZE n sets up a repeatable set of values</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>READCHAR</strong></td>
<td>waits for a keypress, returns its numeric value (Terrapin/Krell Logo uses READCHARACTER)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>READLINE</strong></td>
<td>takes all data typed in up to a carriage return and stores it as a list (Apple Logo uses READLIST; Terrapin/Krell Logo uses REQUEST)</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td><strong>READPICT</strong></td>
<td>reads a picture file from the disk</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td><strong>RECYCLE</strong></td>
<td>performs a garbage collection to regroup unused nodes into one area (Terrapin/Krell Logo uses .GCOLL)</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td><strong>REMAINDER</strong></td>
<td>returns the remainder of a division operation</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td><strong>REMPROP</strong></td>
<td>removes a property from an object</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td><strong>REPARSE</strong></td>
<td>re-analyzes procedures in a workspace after other procedures have been erased</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td><strong>REPEAT</strong></td>
<td>executes a list a given number of times</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td><strong>RE RANDOM</strong></td>
<td>causes the RANDOM function to behave in a reproducible way (Terrapin/Krell Logo uses RANDOMIZE)</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td><strong>ROUND</strong></td>
<td>returns the input number rounded to the nearest integer</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td><strong>RUN</strong></td>
<td>executes the actions specified in a list</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td><strong>SAVE</strong>*</td>
<td>stores data or procedures on disk (TI Logo can also store to a cassette tape; Terrapin/Krell Logo can save entire workspace only)</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td><strong>SAVEPICT</strong></td>
<td>saves the current graphics image on disk</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td><strong>SENTENCE</strong></td>
<td>joins two or more inputs (words or lists) into a list</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td><strong>SET DISK</strong></td>
<td>specifies drive, slot, and volume number of active disk</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td><strong>SHOW</strong></td>
<td>prints the given object followed by a carriage return</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td><strong>SIN</strong></td>
<td>returns the sine of a given input (in degrees)</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td><strong>SQRT</strong></td>
<td>returns the square root of a given input</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td><strong>STOP</strong></td>
<td>stops a procedure</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td><strong>SUM</strong></td>
<td>returns the sum of two numbers (Apple Logo can take more than two inputs)</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td><strong>TEST</strong></td>
<td>evaluates a condition, influences execution of subsequent IFFALSE or IFTRUE command</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td><strong>THEN</strong></td>
<td>marks action taken if the conditional expression of an IF statement is true (Apple Logo uses brackets in place of THEN keyword)</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td><strong>THING</strong></td>
<td>returns the value of the input object</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td><strong>THING?</strong></td>
<td>returns true value if input object has a value</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td><strong>THROW</strong></td>
<td>user-defined error-trapping word</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td><strong>TO</strong></td>
<td>begins the definition of a procedure</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td><strong>TOLEVEL</strong></td>
<td>aborts all executing procedures (Apple Logo uses THROW &quot;TOLEVEL&quot;)</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td><strong>TRACE</strong></td>
<td>causes Logo to single-step through execution of all following Logo procedures until NOTRACE is executed</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td><strong>TRACEBACK</strong></td>
<td>if a program is paused, this command shows the user the nesting of procedures to get to the point at which the program is paused; a debugging aid</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td><strong>UN BURY</strong></td>
<td>cancels the effect of a previous BURY command</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td><strong>WAIT</strong></td>
<td>pauses the program for a specified time</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td><strong>WORD</strong></td>
<td>joins two numbers/words to make a single number/word</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td><strong>WORDP</strong></td>
<td>returns true value if its input is a word (Terrapin/Krell and TI Logo use WORD?)</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>.BPT</td>
<td>exits to the Apple monitor</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>.CALL</td>
<td>transfers control to a user-supplied machine-language subroutine</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>.CONTENTS</td>
<td>outputs a list of information about all the items in the workspace</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>.DEPOSIT</td>
<td>&quot;pokes&quot; a value from 0 to 255 in a specified memory location</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>.EXAMINE</td>
<td>&quot;peeks&quot; the 8-bit value in a specified memory location</td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>

**Graphics-related commands**

<table>
<thead>
<tr>
<th>Command</th>
<th>Apple Logo</th>
<th>Terrapin/Krell Logo</th>
<th>TI Logo</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BACK</strong></td>
<td>moves the turtle backward</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td><strong>BACKGROUND</strong></td>
<td>(Apple Logo) returns the color number of the current background</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td><strong>BACKGROUND</strong></td>
<td>(Terrapin/Krell Logo) sets the background to a given color (Apple Logo uses SETBG; TI Logo uses COLORBACKGROUND)</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td><strong>BACKGROUND</strong></td>
<td>(TI Logo) names the background of the screen as object being talked to</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td><strong>CARRY</strong></td>
<td>tells a sprite which object to carry (LOOKLIKE is a synonym in TI Logo)</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td><strong>CLEAN</strong></td>
<td>clears the screen of turtle graphics but doesn’t move the turtle (Terrapin/Krell Logo uses CLEARSCREEN)</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td><strong>CLEARSCREEN</strong></td>
<td>changes video display to turtle graphics screen, clears screen, and initializes turtle (TI Logo uses TELL TURTLE; Terrapin/Krell Logo uses DRAW)</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td><strong>CLEARTEXT</strong></td>
<td>clears the text screen (TI Logo uses CLEARSCREEN)</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td><strong>COLOR</strong></td>
<td>returns the color number of the sprite currently being talked to</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td><strong>CURSOR</strong></td>
<td>(Apple Logo) returns the position of the cursor</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td><strong>CURSOR</strong></td>
<td>(Terrapin/Krell Logo) puts the text cursor at the given location (Apple Logo uses SETCURSOR)</td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>

286 August 1982 © BYTE Publications Inc
Amdek's Video-300 green phosphor monitor is the easy-reading choice for almost any system—including IBM and Apple.

Everything about our 12" Video-300 monitor was designed to be easy. Easy to read. Easy to use. And easy to match up with practically any computer or word processing system, including the popular Apple and IBM personal computers. So it's easy to see why you should choose Video-300 for your text display needs.

Amdek's Video-300 monitor features:

- Non-glare screen to eliminate distracting reflections
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- 80 x 24 character display
- 18MHz band width 900 lines (center) resolution
- Built-in carrying handle for portability
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- UL, FCC approved
- Full one-year warranty covering parts and labor

So ask your dealer about Video-300—part of Amdek's complete line of color, green phosphor and black and white monitors. Then match Video-300's performance and price against any other display monitor. For quality and value, you'll choose Amdek.
<table>
<thead>
<tr>
<th>Graphics-related Commands</th>
<th>Apple Logo</th>
<th>Terrapin/Krell Logo</th>
<th>TI Logo</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOT put a dot at the indicated point on the turtle graphics screen</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>DRAW clears the graphics screen, makes the turtle visible, and puts it in the center of the screen</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EACH allows a set of commands to be applied to each of a group of sprites, in turn</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>FENCE tells turtle to draw without wraparound—gives error message if turtle tries to plot offscreen (Terrapin/Krell Logo uses NOWRAP)</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>FORWARD moves the turtle forward</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>FREEZE stops all sprite movement</td>
<td></td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>FULLSCREEN devotes entire screen to graphics (no text lines at bottom)</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>HEADING returns the heading number of the active sprite or turtle</td>
<td></td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>HIDETURTLE makes the triangular turtle shape disappear</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>HOME tells active turtle or sprite to go to center of screen</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>LEFT turns turtle or sprite left a given number of degrees</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>MAKECHAR allows user to redefine the shape of a given character (tile)</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>MAKESHAPe allows user to redefine the shape of a given sprite</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>NODRAW returns the entire video display to display of text (Apple Logo uses TEXTSCREEN; TI Logo uses NOTURTLE)</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>NUMBEROF allows user to check current value of a system variable (color, speed, etc.)</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>PEN returns values for pen type and color</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>PENCOLOR (Apple Logo) returns value of pen color</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>PENCOLOR (Terrapin/Krell Logo) sets the current turtle pen color (Apple Logo uses SETPC)</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>PENDOWN makes the turtle pen ready to draw a line</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>PENERASE makes the turtle pen ready to erase a line</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>PENREVERSE makes the turtle pen ready to reverse a line (draws if line isn't there, erases if it is; Terrapin/Krell Logo must use PENCOLOR 6 to get same effect)</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>PENUP makes the turtle pen inactive</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>POS returns the position of the turtle (TI Logo uses WHERE)</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>PUTTILE places a given tile (character) at a given location</td>
<td></td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>RIGHT turns a turtle or sprite right a given number of degrees</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>SCRUNCH returns the current horizontal-to-vertical aspect ratio for output to the video screen</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>SETCOLOR tells a sprite, tile (character), background, or the turtle's pen what color to be</td>
<td></td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>SETHEADING gives the active sprite or turtle a given heading</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>SETPEN sets color and type of turtle pen</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SETPOS moves the turtle to a new position (TI Logo uses SXY, which can also move sprites; Terrapin/Krell uses SETXY)</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SETSCRUNCH sets a new horizontal-to-vertical video display aspect ratio (Terrapin/Krell Logo uses .ASPECT)</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>SETSPEED gives the active sprite a given speed</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>SETX,SETY moves turtle to given x- or y-coordinate, other coordinate unchanged (TI Logo uses SX and SY, which can also move sprites)</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>SHAPE returns the shape number of the active sprite</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>SHOWNP returns true value if turtle is visible</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>SHOWTURTLE makes the triangular turtle shape appear</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>SPEED returns the speed value of the active sprite</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>SPLITSCREEN removes bottom area of graphics screen for text area</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>SPRITE returns optional word used with TELL to name a given sprite as the object being talked to</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>SV sets the x- and y-velocity of the active sprite</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SXV,SYV gives the active sprite a new x- or y-velocity</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>TELL used to activate a sprite, group of sprites, tile (character), background, or turtle to respond to future commands</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>THAW restores sprite movement after FREEZE command</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>TILE used with TELL to make a given tile active</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>TOWARDS returns heading value turtle would have if it were pointing toward a given position</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>TURTLE used with TELL to make the turtle active</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>TURTLESTATE returns pen position, turtle status, background color, and pen color</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>WHO gives the type and number of the active object (tile, sprite, turtle, etc.)</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>WINDOW allows the turtle to plot offscreen (although the plotting can never be seen)</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WRAP causes the turtle to appear on the opposite side of the screen if it attempts to go offscreen</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>XCOR,YCOR returns the x- or y-coordinate of the active sprite or turtle</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>XVEL,YVEL returns the x- or y-velocity of the active sprite</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>YOURNUMBER returns the number of the active sprite</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>
AND NOW...

A 32-BIT CAD/CAM SYSTEM
FOR UNDER $80,000

Last year Auto-trol Technology Corporation shipped the industry’s first 32-bit turnkey CAD/CAM system. Now we are introducing the first 32-bit CAD/CAM system for under $80,000... the Advanced Graphics Workstation (AGW).

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Table 4: Timing benchmarks of three implementations of Logo. The program being timed in test 1 is the Logo command SORT [LOGO IS AN INTERESTING LANGUAGE FOR PICTURE DRAWING, LIST MANIPULATION, AND EDUCATION]. The program being timed in test 2 is SORT [Z Y X W U V T S R Q P O N M L K J H G F E D C B A]. See listing 2 for the definition of SORT. The N/A under TI Logo for test 2 refers to the fact that TI Logo did not finish this test; it gave the error message OUT OF SPACE AT LEVEL 23 LINE 1 OF SORT. The times, given in seconds, are accurate to two significant digits. Also, the comments were taken out of the procedures before the benchmarks were run.

<table>
<thead>
<tr>
<th>Test # (see caption)</th>
<th>Time to Execute, in Seconds, When Running:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Apple Logo</td>
</tr>
<tr>
<td>Test 1</td>
<td>6.2</td>
</tr>
<tr>
<td>Test 2</td>
<td>4.5</td>
</tr>
</tbody>
</table>

Table continued from page 278:

than it is here. All the Apple- and TI-based versions of Logo are products of higher caliber than what we're used to seeing in the microcomputer software industry.

If you don't already have a computer, then your choice of computer will be influenced by such questions as: How much money do I have to spend? What things other than Logo do I want to do with this computer? What kind of person will be using Logo? and Do they have any special needs that would influence my choice? If you already have an Apple computer and don't know which version of Logo to buy, your choice will be influenced by the individual features of each version and how they relate to the intended users and programmers. (My own opinion is that Apple Logo is better for situations involving nontechnical users and that Terrapin Logo is oriented more toward the sophisticated programmer.)

Conclusions

Apple Logo is a very well done implementation of Logo. It contains some advanced features (such as property lists and packages) as well as extremely good documentation and features that are oriented toward usage by children or adults who don't have technical backgrounds. Several features—including its unnecessary use of Logo command inputs in list form and its lack of provision for comments—are not consistent with this orientation and may cause nontechnical users some problems at first. A sprite board will probably be available from the implementers of Apple Logo, Logo Computer Systems Inc.

Terrapin/Krell Logo is also very well done. It includes such advantages as a Utilities Disk with useful programs, a 6502 assembler, and the ability to interface Terrapin/Krell Logo with assembly-language routines. It has a program-tracing function that is very useful during debugging, and its editor and error messages are slightly better than those of Apple Logo. The documentation is very good, and a sprite board (probably cheaper than Apple Logo's but with somewhat different features) will be available. Your choice of Krell or Terrapin Logo will depend on the factors mentioned in the text of this article.

TI Logo is a good implementation of Logo, but it is not as good as the Apple versions. Its advantages are its low cost, sprites, and tiles; disadvantages include a smaller workspace and slower execution than in the Apple-based Logos, poor keyboard layout, and some irregularities in the system caused by poor design decisions.
A General-Purpose I/O Board for the TRS-80 Models I and III

The system bus is described, and plans are presented for an interface board with 24 lines of discrete input/output.

Several months ago (June 1982 BYTE, page 260) I described a general-purpose input/output (I/O) board for the TRS-80 Color Computer. This month I'll describe its counterpart, a general-purpose I/O board for the TRS-80 Model I and Model III. As I imagine that few of you have both a Color Computer and a Model I or III and perhaps some did not read the earlier article, I'll give you the details on the logic of the board, even though it is very similar to the Color Computer version. I'll also describe the internal workings of the Model I/III system bus, which is quite different from the Color Computer bus. And I'll give you the story on the slight differences between the Model I and III buses in the way the external I/O is connected.

The System Bus

It's true the Model I/III system bus is closely related to the Z80 microprocessor signals, although the Z80's manufacturer, Zilog, might not speak of it in mixed company. To describe the Model I/III system bus, therefore, I have to start with the Z80 signals.

Figure 1 on page 292 shows a general block diagram of the TRS-80 Model I system bus. In the following discussion, I'll talk about the Model I bus and then describe the Model III bus, which has some embellishments.

Model I bus. The Z80 has 16 address lines, labeled A15 through A0, most significant to least significant. The address lines are used to address RAM (random-access read/write memory), ROM (read-only memory), and I/O devices. The 16 address lines allow the Z80 to address 64K bytes of memory and 256 I/O devices.

Perhaps I'd better explain that the Z80 can use both memory-mapped and input/output-mapped I/O. Input/output-mapped I/O means that the Z80 has separate instructions (IN and OUT) for input/output, allowing all of the 64K-byte addresses to be used for memory if the system designer chooses. Input/output is specified by certain control signals that inform an external I/O device when an IN or OUT machine-language instruction, rather than a "memory-reference" instruction, is being executed.

Memory-mapped I/O is used in computers based on chips like the 6502 and 6809. A portion of the 64K-byte address space is dedicated to I/O addresses, and there are no control signals to indicate that input/output is being performed. To the processor, an input/output operation looks just like reading or writing data into memory. Of course, the system designer allocates certain addresses to memory and certain addresses to input/output devices, and the programmer works with this allocation in mind at all times.

The Models I and III were designed with both memory-mapped I/O and input/output-mapped I/O, as shown in figure 2. The keyboard, for exam-
S-100 Boards from S. C. Digital

256K DYNAMIC RAM

features: Model 256KE
- 16 or 24 bit address
- Transparent refresh with unlimited OMA, immune to Wait States, halts, resets
- Fast access time: 180nsec from Memr or Psync high, will run with Z80, Z8000 to 6mhz, 8080, 8085, 8086 to 8mhz without Wait States
- Accepts 4116, 4164's

64K DYNAMIC RAM 'Uniselect: 2'

features: Model 64KUS
- 16 or 24 bit address
- 8 bit data
- Bank Select by SW settable 8 or 16
- 16K x 8 Size
- Transparent refresh - same as M:256KE
- Fast access time - 220nsec, will run with Z80, Z8000 to 4mhz, 8080, 8085, 8086, 68000 to 5mhz without Wait States
- Can be configured to various multitasks OS's
- Expandable to 256KB using 4164's

32K STATIC RAM 'Uniselect: 3'

features: Model 32KUS
- Fully Static using 2K by 8 MOS chips
- 16 or 24 bit address
- 8/16 bit wide data
- Bank Select by settable bits in 32K block
- Two 16K block addressing with window capability in 2k increments
- EPROM can be mixed with RAM
- Fast access - 250nsec from address valid - will run with Z80, Z8000 to 4mhz, 8080, 8085, 8086 or 68000 to 8mhz without Wait States
- Provision for Battery Backup

Z80 CPU Board

features: Model CPU Z80
- 2 or 4mhz clock
- Jump on Reset
- 8 levels of prioritized vectored interrupts

I/O, Memory Interface 'Interface: 1'

features: Model 3SPC
- 3 serial using UART, RS-232C or 20ma current loop
- 4 Parallel I/O with handshakes
- 4k Ram, 4k EPROM (not supplied)
- Built in Kansas City Audio Cassette interface
- Baud rate generator from 15.2kbaud to 110 baud

2K Z80 Monitor Program

available for M:3SPC

features: many routines including breaker points, cassette record and play back...etc. Comes in 2 EPROMs and 1K RAM

All boards conform to IEEE696/S 100 specifications, fully socketed, screened legends, static. Gold contacts Guaranteed One Full year.

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Phone: (312) 897-7749

Figure 1: The system bus for the Model I is made up of 40 lines, very closely related to Z80 signals. Sixteen are address lines, eight are data bus lines, four are control signals for external devices, and the remainder are related to memory refresh, interrupt operations, and miscellaneous functions.
The Logo Language is Here for the Apple II

```
TO SQUIRAL :ANGLE :DISTANCE
IF :DISTANCE > 200 THEN STOP
FORWARD :DISTANCE
RIGHT :ANGLE
SQUIRAL :ANGLE :DISTANCE + 3
END
```

Terrapin, the Turtle Company, brings you the Terrapin Logo Language for the Apple II with Turtle graphics, now ready for immediate delivery.

The Terrapin Logo language is a sophisticated and powerful language that is easy for anyone to use. Although originally intended for children, the Logo language is one that the most advanced programmers will enjoy using too. It includes many features common to artificial intelligence research languages permitting programs of great power to be written quickly and easily. Writing comparable programs in other languages is usually much more difficult and time consuming.

The Turtle graphics is fun and easy. With simple commands such as FORWARD, RIGHT, and PENUP you can draw in six hi-res colors. In just a few short sessions you can learn to create figures more complex than the one above whether you know how to program or not.

But the Terrapin Logo language is more than just a graphics language. It supports:
- list structure, allowing easy manipulation of words (strings) and lists
- user defined procedures which can be used exactly as if they were part of the language.
- fully integrated screen editor for procedures and text
- floating point and integer arithmetic
- a total of 120 primitives (commands) including 30 graphics commands
- recursion
- assembly-language interface capability

The Terrapin Logo language was developed by the Artificial Intelligence lab at the Massachusetts Institute of Technology. Terrapin is now authorized by MIT to distribute the results of its 12 years of research to you. To provide quality support for the language, Terrapin has assembled a team that includes two of the three authors who developed the Logo language for the Apple II at MIT, as well as Dr. Feurzeig, an originator of the Logo language.

Every copy of the Terrapin Logo language comes with complete documentation. To run the language, a 48K Apple II with a 16K RAM card or a language card, and one disk drive is required.

Terrapin also offers the robot Turtle, and the following books: "Turtle Geometry, Special Technology for Special Children, Mindstorms, Katie & the Computer," and "Logo for the Apple II" from Byte Books.

Suggested retail price: $149.95
To order or for more information, call or write:

Terrapin, Inc.
360 Green Street
Cambridge, MA 02139
(617) 492-8816

In Canada:
SES Computing, Inc.
(416) 366-4242

Dealer Inquiries invited.
Test continued from page 291:

ple, is memory-mapped at memory locations hexadecimal 3801 through 3880; the cassette is I/O-mapped at hexadecimal location FF. I/O-mapped operations use separate IN or OUT instructions with I/O addresses of hexadecimal 0 through FF; these I/O ports are completely separate from the 64K-byte memory.

The 16 address lines are buffered by 74LS367 bus drivers to provide higher fan-out; they go out to all parts of the Model I, including the external 40-pin connector for the system bus. The address lines are unidirectional, that is, they are outputs only from the Z80.

Back to the Z80 signals. The next largest set of signals is the data bus, which is Z80 signals D7 through D0, most significant through least significant. The data bus is used to pass all data going between Z80 registers and memory and between Z80 registers and I/O devices.

Unlike the address bus, the data bus is bidirectional, permitting 8-bit transfers in both directions. Two sets of 74LS367 bus drivers are used, one controlled by a “data bus out” signal DBOUT*, and the other controlled by a “data bus in” signal DBIN*. (The asterisk is used in all Model I/III circuit discussions to indicate “active low.”) The data bus lines also go to the 40-pin system bus connector on the Model I.

Looking at the Z80 once again, you
Someday, in the comfort of your home, you’ll be able to shop and bank electronically, read instantly updated newswires, analyze the performance of a stock that interests you, send electronic mail across the country, then play Bridge with three strangers in LA, Chicago and Dallas.

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Someday is today with the CompuServe Information Service. CompuServe is available through a local phone call in most major U.S. cities. It connects almost any brand or type of personal computer or terminal with our big mainframe computers and data bases. All you need to get started is an inexpensive telephone coupler and easy-to-use software.

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The CompuServe Information Service is available at many computer stores across the country. Check with your favorite computer center or contact CompuServe.

Welcome to someday.

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An H&R Block Company

Circle 91 on inquiry card.
Our competitor on the right claims high resolution. But what about that glare? The washed-out background? And the black and white screen? It's enough to give you a headache.

The TeleVideo terminal on the other hand, with its finer character dot matrix, sharper background contrast, and a black-on-green non-glare Panasonic screen, is much easier on the eyes.

Obviously.

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find two sets of control signals: IORQ and WR/RD. Signal MREQ (the bar indicates a Z80 "active low" signal) is used to indicate that a memory operation is in effect and that there is a valid memory address on address lines A15 through A0. MREQ is used with RD to read data from ROM or RAM and with WR to write data to ROM or RAM. MREQ is also used for memory-mapped I/O devices, such as the keyboard.

Signal IORQ is used to indicate that an IN or OUT instruction is being executed and that there is an I/O address on address lines D7 through D0. IORQ is used with RD to read data into the Z80's A register from an external I/O device and to write data from the A register to an external I/O device. IORQ is the primary signal used for all types of I/O-mapped input/output.

The signals brought out on the system I/O bus, however, are not MREQ, IORQ, WR, and RD. The RD* signal is active (low) when RD and MREQ are active (during a memory read). The WR* signal is active (low) when WR and MREQ are active (during a memory write). The IN* signal is active (low) when IORQ and RD are active (input). The OUT* signal is active (low) when IORQ and WR are active (output). Then, these signals are partially encoded for external memory or input/output.

Other memory-related signals brought out on the system bus for "memory refresh" are MUX, CAS*, and RAS*. These three signals control memory refresh for the dynamic RAM chips used in the Model I and III. Since they're not used in external I/O, I'll omit any further details.

Other signals brought out on the Model I bus include INT*, INTAK*, TEST*, WAIT*, and SYSRES*.

INT* is an input and provides an external I/O interrupt. INTAK* is an "interrupt acknowledge" signal that indicates the Z80 received the interrupt.

TEST* is a signal that disables all data bus, address bus, and control signals; it is rarely used in Model I operations.

WAIT* is an input signal used to interface slow memory or I/O devices and is not ordinarily used. It dates from the time when memories were significantly slower than the microprocessor.

SYSRES* is an output signal that indicates power-up or reset (by the RESET button). It, like all of the signals with an asterisk suffix, is active low.

Model III system bus. Figure 3 shows a general block diagram of the Model III system bus, which differs from the Model I system bus in that it is more isolated from the internal processor signals. Only eight address lines are brought out, and a special "enable" signal gates the data, address, and control lines to the outside world.

The main enable signal is ENEXTIO*, which means enable external I/O. This signal is generated by 1 bit of a 5-bit latch with port address hexadecimal EC. When this bit is a 1, signal ENEXTIO* goes low, enabling the 74LS245 (XDB7 through XDB0),
the 74LS244 (XA7 through XA0), and the 74LS367 (control lines). If the 
ENEXTIO* bit is a 0, all of these lines 
are in the high-impedance (discon­
nected) state.

The XIORQ*, XM1*, 
I0BUSWAIT*, XRESET*, XOUT*, 
and XIN* control lines have the same 
functions as their Model I counter­
parts—WAIT*, SYSRES*, OUT*, 
and IN*. (IORQ* and M1* replace 
the encoded INTACK*.)

The I0BUSINT* is similar to INT* 
in the Model I, except that an enable 
signal, ENIOBUSINT (enable I/O bus 
interrupt), is used to determine when 
an external interrupt will be recog­
nized from the outside world. 
ENIOBUSINT is made active by 
writing a 1 to bit 3 of port address 
hexadecimal E0. I won’t discuss the 
external interrupts in this article, as 

Figure 4: External I/O operations use an I/O address on the address bus, the IORQ* 
signal, and the RD* or WR* signal to effect 8-bit data transfers to and from the external 
I/O device.

they make an interesting subject all 
by themselves.

The eight address lines are also 
logically equivalent to their Model I counter­
parts; they are XA7 through 
XA0.

The eight data bus lines XDB7 
through XDB0 have a slightly dif­
ferent gating scheme on the Model I 
from that on the Model III. Instead of 
two sets of buffers enabled by RD* or 
WR*, as in the Model I, there is one 
bus driver, a 74LS245. The main 
enable signal for this chip is 
ENEXTIO*, as I’ve already mentioned. Also involved, though, is signal 
EXTIOSEL*. When EXTIOSEL* is a 1, 
the 74LS245 routes lines D7A through 
D0A to the external bus connector. 
When EXTIOSEL* is a 0, the 74LS245 
routes lines from the external bus to 
lines D7A through D0A. EXTIOSEL* is 
normally high, allowing writes to an 
external I/O device to be made by 
simply turning on ENEXTIO* (address 
hexadecimal EC) and performing a Z80 
OUT instruction (or a BASIC OUT). If a 
read of an external device is to be 
done, however, external logic must 
bring down signal EXTIOSEL* at the 
proper time.

General Scheme for External I/O

The general scheme for Model I ex­
ternal I/O is fairly simple.

Output operation. The procedure 
for a write of 8 bits to an external 
device is as follows:

1. The 8-bit value to be written (0 
through 255) is put into the A 
register in the Z80.

2. A machine-language OUT instruc­
tion with an address of 0 through 
255 is executed.

The equivalent in BASIC is:

where XX is the I/O address and V is 
the value of 0 through 255.

Executing the machine-language or 
BASIC OUT puts the address of the 
I/O device on address lines A7 
through A0 and enables the OUT* 
signal. The external I/O device 
decodes the address lines when it 
receives the OUT* signal. If the exter­
nal I/O device recognizes its address, 
it strobos in the data that is present on 
the data bus lines. The entire process 
is shown in figure 4.

Output for the Model III is iden­
tical, except that the external I/O 
lines must first be enabled by setting 
bit 4 of address hexadecimal EC to 
enable signal ENEXTIO*.

Input operation. Input for the 
Model I is the following:

1. A machine-language IN or a 
BASIC INP instruction is ex­
ecuted, with an address of 0 
through 255.

2. Data from the input/output device 
is read into the A register or into 
the BASIC variable specified. 
The BASIC equivalent is 

100 OUT XX,V

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When the machine-language IN or BASIC INP is executed, the address of the I/O device is sent to the address bus lines A7 through A0. Signal OUT goes low, indicating to the external I/O logic that an I/O address is present on the address lines. If the address is decoded as the address of the I/O device, it responds by gating the 8 bits of data onto the data bus.

Input for the Model III is identical, except that the external I/O logic must also bring down signal EXTIOS* so that the 74LS245 bus driver switches direction, routing the data to the processor.

I/O addresses. The I/O port address used must be in the range of 0 through 127 because I/O addresses 128 through 255 are dedicated-system addresses in Models I and III. There are many addresses not used in the higher range, but it’s prudent to stay below 128 to avoid conflict. External I/O can be done without full-address-decoding logic.

A General-Purpose I/O Board

The circuit shown in figure 5 is a general-purpose input/output (GPIO) board that connects to the Model I or III system bus. It provides 24 I/O lines that can be either inputs or outputs. The lines can be used to drive relays for input or output as shown in the figure, to implement digital-to-analog or analog-to-digital converters, or for a variety of other applications. I’ll describe how the circuit works, give you some construction hints, and then show you typical uses in driving an LED (light-emitting diode) display and detecting a remote input.

The GPIO board uses an Intel 8255 Programmable Peripheral Interface, which is essentially a programmable controller. The mode that I am using in this implementation connects lines PA7 through PA0 and PB7 through PB0 as outputs and lines PC7 through PC0 as inputs.

The interface to the Model I or III consists of the eight data bus lines, three address lines, the IN* and OUT* lines, and in the case of the Model III, the EXTIOS* line. The IOBUSINT* line is also implemented but won’t be described in this article.
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Figure 5: The GPIO board for the Model I and III uses an Intel 8255 Programmable Peripheral Interface chip as a 24-line controller. Sixteen of the lines are outputs and control 74LS240 drivers. Eight of the lines are inputs.

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The address of the GPIO is any four sets of addresses in the lower I/O address range of 0 through 127. For convenience, you can look upon the addresses as 0, 1, 2, and 3, but the board will respond to any address with bit 7 equal to 0, ignoring bits 2 through 6. Address binary 01111100, for example, will be decoded the same as address 0.

The address of the latch associated with the PA lines (see figure 5) is address 0. Outputting data to address 0 will store the data pattern in the output and set the lines accordingly. The address of the latch associated with the PB lines is address 1. An identical type of output can be done for this latch. Address 2 controls the PC lines. Inputting data from this address will read the state of the eight lines.

The last address of the GPIO is address 3 (address binary xxxxxxll). This is the address of an internal control register in the 8255. Outputting a control word to address 3 configures the 8255. To get the configuration I've described, output a decimal 137. This needs to be done only once, at the beginning of any power-up sequence.

The normal sequence of events for using the GPIO is shown here:

100 'BASIC DRIVER FOR GPIO
110 OUT 236,16 'Model III only
120 OUT 3,137 'setup 8255
130 OUT 0,XX 'output to PA7-PA0
140 OUT 1,XX 'output to PB7-PB0
150 A=INP(2) 'read PC7-PC0

The first command sets the Model III EXTIOSEL*. (An important point: This command must be done at the start of any entry to a BASIC program and after any CLS command. When in doubt, issue another EXTIOSEL*. ) The OUT 3,137 command sets the 8255 to the proper I/O configuration. The next two commands output a byte to the two output ports. The next command reads in the configuration of the PC7 through PC0 lines.

The 8255 lines are connected to three 74LS240 line-driver chips. These chips provide up to 10 milli-amps (mA) of 5-volt (V) source current or 40 mA of 0-V sink current. The top two chips are connected as output drivers, and the bottom is an input driver.

**GPIO Construction**

The board is assembled on a Radio Shack prototype board (276-154). The board has a 44-pin connector on one end that mates with a Radio Shack plug (276-1551). The board will be identical for both the Model I and III version, but the cable for the plug will be different.

**Socket mounting and wiring.**

Mount five sockets on the board, as shown in figure 6. I used wire-wrap sockets for this version. You may use solder-type sockets if you prefer, as there are not a great many interconnections. The sockets should straddle the two etches that represent the Vcc (+5 V) and GND buses. Solder opposing socket pins to hold the sockets to the board. Connect 0.1-µfd disk capacitors to the Vcc and GND buses close to each integrated-circuit (IC) socket.

The pins are numbered as shown in the figure and correspond to the connector pin numbering. Use pin A as GND and solder a short wire to the GND bus as shown. Use the pin Z, which is on the opposite end of the plug, as Vcc and solder as shown.

Wrap the sockets as shown in table 1. Figure 6 shows the bottom view of the board with correct pin numbering. CON-F, CON-M, etc., shown in table 1, relate to the pins labeled F, M, etc., in figure 6.

**Checking the board wiring.**

After you've wired the board, check the wiring before plugging in any ICs. Two common pins fit nicely into the IC socket holes, as shown in figure 7.

**Cable fabrication.**

If the wiring checks out, you're ready to fabricate the cable. There are two cables, one for the Model I and one for the Model III, as shown in figure 8. Two wires go from the 44-pin connector end of the cable to a +5 V supply, as shown in figure 9.

At one end of the cable, use the Radio Shack 44-pin connector. Solder the connections.

---

Figure 6: The GPIO is built on a standard prototype board using wire-wrap IC sockets.
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Table 1: GPIO board wiring list. (CON-A, CON-F, CON-H, etc., are connection points in figure 6.)
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Figure 7: After GPIO board fabrication, the wiring connections should be checked out. Two common pins and a continuity tester or ohmmeter facilitate checkout.

**Figure 8:** Cable wire list and edge connector orientation.

**Figure 9:** The cable for the Model I is different from the Model III version. The Model I version uses a 40-pin edge connector, while the Model III version uses a 50-pin edge connector. Both versions use a 44-pin connector for the prototype board.

**Table: Prototype Board Connector Pins and Signal Connections**

<table>
<thead>
<tr>
<th>Prototype Board Connector Pin</th>
<th>Model I Pin</th>
<th>Model III Pin</th>
<th>Prototype Board Signal (Pin)</th>
</tr>
</thead>
<tbody>
<tr>
<td>K</td>
<td>19</td>
<td>33</td>
<td>IN *</td>
</tr>
<tr>
<td>J</td>
<td>12</td>
<td>35</td>
<td>OUT *</td>
</tr>
<tr>
<td>L</td>
<td>36</td>
<td>31</td>
<td>A7</td>
</tr>
<tr>
<td>M</td>
<td>27</td>
<td>19</td>
<td>A1</td>
</tr>
<tr>
<td>N</td>
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<td>PA</td>
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<td>1</td>
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<tr>
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<td>SIGNAL GROUND</td>
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<td>3 1</td>
<td>GND</td>
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<td>MODEL I</td>
<td>40 38 4 2</td>
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<tr>
<td>MODEL III</td>
<td>1 3 FRONT</td>
<td>47 49</td>
<td>(LOOKING IN TO EDGE CONNECTOR)</td>
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<tr>
<td>NC    NO CONNECTION</td>
<td>2 4 48 50</td>
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Listing 1: Demonstration program for output and input for the Model III. Delete line 110 for the Model I version.

100 'DEMO MODEL III PROGRAM FOR OUTPUT AND INPUT
105 CLS
110 OUT 236,16
120 OUT 3,137
130 PRINT @512+32,INPC2l
140 OUT 0,0
150 GOSUB 1000
160 GOTO 140
170 OUT 0,125
180 GOSUB 1000
190 GOTO 160
1000 FOR I=0 TO 100
1010 NEXT I
1020 RETURN

At the other end, use a 40-pin edge connector (Radio Shack 276-1558) for the Model I or a 50-pin edge connector for the Model III. Be sure to use the numbering shown in figure 8 for the edge connectors. The Model III connector uses the reverse numbering from the Model I connector! Connections may be made using ribbon cable (and forcing the ribbon cable onto the connector) or by simply soldering 24-gauge stranded copper wire to the connector pins.

If you are using individual wires, use cable ties to band the wire together into a single cable.

Testing the GPIO. When you have "buzzed out" the cable, plug in the ICs, connect the cable to the board, and connect the power-supply leads to the +5 V supply. (Do not plug the cable into the computer at this point.) Make a "smoke test" by momentarily touching the chips. The 8255 should be warm but not hot.

Turn off all power and plug the other end of the cable into the Model I or III. The proper orientation is shown in figure 10.

Execute the BASIC program shown in listing 1. (Eliminate line 110 for the Model I version of the board.) This program "toggles" the outputs of PA7 through PA0 at a low speed rate and also reads lines PC7 through PC0.

Carefully test the outputs of the first 74LS240 by the method shown in figure 11. Of course, you may use a voltmeter, logic probe, or 'scope if you have one. You should see the output change from 0 V to +4 V or so and back again.

Inputs may be grounded by connecting the input pins of the third 74LS240 to ground. You should see a 128, 64, 32, 16, 8, 4, 2, or 1 value displayed on the screen, corresponding to the bit position of the pin grounded.

The PB7 through PB0 outputs may be tested by substituting "OUT 1,0" and "OUT 1,255" for lines 150 and 170, respectively.

Typical Applications
To give you some flavor of how the GPIO board may be used, I’ve implemented a seven-segment LED display driver as shown in figure 12. The LED display used is a Radio Shack

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<td>Diablo 1600's</td>
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<td>DEC LA 34</td>
<td>NEC Spinwriter</td>
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<td>NEC Spinwriter</td>
<td>Okidata Slimline</td>
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<td>Lear Siegler 300's</td>
<td>T.I. 810 &amp; 820</td>
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<tr>
<td>Diablo 1600's &amp; 2300's</td>
<td>Okidata Slimline</td>
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<td>Lear Siegler 300's</td>
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Figure 11: After building the GPIO, the 24 lines may be tested easily by a LED/resistor tester for outputs and by grounding inputs.

Figure 12: Sample LED driver application for the GPIO. The seven segments of the LED display are driven by seven output lines from the 74LS240. LED segments turn on when the lines are at 0 volts.
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Listing 2: Demonstration program for the LED driver.

90 ' DEMO MODEL I PROGRAM FOR 7-SEGMENT LED OUTPUT
100 OUT 3,137
105 INPUT V
110 OUT 0,0
120 GOSUB 1000
130 OUT 0,V
140 GOSUB 1000
150 IF INKEY$="" THEN GOTO 110 ELSE GOTO 105
1000 FOR I=0 TO 1000
1010 NEXT I
1020 RETURN

---

Figure 13: Sample optoisolator application for the GPIO. A remote switch lights the LED contained within the optoisolator. This turns on the phototransistor, bringing the collector to a 0 level.

276-1648, but any similar common-anode display may be used.

The Model I BASIC program shown in listing 2 will drive the LED display and illuminate any combination of the seven segments. Insert a "95 OUT 246,16" for the Model III version.

A second application is a remote sensor. Although I've used just one input, up to eight could be used in the GPIO configuration I'm using.
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Listing 3: Demonstration program for optoisolator input.

100 'DEMO MODEL I PROGRAM FOR OPTO ISOLATOR INPUT
110 OUT 3, 137
120 PRINT INPC2>
130 GOTO 120

remote sensor uses a Radio Shack optoisolator IC. The optoisolator contains an infrared LED and phototransistor in one package, as shown in figure 13. Remote-switch closure lights the LED and causes the transistor to conduct, bringing the input line to pin 17 of the 74LS240 down to 0.

The optoisolator is a "current-driven" device, allowing the connecting line to be any length as long as the current is sufficient to light the LED and cause the phototransistor to saturate. The optoisolator eliminates the noise problem associated with TTL (transistor-transistor logic) inputs.

The wiring diagram for the remote sensor is shown in figure 13. Again, the resistors may be positioned on end. Use the program shown in listing 3 (Model I) or listing 1 (Model III) to test the optoisolator action.

A third application uses relay input or output. The physical layout for both input and output is shown in figure 14. Radio Shack 275 through 228 relays (22.5 mA) are used and may be mounted on the board as shown. These relays will handle up to 0.75 ampere (A) on their contacts and can be used to drive a load larger than the 10 or 40 mA output of the 74LS240.
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The Logo Journal

News and Views of the Logo Community

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Logo Music . Jeanne Bamberger 325
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Learning Physics from a Dynaturtle

Andrea A. diSessa and Barbara Y. White
The Division for Study and Research in Education
Massachusetts Institute of Technology
Cambridge, MA 02139

The Logo turtle has proved a remarkably good microworld in which students can experience and learn mathematics painlessly while pursuing personally satisfying activities. To see if a similar idea could work for physics, author diSessa created a dynamic turtle, dynaturtle for short, which obeys Newton's Laws of motion. A dynaturtle remains at rest or travels at a uniform velocity in a straight line except when acted on by forces. The forces are little pushes, or kicks, specified by the student via the keyboard. Depending upon their direction, kicks can cause the dynaturtle to speed up, slow down, or change direction. (Although a dynaturtle doesn't presently come built in to Logo, the language makes it extremely easy to add one.)

Experience with elementary school students proved that even simple activities with the dynaturtle (such as driving it to intercept a target) were, indeed, both motivating and instructive. For example, the students had an apparently deep-seated misconception that things always go in the direction you push them. In reality, as Newton showed and a dynaturtle exemplifies, a push merely adds to the existing momentum of an object and typically only deflects it.

When the students translated this belief about force and motion into a strategy for hitting the target, as shown in figure 1, they would inevitably miss the target. With time and practice, the feedback from the microworld allowed the students to gain a better understanding of how forces should affect the motion of an object. Subsequent work with university physics students showed misconceptions and patterns of learning similar to those held by the elementary school students. This accords with recent research that shows how little conventional instruction affects intuitive beliefs concerning the laws of physics.

Dynaturtle, like the original Logo turtle, is a tool for students and teachers alike. Various researchers have and are creating materials for using a dynaturtle in the context of a programming experience for elementary school students (including handicapped students, as a replacement for the usual kinesthetic experiences through which we develop physical intuition).

To aid in teaching physics, author White has developed a "curriculum" in the form of a series of games using the dynaturtle. The idea is that with particular goals and problem situations, the games will focus students' attention on difficulties in their conceptions about force and motion and thus, step by step, lead them to a solid understanding of the problem.

White's curriculum began with a detailed study of the many kinds of difficulties high school students have with fundamental force and motion problems. She concentrated on the simplest qualitative ideas where "formula cranking" will not help. Thereafter, she developed the series of games and also devised a set of problems to assess changes in the students' level of understanding. In a controlled experiment, the games proved strikingly successful at eliminating basic misconceptions and at improving overall understanding. This finding is an encouraging indication that such game-like activities can be used not only for entertainment, but also for solving significant pedagogical problems.

References
Logo music has been quietly evolving over the past 10 years within the larger Logo environment. Logo music was first implemented on the PDP-10 with the help of Terry Winograd, using a digital music-box peripheral designed by Marvin Minsky. The present version of Logo music, completed last year, was built by Leigh Klotz and Hal Abelson as a special version of Logo for the Apple II.

Logo music uses an ALF synthesizer board for sound generation connected to a simple stereo amplifier and two speakers. With the full capabilities of Logo itself (except for graphics), together with the ALF board, there are six operative voices, a six-octave range, eight parameters available for user manipulation of the sound envelope, two percussion sounds, and almost immediate response time between typed commands and resulting sound. Altogether this makes quite a powerful system for interactive, composition-like projects.

In the spirit of Logo, the music language has been designed to be as intuitive as possible while at the same time lending itself to serious, almost endlessly expanding musical projects. The system is sufficiently flexible and powerful to be appropriate for beginning or more advanced music students of any age. It can be used as “scratch paper” for musically sophisticated composers who wish to experiment with musical design through procedural descriptions.

The system is also useful as an additional medium (along with turtle geometry, for instance) within which to develop procedural thinking, problem-solving skills, new applications for general arithmetic functions, and concepts concerning speed and distance relations.

Logo music contrasts with other educational computer-music programs in two fundamental ways: (1) based on our ongoing research into musical cognition, we have tried to develop an environment that builds on students' intuitive musical knowledge rather than simply computerizing traditional music instruction, and (2) we have tried to exploit the potential of the computer for truly interactive, real-time experimenting.

For example, we have made it easy for students to design higher-level procedural descriptions of musical relations. For example, the notion of meter is not taken as given but as something to be generated procedurally by the students themselves. The structure of the major scale (or, indeed, tonality) need not be simply taken for granted but rather can be constructed as a procedure that chooses from the complete pitch col-

```logo
TO REPNUM :NUM :TIMES
  IF :TIMES = 0 STOP
  PRINT :NUM
  REPNUM :NUM :TIMES -1

TO BEAT :DUR :TIMES
  IF :TIMES = 0 STOP
  BOOM :DUR
  BEAT :DUR :TIMES -1

TO UPPITCH :PITCH :INCREMENT
  IF :PITCH > 12 STOP
  PLAY :PITCH 6
  UPPITCH :PITCH + :INCREMENT :INCREMENT

TO SQUIRAL :SIDE :INCREMENT
  IF :SIDE > 200 STOP
  FORWARD :SIDE RIGHT 90
  SQUIRAL :SIDE + :INCREMENT :INCREMENT
```

Figure 1: Four Logo procedures with the same structure produce different effects.
ATARI HOME COMPUTERS

ATARI 800  ATARI 400
16K ... $649  16K ... $269
32K ... $729  32K ... $389
48K ... $769  48K ... $489

416 Recorder .......... $76.00
810 Disc Drive .......... $449.00
822 Printer .......... $589.00
825 Printer .......... $89.00
820 Printer .......... $259.00
850 Interface .......... $169.00
New DOS 2 System .......... $29.00
CX30 Paddle .......... $18.00
CX40 Joy Stick .......... $18.00
CX83 16K RAM .......... $74.95
Microtek 16K RAM .......... $119.95
Ramdisk (128K) .......... $429.00
Intec 48K Board .......... $219.95
Intec 32K .......... $19.95
One year extended warranty .......... $70.00
481 Entertainment .......... $29.00
482 Educator .......... $130.00
483 Programmer .......... $49.00
484 Communicator .......... $344.00

ATARI HOME COMPUTER PROGRAMS
HOME OFFICE
CX4040 Atari Word Processor .......... $119.00
CX8102 Calculator .......... $22.00
CX412 Dow Jones Investment Manager .......... $98.00
CX4103 Graph IV Joy Stick optional .......... $17.00
CX4104 Mailing List .......... $22.00
CX4115 Mortgage & Loan Analysis .......... $429.00
CX4103 Statistics I .......... $22.00
CX8107 Stock Analysis .......... $22.00
CX4109 Technical Writer .......... $299.00
HOMESTUDY
CX3080 An Invitation to Programming 2 .......... $22.00
CX4106 An Invitation to Programming 3 .......... $22.00
CX4117 An Invitation to Programming 4 .......... $22.00
CX4128 Energy Car .......... $13.00
CX4114 European Countries & Capitals .......... $77.95
CX4108 Hangman, Joy Stick optional .......... $13.00
CX4102 Kingdom .......... $13.00
CX4107 Music Composer .......... $34.00
CX4123 Scram, uses Joy Stick .......... $22.00
CX4108 States & Capitals .......... $13.00
CX4116 Touch Typing .......... $20.00
HOME ENTERTAINMENT
PAC MAN .......... $35.00
CENTPEDE .......... $35.00
CAVERNS OF MARX .......... $32.00
CX4103 Asteroids .......... $29.00
CX4104 Basketball .......... $27.00
CX4105 Baseball .......... $69.00
CX4109 Computer Chess .......... $99.00
CX4102 Command Game .......... $29.00
CX4108 Space Invaders .......... $29.00
CX4111 Star Raiders .......... $39.00
CX4108 Super Breakout .......... $25.00
CX4110 3-D Tic-Tac-Toe .......... $27.00
CX4105 Video Exercise .......... $27.00
PH41084 Foreign LANGUAGES AND AIDS
CX4100 Assembler Editor .......... $47.00
CX4102 ATARI BASIC .......... $47.00
CX8126 ATARI Microsoft BASIC .......... $70.00
CX4106 PILOT .......... $72.00
CX4050 PILOT (Educational) .......... $195.00

Vicsalc ................. $109.00
Leopard ................. $109.00
Data Soft Textwriter .......... $39.00
City Climber .......... $24.00
Tumble Bug .......... $24.00
Shoot Arcade .......... $24.00
Pacific Coast .......... $24.00
Bishops Square .......... $24.00
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ATARI PROGRAM EXCHANGE
Eastern Front '91 .......... $25.50
Avalanche .......... $15.50
747 Landing Simulation .......... $15.50
Babe '91 .......... $15.50
Dog Death .......... $15.50
Dowhill .......... $15.50
Blackjack-Casino .......... $15.50
Reversi II .......... $15.50
Domination .......... $15.50
Solitaire .......... $15.50
Disk Fixer .......... $15.50
Superiority .......... $15.50
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Invasion .......... $15.50
My First Alphabet .......... $15.50
Mispawn .......... $16.00
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Outlaw Planner .......... $15.50
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Bermuda Fantasy .......... $26.00
Beneath Pyramids .......... $26.00
Gale Force Mountains .......... $26.00
House of Usher .......... $26.00
Frogger Island, Haunted Palace .......... $33.00
Compumax (Acct. Rec., Gen. Ledger, Office) .......... $110.00
Synapse
File Manager 800 .......... $75.95
Doge Racer .......... $16.00
Chicken .......... $24.00
Silk Road .......... $24.00
Nautilus .......... $24.00
Disk Manager .......... $24.00
Fort Apache .......... $24.00
Joysticks optional .......... $39.00
Protect ................. $24.00
EXPY (Automated Simulation) .......... $24.00
Roach ..... $14.50
Crash, Crumple & Crash ..... $24.00
Snowman ..... $24.00
Star Warrior ..... $29.00
Rescue at Rio ..... $24.00
Space Invaders ..... $16.90
Online
Jaw Breaker ..... $27.00
Moust Attack ..... $31.00
Invasion Orc ..... $16.50
Mission Asteroid ..... $22.00
The Next Step ..... $27.00
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Arcade Plus
Ghost Hunter (cassette) ..... $24.00
Ghost Hunter (disk) ..... $30.00
K-Lock
K-BYTE Krazy Shoot Out (ROM) ..... $39.00
K-DOS ..... $69.00
K-Rays Kritters ..... $39.00
K-Star Patrol ..... $39.00
K-Rays Antics ..... $39.00
Disk Stand ..... $6.99

Texas Instruments

TI-99/4A $299

PHA2010 R F Modulator .......... $29.00
PH1000 Telephone Coupler .......... $175.00
PH1200 Peripheral Expansion Box .......... $195.00
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PHM3009 Physical Fitness .......... $26.00
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PHM3018 Video Games I .......... $26.00
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PHM3032 Blackjack and Poker .......... $35.00
PHM3033 Blackjack and Poker .......... $22.00
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T Invaders .......... $34.00
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Printers

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Centronics 739-A .......... $59.00
Centronics 739-B .......... $129.00
Epson
MX80 w/Graftrax .......... $449.00
MX80FT III ..... $2Call
MX1000 .......... $2Call
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K232 .......... $549.00
77007700 .......... $209.00
31550250 .......... $129.00
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B2A .......... $499.00
B5A .......... $749.00
B6 - $1129.00
S Iomega
Disk Fixer .......... $15.00
Diskette 3.5 READY-SET-NOBug .......... $15.00
F10-40 CPS .......... $149.00
F10-55 CPS .......... $5Call
F10-60 CPS .......... $5Call
Disk ProdwooR .......... $499.00
Talley
W184B .......... $1629.00
IDS .......... $15Call

Computer Covers

Most software for Atari 400/800 available on cassette or disk.

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| HP 41CV Calculator | $239.00 |
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Leading Fish to Water
Early Observations on the Use of Logo

Dr. William Higginson, Chairman
Science, Technology, and Mathematics
Faculty of Education
Queen's University
Kingston, Ontario
Canada K7L 3N6

Since August 1981, the Faculty of Education at Queen's University has, through the kind permission of Professor Harold Abelson, been a test site for the MIT version of Logo for the Apple computer. For six months, using a prototype of the system now distributed commercially by Terrapin and Krell, a small group of faculty members, graduate students, local teachers, and interested members of the community has spent time using the Logo facilities of the Instructional Computing Laboratory, which has five Apple II Plus computers.

The Logo learners varied in age from 6 up (several people worked with their own children) and the class size ranged from 1 to 15. Although no systematic study was carried out (our first intention was to familiarize ourselves with the system), there appears to be a consensus on a number of issues. Perhaps the two most important have to do with the potential of Logo and the likelihood of this potential being realized in schools. Briefly stated, our enthusiasm for the language started out high and has continued to grow, but we are not optimistic about the chances of an authentic version of Logo reaching the average classroom.

We cannot fail to be impressed by the quality of the work done by Seymour Papert and his colleagues. The claims made in Mindstorms, for example, are ambitious and ones about which a cautious observer would tend to be skeptical. Our feeling, however, at least at this early stage in our work, is that these claims are substantially sound.

Logo appears to touch something quite fundamental in children's learning procedures irrespective of the "school ability" of the child. The speed at which the group of self-confident 10-year-olds in my afternoon enrichment class grasps ideas is, however, particularly impressive. Negative numbers and Cartesian coordinates, for instance, get gobbled up in a two-minute discussion of SETXY. The unforced way in which powerful ideas emerge from the turtle geometry microworld is in stark contrast to the struggles of traditional teaching. The old riposte "you can lead a horse to Euclid but you can't make him think" did not seem to apply. The naturalness of the children's responses to questions that emerged from Logo situations made me feel that I was bringing not horses (or cats) to this educational pond, but fish.

It seems, then, that Logo is not just the best educational software on the market at the moment (not, in itself particularly high praise), but a new type of educational resource with enormous potential for developing
the social, aesthetic, emotional, and intellectual abilities of learners. I wish that the availability of such a powerful tool would, by itself, imply an improvement in the quality of education of the average child. Unfortunately, a realistic assessment of the situation indicates that such a result is not very likely. One basic problem lies in the absence of what is known in the Third-World context as "secondary infrastructure." At the first or developmental level, excellent work has been done, and at the third or field level, there is a great need for a resource such as Logo. Yet between these two levels, where a substantial group of well-trained and experienced consultants and teacher educators is essential, there is an almost total void. It will be the rare classroom teacher who will be able to get assistance from anyone who has had any degree of experience with the use of Logo. Resource materials such as Abelson and diSessa’s excellent *Turtle Geometry* are simply out of reach of most teachers without regular and sustained assistance. It seems unlikely that this assistance is going to be available to more than a small percentage of teachers.

A second and probably greater barrier to the implementation of an authentic version of Logo in schools is the nature of the underlying philosophy of the language. Logo is child-centered and, at least on the surface, unstructured and nonhierarchical. Many teachers at present feel pressured to have formal, hierarchical and content-centered curricula. There is, however, much more structure to Logo than meets the eye; students are free to roam wherever they choose within the boundaries established by the rich and highly structured Logo environment.

Logo no doubt will be used, but the form of Logo that will evolve in many cases will have little in common with Papert’s original vision. Just as educational psychologists in North America ignored the inherent contradictions between neobehaviorism and the child-development theories of Piaget, curriculum writers will see no difficulties in the creation of turtle geometry workbooks to teach basic mathematics in a highly formalized way.

At another level, however, the "degree of guidance" problem is difficult to cope with. The questions of what sort of assistance is best for which children under what circumstances are not likely to find any quick or widely agreed upon answer. Nor will any of the widespread problems that face classroom teachers automatically disappear with the introduction of Logo. In the long run, languages like Logo may prove to be a help with children who are emotionally disturbed or educationally handicapped, but that remains to be seen.

To say these things is not to disagree with Papert. For teachers who feel comfortable with mathematical ideas like recursion and symmetry and who have some freedom of choice in curriculum matters, Logo is likely to be, at least in the short run, a powerful educational tool. (The value of long-term use of Logo is a more open question. I am aware of no extended studies of children using Logo.) For the other group of teachers a great deal of work must be done before they can realistically be expected to use the power of this most attractive language.

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**Logo Project PROKOP**

Heinz-Dieter Boecker and Gerhard Fischer  
Research Group on Man-Machine Communication  
Department of Computer Science  
Azenbergstrasse 12  
D-7000 Stuttgart  
West Germany

The Logo research project in Darmstadt, West Germany, started in 1974 and ended in late 1979. It was a large project conducted by an interdisciplinary group of up to seven researchers and supported by the federal government.

Work started after an evaluation study of computer uses in schools which concluded that the most promising way to use computers was not CAI (computer-aided instruction) but to give the computer to the student as a tool.

Empirical work was considered important right from the beginning and the project installed several terminals connected to a DEC PDP-10 at a local high school (later on, personal Logo machines from General Turtle were added). Of the different approaches tried in the project, only the work done by the two authors will be surveyed in the following description. Other approaches involved different kinds of experimental classes and students of different ages.

We worked with high school students from 15 to 18 years old. Our main concern was to teach problem solving in the context of an interesting environment. We taught several experimental classes over periods...
ranging from 18 months to 2 years. We considered the long duration important so the students would have time to get beyond the stage of solving trivial problems or fighting with the technical problems of the system.

We used Logo quite differently compared to other Logo projects. Although turtle geometry was one of our projects, our main concern was using Logo as a full list-processing language that makes possible projects of nontrivial complexity. Seen from this perspective, Logo is a version of LISP that is oriented toward the non-expert user.

We have developed extensive curriculum material that we tested with the students and have carefully documented (including a very detailed documentation of the programs) in five volumes covering non-numerical mathematics, linguistics, computer science, artificial intelligence, and games. The publications are in German and can be ordered at the following address: Hessisches Institut fuer Bildungsplanung and Schulentwicklung, Bodenstedstrasse 7, D-6200 Wiesbaden, West Germany.

The theory of our work was based not only on Piaget’s research but also on problem-solving work from Polya and Newell and Simon. We made some efforts to teach cognitive abilities (e.g., planning, abstraction, generalization, and understanding) by doing projects in the above areas.

We made a big effort to integrate our work with the students’ other activities and interests. It seems to us that many Logo projects failed to achieve this integration. We felt we had to build bridges between the innovative strategies of the Logo work and the other interests of students and teachers. One of our goals was to create a place for this work in German schools, and we were in favor of establishing a new discipline of computer science (not just an imitation of the university subject) in German high schools.

We tried to use the existing expertise in German schools, which was in BASIC programming, and showed how to practice a functional, procedure-oriented style of programming with some versions of BASIC.

Our more theoretical work included among other things the development of a theory for the construction of learning environments through the creation of entry points, transient objects, and microworlds. The last two topics are described in two English papers by the authors published in the proceedings of the International Federation for Information Processing world conference on “Computers and Education,” Lausanne, 1981. These two papers also give references to our other related work.

The Group of the Turtle

Dr. Uri Leron
Computers in Education Laboratory
The School of Education
Haifa University
Haifa, Israel 31999

When observing children working with the Logo language, it is obvious that a lot of group theory goes on. This project investigates the place of group theory in Logo work from three points of view: mathematical, computational, and educational. [Editor's Note: Group theory is a branch of mathematics that deals with the study of mathematical groups. In common terms, a mathematical group is a collection of objects (such as members) and operations (such as addition) such that the result of every operation is another object in the group. The set of actions carried out by the Logo turtle form a mathematical group, called “the group of the turtle” in this article. The article refers to a set of studies of the ways that children who learn Logo learn about the properties of mathematical groups.]

Mathematically, myself and my colleagues want to make explicit the group-theory concepts and structures that are implicit in Logo. This forms a bridge between Logo and standard mathematics and prepares the ground for the later stages. The basic object here is the turtle group, generated by the turtle operations FORWARD, BACK, RIGHT, and LEFT with all possible inputs. (Adjoining the PEN and ERASER commands to the group raises interesting issues.) Here are, in brief, some more group-theory concepts that we have observed in the children’s work (accompanied by their Logo counterparts):

• products and decompositions (paths traced by the turtle)
• inverses (opposite operation)
• the order of a group element (the number of repetitions to close a path)
• conjugacy (transparent operations and procedures)
• subgroups (limiting oneself to only a special subset of allowable inputs)
free groups (this is where the Logo procedures live)

• homomorphism (the relation between Logo procedures and their products)

For example, the fact that the path drawn by REPEAT 5 [FORWARD 50 RIGHT 144] closes is reflected in the group by the relation \((F_{50} \times R_{144})^5 = I\) (the identity element); that is, by the fact that the group element \(F_{50} \times R_{144}\) has order 5.

Computationally, we try to bring these concepts to the fore by implementing a special-purpose set of primitives to encourage explorations in the turtle group. This is related to Seymour Papert’s notion of micro-worlds. For example, the procedure FIND.ORDER takes a list of turtle commands as input, repeats this list until the path closes, and outputs the number of repetitions.

Educationally, we plan to observe children of various ages (as well as adults) working with a group-theory-speaking turtle and see to what extent informal learning of these concepts does occur.

This work may be extended in many ways. Here are two. First, different turtles give rise to different turtle groups (see diSessa’s dynaturtles, in Papert’s Mindstorms and see page 324 in this issue), and it is interesting to explore the collection of groups that can be naturally represented as turtle groups for some turtles. Second, the method of implementing a special-purpose vocabulary may be applicable in many areas. This is probably the Logo analog of the notion of courseware development in more standard computer applications. It helps direct the explorations of the children working in Logo to specific subject-matter areas, without sacrificing the spirit of spontaneous and meaningful learning.

The Lamplighter Project

Henry Gorman Jr.
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Austin College
Sherman, TX 75090

Typically, when researchers wish to determine the effectiveness of an educational method, they design a program, randomly assign students to either that program or a control group, administer a test instrument specifically designed to measure performance from the program, and then express surprise that the students in the control group do not perform as well as the students in the special program.

Many advocates of the use of computers in education have been among the most flagrant with such techniques. The research literature overflows with such studies where, for example, after six months of intensive drill on addition, students’ addition skills improve. Perhaps such teaching to specific test questions has an appropriate place in education, but it is much more important that students learn how to think, how to solve problems, and how to learn. One of the objectives of the Lamplighter project was to determine if Logo could be used by students to learn better thinking, problem-solving, and learning skills.

It is, of course, a simple matter to assess addition skills. By comparison, it is quite complicated to measure thinking, problem-solving, or learning skills. No one test and no single study can do more than begin to explore these skills and changes in them that result when children use Logo.

I used a test called rule learning, taken from cognitive psychology. In rule learning, students are shown a series of pictures, usually with one of several shapes shaded in one of several colors, with the size of the shapes shown either small, medium, or large (comparatively) and with either one, two, or three exact replicas of the shape present. For example, a picture might show three small, red triangles or one large, blue circle. In rule learning, students are told which features to pay attention to, e.g., a problem might have red and circle as relevant features, and students would be told to pay attention to them. Students are then required to learn what combination of those relevant features satisfies the binary rule chosen by the experimenter. For red and circle relevant, the possible rules are conjunction (only pictures of red circles obey the rule), disjunction (pictures of any red shape and of any circle obey the rule), conditional (pictures of red circles and of any circle obey the rule), and biconditional (pictures of red circles and of all nonred shapes fit the rule “if red, then circle; if not red, then any shape”), and biconditional (pictures of red circles and of nonred, noncircular shapes fit the rule “if red, then circle; if not red, then not circle”).

To solve a rule-learning task, students have to be able to symbolically manipulate the features, ignore irrelevant features, process information from current pictures, and combine that information with their memories from previous pictures. For third
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graders, the conjunctive and disjunctive rules are fairly simple because the students experience forms of these rules in their everyday lives. The conditional rule is much more difficult for them, and the biconditional is harder still.

Students in the Lamplighter School third grade were randomly assigned to one of three homerooms which had two Texas Instruments computers. Five more computers were located in the shared space between the three rooms. After homeroom, students went on to classes with each of the third-grade teachers. Two of the third-grade homeroom teachers elected to ensure that each pupil received one half hour of Logo a week and the other teacher set a one-hour-a-week minimum for her students.

This difference existed from the start of the school year through the last week in April when students from all three classes were given the task of learning the conditional rule. The students from the one-hour Logo homeroom performed significantly better than the other two groups and better than even a sixth-grade level.

What is most important about these results is that the children were not taught to the test. Rather their extra Logo sessions improved a more general problem-solving skill. It would be premature to take this one study as conclusive evidence that Logo improves all thinking. The results should be taken to encourage similar studies with other measures of thinking and other groups of people.

Microcomputers are being used in many schools throughout the United States in the belief that they have important educational potential for children. However, little research indicates what children learn from working with microcomputers, how they learn to work with the technology, and in what ways such skills relate to other academically relevant skills. We are particularly interested in the educational possibilities for children who learn to program microcomputers with Logo. Among the organizations funding the Center's research are the Spencer Foundation, the Xerox Foundation, and the International Paper Company Foundation.

Our research is concerned with revealing how children acquire computer programming skills and how the use of microcomputers in classrooms may relate to other cognitive and social skills. Research supported by the Spencer Foundation is being conducted in two classrooms (one of 8- and 9-year-olds and another of 11- and 12-year-olds) of the Children's School at Bank Street College of Education. The children are learning to program with Logo, and in each classroom they have access to six microcomputers. They can work alone or together as active programmers of their own projects.

We are investigating a number of specific questions concerning
children's experience with Logo. One set of studies addresses the relationship between computer programming and problem-solving skills. It has been widely assumed that computer programming experience will enhance problem-solving abilities (Papert, 1980) because of the modular character of the work and the necessity of using debugging processes. However, this assumption has never been systematically tested. Therefore, one aim of our research is to examine relationships between the degree of Logo programming expertise and problem-solving and planning skills through longitudinal studies. This will enable us to determine the impact of Logo programming skill development.

As part of this investigation of the development of children's programming abilities, we will document the growth of knowledge about Logo as a language as well as knowledge of computers. Our work on Logo programming expertise will center on case studies of changes in children's knowledge of Logo over time in relation to the use of their knowledge to achieve project goals.

We are also investigating the social context of microcomputer use in classrooms. It has been observed in several different educational contexts that children seem to collaborate and teach each other more when they work with microcomputers. One study which we have completed indicates that children talk more to each other about problems they are doing when they work with the microcomputers, as opposed to other classroom work. Both the occurrence and quality of the interaction when children work together are of interest to us because we believe collaborative work to be an important learning context.

In addition, we are documenting the process by which the teachers incorporate microcomputers and the use of Logo into their classrooms. This work will be useful for addressing key questions concerning the best ways of using microcomputers with children in school. The research is intended to clarify our basic understanding of planning, problem solving, and peer interaction in classrooms for this relatively new domain.

And this is the way to educate children: the instinctive way of mothers. There should be no effort to teach children to think, to have ideas. Only to lift them and urge them into dynamic activity. The voice of dynamic sound, not the words of understanding. Damn understanding. Gestures and touch, and expression of face, not theory. Never have ideas about children—and never have ideas FOR them.

—Fantasia of the Unconscious and Psychoanalysis and the Unconscious

D. H. Lawrence

This quote from D. H. Lawrence is what the Young People's Logo Association is all about. But at the time of our founding, in summer 1981, no one was thinking about Lawrence's statement. We thought we could just buy a few TI-99/4 Logo systems and let my son, Larry, and his friends enjoy having a young people's users' group and software exchange. We soon started writing a newsletter.

We also wanted disabled individuals to enjoy the fruits of the computer revolution. We were dismayed to find so little information available on computer applications for the disabled but pleased to learn of the experimental success in this field with Logo.

We soon developed into a small group of teachers, media specialists, and journalists who wanted young people and the disabled to participate fully in the world of computers. We have come to believe that Logo and turtle graphics can open this world to both groups.

At first we thought we would be corresponding with children who were already using Logo in their classes. We were surprised when our publicity generated interest from all over the world and from people using all types of computers. When I brought home an Atari 800 system, we had another surprise. The young people immediately began to ask whether Logo could run on the Atari, and whether the Atari graphics could be duplicated in Logo. We then began to look at the differences between the Atari 800 and the TI-99/4. From that point, the imagination, curiosity, and energy of the young people took over and became infectious.

Logo and the Young

When people learned about the international membership of the association, they wanted to see chapters
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formed in schools around the United States and around the world. As our group grew, members wanted to learn about all kinds of computers and languages. A reporter asked why we called our organization a Logo association when it was obvious that we were doing much more. But nothing can be "much more" than Logo. A well-structured, procedural language, Logo lets young people start with what they know—their own everyday language. Logo lets you define a problem in its simplest components and then reassemble the components in a procedure for solving the problem with a computer. Using turtle graphics, people learn to "play" the computer, creating their own language through Logo. In the process, they not only gain valuable experience in problem solving and decision making, but also develop confidence and self-esteem.

Young people see the computer for what it is—a tool of the mind. Just as they don't blame the pencil for a mistake in writing, they don't blame the computer for a mistake in programming. Indeed, young people don't view their errors as mistakes but as bugs to be defined and eliminated. Logo introduces problems to children in a way that makes them eager to learn. Children are, in Lawrence's words, lifted and urged into dynamic activity. You can see the dynamic power of Logo in the eyes of a 6-year-old as he sees his procedures run correctly for the first time. You can see the power in the concentration of a hyperactive child still working over the keyboard after an hour of programming.

Logo and the Disabled

Logo can be equally powerful in the service of the physically and mentally handicapped. Personal computing is a whole new world for these people, and Logo can help them build confidence, self-reliance, and dignity. Logo creates opportunities for education, communication, productive employment, and significant contributions to society. Logo provides outlets for creativity and imagination.

The YPLA has members throughout the United States and in many other countries. Young people 18 and under can receive our newsletter, Turtle News, at no charge. We ask adults in North America to contribute $25 per year to receive Turtle News plus the Logo Newsletter, which is oriented toward adults. The requested contribution for international membership is $40. Our software exchange disks and tapes are available at $10 each or at no charge when exchanged for a working program.

We have active local chapters in Texas and others on the way in California, Minnesota, Delaware, Pennsylvania, Florida, Virginia, and elsewhere. Local chapters will offer competitions, achievement levels, badges, T-shirts, and all the other elements necessary to give children a sense of belonging to an organization of their own.
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Teachers College at Columbia University in New York, to the Marin Computer Center in Corte Madera, California. Telephone calls to participants in many Logo activities invariably found people enthusiastic about Logo and its future. It was seldom necessary to ask questions after saying something like, "Tell me what you're doing with Logo." Explanations and anecdotes came pouring out. What follows is only a sampling.

East Aurora High School
Erie County, New York

Dan Rolfler teaches in the mathematics department at East Aurora High School. Last February and March, the school offered an enrichment program called "EastOz." This program provided learning experiences for children on six Saturday mornings.

Texas Instruments lent the school six TI-99/4 computers. Forty students took part. Separate classes were held for grades 2-5 and 6-8. Children were taught problem solving and organized thinking. "You see different children solve the same problem in different ways," Rolfler says. "It's exciting to watch the kids. Logo is the best means I've seen for discovery-method learning."

While the younger children needed more class time, the children from fourth grade up "took off on their own," Rolfler reports. "What Papert suggested really does happen." Rolfler also noted the tremendous educational potential of Logo in the home.

Besides the program for students, East Aurora High School has a computer-literacy course for teachers that introduces them to both Logo and BASIC. Furthermore, the Erie County Board of Cooperative Educational Services is considering using Logo in curriculum development work.

Eastside Alternative School
Eugene, Oregon

Tim Riordan teaches Logo at the Eastside Alternative School and expresses few reservations about the language. "It's real fantastic in terms of developing analytical thinking and problem-solving skills," he says. "The graphics approach appeals to kids' interests, both girls' and boys'." Riordan also commented, "There's no limit. Kids as young as third grade can work with the idea of variables and can use recursion and develop things that are ongoing."

Riordan offered an example of the kind of abstract thought developed by children using Logo. When a math teacher described a circle as having no sides, a 10-year-old student in a Logo class remarked that a circle could be thought of as an infinity of very small sides. Logo had enabled that child to internalize the concept of the infinitesimal, so important later in calculus.

Riordan is also optimistic about Logo's surviving any imposition of curriculum standards. "I see no reason," he says, "why you couldn't put all of junior high geometry in Logo classes."

The Eastside Alternative Logo effort teaches 75 children from first to sixth grade. There is one 45-minute Logo period every day for three weeks. Some parents have taken the Logo class with their children.

Hamilton-Wenham School District
Hamilton, Massachusetts

Pat Ruane, curriculum coordinator for the Hamilton-Wenham School District in Hamilton, Massachusetts, reports that the district has been experimenting with Logo for one year. As a result, it has decided to focus its Logo program beginning in the third grade in three different schools. Classes for sixth graders, junior high students, and a formal Logo programming course for adults have been set up.

One of the third-grade programs has three Apples circulating among three classrooms. The machines are in use all day, and every child has lots of time with a machine. For children in the program, using computers has already become second nature.

Some of the children first developed an interest in computers in first and second grade while using the school's Big Traks—robot-like, programmable toy vehicles. Programming more than one Big Trak, coordinating the movements in what the school calls "Big Trak Ballet," required children to plan carefully. Highlights of Big Trak Ballet include programming vehicles to mirror each other's movements or to arrive simultaneously at the same place after leaving different origins at different distances.

As for the Logo program itself, Ruane sees students receiving more benefits than just an early introduction to programming. Because they share machines, the children gain important social experience. They are grouped heterogeneously and their interaction leads to increased mutual respect.

Children also learn general thinking skills, especially how to analyze problems. Third-grade teachers say that the children who excel with Logo are not necessarily those who do well on traditional mathematics tests. This suggests that traditional measures of ability in mathematics overemphasize computation.

Logo also provides benefits for teachers. According to Ruane, there is "a different relationship between teacher and learner. Teachers ask, 'Can I still engage as a learner?' This changes teachers' views of teaching. Logo has opened up the whole question of how mathematics should be taught."

As for other educational software now on the market, Ruane says, "I would as soon throw out all our other software and just use Logo."

Falk School
Pittsburgh University
Pittsburgh, Pennsylvania

Sharon Lesgold is curriculum developer for a Logo demonstration class in the Falk School, a laboratory school at Pittsburgh University. The program has 49 children aged 5 to 8 using Terrapin Logo for the Apple.
The children, some from the Pittsburgh urban area and some of the children of faculty, share a total of three machines in a connected suite of several large rooms.

Lesgold describes the Pittsburgh program as "very developmental. Not much real programming yet. The children are mostly drawing pictures." Each child has use of a computer for 30 minutes a week.

Lesgold has altered the Logo commands somewhat, notably making turtle steps 10 times as big as usual. The children find these terms easier to use, partly because the directions are given during the school year. Children will have more structured than that given during the summer.

A summer day camp is planned for children from first to sixth grade, with the majority in the fourth and fifth grades. The camp will offer 4 computers for a class of 20 children, with 1 teacher and 1 aide. Lesgold has altered the Logo commands somewhat, notably making turtle steps 10 times as big as usual. The children find these terms easier to use, partly because the directions are given during the school year. Children will have more structured than that given during the summer.

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The Young People's Logo Association
Richardson, Texas

Jim Muller of the YPLA reports that the group is developing a version of Apple Logo that incorporates a single-keystroke language for the physically disabled. (See page 333 for a report by Muller on YPLA.) The enhanced Logo will present a menu of words and phrases and convenient means to construct sentences from them and print the results. Toggle switches and character switches will replace standard keys and make using the computer easier.

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Jack Kishpaugh, who finished near the top in the Johns Hopkins competition for computer applications for the handicapped, is using Logo to develop a utility disk for the severely disabled. Kishpaugh, himself disabled, is trying to reduce the number of keystrokes required for successful communication from the usual range of 200-300 to only 20-25.

The YPLA is also beginning to investigate the use of voice input and is seeking ways to interface voice-recognition systems with the Logo language.

As for instruction in Logo, the YPLA tries to help elementary school children learn fundamental programming concepts like interrelationships among blocks of data. Muller notes that "Logo also helps children develop good social relationships." At least two children work on each project, and as a result, children get a greater sense of accomplishment on completing a project.

Muller expects tremendous growth in the exploitation of Logo's powerful list-processing capabilities. The most obvious application is in the language arts. Logo's features make it relatively easy to develop word games and language exercises. He also believes that the use of Logo will expand in many other directions.

Austin College
Sherman, Texas

Dr. Henry Gorman, whose report on the Lamplighter Project appears on page 331 of this issue, uses Logo in his Principles of Learning class at Austin College. The class has four TI-99/4s that are used most of the day for Logo. Each of the 40 college psychology students uses Logo in working with 1 student between the ages of 7 and 14. Thirty-nine of the college students were enthusiastic about Logo.

Celeste Alexander, one of Dr. Gorman's college psychology students, describes her experience with a young Logo pupil this way: "After the first day we worked nearly exclusively with sprites. He liked everything to be put into a program." Of her own reaction to Logo and to learning to use a computer, Alexander says, "I found my first apprehensions dissolved and I realized I could not only run or manage this computer, but also understand what I was doing."

Janet Truska, another of Dr. Gorman's students, also had good results to report. "I was concerned as to whether my student would enjoy it or not," she says. "After we worked with it a while, he began to enjoy it, as did I, and we both found it to be very rewarding learning experience."

This summer, Austin College is offering a continuing education course in Logo. Students range from the second grade to the twelfth, divided into...
four classes with a three-year age span. The college may offer a Logo course for parents at night this fall.

Ponderosa Elementary School
Cherry Creek School District
Aurora, Colorado

Jim Wilborn, who is active in the Logo program at Ponderosa Elementary School, says that the school is now using seven TI-99/4s with Logo. Since October 1981, pairs of children have had access to TI-99/4s, with each session lasting 15 minutes. The students show enthusiasm for Logo, battling for additional time at the Logo keyboard, but also sharing ideas. The students are developing improved skills in general problem solving, logical-sequential organization, and spelling. Many of the children who are doing well are "surprises." More than 25 teachers are cooperating in the program and working hard with the computers.

This summer the Cherry Creek School District is offering a Logo program for gifted and talented students. Each student sometimes faces specific challenges, such as making a sprite carry his or her initials across the video screen.

Driscoll School
Brookline, Massachusetts

Driscoll School is training all fourth and fifth graders to continue Logo classes. Each student in the existing Logo classes must achieve specific goals, first achieving each goal with help and later doing it alone. Boys and girls are showing equal interest in Logo.

Joyce Tobias of Driscoll School reports that Logo instruction in the fourth and fifth grades has been successful enough to warrant writing a curriculum for the fifth and sixth grades to continue Logo classes. Each student in the existing Logo classes must achieve specific goals, first achieving each goal with help and later doing it alone. Boys and girls are showing equal interest in Logo.

Some children have passed graphics and gone into full-scale programming. Tobias reports that "one student is writing a Logo program that tutors other students in the use of Logo." Another boy is writing simulations, including one program that simulates taking a trip across the United States.

Queen's University
Kingston, Ontario

Dr. William Higgins of Queen's University in Kingston, Ontario, says that about 15 schools in eastern Ontario are using Logo (see page 328). Interest in Logo is running high. The Educational Computing Organization of Ontario gave a conference in May...
that drew 1400 participants. The program included 14 sessions on Logo.

Queen’s University now offers a continuing education course to introduce school teachers to Logo. Classes meet one night a week for seven weeks. The university is also developing a diploma program in educational computing. “Logo would probably be a significant part of that program,” Dr. Higginson says.

Microcomputer Resource Center Teachers College Columbia University New York, New York Ursula Wolz reports that Teachers College is training teachers in Logo. Training in the field is taking place in New Jersey, New York’s Westchester County, and New York City.

Also a month-long Logo course at Teachers College provides a two-week introduction to the programming language followed by a two-week practicum with an experienced teacher of Logo.

While Wolz believes that the use of Logo is an important part of education, she stresses that in order to be successful, teachers must have a good understanding of the developmental education concepts behind Logo. She believes it is equally important for teachers to have a strong working knowledge of Logo, noting that “teaching children Logo without really knowing Logo yourself would be like trying to teach Shakespeare without having read the plays.”

The Teachers College Microcomputer Resource Center and the Department of Communications and Computing together offer an internship program for teachers. Teachers College also has Logo classes at its Center for the Gifted (classes are not restricted to the gifted). Wolz says one of the most exciting things about working with Logo is “seeing kids in their third or fourth session who have gone significantly beyond rudimentary Logo.” She also enjoys seeing children sharing information and “working problems through as a group.” Teachers College uses both TI-99/4s and Apples in teaching Logo.

A Final Note
Most of the people interviewed for this report did have one complaint about current Logo classes and projects: a shortage of machines and machine time for children. Under the circumstances, it is remarkable that so many early users and teachers are so enthusiastic about Logo. When we look back a few years from now, we will probably wonder how the pioneers in this field did so much with so little.
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A veteran computer user voices his opinions.

Jerry Pournelle
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First we had M-Drive, or Warp Drive, the Godbout/G & G Engineering system that tricks your 8085/8088 into thinking memory is a disk. Now we have Semidisk, which does the same thing and will work with any CP/M 2.2 system; unlike Godbout's M-Drive, Semidisk doesn't require a DMA (direct memory access) disk controller.

Semidisk comes in big chunks—512K bytes is standard, with a full megabyte on special order—and works with the S-100 bus. The firm says it'll have Semidisk available for the TRS-80 Model II and the IBM Personal Computer. I know Semidisk works with an S-100, either 8085 or Z80, because we have it running. We got it only yesterday; full report next month. So far it works fine and is comparable in speed to M-Drive. If you do a lot of programming with long compilations and assemblies, once you try either Semidisk or M-Drive you'll wonder how you ever lived without it.

Software Tools is one of those books you can't do without if you're serious about learning to program.

Software Tools

Not too long after Ezekial, my friend who happens to be a Z80 computer, came to live here at Chaos Manor, my (alas, late) mad friend Mac Lean brought me a book: Software Tools by Brian W. Kernighan and P. J. Plauger. Those were the days when I insisted I was monumentally uninterested in learning to be a programmer. "I only want to use the machines," I insisted. "I don't care how programs work."

"You'll want to learn," Mac Lean said. "So here's a painless way to get started. Read it. Hell, you know one of the authors."

It happened that I already admired Bill Plauger's work as a science fiction writer. Even so, I was reluctant to get started. Wisely, Mac Lean insisted—one of the many great favors he did for me and one of the countless reasons I'll continue to miss him for a long time.

(My wife says not to worry; sure as anything, some night I'll fall asleep at the keyboard, and in the morning, there'll be a disk file with a long diatribe on some totally unexpected subject, complete with telltale mad similes and the like. I can hardly wait.)
### Commodore Computer

<table>
<thead>
<tr>
<th>Model</th>
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<tbody>
<tr>
<td>VIC 20 Personal Computer</td>
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### Atari

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### Amdek Monitors

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<td>Color 1</td>
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<td>Color 2</td>
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### Epson Printers

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<tr>
<td>MX-80 w/Graphtrax</td>
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<td>MX-100 FT</td>
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<td>INTERFACE CARDS</td>
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<td>8161 IEEE Interface Board</td>
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<td>8232 Apple Interface Cable</td>
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<td>8220 TRS-80 Cable</td>
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### Qume

- Sprint 9/45: $2495.00
- Tractor Option: $210.00

### CMD Mupet

- MC-800A Mupet Controller: $995.00
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Software Tools is one of those books you can’t do without if you’re serious about learning to program. As Kernighan and Plauger say many times, you learn to write good programs by reading and studying good programs; and they show you a book full of them. The original edition of the book presents RATFOR (rational FORTRAN), an attempt to make a good language out of FORTRAN by adding conditional statements such as UNTIL, WHILE, CASE, and other requirements of structured programs. Way back in the book, they also give you a RATFOR precompiler that takes programs using the RATFOR conventions and turns them into reasonable FORTRAN.

The book is full of illustrative programs, and most of them are quite useful. The programs fit together into a set of “software tools,” mostly for text processing, but also include a macro instruction expander and other items useful for programmers. Kernighan and Plauger’s text editor is a bit out of date, but there’s a lot in there that I thirsted for the instant I began to read the book.

There’s a problem, though. Although I learned a bit about FORTRAN in the old days (1960s) and have Microsoft FORTRAN for my Z80, FORTRAN isn’t really a very good language for microcomputers. Its string-handling capabilities are ghastly. There’s no BEGIN...END construct to let you do several things following IF...THEN. The dreaded FORMAT statement doesn’t make sense for today’s input/output (I/O), and FORTRAN was really designed to work with 80-column lines, preferably from cards (so was Pascal; more on that later). The structure of FORTRAN, even with RATFOR, doesn’t really encourage writing readable programs. It seemed to me that FORTRAN was a language whose time had passed, and I wasn’t willing to in-

---

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No one knows how many Florida panthers are still alive. Perhaps fewer than 100. If these mountain lions die, another creature will be gone from the earth forever...the victim, first, of predator elimination programs, and more recently, of ever-shrinking habitat. But we don’t have to bid farewell to the Florida panther. The National Wildlife Federation has awarded a grant to researchers to study the panther and its future...and to draw up a plan for saving it. That’s just one small example of how the National Wildlife Federation is working to save endangered species from extinction. You can be a part of the effort. Join the National Wildlife Federation, Department 108, 1412 16th Street, NW, Washington, DC 20036.
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<thead>
<tr>
<th>Model</th>
<th>Capacity</th>
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<tr>
<td>TM602</td>
<td>5MB Tandon Winchester</td>
<td>$1795.00</td>
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<tr>
<td></td>
<td>Same system with 10MB Tandon Winchester</td>
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<td>64K</td>
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<td>512K</td>
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QUIME DISK DRIVES

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<tr>
<td>DT-5 5½&quot; double sided, dual density drive, ANSI compatible, 500KB unformatted capacity, 48 TPI, 35 or 40 cylinders, 70 or 80 tracks</td>
<td>$279.00</td>
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<tr>
<td>DT-8 8&quot; double sided, dual density, IBM compatible, 1.2MB/disk capacity (IBM format), 48 TPI, 77 cylinders, 154 tracks</td>
<td>$479.00</td>
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SHUGART

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<tr>
<td>SA400</td>
<td>5¼&quot; single/dual density, 250KB capacity, 48 TPI, 40 tracks, 1 head, '0 sectors/track</td>
<td>$215.00</td>
</tr>
<tr>
<td>SA450</td>
<td>5¼&quot; single/dual density, 500KB capacity, 48 TPI, 40 tracks, 2 heads</td>
<td>$269.00</td>
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<tr>
<td>SA800/801</td>
<td>8&quot; single/dual density, 800KB capacity, 48 TPI, 77 tracks, 1 R/W head, 32/16/8 sectors/track</td>
<td>$379.00</td>
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<tr>
<td>SA850/851</td>
<td>8&quot; double sided, dual density floppy drive, 1.6 MB capacity, 48 TPI, 154 tracks, 32 sectors/track</td>
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TEAC

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<td>Single sided, 5½&quot; floppy disk</td>
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<td>FD50B</td>
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<td>FD50E</td>
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<td>FD50F</td>
<td>160 tracks, 96 TPI, 5½&quot; double sided, floppy drive</td>
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TANDON DISK DRIVES

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<td>TM100-2*</td>
<td>5¼&quot; double sided, Northstar/Cromenco/TRS-80 compatible, 500KB unformatted capacity, 48 TPI, 80 tracks</td>
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<tr>
<td>TM100-3*</td>
<td>5¼&quot; single sided, 500KB unformatted capacity, 96/100 TPI, 80 tracks</td>
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<tr>
<td>TM100-4*</td>
<td>5¼&quot; double sided, Zenith/Heath/etc. compatible, 100KB unformatted capacity, 96/100 TPI, 160 tracks</td>
<td>$399.00</td>
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<tr>
<td>TM848-1</td>
<td>Thineline 8&quot; drive, single sided, 8MB unformatted capacity, 48 TPI, 77 tracks</td>
<td>$499.00</td>
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<td>TM848-2</td>
<td>Thineline 8&quot; drive, double sided, 1.6MB unformatted capacity, 48 TPI, 154 tracks</td>
<td>$549.00</td>
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<tr>
<td>TM602</td>
<td>5MB Winchester drive, 6.4MB unformatted capacity, 254 TPI, 153 cylinders, 612 tracks, 2 platters, 4 recording heads, 3600 RPM</td>
<td>$1025.00</td>
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vest a lot of time in getting it running properly on Ezekial.

Neither was Mac Lean, and thus I read Kernighan and Plauger but never actually ran their programs. When the CP/M Users' Group put out the tools found in the book on one of the Group's disks, we made an abortive attempt to get FORTRAN running because this was, after all, back in the dark ages when there weren't many modern languages for microcomputers. You couldn't get C, and the only Pascal was the old version of UCSD (my son Alex, who's a senior there, pronounces that "Scud")
Pascal. There was no LISP, Wordstar didn't exist, and a microcomputer version of PL/I was only a gleam in Digital Research's eye. There wasn't even an affordable FORTH. As I said, the dark ages. So we seriously considered RATFOR as the language to learn; but we had trouble hooking it into CP/M, and about then we became enamoured of Pascal, there being promised a number of microcomputer versions "real soon now." Thus, although I did try to get RATFOR going a couple of times, nothing useful came of it.

That disturbed me because the idea of "software tools" is a very good one. If you take a number of tasks, such as finding text patterns in files or archiving files, and build programs to accomplish these tasks in modular blocks, not only do you have useful programs, but you also have a number of procedures, subroutines, and functions you can lift out and put into other programs. You can incorporate the code into the source or keep the "tools" compiled in relocatable machine language for linking in. That way you don't have to reinvent the wheel every month or so.

It all sounded great, especially back when I had more time just to play around. Every now and then I'd read Software Tools with a sigh of regret that I'd never got the tools running.

That's all changed now.

Now Unicorn Systems has formed a Software Tools Users' Group and, more to the point, will sell you the whole box of tools carefully rigged to run with CP/M. The firm also furnishes a lot of documents, including a tutorial.

Unicorn Systems has even put a Unix-like shell around CP/M. For example, if you want to use the FIND tool to scan the file SYSTEM.TXT for all instances of the word LOBO, you type:

```
FIND < SYSTEM.TXT LOBO
```

and all lines in the file SYSTEM.TXT containing the word LOBO will appear on the console. Note the <, which indicates input source. If you typed:

```
FIND < SYSTEM.TXT.TXT > FOO.DAT
```

then the program would create file FOO.DAT and put the output into it. Very convenient, and there's a whole raft of Unix-like extensions and features built into the shell. It would take most of the column to describe them all.

In addition to the tools and the shell that make CP/M friendlier, you get a spelling program and, of course, RATFOR, including the source code,
TRAN compiler, you could write a
which is written in RATFOR. With
lot of awfully useful programs.
like this. So, when at the West Coast
plastic boxes that contain 15, count
Computer Faire, Deborah Sherrer,
a thick loose-leaf binder full of fairly
using 2.0 or a later version.
bulky as it all was, rather than chance
losing it. But, alas, the excitement
home, I didn't do much with it and
has gone to a lot of work to produce
ware tools. The Kernighan and
encouragement this profession can give
haven't yet.
screen, and anyone who's using a
mend spending much time learning it.
languages whose time has passed,
have put out Software Tools in Pascal,
package plus Kernighan and Plauger are
teaching RATFOR, I can't recom-
and I hope it sells a lot of its
ware Tools editor was great in its
doesn't? ED is only a little better than
Plauger editor beats the daylights out
Some of the other tools, like FIND,
are useful; but ye gods, FIND.COM
is a 29K-byte file, and it doesn't run
very fast, either. Ditto for most of the
other tools: too big, too cumbersome,
too slow—and written in the wrong
language.
If you really want to use Unicorn's
Software Tools—and they are indeed
useful foundations to build on—then
you probably want them in a lan-
guage you speak, not in FORTRAN.

Software Tools in Pascal
Which brings me to a mild conflict
of interest, so I want to make sure
you all understand a possible bias on
my part.
In my judgment, Unicorn has done
a great job, and I really encourage it.
But if you want the Software Tools,
my recommendation is that you build
your own set in Pascal or C. Ker-
nighan and Plauger have put out
Software Tools in Pascal, a book
functionally identical to the original
(all the old programs are in it, except,
of course, the RATFOR compiler).
My son Alex has put together a disk
of the first couple of chapters' worth
of the programs together with the
primitives and inclusion files needed
to get the Tools running under either Sorcin’s Pascal M or Digital Research’s Pascal/MT+. He’s added the introductory programs from Peter Grogono’s book *Programming in Pascal* (Addison-Wesley, rev. ed., 1980), and then he and Barry Workman ganged up to induce me to add my own comments. The result, called the Pascal Introduction Package, isn’t anywhere near as complete as what Unicorn Systems furnishes. If you want all the Software Tools to run in Pascal, you’ll have to type in a number of them yourself; but that’s the way I recommend you go, because with the Workman package you learn a language you can build your own tools with.

However, Unicorn does give you a nifty CP/M shell you can use to get the feel of Unix, and of course, there are all the tools and some interesting extensions already compiled and ready for use. If you do plan to use FORTRAN in the future, the Unicorn deal is the best bargain in town.

### The Hollerith Card Blues

A while back I mentioned that FORTRAN expects its input from 80-column cards. If you use Unicorn Systems’ package of Software Tools on text files created by WRITE, Wordstar, or Magic Wand, then what the Tools think is a line can cause some pretty strange results. Alas, it’s true for many other languages. We will regret the legacy of the Hollerith card for a very long time.

Take Pascal as an example. ISO (International Standards Organization) Pascal has no strings at all. Most implementations put in strings as an extension, but they do it in a way that cripples the language. Pascal M and Pascal/MT+ follow the UCSD Pascal system in which the longest string possible is 255 characters. There’s nothing you can do about it because these Pascal implementations store the string length as a single byte put in front of the string. The input situation is even worse: microcomputer versions of Pascal can’t grab lines longer than 255 characters, and, indeed, the implementations I’m familiar with truncate line inputs to 80-character lines unless you explicitly tell them differently.

None of this is a problem for text processing if you’re using a line-oriented editor with each line 80 characters long terminated by a NEWLINE (which in ASCII is also a problem because that’s two characters not one, but we’ll leave that for another time). Suppose, however, you want a modern full-screen editor, one which leaves the line lengths variable and marks only the ends of paragraphs. For example, one like WRITE, the editor I use. What now?

Well, of course you can get around that, and Alex shows how in his Pascal Introduction Package. He gives you two ways. Neither is very elegant, but we don’t know any elegant methods. One way is to get your input one character at a time, which works fine but slows things down a lot. The other is through a small machine-language program that “standardizes” your text files by making a copy with paragraphs broken up into lines of 80 characters or less, using different characters to mark the (artificial) line endings from those used to mark paragraph endings. This grabs WRITE, Electric Pencil, and Magic Wand files and runs about as fast as CP/M’s PIP. The various Pascal tools run much faster on files passed through this filter because the programs can now get their input by “lines.”

Or you can shelve it all and learn C, or even Digital Research’s CB-80 (the compiling version of CBASIC). We’ve done a few preliminary comparisons of CB-80 and Pascal, and they’re closer than I expected on both speed and final program code size. We’re doing some experiments on that, and we’ll have the results in a few weeks.

One reason Alex didn’t try CB-80 sooner was that CB-80 had a ghastly license agreement that required you to pay $2000 a year upfront before you could sell programs compiled with the language; but the company dropped that some time ago.

CB-80 has some terrific advantages for text processing: it can read a “line” of up to 31,000 characters in length, yet you don’t have to dedicate
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an enormous buffer to do that. CB-80 takes care of that dynamically, so that all you must have is enough free memory to put the string in. The program then grabs everything up to and including the carriage return and ignores the linefeed character at the end. Now that the licensing of CB-80 is rational, I predict a rash of text-processing programs using it.

I showed this column to Tony Pietsch, and he got another brainstorm: a way to overlay WRITE so that it will put out text in any format you like, including lines of 64 or 80 characters terminated by a cr-lf (carriage return-linefeed) pair. I wouldn’t be surprised to have that in a couple of weeks; when Tony gets to working, he works hard.

Good Stuff at Low Cost

The idea of software tools has wide appeal, and I presume that the Kernighan and Plauger book was responsible for Walt Bilofsky’s naming his company The Software Toolworks. From the address I know that he’s a neighbor, but in fact I never met him until the West Coast Computer Faire.

Bilofsky began by filling a much-needed niche as supplier of programs to the Heath market (he later converted them to CP/M), and it shows: many of his programs run best with a Z-19 terminal, and some, like his graphics package, won’t run without one. (Lately, though, he’s gotten heavily into programs for the Osborne 1.)

Bilofsky sells a wide range of programs, all at low cost (generally under $50). All the ones I’ve tried are excellent. His Ed-a-Sketch for the Z-19 (and the Osborne 1), for example, will let you draw and save all kinds of fancy stuff. His PIE full-screen editor (also only for the Z-19 terminal), while no Magic Wand or WRITE, is certainly more than worth the $29.95 he charges. I haven’t tried his spelling checker ($49.95 with 50,000-word dictionary equivalent; it runs on the Osborne 1), but if it works as well as his other software does, it has to be a bargain.

He’ll also sell you Eliza, that rather stupid psychiatrist program, for $24.95 (CP/M or Osborne). You’ll get tired of Eliza pretty quickly, but it is a nice thing to have next time someone asks you to demonstrate your computer at a party.

There are also games (including Mychess for the Osborne), a LISP interpreter, a C compiler, and more to the point of this column, languages, including RATFOR for Microsoft FORTRAN (keyed to the Software Tools book). I somewhat prefer Zolman’s BDS C (B. D. Software C), if for no other reasons than the extensive documentation and library utilities that come with the BDS package. But the Software Toolworks program compiles to 8080 assembly language, meaning that you can get in and hand-optimize important loops if you need to. It’s fast, and I may well end up writing some operating utilities in it.

Things have been a bit hectic here at Chaos Manor, so we haven’t had a chance to try all of Bilofsky’s programs; but we’ve tested several, and all work as advertised. I strongly recommend his philosophy and approach. By all means get his catalog; for sound programs at very reasonable costs, Software Toolworks is hard to beat.

One Strange Bug

I can’t think of anywhere else to put this. If you don’t use CBASIC, you can skip this section.

I’ve written my Journal program in CBASIC. It compiles fine on Ezekiel, who runs CP/M 1.4 at 2 MHz. But when I tried to compile the exact same program on the Godbout 8085/8088 (running at 6 MHz), I got the goofiest errors you have ever seen. Things like “BDOS ERROR ON X: Bad Sector,” and no, the “X” is not a misprint. And sometimes the compiler would just keep running: it would reach the end of the program and start right over again. Transfer the disk down to Zeke and no problems; put it in the Godbout and get nutty error messages or infinite loops.

Eventually I solved the problem. First, on a Godbout 8085 running CP/M 2.2x at 6 MHz, the END statement to terminate a CBASIC program is not optional. Always include it; it helps the compiler find the end.
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IBM DIDN'T MAKE IT SIMPLE

Well that's good, because simple usually means limitations, and so far we have not found a lot of limitations. It is hard to pick IBM cards when you have only five slots. Now let's see. If you want graphics and color you buy one board. And if you want a printer port you buy another. Or you buy a monitor adapter and you get a printer port on the same board. When you want to add serial communication it's another board. Add some memory at 64k per board. Wait a minute. That's two plus one, plus one, plus one more, minus one if you don't want graphics—HELP! Your PC is now a mass of boards and you still want to do more. Not only that, but now you have spent so much money on boards you may have to compromise somewhere else in your system.

A QUICK SURVEY

We decided the answer was a board that could do several jobs and use a single slot. First we called IBM to find out what kinds of boards and accessories are sold in what percentages. Wrong question. You would have thought we had asked what was on the missing 18 minutes of the Watergate tapes, because that's what we got—a long silent pause. The official answer was "that information is not available to non-IBM people." So we started calling dealers and asking them. Turns out that about 85% of the systems they sell have the monitor board with the printer port. The next most popular item is the asynchronous serial board, and then memory. Almost all of the salesmen we talked to tried to tell us we didn't want IBM 64k memory boards, and they would be happy to sell any number of aftermarket boards for prices ranging from $795 to $1195. A.C. Nielsen would be proud.

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Land. Printed circuit area is called land. If you have enough land, and you are real clever in how you use it, you can "grow" everything you want on one board. In this case we have enough land to do all the popular things. First 192k. This combined with the 64k in the PC gives you 256k. Just the right number. Count 'em. Nine per row of 64k bit chips you get parity checking. Our board comes standard with an RS232C serial port. All of the good things like solder masking, silk screening of part locations, and of course gold plated connectors are standard. Each board is tested and burned in.

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One of the best things you can use the PC for is a spreadsheet program like VisiCalc. That's how we figured out exactly how much this board cost us to build and how much to sell it for. Then we discovered SuperCalc. All the things we liked about VisiCalc are in it, and all the things we didn't like are corrected. It addresses all the memory (256k), and in fact will address 512k if you have it. Now the offer. If you buy the package from us, the board and SuperCalc, it will only cost you $575. Look around. You don't have to take our word for it. But you should. The offer is only good if you buy them both at the same time.

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Second, always end the program with no fewer than five carriage return/linefeed pairs. You must have at least one at the end of the program, or it won't compile at all. But for my fast machine, it turns out that if one carriage return/linefeed pair is good, more's better, and about five keep the errors away. I haven't a clue as to why this works, but it does.

Them Old BDOS Blues

I suppose I don't have to say that all in all I like CP/M; but there are times when I grow very weary of its flaws. It gets particularly annoying when there might be a hardware problem. "BDOS ERROR ON B: Bad Sector" (BDOS stands for basic disk operating system) isn't very informative when you know you can get that message because of any one of a dozen reasons.

I suppose one reason CP/M hasn't annoyed me as much as it does most people is that I've always had Tony Pietsch's protective software. Ezekial, for example, has a very large PROM (programmable read-only memory) monitor that looks at everything and has complete diagnostic messages. Thus when I forget and leave Zeke's drive doors open and try to save something, he says, "PLEASE CLOSE DRIVE DOOR." When I close the doors, he goes on as if there'd never been a problem.

Unfortunately, the CBiOS (customized basic input/output system) supplied by Bill Godbout with his 8085/8088 isn't anywhere near that friendly, as I found out while doing my taxes. I was entering stuff into my journal, which is a CBASIC program, and my wife called me to dinner. I didn't expect to be long—during tax time at Chaos Manor everyone avoids me—so I opened the drive doors and left the Godbout running. When I returned I made some more entries, then tried to save the enlarged

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file. Like an idiot, I used the same filename that I'd used before. And, alas, I hadn't closed the drive doors.

"BDOS ERROR ON A: Select Error," it said to me. "Bah," I replied.

"It's an open drive door." And unthinkingly I closed the drive door. Whereupon it proceeded to completely clobber my file and thoroughly crash the system.

Fortunately, I'd thought of that one long ago when I wrote the Journal program: the actual entries are in files called "JRNLL-21" and the like, while the first thing the program tries to write is a summary file called "JRSUM-21" that contains only summary stuff like the number of entries and heading data. It's easy enough to recreate the JRSUM file and thereby save the data in the JRNLL file. But it's still infuriating to have to do it.

"You've had it too easy," Tony said. "You're used to my software."

"I know that," I said. "But what do I do now?"

"Well, I've done a new CBIOS for the Godbout. . . ."

Meaning that open drive doors no longer crash my system. I'm encouraging Tony to send a copy of the new CBIOS to Bill Godbout so others can have that benefit also. I hope he'll do it. The only problem is that he doesn't want to maintain the thing and answer hundreds of questions from users.

He's also taken care of the problem of open doors in WRITE (Writers' Really Incredible Text Editor), which he keeps improving monthly. With WRITE, you can leave the drive doors open, change disks, put in full disks, and put in disks with bad media, and WRITE still recovers.

Or tries to. The problem is that Tony can't be responsible for your CBIOS, and if that's not well written, there may not be anything the program can do.

There are only three error messages in CP/M: "Select Error," meaning that the system can't find the drive it's trying to write to; "Bad Sector," meaning that it can't perform whatever operation it's trying to do, like read or write a sector; and "R/O," which means that the directory doesn't match the bit map. That may be because you didn't press Control-C after changing disks, but "R/O" sometimes means either the disk or the directory is full.

None of these errors should be fatal. With careful study of CP/M you *ought* to be able to return control to your program. Tony catches stupid errors, such as open doors and the like, in the CBIOS, and the people at Sorcin told him how to let programs recover from other BDOS errors. Unfortunately, most programmers don't know enough about CP/M to catch stupid errors, and CP/M documentation, including all the books I've seen on the subject, isn't helpful.

The trick—which is *not* supported by Digital Research and, in fact, is specifically forbidden in the CP/M documentation—is absurdly simple. In CP/M, location 00 has a jump instruction, and the address of the "warm start" (the place in memory you go to do the equivalent of Control-C) is in locations 001 and 002. The Digital Research documents say that this must be left unchanged; but in fact, CP/M 1.4 and 2.2 never call that location unless there is a BDOS ERROR.

All of which means that a clever programmer can snatch that warm-start location, store it, and put the address of an error-trap routine into locations 001 and 002. On exiting the program, you put the warm-start address back. If none of this makes any sense to you, don't worry about it. What I'm doing is giving out some underground information for those who can make use of it. I repeat, this is not supported by Digital, and there are no guarantees that future releases of CP/M (or MP/M) will be compatible with this recovery method.

Also, if your CBIOS is incompetently done, then clever programmers can't compensate. Alas, there is more than one incompetent CBIOS floating around. There are even companies that won't give you the source code of your CBIOS. If you've been unfortunate enough to get yours from one of those companies, you have my sympathy and advice, which is to think again before dealing with a company that withholds vital infor-
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tion. The CBIOS matches your particular hardware to the general CP/M operating system, and if it isn’t well done—or if you can’t modify it—then you can be in big trouble.

The potential for error recovery is inherent in CP/M because the bit map, which tells precisely where the various chunks of your file are hidden, and the directory are right there together. Both are updated quickly and efficiently each time you go Control-C, or each time your program makes the appropriate call to accomplish the same thing. WRITE, for example, does the equivalent of Control-C before every read or write operation; thus it’s always working with an up-to-date bit map and can cope with changes of disk and the like. (Remember, Tony put WRITE together from specs furnished by Larry Niven and me; and we’re very paranoid about losing text, so WRITE is extremely defensive. Since Larry and I often write with, uh, lots of brandy for the coffee, WRITE has to be tolerant of operator errors as well.)

But despite the fact that clever programmers can overcome many CP/M flaws, we still have a problem: CP/M, our de facto “standard,” has holes you can drive a truck through. The question before the house is, “Is Digital Research doing anything to fix them?” When we get our 16-bit and 32-bit machines, must we endure more “BDOS ERROR ON X: R/O” when we know darned well the disk isn’t Read Only because we physically removed the write-protect mechanism from the disk drive?

CP/M is a good operating system; but there are some improvements needed. We can hope Digital Research will make them. If not—well, think of it as evolution in action.

Utilities
I hope CP/M cleans up its act. Meanwhile, I have a temporary solution to some of the problems.

First, if you’re not getting the public-domain CP/M utilities, either “raw” from the CP/M Users’ Group or “filtered” through someone like Barry Workman, you ought to do something about it.

And more good news: CP/M will give you a reasonably well formatted directory or tell you file sizes; it won’t do both. You can, however, get XDIR or XD, which will. Both have long been available from the CP/M Users’ Group, and Workman furnishes versions for both 1.4 and 2.x on his Utility Disk One. But there’s better news.

Tony Pietsch has just written a real doozy of an XDIR that lets you put in wild card characters (XD *.FOO will list all and only those files with an extension of FOO), optionally allows you to alphabetize by extension (it groups all the .ASM files, then the .COM files, etc., with the filenames alphabetized within each extension), tells you the number of kilobytes each file takes up, tells you what user number is logged on, will show you the directory of another user without your having to log on as that user, tells you how many directory entries and how many kilobytes remain on that disk, and does it all speedily and efficiently. It’s the equivalent of STAT in usefulness and reliability. There’s even an XD.DOC file you can call for help. I can’t imagine how I got along without it. Tony wrote it for me, Larry, and himself. You can get it and other programs from Barry Workman on his Utility Disk Four.

Then there’s Power, which comes to you from an outfit with the cutesy name Computing! The exclamation point is part of the firm’s name. I wonder, is it trademarked? For that matter, some day I suppose I’ll wake up to discover that my own name has been trademarked—by someone else. In any event, at the West Coast Computer Faire the utility was called CPMPower, but since then the company has changed the name of its package because of legal complications, and it is now called Power.

Incidentally, the “licensing agreement” for Power makes more sense than most do. Computing! disclaims any responsibilities, of course, but
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Superbrain

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simultaneously demands only that the user not redistribute the programs. It doesn’t ask the buyer to restrict use to one machine.

One of the things Power claims to do is intercept the horrible "BDOS ERROR ON A: Select Error" message if you leave the drive door open. Unfortunately, if you follow the instructions to test this feature, you get the same old BDOS ERROR nonsense that you always get. The document says "NOTE: Error trap flag must be set at 10D Hex if your CP/M system accommodates this feature. (See CUSTOMIZATION.)" On turning to "CUSTOMIZATION" (which I had trouble finding; there's no table of contents, but fortunately CUSTOMIZATION is where the index would be if the document had one), I found no explanation whatever but an assembly listing that told me:

010D 00 ERRTRP: DB 0 0
0FH=trap hard disk errors

If you can tell me what that means, I'll give you sixpence. So I haven't the foggiest whether some kind of magic manipulation (such as setting 10D to something other than 0) will intercept the BDOS ERROR or not.

Once I got Power transferred onto my master disk (it's a 12K-byte program with a 6K-byte overlay), I played around with it. It's got some nice features. For example, there's a kind of mini-monitor built into it. You invoke Power, and not only can you do all the usual CP/M things like TYPE and STAT and RENAME, but you can dump, display COM files as hexadecimal numbers with ASCII messages out to the side just as DDT (the CP/M debugger) does, fill memory, search memory (but alas not search files) for a given text pattern, set DIR and USER number and all that stuff, go to a certain memory location, load and execute programs at any memory location, etc.

In other words, the program overcomes some of the limitations of CP/M. Of course, many of those are limitations only to hackers; most users aren't terribly interested, especially at the memory cost Power exacts. You'll also pay another way:

Power lists the directory in two columns that aren't in alphabetical order, so that if you use double-sided double-density disks with lots of files on them, you'll go nuts trying to find the filename you're interested in. To compensate, though, Power will assign a number to each filename on the disk, and to copy a file, you only have to type its number, not type (or, as they say, mistype) the whole filename. The same is true when erasing something. The bad news is that you must use the menu number, and it probably scrolled off the top of the screen before you caught it.

Another feature of Power is that you can reclaim lost files; this is especially helpful if you've inadvertently typed "ERA *.BAS" when you meant "*.BAK". Power will get all those .BAS files back for you. Unfortunately, the documentation does not explain that large files may be reclaimed improperly under certain circumstances.

There are a lot of other features, including the ability to read and write to disk by sector and track, which means that if you knew what you were doing, you could use Power to recover files from disks with messed-up directories. Power also claims the ability to operate without having a system disk in either drive.

All in all, Power looks useful, and I'm glad I have it. I'm even gladder of Tony's XD and some of the Workman-CM/Us' Group utilities. I'd probably be even gladder of Power if the documentation were a bit clearer, and I'd like a bit more explaining of what Power does and how it does it. I suspect Power is more useful to hackers than users. It's obvious the writers understand CP/M very well indeed; I wish they'd shared a bit more of their knowledge.

Again, LISP

We recently had our big L-5 Society Conference on Space Development here in Los Angeles, and two of our speakers were John McCarthy, who wrote LISP back in the fifties, and Marvin Minsky, who designed and built the LISP machines used at MIT. (Plug: help the space program. Join the L-5 Society. Send $25 to L-5,
As I've noted before, LISP has become the language of the artificial-intelligence community. Moreover, a number of LISPers have taken up my challenge and shown me all kinds of useful programs written in LISP: accounting programs, library programs, and the like, all with really good user features like self-prompting and error trapping. I confess I’m impressed with what you can do with the language.

Walt Bilofsky says LISP is the ideal breadboard language; once you know it, you can do things quickly and without fuss, as long as you’re not after elegance. After all, no one complains if a breadboard layout has resistors sticking up in the air and cut traces.

I’m also impressed at the chaos you can create; LISP programmers really and truly do go around handing each other lines of code and saying gleefully “I bet you can’t tell me what that does.” But I’ve long since conceded that if you’re interested in artificial intelligence, you have to learn LISP, and if you expect to make a living in the computer world, you probably ought to avail yourself of any opportunity to learn LISP because there are some things you can do with it that you can’t do elegantly in any other language.

Software Toolworks’ LISP will let you play around with the language to find out if you’re really interested.

The problem has been that there aren’t many LISPs for microcomputers. That’s still true, but I have received two more, one of which on first inspection may be the best of the microworld’s LISPs, while the other is certainly the cheapest. The first is from Supersoft, and it looks to be more complete than the Microsoft LISP originally developed by the Soft Warehouse. The Supersoft LISP resides partly in memory and partly on disk, using swapping overlays as needed. Obscure user-defined functions can be kept on disk, leaving lots of free memory.

This allows Supersoft LISP to have full recursion—that is, a function may call itself any number of times. (Well, I presume there is some limit, but it’s a pretty big number.) Because recursion is a standard, indeed vital, LISP feature, this makes Supersoft LISP pretty powerful. Supersoft claims its LISP is a full MIT LISP 1.5 with extensions. Because I’m not a LISP hacker (although I am getting more and more interested in the crazy language), I can’t verify that. I do know mine works. Some functions are a bit slow due to the need to call in overlays from the disk, but put all that on M-Drive or Semidisk, and it really wails.

The Supersoft documents are complete in that they describe each function in the language, but they’re not very good. There’s no index and no
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Pacific Grove, CA 93950  
(408) 649-3896

Power
Computing!  
2519 Greenwich St.  
San Francisco, CA 94115  
(800) 227-3800, operator 28

LISP
The Software Toolworks  
24478 Glorietta Dr.  
Sherman Oaks, CA 91423  
(213) 986-4885

LISP
Supersoft  
POB 1628  
Champaign, IL 61820  
(217) 359-2112

CP/M version $150
TRS-80 cassette version $75
TRS-80 disk version $100

Pascal Introduction Package  
and
Utility Disk Four
Workman and Associates  
112 Marion Avenue  
Pasadena, CA 91106  
(213) 796-4401

Software Tools for CP/M
Unicorn Systems  
30261 Palomares Road  
Castro Valley, CA 94720  
(415) 861-4490

Semidisk
Semidisk Systems  
POB GG  
Beaverton, OR 97075  
(503) 642-3100

512K bytes $1995  
1 megabyte $2995  
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WRITE (Writers' Really Incredible Text Editor)
Ashton-Tate  
9929 Jefferson Ave.  
Los Angeles, CA 90230  
(213) 204-5570

$395

Books Reviewed

Software Tools
Brian W. Kernighan and P. J. Plauger  

$14.95

Software Tools in Pascal
Brian W. Kernighan and P. J. Plauger  

$15.95

real explanation of what LISP is; to learn the language you'll need a lot more than Supersoft furnishes. Some of the discussions are completely opaque. On the other hand, I'm not convinced you can learn LISP from books anyway; I think you need tutorial help.

Supersoft furnishes everything you'll need, like a tracer. The hooks into CP/M are reasonable, or at least not unreasonable. (But there's no implementation of a random-access file; you'd have to write that in LISP yourself.) Again I emphasize that you'd better know what you're doing.
because the explanations on using LISP with CP/M are terse beyond belief. Ditto for the section on "Machine Representation of LISP Objects." I expect it all makes very good sense to Minsky and McCarthy, and indeed every now and then I understand a line or two; but one should read this manual with a book like Winston and Horn (Patrick Henry belief. Ditto for the section on "Machine Representation of LISP Objects." I expect it all makes very good


With that warning, I can recommend Supersoft LISP.

If you just want to get a feel for the language, you can try Software Toolworks' LISP at $39.95 for either Osborne 1 or any 8-inch CP/M system. This one was written in C and is somewhat slow, but it is fairly complete. The documents are better than Supersoft's. Software Toolworks' LISP will let you play around with the language to find out if you're really interested. How can you pass it up at the price?

Immortal Paperwork

I often get letters asking why I haven't reviewed one product or another. Often the suggestions are very helpful. But, there's a ton of software around here; lately everyone has been sending me stuff to review. I'm very grateful, but I do sometimes feel guilty about not getting to everything as quickly as I should.

One difficulty is that I have had two systems: a Z80 running CP/M 1.4 and an 8085/8088 running CP/M 2.2. But people kept sending me software that requires a Z80 running CP/M 2.2. Eventually I solved that problem: I got another computer. Next week we'll set up a Z80 running CP/M 2.x, and we'll reduce the size of that pile of unreviewed software that menaces me from the corner. We'll also be able to install Semidisk, which just arrived.

Meanwhile, I'm working on not one but two computer books. One will be in loose-leaf format and contain all my back columns (updated and revised as necessary) plus my fulminations about famous brand-name equipment, what hardware I really can't stand, and random walks around Chaos Manor—in other words, much like these columns. Since it will be topical, it'll probably need revising fairly often. That means small print runs, so that (1) the price will have to be outrageous, around $18 postpaid, and (2) I will want to keep it close to me and under control, so I'll let Barry Workman handle it. It may even be available by the time you read this. The other book is for a major publisher to be pitched at a mass market; BYTE readers may find it interesting, but you'll be more likely to give it to someone who asks you about computers (at least I hope you'll want to do that).

So, what with the books, getting the new Z80 system running, the pressure of being chairman of the Citizen's Advisory Council on National Space Policy, finishing *Janissaries II: Clan and Crown*, and working with my partner Larry Niven to finish *Footfall* by next spring, it's amazing I get these columns written at all. But I do thank everyone for letters and suggestions, and I try to answer as much of my mail as I can. If I owe you a letter, please have pity.

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Commodore has introduced a new microcomputer for the small-business market: the Model 8032. Inside the 8032 is a new operating system that makes up for some of the deficiencies of Commodore's old operating systems. Also available is a version of this new operating system for Commodore's older machines.

Commodore has also upgraded its dual floppy-disk system, now called the 4040. It is used with an improved disk operating system (DOS), which is more reliable and can now randomly access disk files. Commodore has also released the 8050, a dual 5¼-inch floppy-disk-drive system with 500K bytes of storage per drive. Although the 8050 drives are single-sided, they allow double density and 96 tracks per inch. The disk operating systems for the 4040 and the 8050 are similar and the commands are basically the same. Any comment about the 4040 is usually applicable to the 8050 as well.

The release of this new equipment is accompanied with new software that makes this Commodore Business Machine (CBM) truly a professional piece of equipment. With a combination of software packages (not produced by Commodore), this microcomputer system will find its way into both small and large businesses.

New System Features

First, a look at the 8032. Its new 80-column, 12-inch video screen is the most obvious difference from Commodore's other systems. As before, the system's cabinet is a one-piece housing for the main logic assembly (the circuit board on which the system is built), power supply, video display, and keyboard. The clean design makes the system aesthetically suited for residence in an office.

The main logic assembly runs the depth of the cabinet, with the power supply at the back left corner and the video circuitry mounted above. Heated air is allowed to rise upward, out of the cabinet, while cooler air enters through the bottom; a fan is unnecessary.

All interface circuitry is built into the system. It is accessible by way of three edge-card connectors at the back of the cabinet. This includes the famed IEEE-488 interface that allows the computer to control test equipment (among other things), the user parallel port, and one of two cassette ports. The memory-expansion port can be accessed through an opening in the side of the machine.

One of the features for which the old PET microcomputer was known was its real-time clock; thankfully, this feature is included with the 8032. For high-level-language use, this 24-hour clock reads out hours, minutes, seconds, and "jiffies" (sixtieths of a second). Through machine language, resolution down to 1 millisecond is available, making the system suitable as an instrumentation controller. Software has eliminated keyboard bounce. Of course, the 8032 has the unique CBM graphics characters and standard uppercase and lowercase letters.

The most dramatic improvement is in the video circuitry. Because the number of characters on the
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II. HARDWARE LIMITATIONS
A. Requires minimum of 48K main memory.
B. Requires 2 disk drives (500 records max. [single density]; 1,000 records max [double density]).
C. CP/M Operating System

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80-column screen is double that of the old 40-column display (expanding the video buffer to 2K bytes), the time needed to perform screen-oriented functions (clearing the screen, scrolling, etc.) would be increased. However, the display is now controlled by a 6845 integrated circuit that frees the microprocessor from having to perform display functions. It also provides extra spacing between lines of text. Descenders on one line no longer touch the ascenders of the line below. By changing to the graphic mode, lowercase and uppercase characters are replaced with upper and lowercase characters, respectively, and the extra spacing between lines is removed.

Turning on the system or moving the cursor past the seventy-fifth column rings the system's bell. The speaker (actually a piezoelectric transducer) is connected to the CB2 line of the parallel port. Since this is the same line often used to create sound effects, these sounds can now be heard through the bell without an audio amplifier. The bell also rings when the ASCII bell code is printed.

New Software

To accompany the hardware modifications, Commodore has updated the operating system to version 4.0 in a way that complements the DOS. It now includes a new screen-oriented text editor, commands to simplify disk operations, and better string handling. Because the major change in this operating system is the addition of disk commands, the new version of BASIC is known as Disk BASIC (see the text box "A Quick Reference"). Notice that the new commands only make it easier to perform disk functions—they do not add any new features. The system defaults to device number 8, drive 0 (if this default can be changed, it is not documented).

To make these features available on older 16K- and 32K-byte CBM computers (those using version 3.0 BASIC), Commodore has released a version 4.0 read-only memory (ROM) upgrade. This will give the user all the enhanced commands, but not an 80-column screen. One catch is that the RECORD command (for random-access disk files) can only be used with DOS 2.1 and a 4040 floppy-disk-drive subsystem.

The disk commands are not the only change to BASIC, however. One other improvement is the string handling. When a string variable is used in a BASIC program, the BASIC interpreter sets aside memory space. As the string is reused, BASIC abandons the space and finds a new place in memory for the string's contents. Eventually, when all the free memory is used, the interpreter must collect and reuse the abandoned memory.

Garbage collection, as it is called, is also done when the system is asked to count the free memory locations. While garbage collection is going on, the system will not respond to the user. It therefore appears "dead" until the collection is done. The new version of the software does garbage collection in much less time. A collection that formerly might have taken as long as 21 minutes now takes only 0.64 seconds.

Commodore has also added disk-status flags to the new software. These special variables, DS and DS$, contain the status of the last disk operation and disk error. Without these, it would be necessary for the user to write a three-line program to determine the nature of a disk error.

Three other improvements have been made:

• when sending data to a device via the IEEE-488 interface, the system will send only a carriage-return character; it will not be followed by a linefeed character
• it is now possible to append data to an existing disk file
• if the input string from a device is more than 80 characters long, the system will generate a trappable error with the message "String too long error"

---

**At a Glance**

**Name**
CBM 8032 computer system

**Manufacturer**
Commodore Business Machines
Computer Systems Division
The Meadows
487 Devon Park Dr.
Wayne, PA 19087
[215] 687-9750

**Price**
$2829.95 (suggested retail) including all required cables

**Dimensions**
Computer: 35.5 by 41.5 by 46.5 cm, 22.5 kg (14 by 16.5 by 18.5 inches, 50 lbs)
Disk drive: 16.5 by 38 by 36 cm, 12.5 kg (6.5 by 15 by 14.3 inches, 28 lbs)

**Description**
CBM 8032 computer: 6502 MOS Technology microprocessor, 73-key business-style keyboard, 12-inch green-phosphor display (80 characters by 25 lines; 2000 characters, 8 by 8 dot-matrix characters), IEEE-488 bus, 8-bit bidirectional parallel port, and two Commodore cassette ports included. 3-MHz system clock 32K bytes (1K used for operating system overhead) plus 2K-byte screen buffer

4040 dual disk drive: Shugart 5¼-inch floppy-disk drives, single-sided, single-density, 174,848 bytes unformatted, 168,656 bytes formatted, 144 file entries per disk

Controller: 6504 microprocessor
Interface: 6502 microprocessor
Disk buffer: 4K bytes

CBM operating system included with 8032 computer: Microsoft BASIC, screen editor, and built-in IEEE-488 and disk commands (18K ROM)

**Disk operating system included with 4040 disk drive:** Program load and save, sequential, User, Relative, and Program files, file utilities (Copy, Rename, Scratch, Duplicate), New disk; Disk Directory; and Error Recovery

**Software**
Business software available (also see the Commodore Software Encyclopedia): Wordpro 4 Plus [word processing—Professional Software Inc.], Visicalc [electronic blackboard—Viscorp]. The Manager [database—Canadian Micro Distributors], BPI, and CMS accounting software

**Audience**
This system is well suited for use in a modern office environment, as well as educational institutions and other business applications
16 Bit 8086 Multi-User Microcomputer System

FOR MP/M-86™

$7595

FOUR USER SYSTEM

$1899*

PER USER

THE TEC 86M

STANDARD FEATURES

16 BIT 8086 CPU - Processor performance is the most critical element in a Multi-User System. Speed, power and the increased throughput of our 16 Bit 8086 CPU are just a few of the reasons why our TEC 86M Multi-User Systems really perform.

1/2 MEGABYTE OF MEMORY - The second most important factor which affects system performance is available user memory. Our 1/2 Megabyte, four user system gives each user well over 100K Bytes of memory, eliminating program size compromises which lead to poor Multi-User system performance.

MP/M-86™ COMPATIBILITY - The TEC 86M includes a ROM Boot for MP/M-86™ and is designed to provide optimal support for MP/M-86™. The MP/M-86™ Operating System is available separately from Tecmar for $600. See Software Options listed below for important MP/M-86™ features.

FULLY INTERRUPT DRIVEN - The TEC 86M provides terminal and disk I/O interrupts to MP/M-86™, allowing for maximum system performance in Multi-User operation.

TWO 8 INCH DOUBLE DENSITY FLOPPY DISK DRIVES - The two Double Density floppy disks total 1.2 Megabytes of storage. Options include double sided floppy disk drives and Winchester drives.

FOUR SERIAL USER PORTS - Four serial user ports are provided. Each port can be independently set for speeds from 50 to 19200 Baud.

MULTIPLE PARALLEL PORTS - Parallel ports are provided for operating printers as well as other parallel devices.

EASILY EXPANDABLE - The modular design of the Tec 86 and Tec 86M assures you of continued system expandibility. All options are easily field installable. Available options include: Memory 64K and 256K, additional users, double sided floppy disks, Winchester 3L Megabyte hard disk, terminals, and printers.

ATTRACTIVE DESKTOP ENCLOSURE - Tecmar Single and Multi-User systems come in your choice of an attractive desk top enclosure with wood grained side panels to blend nicely into your office surroundings, or an industrial quality cabinet for more hostile environments. Rack mount enclosures are available as options.

ONE YEAR WARRANTY - Tecmar Systems are fully assembled and thoroughly tested. All Tecmar Components carry a full One Year Warranty.

SOFTWARE OPTIONS

MP/M-86™ - Multi-User interrupt driven Operating System for the 16 Bit 8086 TEC 86M Microcomputer System. FILE PASSWORD PROTECTION - Access to user files can be restricted to require proper passwords prior to access. CONCURRENT FILE ACCESS - Files may be accessed by multiple users, each reading and/or writing the same file, with protection provided at both the file and the record level. FILE TIME AND DATE STAMPING - Files contain creation, and modification Times and Dates for ease and accuracy in determining the latest or most useful file versions. PRINT SPOOLER - Files may be submitted to the System Spool file for printing. This frees the user terminal to continue operation during the independent printing function.

LANGUAGES - BASIC-86™ FORTRAN-86™ PASCAL-86™ CBASIC/86™ CIS-COBOL™ PASCAL/M86™ FORTH

*NOT INCLUDING MP/M-86 and User Terminals.

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Circle 399 on Inquiry card.

BYTE August 1982 369
This 80-character limitation becomes apparent during disk-file operations. Although a record written to disk can be as long as 254 characters, and a string can be as long as 255 characters, any record that is more than 80 characters long must be accessed one character at a time, using the GET# command.

Better Editor

Although the editor has been improved, its operation is still the same. To change a line in a program, merely move the cursor to where the corrections are to be made, make the corrections (insert, delete, etc.), and push Return. The corrected line is entered as if you had retyped the whole thing.

What makes the editor so easy to use are the keys designated to perform each of the cursor movements, insertions, and deletions. Whole sections of programs can be copied from one program to another by listing the lines to be transferred on the screen, calling in the new program (which clears out the old one), moving the cursor to the start of the lines to be transferred, and pressing return for every line. The cursor does not have to be moved over each line, nor even moved to the end of each line. It is as simple as that and saves a lot of typing.

Special characters have been added to the screen editor that perform functions by using the video controller. (I've found that the graphics characters can be accessed from the keyboard if the 2 key is hit while pressing both shift keys.) The screen can now be scrolled up or down just by printing a special character; whole lines can be inserted or deleted, a line can be cleared to its end from any position, or from its beginning to any position.

Two of the special characters define the upper-left and lower-right corners of a scrolling window—a portion of the screen in which the movement of the cursor is restricted to preset boundaries. For instance, if you wanted to simulate the older 40-column screen, you could set one special character at the top of the screen, indented 20 spaces; the second special character would be indented 60 spaces on the bottom line. The cursor movement would then be restricted to this area.

This is also useful for defining split screens to display information. The information will scroll in the window, leaving the rest of the screen untouched, no matter where on the screen the window is defined. Normally, when the computer is turned on, the entire screen is the scrolling window.

One problem occurs if tabs are used in the program. The tabs are always computed from column 1 regardless of the scrolling window. If the tab is before or beyond the scrolling window, the cursor will be placed on the nearest edge within the scrolling window. The window is cleared simply by printing the ASCII Home character or pressing the Home key twice. A complete list of special screen-

---

**A Quick Reference**

**DOS 1.0** is the operating system of a 2040. **DOS 2.1** is the operating system of a 4040. **DOS 2.1** can read a **DOS 1.0** disk and **DOS 1.0** can read a **DOS 2.1** disk; however, neither should write on a disk formatted by the other.

<table>
<thead>
<tr>
<th>New Disk BASIC Commands</th>
<th>Operation</th>
<th>See Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSAVE</td>
<td>Saves current program in memory on disk</td>
<td>1</td>
</tr>
<tr>
<td>DLOAD</td>
<td>Loads specified program into memory</td>
<td></td>
</tr>
<tr>
<td>CATALOG</td>
<td>Lists the programs stored on the disk</td>
<td></td>
</tr>
<tr>
<td>DIRECTORY</td>
<td>Same as CATALOG</td>
<td>1</td>
</tr>
<tr>
<td>SCRATCH</td>
<td>Scratches specified program from disk</td>
<td></td>
</tr>
<tr>
<td>RENAME</td>
<td>Renames a file on disk</td>
<td>1</td>
</tr>
<tr>
<td>CONCAT</td>
<td>Concatenates two files</td>
<td>1</td>
</tr>
<tr>
<td>COPY</td>
<td>Copies specified file on disk</td>
<td>3</td>
</tr>
<tr>
<td>BACKUP</td>
<td>Track-to-track duplication from one disk to another</td>
<td>1</td>
</tr>
<tr>
<td>COLLECT</td>
<td>Collects disk space from unclosed files and verifies disk</td>
<td>1</td>
</tr>
<tr>
<td>HEADER</td>
<td>Formats a new disk for file storage</td>
<td>2</td>
</tr>
<tr>
<td>DOPEN</td>
<td>Opens a disk data file</td>
<td>1</td>
</tr>
<tr>
<td>DCLOSE</td>
<td>Closes a disk data file</td>
<td>1</td>
</tr>
<tr>
<td>APPEND</td>
<td>Opens old disk file to append additional data</td>
<td>1</td>
</tr>
<tr>
<td>RECORD</td>
<td>Specifies what record in a file will be read or written</td>
<td>4</td>
</tr>
</tbody>
</table>

**Note 1:** These commands cannot be used with **DOS 2.1** with a disk that has been formatted with **DOS 1.0** because they perform write functions and cause the "72,cbm v2 dos error."

**Note 2:** These commands will ask, "ARE YOU SURE?" A response of "Y" or "YES" to this will then perform the desired function.

**Note 3:** **COPY** can copy all the files on one disk to another. Use **COPY** to convert **DOS 1.0** disks to **DOS 2.1**.

**Note 4:** This command (as well as some versions of **DOPEN** and **COPY**) will not work with **DOS 1.0**.

Continued on page 372
The MICROMINT Z8 BASIC COMPUTER/CONTROLLER board represents a milestone in microcomputer price-performance. It is cheap enough to be programmed directly in a high level language, and efficient enough to be battery operated if required. The entire computer is 4" by 4½" and includes a tiny BASIC interpreter, 4K bytes of program memory, one RS-232 serial port and two parallel ports, plus a variety of other features. Using a powerful Z8 microcomputer chip and Z8132 4K x 8 RAM, the Z8 BASIC COMPUTER/CONTROLLER board is completely self-contained and optimized for use as a dedicated controller. The unit is assembled and tested and comes with over 200 pages of documentation. The price, in single quantity, a tiny $195. * Optional power supply (+5, +12 and -12V) $35. Please include $4 for shipping and handling. * Call Micromint for quantity pricing.

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Continued from page 370:

<table>
<thead>
<tr>
<th>Screen-Control Function</th>
<th>Description</th>
<th>Decimal Code</th>
<th>ASCII Character</th>
</tr>
</thead>
<tbody>
<tr>
<td>BELL</td>
<td>Sounds bell for 1/4 second</td>
<td>7</td>
<td>g</td>
</tr>
<tr>
<td>TEXT MODE</td>
<td>Sets TEXT mode (uppercase/lowercase and extra spaces)</td>
<td>14</td>
<td>n</td>
</tr>
<tr>
<td>SET TOP</td>
<td>Sets top left of scrolling window at position</td>
<td>15</td>
<td>o</td>
</tr>
<tr>
<td>DELETE LINE</td>
<td>Deletes current line and scrolls screen up one line</td>
<td>21</td>
<td>u</td>
</tr>
<tr>
<td>ERASE TO END</td>
<td>Erases from current position to end of line</td>
<td>22</td>
<td>v</td>
</tr>
<tr>
<td>SCROLL UP</td>
<td>Scrolls screen up from bottom, top line lost</td>
<td>25</td>
<td>y</td>
</tr>
<tr>
<td>GRAPHIC MODE</td>
<td>Sets GRAPHIC mode (uppercase/graphic no space)</td>
<td>142</td>
<td>N</td>
</tr>
<tr>
<td>SET BOTTOM</td>
<td>Sets bottom right of scrolling window at position</td>
<td>143</td>
<td>O</td>
</tr>
<tr>
<td>INSERT LINE</td>
<td>Inserts a line at current position, scrolls down</td>
<td>149</td>
<td>U</td>
</tr>
<tr>
<td>ERASE BEGINNING</td>
<td>Erases from start of line to current position</td>
<td>150</td>
<td>V</td>
</tr>
<tr>
<td>SCROLL DOWN</td>
<td>Scrolls screen down from top, bottom line lost</td>
<td>153</td>
<td>Y</td>
</tr>
</tbody>
</table>

Poking a 12 or 14 to location 59468 will not change the line spacing between lines. A function's code and inverse (i.e., DELETE LINE versus INSERT LINE or SCROLL UP versus SCROLL DOWN) are 128 apart (i.e., 21 (DELETE LINE) + 128 = 149 (INSERT LINE))

Further Notes (Some known bugs in the disk operating system)
1. Sometimes when the pointer is moved from the middle of one record, it does not go to the beginning of the next record as it should. The RECORD command should be used to position the pointer before each I/O to the file.
2. The save and replace also found in DOS 1.0 has not been corrected.
3. When DS is less than 20 (but greater than 1), DS$ is blank.
4. Opening a data file without specifying the drive number causes a "FILE TYPE MISMATCH ERROR" by the DOS (this is taken care of in Disk BASIC).
5. The BLOCK-ALLOCATE command does not function properly.
6. The pattern matching with trailing '?'s does not match properly. "A??" will match the file "A", "AA", "AAA", or "AAAA", but not "AAAAA".
7. The DS$ variable does not always match the ST variable after a disk operation.
8. SCRATCH will not remove a recently used data file because it finds that was used and believes that the file is still open.
9. The work-space buffers are not reclaimed when a disk file is not properly closed.
10. Scratching an open file will give the file a "DELETED" file type in the directory and garbles DS$.
11. Relative files cannot be copied with the COPY command. They must be rewritten or the disk they are on must be duplicated (backed up).
12. When drive 1 is automatically initialized, DS$ becomes incorrect.
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*Requires CPM, 40 K RAM, at least one disk, and the dumbest of terminals.
control characters can be found in the text box “A Quick Reference.”

The screen editor also gives the space-bar and the cursor-control keys an automatic repeat and enables both the Repeat key and the Tab key. Holding down the Repeat key while pressing any other key will cause that key to repeat. The Tab key causes the cursor to move to the next tab stop. By pressing a Shift/Tab combination, a tab stop will be set (or cleared if one already exists) at the current cursor position. Since a tab stop can be set for each column, a total of 80 tabs can be set at any one time.

The ESC (Escape) key has also been given a function. One wants cursor controls to function while the program runs, but the same controls should be visible as special characters in a listing (it would be difficult to read the listing if the screen would clear each time a Clear Screen character was used). To avoid this problem, Commodore decided that if an odd number of quotes were typed on a line, the system would be in quote mode and a screen-control character would appear as a white-on-black character. The quote mode is also initiated when spaces have been inserted into a line with the Insert key. To end quote mode, you have to type another quote (unless it was initiated by the Insert key) or hit Return (and accept a line that should possibly not be accepted). By hitting the ESC key, you will escape from quote mode and the cursor keys will function normally.

The Run/Stop key has also been changed. In the old OS, it would load the next program from tape and run it. Now, it automatically loads and runs the first file from disk drive 0. This makes it easier for inexperienced operators to use software packages.

The Rest of the Story

Disk BASIC (OS version 4.0) was primarily designed to be used in conjunction with the new DOS 2.1. Though it can be used with the older DOS (version 1.0), the full potential of the system cannot be realized. Although access is the major and most important improvement to the DOS, Commodore has made other improvements.

The reliability of the disk drives has been improved by the removal of one sector (256 bytes) from each of the inner seven tracks on the disk. Because one of these sectors came from the directory track, there is now a maximum of 144 entries to the directory. This change also resulted in the loss of six data blocks from the disk. Because of this change, the disks made by the different DOSes are not compatible: but one can read disks made by the other (note that an 8050 can read only an 8050 disk). DOS 2.1 will generate a “CBM DOS V2” error if you try to write on a disk formatted by a version 1.0 system; however, if you write to a 2.1 formatted disk with DOS 1.0, the directory track will be disturbed and subsequent operations will cause disk errors.

Other changes to DOS 2.1 include an error counter in the BACKUP (a track-by-track duplication that destroys any data originally on the destination disk) command. To back up a disk now takes 2 minutes and 15 seconds instead of 6 to 7 minutes. Also, if the system encounters an error during a COLLECT (verify), the system will restore a bad Block Availability Map (which tells the DOS what blocks are free for use as storage). This was not available under DOS 1.0.

Another improvement is in the COPY command, which will now copy all the files on one disk to another. Trying to copy a file to disk where that file is already in use will produce the “FILE EXISTS” error message, and the COPY will be halted. When converting disks from DOS 1.0 to DOS 2.1, the COPY command is the one to use.

With random-access files, each record must be the same length, making it important to inform the DOS how large each record will be when the file is created. This is so that the DOS can compute where to position the disk’s head for the next appropriate record. The maximum record length is 254 characters, with a maximum of 65,535 records in a file. (The disk would not be able to hold all 65,535 records if the record length was more than two characters.)

Part of the beauty of Commodore's system using intelligent peripheral devices is that they can be doing one thing while the microprocessor is doing another. For instance, when the disk drive sends out a record, it automatically does a “look-ahead” operation and gets the next record (this makes sequential operations faster) while the microprocessor busies itself with computations.

Software availability for any system is quite important. Usually, after the introduction of any new computer, it normally sits around for a time before any good software is available. For the CBM 8032, however, this is not the case. Any software written in standard BASIC or for Commodore computers should run on the 8032 without modification. It does, however, depend on how the program was written.

Because the 8032 uses the new version 4.0 OS (meaning different ROMs), any program that has machine-language calls to the operating system probably won’t work without some modification. For instance, in the 8032, the interrupt vector points to a different location than in the older CBMs.

The other major difference that will cause a compatibility problem is the difference in the screen sizes. Programs (mostly games) that peek and poke at the screen buffer won’t work due to the difference of line lengths on the screens and the additional 1000 bytes in the screen buffer of the 8032.

Since the 8032 is ostensibly a business computer, it is more important to have professional business software available than games. Fortunately, some very powerful business programs are on the market. One is Professional Software’s Wordpro 4 Plus. This is possibly the most powerful word-processing software available for a stock microcomputer.

Another powerful software package available for the system is Visicalc. On the 80-column screen, you can lay out spreadsheets of all types (i.e., budgets, balance
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Completely integrated BINARY SEARCH TREE programs now available. This series of programs fully implements the B-TREE structures including INSERTION, DELETION, EDITING & TRAVERSAL. For more sorting or less data file searches and yet files can be larger than memory. Duplicate keys are fully supported. Files can be retrieved in sorted order via B-TREE traversal. Each of the programs come with fully commented source code so that you can use the modules in your own programming. A Screen oriented input routine is also included in each module. The following B-TREE programs are now available and each includes the above mentioned modules and full documentation included.

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GRAPPLET Color (organize your video cassette library, print labels, etc)........ $39.95
B-TREE Mailin List (keyed by name or zip label printing, etc)............. $49.95

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sheets, etc.) to see how changing one element affects the rest.

Documentation

One area in which Commodore has made a remarkable improvement is documentation. In the past, documentation for Commodore computers has been quite poor, lacking both in content and approach. The 8032 comes with a User’s Reference Manual that explains in a clear, concise manner the capabilities of the system and the entire command set. The command set is presented in a form used by other technical manuals showing the command format and syntax, in which version of Commodore BASIC it can be used, its purpose, remarks about the command, and detailed examples. The manual included with the 4040 explains the operation of the disk and the disk organization, as well as how to use the various disk commands.

I believe, however, that some documentation is lacking. From past experience, I know that a command can be abbreviated to the first few letters (i.e., goto = GO, gosub = GO, print# = PR, etc.). This time-saver is not mentioned in any of the manuals. The screen-control characters and the use of the screen editor (one of the nicer programming features on the system) are also completely missing from the documentation.

In the User’s Guide is a system memory map by 1K-byte blocks. Included in that manual’s appendix is a list of more than 20 system calls, plus the missing machine code needed to perform the listed function. All these system calls are common to all versions of Commodore’s operating system. This is quite helpful for those who wish to do machine-language programming; however, Commodore omits the zero-page memory map, one of the most important memory maps for a 6502-based machine. My interpretation is that Commodore wants other people to write software for its machines that is independent of the model it was written on.

The upgrade ROM for Model 2001 computers will give you all the features and improvements of Disk BASIC, without an 80-column screen. Though the new operating system uses an additional ROM, helpful commands such as TRACE and RENUMBER were not included. (The request for "Programmer’s Aid" routines has been answered by Power, a 4K-byte ROM from Professional Software Inc., 51 Fremont St., Needham, MA 02194.) Likewise, Commodore is offering an upgrade for the 2040 disk drive that makes it a 4040. This set of three ROMs and one controller will give an old 2040 random-access capability and increased reliability. Remember that if you upgrade to a 4040, your 2040 disks must be converted to the new DOS 2.1 format before you can write on them.

Conclusions

The CBM 8032 computer and 4040 disk drive form a good business system for the small to medium-size business. The lack of a marketing strategy by Commodore, as well as its past nonchalant attitude toward the encouragement and development of good software, has hurt its credibility, especially in comparison to the other systems on the market.

The available business software, Wordpro and Visi-calc, make excellent use of the capabilities of the CBM 8032 and coincide with the environment in which it is best suited. The recognition of the companies who market these types of programs will keep this computer in a business atmosphere.

With an increasing number of competitive machines being brought to the marketplace, Commodore appears to be now providing better support and documentation on its systems. The documentation included with the CBM 8032 and the 4040 disk drive has improved over the documentation provided with past Commodore computer systems.
INEXPENSIVE MASS STORAGE
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GALLIUM SOFTWARE
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Utilities provided include programs to copy from floppy to Gallium and from Gallium to floppy, format volumes, and a demo program to show you how your disk can be used.

SERVICE
Gallium-10 disk drives come with a 90-day parts & labor warranty. An extended warranty is available at extra cost. Gallium disk systems require no preventive maintenance.

SPECIFICATIONS:

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11527 20 SW Pacific Hwy, Pacific Terrace Shopping Center, Portland, OR. Discount on over-counter sales only. On I-5 between Rtes. 207 and Interstate 5. 1245-1202.

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The Motorola MC68701 is an enhanced version of the MC6801 microprocessor. One of its chief features is the ability to program itself. The processing unit controls all movement of data into an on-chip EPROM (erasable programmable read-only memory). It controls programming power ($V_{pp}$) to the EPROM during programming, requiring only a few external devices to accomplish this.

On-chip resources of the MC68701 include a 2K-byte EPROM, a three-function timer, a serial-communication interface, up to 29 parallel I/O (input/output) lines, 128 bytes of RAM (random-access read/write memory), and an oscillator. These items provide a great deal of power and flexibility in a small package that's easy to use and design with.

In this article, we will explore how the MC68701 programs itself. We'll also discuss a fully tested MC68701 programmer, including software and a hardware design.

On-Chip EPROM

A dual-purpose MC68701 pin, RESET/$V_{pp}$, is used both to reset the processor and to power the EPROM. This pin is normally +5 volts (V) during nonprogramming operation. It must be raised to $V_{pp}$ ($21 \text{ V} \pm 1 \text{ V}$) during programming of the EPROM. However, the processor will operate normally with $V_{pp}$ applied at all times.

The MC68701 EPROM is controlled by two bits in the RAM/EPROM control register (see figure 1). Bit 0 of the register is called the programming latch control (PLC) and is used to control an address latch used during programming of the EPROM. Bit 1 of the register is called the programming power control (PPC) and is used to control $V_{pp}$ to the EPROM during programming.

When PLC is set, the latch is transparent. When PLC is clear, the address latch is enabled and latches each EPROM address asserted by the processor. PLC should be set during normal nonprogramming processor operation; it should be cleared only to program the EPROM. This bit is set at RESET and can be cleared only in Mode 0 (more about modes later).

When PPC is set, $V_{pp}$ is not applied to the EPROM; when PPC is clear, $V_{pp}$ is applied to the EPROM. PPC should be set during normal nonprogramming operation; it should be cleared only to program the EPROM. This bit is set at RESET and whenever the PLC bit is set, and can be cleared only in Mode 0 with the PLC bit clear.

The MC68701 is programmed in Mode 0 only. In this mode, all the interrupt vectors and reset vectors are in the locations BFF0 to BFFFF hexadecimal, and the on-chip EPROM is at locations F800 to FFFF hexadecimal. The
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<td>TRS-80 Cassette Version</td>
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<td>TRS-80 (Mod-I or III), Pet, Apple or Atari Versions</td>
<td>$99.95</td>
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<tr>
<td>TRS-80 Mod-II, IBM, Osborne and 8&quot; CP/M Versions</td>
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reset vectors should direct the processor to what is essentially a bootstrap-loading program that will fetch data sequentially from memory or a peripheral controller and "burn" each byte into the EPROM. Once \( V_{pp} \) is applied to the RESET/\( V_{pp} \) pin, each data byte is programmed into the onboard EPROM as follows:

1. Clear the PLC bit and set the PPC bit. This enables the EPROM address latch and inhibits \( V_{pp} \) to the EPROM.
2. Write data to the EPROM location to be programmed. Both the data and address will be captured by internal latches.
3. Clear the PPC bit for 50 milliseconds (ms). This controls programming power to the EPROM, allowing the data byte to be burned in.

These steps are repeated until all bytes have been programmed.

An MC68701 Programmer

Fully assembled and tested modules designed to program the MC68701 are available through Motorola distributors. Some users, however, may require custom programming boards designed to meet specific needs.
How to Get 256K of 16K Increment Bank Selectable Memory or 2 Megabytes of Contiguous Memory on One S100 Board

The 256 KMB-100 from Intercontinental Micro Systems is one of the most flexible and easily integrated S100 bus, 256K memories available today. Its advanced features include:

- Complete Cromix™ CP/M™ MP/M™ and other major systems compatibility—up to 16 users are now possible on a Cromemco System.
- Bank selectable in any combination of 16K banks (e.g. 4 64K users, 8 32K users, 16 16K users or any other combination.)
- Up to 2 contiguous megabytes are easily configurable.
- Configures for phantom deselection.
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- 4 Megahertz operation, no wait states.
- Parity error detection through interrupts.
- IEEE 696/1D2 Spec S100 Bus.
- One year complete warranty.
- Fully compatible with Intercontinental Micro’s advanced CPZ-48000 S100 Bus single board CPU, which features: Z80 based system, single or double density floppy disk controller, 64K onboard dynamic RAM, 4 channel DMA controller and memory management.

The others are still talking about their S100 Bus 256K memories—ours is in production—call today for further details and applications information.

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Anaheim, California 92806
(714) 978-9758 Telex: 678401-TAB-IRIN

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JOHN STARKWEATHER'S

NEVADA PILOT

$149.95 For all CP/M systems. Works with Apple (softcard needed), Osborne 1, TRS-80, North Star, Superbrain, Micropolis, Vector and many other microcomputers. Needs 32K RAM, one disk drive and CRT or video display and keyboard.

- PILOT for Programmed, Inquiry, Learning Or Teaching.
- An excellent interactive language for education and office automation.
- Perfect companion for BASIC, COBOL and PASCAL to solve training and documentation problems.
- John Starkweather, Ph.D., creator of PILOT, wrote this version to meet all PILOT-73 standards and added many new features.
- New features include full screen text editor, commands to drive optional equipment such as VTR's & voice response units.
- Currently used in many college and progressive high schools.
- Use for interactive applications—data entry, programmed instruction and testing.

NEVADA EDIT

$119.95 For all CP/M-based systems. Requires 32K RAM, one disk drive and CRT or video display and keyboard.

- A character oriented full screen video display text editor designed specifically for program preparation of COBOL, FORTRAN, BASIC and similar programs.
- Features include single key commands for cursor control, scrolling, block moves, search and replace, tab setting and multiple file insertions.

NEVADA COBOL

$199.95 For all CP/M or MP/M operating systems. Requires 32K RAM and one disk drive.

- Edition II of Nevada COBOL is based on ANSI-74 Standards.
- With 48K RAM, you can compile and execute up to 4000 statements.
- COPY statement for library handling.
- CALL...USING...CANCEL
- PERFORM...THRU...TIMES...UNTIL...
- IF...NEXT SENTENCE...ELSE...NEXT SENTENCE AND/OR < > NOT.
- GO TO...DEPENDING ON...
- Interactive ACCEPT/DISPLAY...
- RELATIVE (random) access files
- Sequential files both fixed and variable length.
- INSPECT...TALLYING...REPLACING.

The programmer described in this article (see figure 2) is designed for simplicity, low cost, and ease of use. The hardware and associated software verify that an inserted MC68701 is initially fully erased, do the programming, and verify the "entered" code. The user only applies power and monitors three light-emitting diodes (LEDs) that indicate EPROM status. The programmer enters the entire 2K-byte content of EPROM IC4 into the MC68701 EPROM. The system can be modified to, for instance, provide more detailed failure information or to program only a portion of the EPROM.

Using the Programmer

The user needs no knowledge of MC68701 operation and very little knowledge of electronics in order to use the programmer. Four steps are required:

1. Insert the EPROM containing the code to be programmed into the MC68701 into the socket at IC4.
2. Insert the MC68701 into the socket.
3. Apply power.
4. Monitor LEDs.

Within a few seconds after power is applied, LED 1 should light, indicating that the MC68701 EPROM is fully erased. Approximately 105 seconds after power is applied, LED 2 should light, indicating that the EPROM has been programmed and its contents verified. At this time, power can be removed from the system, and another MC68701 can be programmed.

LED 3 will light to indicate either a not fully erased MC68701 EPROM when power is initially applied, or failure to verify after attempted programming. If LED 3 lights and LED 1 is not lit, the MC68701 was not fully erased when inserted into the board. If this occurs, no attempt is made to program the EPROM. If LED 3 lights while LED 1 is lit, the EPROM's contents did not verify after attempted programming.

The LEDs should be color-coded to give readily recognized pass and fail indication. A good color scheme is amber for LED 1 (erased), green for LED 2 (pass), and red for LED 3 (fail). Zero insertion force sockets should be used for the MC68701 and EPROM.

Memory Map

The memory map, consisting of five special address spaces, is shown in figure 3. Four of the address spaces are fixed by the MC68701 during programming and cannot be relocated. These consist of an internal-register area (0000 to 001F hexadecimal), internal RAM (0080 to 00FF hexadecimal), external interrupt vectors (BFF0 to BFFF hexadecimal), and internal EPROM (F800 to FFFF hexadecimal).

A fifth address space is used for an MCM2716 that contains the code to be entered into the MC68701 on-chip EPROM. This MCM2716 has been arbitrarily placed at locations 7800 to 7FFF hexadecimal and can be relocated for custom programmer design.
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Circuit Description

The MC68701 programmer consists of two MCM2716 EPROMs, a 74LS373 transparent latch, a 74LS00 NAND gate package, an MC68701 socket, and associated “glue,” as shown in figure 2.

A 4-megahertz (MHz) crystal is used to yield 1-MHz operation. This clock frequency can be increased to accommodate higher-speed MC68701s, but changes in the operating frequency require changes in the MINPRG bootstrap software to ensure 50 ms programming time for each byte entered into the EPROM, or to minimize programming time.

This delay is governed by the value of WAIT in MINPRG and is indirectly related to the clock frequency. An increase in the clock frequency requires a proportional increase in the value of WAIT; a decrease of the clock frequency allows a proportional decrease in the value of WAIT.

The MC68701 can also be driven by an external transistor-transistor logic (TTL) clock at pin 3, with pin 2 grounded. If this clock option is used, the capacitors tied to pins 2 and 3, used to ensure stable crystal operation, are not required.

Pins 8, 9, and 10 are tied to ground to place the MC68701 into Mode 0 (programming mode) at RESET. IRQ (interrupt request) and NMI (nonmaskable interrupt) are tied high to eliminate external interrupts.

Three LEDs are tied to I/O pins 13, 14, and 15. They are used to indicate the state of the MC68701 EPROM during programming operations. High-current drivers force the pins low to light the LEDs.

The RESET/Vpp pin is driven by a transistor to assure adequate power to the pin during programming. The base of this transistor is controlled by an RC (resistor-capacitor) network that provides adequate delay between

Text continued on page 394

Listing 1 is on pages 388-392
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Listing 1: MINPRG is the software that allows the MC68701 to program itself.

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Listing 1 continued on page 390
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Listing 1 continued:

00059A B8A 26 EA B876  BNE  STALL1  NOPE
00060A B8C 20 06 B694  BRA  PGINT
00061   * * 00062A B8E 86 83  A  ERROR1  LDAA  #$83  LIGHT ERROR LED ONLY
00063A B890 97 02  A  STAA  PIDR
00064A B892 20 5D B8F1  BRA  SFLF
00065   * * 00066A B94 CE 7800  A  PGINT  LDX  #$7800  INIT. IMBEG
00067A B97 DF 80  A  STX  IMBEG
00068A B99 CE 7FFF  A  LDX  #$7FFF  INIT. IMEND
00069A B9C DF 82  A  STX  IMEND
00070A B9E CE C350  A  LDX  #$C350  INIT. WAIT (4.0 MHZ)
00071A B8A1 DF 86  A  STX  WAIT
00072
00073   * *  THIS PART FROM 68701 DATA SHEET
00074
00075A B8A3 DE 84  A  EPROM  LDX  PNR  SAVE CALLING ARGUMENT
00076A B8A5 3C  PSHX  RESTORE WHEN DONE
00077A B8A6 DE 80  A  LDX  IMBEG  USE STACK
00078   * 00079A B8A8 3C  EPROM2  PSHX  SAVE POINTER ON STACK
00080A B8A9 86 FE  A  LDAA  #$FE  REMOVE VPP, SETLatch
00081A B8AB 97 14  A  STAA  EPMCNT  PPC=1, PLC=0
00082A B8AD A6 00  A  LDAA  0,x  MOVE DATA MEMORY-TO-LATCH
00083A B8AF DE 84  A  LDX  PNR  GET WHERE TO PUT IT
00084A B8B1 A7 00  A  STAA  0,x  STASH AND LATCH
00085A B8B3 08  INX  NEXT ADDR.
00086A B8B4 DF 84  A  STX  PNR  ALL SET FOR NEXT
00087A B8B6 86 FC  A  LDAA  #$F6  ENABLE EPROM POWER (VPP)
00088A B8B8 97 14  A  STAA  EPMCNT  PPC=0, PLC=0
00089   * 00090   *  NOW WAIT 50 MSRC TIMEOUT USING COMPARE
00091
00092A B8BA DC 86  A  LDD  WAIT  GET CYCFL COUNTER
00093A B8BC D3 09  A  ADDD  TIMER  BUMP CURRENT VALUE
00094A B8BE 7F 0008  A  CLR  TCSR  CLEAR OCF
00095A B8CD 00 0B  A  STD  OUTCMP  SET OUTPUT COMPARE
00096A B8C3 86 40  A  LDAA  #$40  NOW WAIT FOR OCF
00097A B8C5 95 08  A  EPROM4  BITA  TCSR
00098A B8C7 27 FC B8C5  BEQ  EPROM4  NOT YET
00099   * 00100A B8CA 3B  PULX  SET UP FOR NEXT ONE
00101A B8CA 08  INX  NEXT
00102A B8CB 9C 82  A  CPX  IMEND  MAYBE DONE
00103A B8CD 23 D9 B8A8  BLS  EPROM2  NOT YET
00104A B8CF 8E FF  A  LDAA  #$FE  REMOVE VPP, INHIBIT LATCH
00105A B8D1 97 14  A  STAA  EPMCNT  EPROM CAN NOW READ
00106A B8D3 38  PULX  RESTORE PNR
00107A B8D4 DF 84  A  STX  PNR
00108   * *  START NEW CODE
00109
00110   * 00111A B8D6 CE 7800  A  LDX  #$7800  SET UP POINTER
00112A B8D9 3C  VERF2  PSHX  SAVE POINTER ON STACK
00113A B8DA A6 40  A  LDAA  0,x  GET DESIRED DATA
00114A B8DC DE 84  A  LDX  PNR  GET EPROM ADDR.
00115A B8DE E6 00  A  LDAR  0,x  GET DATA TO BE CHECKED
00116A B8E0 11  CRA  CHECK IF SAME

Listing 1 continued on page 392
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00117A B8F1 25 10 B8F3        BNE ERROR2 BRANCH IF ERROR(LIGHT LED)
00118A B8E3 08               INX NEXT ADDR
00119A B8E4 DF 84 A          STX PNTR ALL SET FOR NEXT
00120A B8E6 38               PULX SETUP FOR NEXT ONE
00121A B8E7 08               INX NEXT
00122A B8E8 8C B000 A        CPX #$B000 MAYBE DONE
00123A B8EB 26 EC B8D9        BNE VERF2 NOT YET
00124                       *
00125A B8ED 86 84 A          LDAA #$84
00126A B8EF 97 02 A          STAA PIDR LIGHT VERIFY LED
00127                       *
00128A B8F1 20 FE B8F1 SELF   BRA SELF WAIT FOREVER
00129                       *
00130A B8F3 86 82 A ERROR2 LDAA #$82 LIGHT ERROR & ERASED LED'S
00131A B8F5 97 02 A          STAA PIDR
00132A B8F7 20 F8 B8F1        BRA SELF
00133                       *
00134                       RESTART AND INTERRUPTS.
00135                       *
00136A BFF0                  ORG $BFF0
00137A BFF0 B8F1 A           FDB SELF
00138A BFF2 B8F1 A           FDB SELF
00139A BFF4 B8F1 A           FDB SELF
00140A BFF6 B8F1 A           FDB SELF
00141A BFF8 B8F1 A           FDB SELF
00142A BFFA B8F1 A           FDB SELF
00143A BFFC B8F1 A           FDB SELF
00144A BFFE B050 A           FDB START
00145 END
TOTAL ERRORS 00000-00000

0014 EPMCNT 00016*00081 00088 00105
B8A3 EPROM 00075*
B8A8 EPROM2 00079*00103
B8C5 EPROM4 00097*00098
B8E0 ERASE 00035*00041
B8E0 ERROR1 00037 00062*
B8F3 ERROR2 00117 00130*
0080 IMBEG 00021*00007 00077
0082 IMEND 00022*00069 00102
B86D NEXT 00039 00043*
0080 OUTCMP 00015*00054 00095
0000 PIDR 00011*00029
0002 PIDR 00012*00030 00044 00063 00126 00131
B894 PGINT 00060 00066*
0084 PNTR 00023*00033 00075 00083 00086 00107 00114 00119
B8F1 SELF 00064 00128*00128 00132 00137 00138 00139 00140 00141 00142 00143
B876 STALL1 00050*00059
B883 STALL2 00056*00057
B850 START 00027*00144
0008 TCSR 00013*00053 00056 00094 00097
0009 TIMER 00014*00052 00093
B8D9 VERF2 00112*00123
0086 WAIT 00024*00048 00071 00092

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<td>SPECIAL</td>
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<td>Tandon TM 100-1</td>
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<tr>
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<td>$1095.00</td>
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Figure 4: Flowchart of the programmer software called MINPRG. The program is shown in listing 1.

Text continued from page 386:

the application of $V_{CC}$ and RESET. During programming, $21 \pm 1 \text{V} (V_{pp})$ must be applied to the RESET $V_{pp}$ pin. A 5- to 26-V voltage converter is used to eliminate the need for two power supplies. R1 and R2 form a voltage divider that provides a proper voltage level to the RESET/V$_{pp}$ pin. R2 also serves to discharge C1 during power-down.

A 74LS373 transparent latch is used to demultiplex port 3, which is used both as a lower address port (signals A0 through A7) and as a data port. An address strobe (AS) from the MC68701 is tied to latch enable (LE) of the 74LS373 to latch the lower-order address at the proper time each bus cycle. Once the lower address is latched, the port is used for data transfer.

Four NAND gates are used for address decoding of the two external EPROMs. Each EPROM is selected with high A13 to ensure deselection during access of MC68701 internal RAM and internal registers. EPROM IC3 drivers are enabled with low A14 and high E; EPROM IC4 drivers are enabled with low A14 and high E. Controlling with E ensures that drivers are in the high-impedance state during E low, eliminating driver contention on the multiplexed lower-address/data bus. Controlling the drivers with low A14/A15 assures separation between the off-chip and on-chip EPROM address spaces. EPROM IC3, containing MINPRG, is selected at locations B800 to BFFF hexadecimal; EPROM IC4, containing the program to be entered into the MC68701 EPROM, is selected at locations 7800 to 7FFF hexadecimal. Incomplete address decoding is used for IC3 and IC4 to minimize the number of devices used in the system, allowing their selection in several address spaces. Care must be taken when writing software for the system to ensure that only one device is accessed at any time.

Note that only Motorola MCM2716 EPROMs allow an optional active high chip select (pin 20) by tying $V_{pp}$ (pin 21) low during reads. If non-Motorola 2716 EPROMs are used, $V_{pp}$ must be tied high and A13 must be inverted to the active low chip selects.

Program Description

The programmer uses a bootstrap program, MINPRG, to control programming of the MC68701 EPROM. The program performs the following functions:

1. Initialize the MC68701.
2. Check that the EPROM is erased.
3. Program the EPROM.
4. Verify the program.
5. Stop.

MINPRG also controls three LEDs that indicate MC68701 EPROM status during programmer operation. A detailed flowchart of MINPRG is shown in figure 4; a complete listing is shown in listing 1 on page 388.

Program Modifications and Considerations

Additions and modifications to this code can be made easily by inserting routines between the basic blocks on the flowchart. For convenience, the start and stop addresses of each block are located directly to the left of each block.

Parameters IMBEG, IMEND, PNTR, and WAIT, stored in RAM locations 80 to 87 hexadecimal, determine the size of the data block to be programmed into the MC68701, the first MC68701 EPROM location to be programmed, and the time period each byte will be burned into the EPROM. These parameters can be changed to allow programming of selected EPROM locations and to allow changes in operating frequency. These parameters, once selected, should remain constant throughout the entire program.

A modification to MINPRG that should be considered is verification of the EPROM if the EPROM is not initially erased, rather than to simply light LED 1 and wait. This change would allow verification of MC68701 EPROMs that have already been programmed and used.
Get Omni quality for as little as $1.99... even if all you

Call toll-free for great savings on Omni's complete line of 5¼" premium disks. Each is certified error-free at a minimum of twice the error threshold of your system. Each is rated for more than 12 million passes without disk-related errors or significant wear. And each is precision fabricated to exceed all ANSI specifications with such standard features as reinforced hub rings and Tyvec sleeves. Get same day shipment and an

---

**be sure to indicate system name and model # at right.**

<table>
<thead>
<tr>
<th># of 10 Packs</th>
<th>5¼&quot; Disks</th>
<th>Price Per 10 Pack</th>
<th>Total Price</th>
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<tr>
<td>Single side/single density</td>
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<td>$</td>
<td></td>
</tr>
<tr>
<td>Single side doubles density</td>
<td>$23.90</td>
<td>$</td>
<td></td>
</tr>
<tr>
<td>Double side/double density</td>
<td>$39.90</td>
<td>$</td>
<td></td>
</tr>
<tr>
<td>Flip Floppy reversible</td>
<td>$39.90</td>
<td>$</td>
<td></td>
</tr>
<tr>
<td>Double side/double density</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protective plastic library case (in lieu of soft storage box)</td>
<td>$2.99</td>
<td>$</td>
<td></td>
</tr>
<tr>
<td>Shipping and handling</td>
<td>$1.50</td>
<td>$</td>
<td></td>
</tr>
<tr>
<td>5% sales tax (Mass. only)</td>
<td></td>
<td>$</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>$</td>
<td></td>
</tr>
</tbody>
</table>

- Check
- COD
- Master Card
- VISA

Card #: __________________________ Exp. __________________________

System and model #: __________________________

Name: __________________________

Address: __________________________

Tel.: __________________________
A whole new generation of Epson MX printers has just arrived. And while they share the family traits that made Epson famous — like unequalled reliability and ultra-fine printing — they’ve got a lot more of what it takes to be a legend.

For instance, they’ve got a few extra type styles. Sixty-six, to be exact, including italics, a handy subscript and superscript for scientific notation, and enough international symbols to print most Western languages.

What’s more, on the new-generation MX-80, MX-80 F/T and MX-100, you get GRAFTRAX-Plus dot addressable graphics. Standard. So now you can have precision to rival plotters in a reliable Epson printer. Not to mention true backspace, software printer reset, and programmable form length, horizontal tab and right margin.

All in all, they’ve got the features that make them destined for stardom. But the best part is that beneath this software bonanza beats the
heart of an Epson. So you still get a bidirectional, logical seeking, disposable print head, crisp, clean, correspondence quality printing, and the kind of reliability that has made Epson the best-selling printers in the world.

All of which should come as no surprise, especially when you look at the family tree. After all, Epson invented digital printers almost seventeen years ago for the 1964 Tokyo Olympics. We were the first to make printers as reliable as the family stereo. And we introduced the computer world to correspondence quality printing and disposable print heads. And now we’ve given birth to the finest printers for small computers on the market.

What’s next? Wait and see. We’re already expecting.

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<table>
<thead>
<tr>
<th>FEATURE</th>
<th>ORIGINAL MX-80</th>
<th>GRAFTRAX-80*</th>
<th>ORIGINAL MX-100</th>
<th>MX-80 FT</th>
<th>MX-100 with GRAFTRAX-Plus</th>
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<tr>
<td>Bidirectional printing</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Logical seeking function</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Disposable print head</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Speed: 80 CPS</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Matrix: 9 x 9</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Selectable paper feed</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
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<td><strong>PAPER HANDLING FUNCTIONS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Line spacing to n/216</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Programmable form length</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Programmable horizontal tabs</td>
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<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Skip over perforation</td>
<td></td>
<td>X</td>
<td>X</td>
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<tr>
<td><strong>PRINT MODES AND CHARACTER FONTS</strong></td>
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<td></td>
<td></td>
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<tr>
<td>96 ASCII characters</td>
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<td>Special international symbols</td>
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<td>X</td>
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<tr>
<td>Normal, Emphasized, Double-Strike and Double/Emphasized print modes</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<td>Subscript/Superscript print mode</td>
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<tr>
<td>Underline mode</td>
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<tr>
<td>10 CPI</td>
<td>X</td>
<td>X</td>
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<tr>
<td>5 CPI</td>
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<td>17.16 CPI</td>
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<td>8.58 CPI</td>
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<tr>
<td><strong>DOT GRAPHICS MODE</strong></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Line drawing graphics</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Bit image 60 D.P.I.</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Bit image 120 D.P.I.</td>
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<tr>
<td><strong>CONTROL FUNCTIONS</strong></td>
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<td></td>
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<tr>
<td>Software printer reset</td>
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<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Adjustable right margin</td>
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<td>True back space</td>
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<td>X</td>
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</tr>
<tr>
<td><strong>INTERFACES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard — Centronics-style 8-bit parallel</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Optional — RS-232C current loop w/2K buffer</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>RS-232C x-on/x-off w/2K buffer</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>IEEE-488</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

*Tandy TRS-80 black graphics only available with GRAFTRAX 80.*

Circle 171 on inquiry card.
The Heath/Zenith Model 47 Dual Floppy-Disk System

Christopher O. Kern
201 I St. SW, Apt 839
Washington, DC 20024

The H-47-BA (also called the Z-47-BA) is a dual-drive 8-inch floppy-disk subsystem for the Heath H-8 and H-89 (or Z-89) computers (the "H" models are provided in kit form by Heath Company; "Z" designates assembled products sold by the parent Zenith Corporation). The H-/Z-47 (the BA suffix is dropped throughout) provides approximately 2 megabytes of online storage, which should be adequate for most hobby and many small-business purposes. Equally important, it provides standard IBM soft-sectored floppy-disk compatibility for the Heath/Zenith product line, which substantially increases the amount of software that is available.

Under CP/M, a formatted double-sided, double-density disk (with twenty-six 256-byte physical sectors per track) has 980K bytes of usable storage capacity. The comparable figure for HDOS is 999K bytes. The difference is the result of how the two operating systems organize their disk directories and other supporting software. Heath's implementation of CP/M also supports an "extended double-density" format where each track is divided into eight sectors of 1024 bytes each. With extended double density, the usable capacity of a double-sided disk is 1208K bytes. This format is not in general use and disks using it normally will not be readable by other CP/M-based computer systems.

Disk de-blocking under CP/M (transforming the 256- and 1024-byte sectors that are physically present on the disk into the 128-byte logical sector that CP/M expects) is invisible to the user. One of the advantages of the denser recording formats is that multiple logical read-sector operations can be performed by a single physical disk access. This speeds up disk I/O (input/output) because it is faster to withdraw data from a buffer in semiconductor memory than to read it from the disk. Both Heath-supplied operating systems identify the number of sides and the density of the disk at the time that it is logged in. Densities can be mixed, and a single-sided disk can be used in one drive while a
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Circle 86 on Inquiry card.

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...continued on next page...

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BYLT August 1982
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![Image of DISK SYSTEMS](image)

**GENERAL SPECIFICATIONS**

- **DRIVE:** FUJITSU 20MB Winchester type
- **MAINTENANCE:** Free
- **I/F:** GPIB/IEEE-488 (3978)
- **RS-232C Switch selectable **
- **BAUD-RATE:** 300 to 38,400 baud
- **COMMAND:** A, R, W, E, S, and Maintenance Command
- **SOFTWARE:** All necessary handler programs included on diskette
- **POWER:** AC100-240V ISOVA
- **DIMENSIONS:** 430W×150H×450D
- **Approx:** 25k g
- **PRICE:** $6200.00 F2P/F2

New 8'FD subsystems for CROMEMCO* and other general systems

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- **DRIVE:** Ultra-compact NEC FD1165X2 (8" double-sided density, direct drive, fully compatible with Shugart SASSOR)
- **ENCLOSURE:** 160W×230H×500D cm cu, power supply and noise filter included
- **PRICES:**
  - F2P (signal compatible with Percom 299) $2,580.00 (including FSC-1250)
  - FSC-1250 (I/F for 16FD & Shugart type drive, no modification required of CP/M) $550.00
  - F2 (pin compatible with Shugart drives) $1,990.00

**GPIB-100**

S-100 multifunction board meeting IEEE-488 specifications

**GENERAL SPECIFICATIONS**

- **GPIB:** (IEEE-488, 1975/1978/NS/N89)
- **TIMER:** 100 use to 18 hours (8253)
- **DISK:** Universal interrupt controller (A39515)
- **CLOCK:** Real time, battery-backup (NSM331)
- **BLIND:** IEEE S-100
- **SOFTWARE:** All necessary handler programs included on diskette
- **PRICE:** $850.00

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Photo 1: Front view of the Heath/Zenith 47 dual floppy-disk system.

Previous Heath disk systems, based on single-density 5½-inch floppy-disk drives, provided a maximum of roughly 300K bytes of online storage, so the 2-megabyte H-/Z-47 represents a major increase in system capacity. Up to three 5½-inch drives can still be used in addition to the H-/Z-47 with either the H-8 or H-/Z-89 computers.

**Speed of Disk I/O**

An incidental benefit of adding 8-inch drives to an existing 5½-inch system is an increase in disk-access speed, especially when using extended double density under CP/M. According to Heath's specifications, the average time required to access a particular sector is about 15 percent faster on the H-/Z-47 than on Heath's 5¼-inch drives (191 ms compared with 225 ms). My rudimentary tests confirmed that most disk-bound programs run about 15 percent faster.

The most noticeable speed-up is in the time required to initiate a CP/M transient program or open a data file. This is particularly apparent when lengthy "batch" jobs are being run under CP/M's SUBMIT facility. An experimental Unix-like disk operating system I have been using, which must often read down a hierarchy of file directories, was rather laggardly with 5½-inch drives. It perked up considerably when run on the H-/Z-47.

**Operating Requirements**

Interface cards for the H-8 and H-/Z-89 computers are sold separately. These provide the control logic for disk input and output, as well as the buffer memory required to store data that has been read from or written to the disk. The interface board for the H-8 also provides two programmable RS-232C serial channels. If a system has only serial peripheral devices (e.g., a terminal and a printer), this can free an extra card position on the H-8 bus.

The H-/Z-47 is large (19 by 18½ by 10½ inches) and fairly heavy (65 pounds). The twin cooling fans in the back of the unit are relatively quiet and they provide excellent, filtered, positive ventilation (this should keep dust away from the surfaces of the disks). The noise level of the active drives is about average, but I don't think the H-/Z-47 would be intrusive in the average office.

The H-/Z-47 carries an FCC-required warning label to the effect that its operation in residential areas may cause RFI and TVI (radio and television interference) and that the user is responsible for ensuring that this doesn't happen. But there was no sign of TVI when I operated the unit...
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Increase floppy disk system speed from 2 to 5 times using our new CACHE-C CP/M®. This will only work with the Tarbell CPU/IO board and the Tarbell Double Density Floppy Disk Interface, so we have a combination package available.

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- Double Density Floppy Disk Interface with boot ROM, Direct Memory Access and extended memory addressing.
- CP/M 2.2 on single density disk with manuals
- New CACHE-C CP/M 2.2 on double density disk. This system keeps up to 64k of most recently used 512-byte sectors in extended address memory.

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CP/M is a registered trademark of Digital Research
within a few feet of a portable television set that has proved sensitive to interference from other sources.

No preventive maintenance is required. The drive manufacturer (Remex) does not even recommend cleaning the read/write head. Repair service is available at the various Heathkit Electronic Centers around the country and from the factory in Benton Harbor, Michigan. In my experience with previous Heath products, repairs are invariably done correctly and usually within a week. Heath also maintains a special technical-service telephone number for those who want to troubleshoot Heath equipment themselves. I have found this fairly helpful on occasion, although there are obvious limits to how much can be accomplished on the phone.

Construction

Heath is one among the dwindling number of manufacturers that still supplies computer products in kit form. I have been building Heathkits off and on for the better part of 20 years, and construction of the H-47 was more reminiscent of some of those earlier projects than, say, of building my H-8 computer. Most of the required wiring is point-to-point. The two disk drives, along with their associated electronics, come preassembled. There are only two small printed-circuit boards that must be prepared. One contains two front-panel switches that make it possible to write-protect a disk electronically (as well as by the usual method of removing the adhesive write-enable tab). The other circuit board, on the rear panel, provides various connectors for the wiring harnesses.

The rest of the job falls into two main categories: wiring the power supply and assembling the sheet-metal parts that form the chassis. Most of the power-supply components are easy to get to, although there are a few places where wires are packed closely enough to require care in maneuvering a hot soldering iron. The chassis assembly is considerably more complex than that of other Heath products I have built, and it gets fairly involved as more and more parts are added. There were a couple of times when a second pair of hands would have helped. Despite the relatively large number of sheet-metal components, everything fits together with gratifying precision and the finished product is very solid.

Heath's assembly instructions have long been the standard against which others are judged, and the 65-page manual for the H-/Z-47 (supplemented by a schematic diagram and a 30-page booklet of large illustrations) fully lived up to my expectations. I found only one minor error—the picture of the AC line filter in the assembly manual didn't match the part that was actually supplied—but it was obvious from other illustrations how the part was intended to fit. From start to finish, the unit required 91/2 hours of construction time, and it worked perfectly the moment it was powered up.

The H-8 and H-/Z-89 interface cards, like the controller electronics on the two disk drives, are supplied prewired. Apparently there is little savings to be had in providing printed circuits in kit form now that auto-

The DS120 Terminal Controller makes your LA36 perform like a DECwriter® III.

The Datassouth DS120 gives your DECwriter® II the high speed printing and versatile performance features of the DECwriter® III at only a fraction of the cost. The DS120 is a plug compatible replacement for your LA36 logic board which can be installed in minutes. Standard features include:

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- Horizontal & Vertical Tabs
- Page Length Selection
- 110-4800 baud operation
- 1000 character print buffer
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- Self Test
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- 20 mA Current Loop interface
- Top of Form
- Adjustable Margins
- Double wide characters
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- Optional APL character set

Over 5,000 DS120 units are now being used by customers ranging from the Fortune 500 to personal computing enthusiasts. In numerous installations, entire networks of terminals have been upgraded to take advantage of today's higher speed data communications services. LSI microprocessor electronics and strict quality control ensure dependable performance for years to come. When service is required, we will respond promptly and effectively. Best of all, we can deliver immediately through our nationwide network of distributors. Just give us a call for all the details.
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WORDS/HR
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VISION
BPI BUSINESS SOFTWARE
WORDSTAR
HAYES MICROMODEN 8
NOVATION CAT I
MICROSOFT 2.80 SOFTWARE
VIDEX 80 COLUMN CARD
DISKETTES
BASF 5/4" SS/DD/HUB RING (10)... 23
BASF 8" DISKETTES (10) ... 24

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BASF 5/4" SS/DD/HUB RING (10)... 23
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WORDS/HR
APPLE II SOFTWARE
VISIONCALC
VISIREND VISIPLOT
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BPI BUSINESS SOFTWARE
WORDSTAR
HAYES MICROMODEN 8
NOVATION CAT I
MICROSOFT 2.80 SOFTWARE
VIDEX 80 COLUMN CARD
DISKETTES
BASF 5/4" SS/DD/HUB RING (10)... 23
BASF 8" DISKETTES (10) ... 24

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mated assembly equipment is available to manufacturers. I don't mourn the loss. Stuffing printed-circuit boards is boring and it demands intense attention to soldering technique because of the high speeds involved in digital electronics and the high component density of modern boards.

The Heath operating system, HDOS, includes a disk-drive test program along with a number of other useful diagnostics. The program—which runs for a full hour on an 8-inch double-sided disk, reading and writing random as well as sequential disk sectors—provides a fairly stringent test of the drive's ability to stand up to heavy usage. Both H-/Z-47 drives performed perfectly, with no soft (recoverable) or hard (nonrecoverable) errors. Even after two hours of strenuous operation, the unit did not heat up noticeably.

Use with Existing Systems

The H-8 computer requires a minor hardware modification (Heath's "extended configuration" card) when the H-/Z-47 is used with an 8080A central processor. The Z-80 CPU board for the H-8 includes the extended configuration option. Older H-/Z-89 models also need modification to use the 8-inch disk unit. Recent models—those with an external control to adjust video-screen brightness—can accept the H-/Z-47 as is. Once the hardware is properly configured, integrating the H-/Z-47 into an existing system amounts to little more than plugging it in.

Both Heath's version of the CP/M operating system and the company's own HDOS operating system come complete with device drivers for 8-inch as well as 5¼-inch drives. The presence of the 8-inch disk unit is determined automatically at the time of the initial bootstrap load by special configuration programs that are provided as part of the Heath software. New system disks created by the system-generation program (provided with each operating system) will "remember" what disk devices are available. This means the configuration process does not have to be repeated each time the system is loaded.

Heath's CP/M BIOS module includes all the source code for the disk drivers and device tables (the BIOS—basic input/output system—contains the hardware-dependent routines for a specific computer system). The corresponding source modules are also provided with the Heath operating system. The entire HDOS source code is available in printed form at extra cost. Heath's liberal policy with regard to source-code distribution is unusual and very welcome. While most users will never need the source for the operating system, it is critical for some specialized applications.

The H-/Z-47 can be used as either the primary or secondary disk unit in a system. The primary unit is the one from which the operating system is usually booted up. The H-8 computer (but not the H-/Z-89) permits the system to be booted from either the primary or the secondary unit. The Heath software manuals contain step-by-step instructions for generating new system disks for secondary drives. The operating systems that are distributed on 5¼-inch and 8-inch disks are identical, so no new software is required when H-/Z-47 is added to an existing system.

Conclusions

The H-/Z-47 provides a maximum of 999 and 1208K bytes of usable storage under HDOS and CP/M, respectively, for the Heath H-8 and Heath/Zenith-89 computers. It also provides compatibility with the standard IBM soft-sectored 8-inch disk format, substantially increasing the availability of software for the Heath/Zenith product line.

The kit version of the unit requires point-to-point wiring, since all but two small printed-circuit boards come preassembled. Construction took about 9½ hours. Heath's documentation is excellent, and the H-/Z-47 is easily integrated into existing Heath/Zenith computer systems without the addition of any new software. H-8 computers with an 8080A microprocessor and some older H-/Z-89 models require minor hardware modification, available at a nominal extra cost. Interface circuit boards are sold separately.
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<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>4800 Baud (3&quot; per second)</td>
<td></td>
</tr>
<tr>
<td>10^-8 Error Rate</td>
<td></td>
</tr>
<tr>
<td>Controlled by Hand-shake</td>
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<tr>
<td>DB25P Connector installed</td>
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</tr>
<tr>
<td>Speed Stability (long term) ± .1%</td>
<td></td>
</tr>
<tr>
<td>RS232 Output standard</td>
<td></td>
</tr>
</tbody>
</table>

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**The Transformation People.**

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Computer-assisted instruction (CAI) in public schools and colleges has increased in the last few years. Until now, however, two limitations made extensive CAI programs impractical for most school systems: (1) the time and cost involved in writing separate programs in BASIC, PILOT, or other language for each new lesson; and (2) the shortage of experienced educational programmers who could provide a school with its own personalized software.

The Assisted Instructional Development System (AIDS) represents a significant effort to overcome these constraints. The AIDS package, which includes both hardware and software, is a versatile educational system which makes creating CAI lessons cost-effective. It also does away with the instructor's need for extensive programming experience.

The economic catalyst for AIDS's development was the Norfolk (Virginia) Public School System, which has been experimenting with CAI for several years. The school system decided to move from the Hewlett-Packard HP3000 minicomputer system it had been using to individual Apple II microcomputers.

The Small Business Computer Center of Virginia Beach was commissioned to develop an adaptable, easy-to-use CAI package that would meet the school's educational needs. The result of this project is the AIDS package.

**The System**

Through elaborate use of text files and string variables, AIDS allows teachers with virtually no programming experience to write elaborate CAI lessons. A teacher simply types in the lesson and then inputs questions pertaining to the lesson. The questions must be in the standard objective formats of true/false, multiple choice, or short answer. A special string search option enables the computer to search for any keyword the teacher may be looking for in a student response.

The instructor can input personalized reinforcing responses for correct and incorrect answers. A failure message, which the teacher can input, informs the student that he or she did not enter the correct response. A hint feature also exists for the student if a question poses great difficulty. The teacher has the option to include this feature in any question—without limit to the number of hints that can be given for each question. The number of questions per lesson is limited only by the storage space available on the lesson disk.

**At a Glance**

<table>
<thead>
<tr>
<th>Name</th>
<th>Assisted Instructional Development System (AIDS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use</td>
<td>Comprehensive computer-assisted instruction (CAI) system</td>
</tr>
</tbody>
</table>
| Manufacturer | Instructional Development Systems  
2929 Virginia Beach Blvd.  
Virginia Beach. VA 23452  
(804) 340-1977 |
| Price | $5345 |
| Features | AIDS interface card with on-board calendar/time clock; 5¼-inch disk in Apple DOS 3.2 or 3.3 (demonstration disk available upon request for $25) |
| Language | Applesoft BASIC with supplementary machine-language subroutines |
| Hardware required | Currently for Apple II Plus with 48K bytes of RAM. TRS-80 version available soon |
| Documentation | 200-page instruction manual in a 3-ring binder |
| Audience | Elementary and secondary schools and colleges—especially those with limited access to experienced programmers |
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Table 1: The Daily Report, one of the three reports generated by the Assisted Instructional Development System (AIDS), consists of a daily summary of all students' completed lessons.

Table 2: The Usage Report shows the number of hours and sessions each student used the system.

Table 3: The Cumulative Student Report lists all lessons attempted by an individual student during the standard nine-week session.

CAI Options
Each student is assigned an ID number for reporting purposes, but lessons can call the student by name, which adds a personal touch. Exercises can be presented in either a timed or nontimed format for the entire lesson or for individual questions. As the student works through the lesson(s), the system keeps an ongoing record of the student's usage and performance. After each lesson is completed, AIDS displays lists of the number of problems attempted, number of correct and incorrect answers, percentage score, and next assigned lesson.

With the lesson-branching option, students can be assigned an additional exercise based on their performance during a previous lesson. For example, an excellent score permits a branch to an enrichment lesson, average performance can branch to a reinforcing exercise, or a low score to a remedial one. A message file allows the teacher to make a follow-up assignment in a text, workbook, or other supplementary material.

Three types of permanent records are kept automatically by the system on student performance:

1. Daily report, an itemized account of the work done by a student on a given day (see table 1)
2. Usage report, a record of system usage in terms of hours and number of individual student sessions (see table 2)
3. Cumulative student report, a cumulative listing of all lessons taken by the student over a nine-week period (see table 3)

In addition to these lesson-design options, AIDS makes possible multiple lesson assignments that can be given in a specified order. Entire curriculum modules can then be developed on the system. When used, this feature supersedes the AIDS lesson-branching option. Finally, a lesson index lists all the lessons contained on a lesson disk for easy access to any material filed either by number or name.

Editing Features
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<th>EPSON*</th>
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<tbody>
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<td>82A 80-column</td>
<td>MX-80 80-column dot matrix</td>
</tr>
<tr>
<td>83A 136-column</td>
<td>Call</td>
</tr>
<tr>
<td>84AP 136-column, parallel</td>
<td>MX-80FT 80-column parallel</td>
</tr>
<tr>
<td>84AS 136-column, serial</td>
<td>$ 695.00</td>
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<td>Call</td>
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Documentation

Accompanying the AIDS hardware and software is a 200-page, 6-chapter instruction manual that comes in a 3-ring binder. This manual is designed to give the user a thorough understanding of all the system's features. A demonstration disk is also available for potential buyers desiring to review the system themselves.

Hardware/Software

The Assisted Instructional Development System is currently available for the Apple II Plus microcomputer with 48K bytes of RAM and DOS 3.2 or 3.3. (According to a spokesperson for Instructional Development Systems, the company intends to make the AIDS package available for Radio Shack's TRS-80 microcomputers.) In addition to the program and instruction manual, the AIDS package includes a hardware interface card with an onboard calendar/time clock for dating records as well as timing lessons and student responses. The cost of the entire package is $345.

Conclusions

The AIDS package has been designed with the educator in mind and has several practical advantages over previous software approaches to CAI. A few shortcomings, however, should be mentioned.

First, the question/answer formats presently do not accommodate matching-type questions. Also, the lesson-design format favors an information-oriented approach, providing limited flexibility for alternative designs.

Second, after every three or four questions the disk must be accessed to load the next questions. Low-resolution animated graphics entertain the student while this loading is taking place, but, after a while, such frequent delays can become tedious.

Finally, although the graphics are an entertaining part of the system, no means is available (as yet) for incorporating graphics into the teacher's written lesson. According to Instructional Development Systems, this will be remedied in the near future by the inclusion of both low- and high-resolution graphics options. Other enhancement plans include a question-evaluation feature and a special interface to videotape or videodisc systems so that audio-visual material can be incorporated into the lessons.

Despite any shortcomings, the AIDS package is a flexible, simple, and time-efficient way for teachers to create CAI lessons. Although it can never be a substitute for programming expertise, the Assisted Development Instructional System can fill the needs of many educators and will serve as a model for future systems dedicated to the development of CAI.
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For Atari users, the VOICEBOX for 16K and up Atari plugs directly into the serial port. No extra cables are needed and no speaker is needed since the speech comes directly over your TV monitor. This unit has all speech synthesis features except singing and firmware ROM.

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Software Design: Methods & Techniques

Lawrence J. Peters
Yourdon Press
New York, 1981
248 pages
softcover, $23

Reviewed by
Paul S. Swanson
97 Jackson St.
Cambridge, MA 02140

Software Design: Methods & Techniques is a valuable source book for both the experienced software designer and the initiate. A compilation of various methods and techniques available to software designers, the book examines each method individually and summarizes its advantages and disadvantages.

Peters begins with a discussion of a quandary that software designers face. Like other engineers, software engineers require problem-solving methods. While other engineers have access to fixed, known solution methods for a specific problem, no such clear-cut solutions are available to software engineers. In software, not only are the methods of solution in their stages of infancy, but the problems themselves are usually only vaguely defined. And that brings us to Peters’ second major topic: defining design. Although he asserts that design has never been adequately defined, he provides a thorough description of the subject from several viewpoints.

Software Design: Methods & Techniques addresses 44 of the many different methods currently used in software design representation, treating system architecture, design structure, database structure, and software behavior separately. Each category in turn contains several methods. Summary charts show the relative strengths and weaknesses of each.

Among the methods Peters presents is the design tree, from which many other methods are derived. The derivatives, however, either stress or ignore various items in the system and therefore have different strengths and weaknesses. Some methods are hybrids that combine advantages.

After exploring different approaches to design representation, Peters turns to software design methods. He divides these into three types: data-flow-oriented, data-structure-oriented, and prescriptive. Each is presented in synopsis form with descriptions, examples, and tables showing its relative strengths and weaknesses. Peters includes a list of references for those interested in further reading.

Peters’ views on flowcharts struck me as particularly amusing in light of the emphasis I have heard placed on them. He seems to have the same opinion of them that I do—they simply answer the wrong question. At one point, he mentions that they were invented to document existing software. That they are used in the design stages of software may have some bearing on why many people I know dislike them so much.

After presenting the methods, Peters describes ways to combine them. As he points out, some methods are better suited to people who do the programming, while others are better suited to users. The section on forming a methodology offers guidelines for developing a software design tailored to a particular project.

Peters’ book is not only pleasant reading but will make a good reference manual because specific information in it is easy to locate. The charts and diagrams are plentiful and, for the most part, very informative. And the order of the book makes for logical transitions from one section to the next.

I recommend Software Design: Methods & Techniques to anyone who assembles or plans to assemble larger software systems on any computer system. Any programmer who understands the value of using a disk for program and data storage would benefit substantially from the information presented in this book.

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**Tips on Homebrewing**

Dear Steve,

I have started doing some research for my next project: building my own microcomputer and am interested in your book *Build Your Own Z80 Computer*. I have read several similar books and am getting ready to start design and construction; however, I have a number of questions:

- If I wish to incorporate a BASIC interpreter in my computer (not tiny BASIC but something akin to TRS-80 Level II, etc.), I presumably need to purchase a ROM (read-only memory) containing this program. Where do I find one? I haven't seen them advertised in the mail-order places in the popular magazines.
- Along the same line, where can I buy an interpreter for assembly language so that I can use mnemonic op codes instead of hexadecimal codes for programming?
- Is it possible for a home-built machine to be software-compatible with, say, the Radio Shack TRS-80 Model I? In other words, is it realistic to try and build a machine that will be able to load and run tapes or disks made for the TRS-80?
- Are there any different BASIC interpreters from which to choose? If so, which do you consider the best from a homebrewer's point of view?

David J. Abineri  
Lakewood, OH

Microsoft BASIC is the de facto standard among BASIC interpreters and is the most popular BASIC in use today. Netronics Research & Development Ltd. (333 Litchfield Rd., New Milford, CT 06776, (800) 243-7428; in Connecticut, (203) 354-9375) markets an 8K-byte Microsoft BASIC for the Intel 8085 microprocessor that you might want to look into. A cassette version is available for $64.95 postpaid, and a ROM version is available for $99.95, plus a $2 shipping charge. The 8085 is 100% software-compatible with the 8080A and the Z80 (but it does not have all of the Z80 instructions).

For programming in assembly language, you need an assembler, not an interpreter. An assembler allows you to type in the instruction-set mnemonics and specify the program's start address. It then will "assemble" machine language starting at the specified address. Unfortunately, most of the assemblers sold today are geared toward a particular computer. However, I know an excellent book that provides a detailed explanation and complete listing of an assembler for an 8080-based system. It's called TEA: An 8080/8085 Co-Resident Editor/Assembler by Christopher A. Titus. It's published by Howard W. Sams & Company (4300 West 62nd St., POB 7092, Indianapolis, IN 46206, (800) 428-3696; in Indiana, (317) 298-5400) and sells for $10.95.

For a home-built machine to be software-compatible with the TRS-80, it would need the TRS-80 operating system and TRS-80 Level II BASIC. It is not realistic to try to build a TRS-80-compatible machine from scratch. Rather than try to copy the TRS-80, I would suggest that, if you wish to build a Z80 computer, build it along the lines of my ZAP computer. Make it 8-100-bus-compatible and add some memory and a floppy-disk controller. You can use CP/M (a disk operating system that can run a good Microsoft disk BASIC called BASIC-80) and you will have an unlimited amount of good software available.

The only real problem in custom building your own computer is that you are not software-compatible with anyone and you are constantly "reinventing the wheel" every time you write a program. . . . Steve

---

**Disturbing Line Disturbances**

Dear Steve,

I own an Atari 800 that has been sent for repairs three times. I use it with an RCA XL-100 TV, which occasionally loses its screen or flickers for a second when the furnace switches on or off. However, the Atari does not "crash" during the display disturbance. Should I be concerned about the possibility of voltage spikes? I've heard that they can damage the internal parts of a computer, but can they damage a computer when it's off? What should I look for in a power-line protector? The literature from manufacturers seems inadequate.

Walter M. Lee  
Olrey, MD

The symptoms you describe suggest that you are experiencing a voltage drop as well as possible spikes. Many devices on the market protect against voltage transients by clipping the peaks, thereby keeping them in a safe range, but such devices will not prevent the line voltage from dropping to the point where the computer memory becomes erratic.

From the fact that your Atari 800 does not "crash" during these disturbances, I would suggest a device to clip the transients. This will protect your computer from damage. These units are usually MOVs (metal-oxide

---

**Where Does the BASIC Go?**

Dear Steve,

I don't know much about computers yet, but I read or heard somewhere that if you wanted to use Pascal or any other language instead of the BASIC that comes with a certain system, you would replace the BASIC with Pascal in the ROM (read-only memory). Would I still have the BASIC in ROM or not? Can you explain it to me?

Thanks.

Keith McCrery  
Portage, MI

Using Pascal in a computer that has BASIC in ROM does not affect the BASIC in any way. Pascal is just loaded into user memory. Normally, when another language is used, additional user memory is mapped into the memory-address space used by the ROM BASIC. In this way, the full addressing capability of the microprocessor can be used.

For example, in the Apple II computer, which has BASIC in ROM, supplementary languages are employed through the use of a "language card." This provides an additional 16K bytes of memory in place of the BASIC ROM when Pascal is used. The ROM BASIC is still in the computer, but it's bypassed. . . . Steve
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varistors) and are rated by their energy absorption, usually in joules. Choose the largest one that you can find.

If the voltage spikes do not exceed the voltage-breakdown rating of the computer's plug transformer, there is little harm in leaving the computer plugged in after it is turned off. With the transient suppressor in the line, this problem vanishes. . . . Steve

Always Correct Clock

Dear Steve,

Some time ago I saw Don Lancaster's TTL Cookbook and became very interested in the "always correct clock" he talked about. I have tried to find the Popular Electronics issues he refers to but have not been able to do so (Popular Electronics does not have back issues that old). What I want to do is build that clock and bring the time value to a series of ports that connect with my S-100 system. With this approach, the clock will be correct so long as there is power for the computer. Any information you can supply would be helpful.

Tim R. Norton
Richardson, TX

The articles that Don Lancaster referred to were in the July 1972 and July 1973 issues of Radio-Electronics, not Popular Electronics. What he also neglected to mention is the complexity of the receiver necessary to receive and decode the information broadcast at 60 kHz from station WWVB in Boulder, Colorado.

Many S-100 clock boards on the market feature quartz crystals for their timing and should be accurate to within a few seconds a month. This is more than adequate for almost all conceivable timing applications. Some even have onboard battery backup to maintain their accuracy when the computer is shut off. The ready availability and moderate cost of these boards makes them the obvious choice.

For further information, see my article "Everyone Can Know the Real Time" (May 1982 BYTE, page 34). . . . Steve

Composite Video from PETs

Dear Steve,

I own a Commodore PET 2001 computer with the old ROM (read-only memory) set. I recently purchased a Sanyo DMS112CX video monitor that I intend to use along with the PET's 9-inch monitor. Are you aware of a simple circuit that would take the signals from the PET and give me the composite-video signal that I need for the Sanyo? From the PET, I can easily get the following signals:

<table>
<thead>
<tr>
<th>horizontal drive (TTL)</th>
<th>vertical drive (TTL)</th>
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<tr>
<td>video (TTL)</td>
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</table>

I can also get a +5-volt signal from the main logic board.

David Rene Anatol
Philadelphia, PA

Obtaining a composite-video signal from the horizontal sync, vertical sync, and video signals from the PET 2001 is very easy. The circuit shown in figure 1 is a video combiner that transforms the three separate inputs into a composite-video output. . . . Steve

ZB-Based Voice-Recognition System

Dear Steve,

I'm working on a voice-recognition system using the Zilog Z8 microprocessor. I need advice on interfacing the Z8 board with an inexpensive speech recognizer that handles 32 words.

I'm a rank beginner.

Robert J. Marek
Waltham, MA

Interfacing a voice-recognition system to the Z8 is not difficult because there are sufficient I/O ports for the hardware portion of it. The tiny BASIC may not be sophisticated enough, so you may have to use machine language.

Since its initial presentation in the July and August 1981 BYTES (see "Build a Z8-Based Control Computer with BASIC," Part 1, July, page 38; Part 2, August, page 50), many accessories have become available for the Z8-BASIC Microcomputer from The Micromint (917 Midway, Woodmere, NY 11598, (800) 645-3476; in New York, (516) 374-6793). In addition to cross assemblers that run on TRS-80 and CP/M systems, The Micromint has a memory, parallel I/O, and cassette-interface expansion board; a motherboard; and an EPROM (erasable programmable read-only memory) programmer. Other peripherals are in the works.

An excellent article by James R. Doddington and Thomas B. Schalk (IEEE Spectrum, September 1981, page 26), and my article "Use Voice Prints to Analyze Speech" (March 1982 BYTE, page 50). With help from these articles, you should be able to write the necessary software. . . . Steve
## Software Received

<table>
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BYTE August 1982
files into DIF files for use with floppy disk, $65. Micro Decegment to convert text or printout, and print file reading. For the Apple II Plus; floppy disk, $44.95. Data

Security Concepts, POB 31044, Des Peres, MO 63131.

Word Handler, a word-processing program that gives you a 66-column display without hardware modifications. It includes all standard word-processing functions such as lowercase, underlining, superscript, and unlimited tabs. All functions are displayed on the screen. For the Apple II; floppy disk, $199. Silicon Valley Systems Inc., 1625 El Camino Real #4, Belmont, CA 94002.

Zero Gravity Pinball, an arcade-type game. This game simulates pinball as it might be played in zero gravity. For the Apple II; floppy disk, $29.95. Avant-Garde Creations, POB 30160, Eugene, OR 97403.

Atari

Rear Guard, an arcade-type game (see description above). For the Atari 400 and 800; floppy disk, $29.95. Adventure International, POB 3435, Longwood, FL 32750.

Ricochet, an arcade-type game (see description above). For the Atari 400 and 800; floppy disk or cassette, $19.95. Automated Simulations, POB 4247, Mountain View, CA 94040.

CP/M

Accounts Payable, an accounts payable package. For CP/M with RM/COBOL; floppy disk, $1000. Micro Business Software Inc., 460 Exbury Drive, Doyle Rd., Willet Hill Building, Chichester, NH 03263.

Accounts Receivable, an accounts receivable package. For CP/M with RM/COBOL; floppy disk, $1000. Micro Business Software Inc. (see address above).

General Ledger, a general ledger package. For CP/M with RM/COBOL; floppy disk, $1000. Micro Business Software Inc. (see address above).

Order Entry/Billing, this package provides complete order-entry and billing functions including printing credit memos and invoices, receiving transaction entry, editing and posting with edit list and journal, order-entry, and interactive inventory control. Interfaces with other Micro Business Software accounting packages. For CP/M with RM/COBOL; floppy disk, $1000. Micro Business Software Inc. (see address above).

Perfect Writer, a word-processing program featuring virtual memory architecture that allows editing of documents larger than memory. Includes multiple file display and user-definable commands. For CP/M; 8-inch floppy disk, $399. Perfect Software Inc., 71 Murray St., New York, NY 10007.

Payroll, a full payroll system for a small business. Handles both hourly and salaried employees, prints checks and check register, payroll and deductions register, and performs all payroll calculations. Interfaces with the Micro Business Software General Ledger package, or it can run as a stand-alone system. For CP/M with RM/COBOL; floppy disk, $1000. Micro Business Software Inc. (see address above).

Sales Analysis, this program tabulates and prints sales analysis reports according to customer types and volumes, item type, category, and volume. Also analyzes sales force performance. For CP/M with RM/COBOL; floppy disk, $500. Micro Business Software Inc. (see address above).

UMVMAC Z80—Absolute Macro Assembler, this utility uses source files similar to CP/M assembly language. It supports file inclusion, conditional assembly, and listing control, and it produces .COM files. Includes a non-macro version. For CP/M (Z80); floppy disk, $29.95. The Software Toolworks, 14478 Glorietta Dr., Sherman Oaks, CA 91423.

Exidy Sorcerer

Duel: A Dogfight in Space, an arcade-type game for two players. Written in machine-language, this high-resolution graphics game features two ships that accelerate, rotate, and fire weapons. For the Exidy Sorcerer; cassette, $20. Dasyspring Computer Enterprises, POB 1910, Eugene, OR 97440.

Heath

Recipe-Master Version 1.01, a program to index and select recipes from a master file. It lets you display or print a recipe, create a sorted index, search for a specific recipe, and scan titles for specific keywords. For the Heath H-8 and H-89; floppy disk, $19.95. Interactive Micro Systems, POB 21007, Columbus, OH 43221.

IBM Personal Computer

Diskette Library Management System, a disk-library cataloging system that creates a file of the programs on each of your disks. Files can be updated and edited at any time. For the IBM Personal Computer; floppy disk, $100. Software Architects Inc., 27B Griffith Lane, Ridgefield, CT 06877.

Floppy-Disk Librarian, a disk-library cataloging system. This interactive set of programs maintains files and shows the location of each program on any particular disk. Requires PC DOS. For the IBM Personal Computer; floppy disk, $39.95. Little Bit, 469 Edgewood Ave., New Haven, CT 06511.

The Programmer, a program generator. Designed to run under BASICA, the Programmer allows you to create a program by selecting func-
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tions from a series of menus. Once the function of the program has been defined, the programmer writes the BASIC code. For the IBM Personal Computer; floppy disk, $495. Advanced Operating Systems, 450 St. John Rd., Michigan City, IN 46360.

VisiCalc, electronic spreadsheet. This latest version displays 63 columns by 254 rows and allows viewing the display through two windows. For the IBM Personal Computer; floppy disk, $250. Visicorp, 2805 Zanker Ave., San Jose, CA 95134.

TRS-80
Aircraft Instrument Approach Simulator, a program to train pilots for instrument landings. It features six types of approaches to an airfield and uses a full instrument panel display. For the TRS-80 Models I and III; cassette, $9.95. J. C. Sprott, 502 Sheboygan #207, Madison, WI 53705.

Astroids, two arcade-type games. In the first game, you pilot a spaceship through an asteroid field. In the second game, you shoot the asteroids. For the TRS-80 Color Computer; cassette, $6.65. MFJ Electro Enterprises, POB 13076, Kanata, Ontario K2K 1X3, Canada.

Cubie Movie, a Rubik’s Cube puzzle-solving program. For the TRS-80 Models I and III; cassette, $20. Five Stones Software, POB 1369, Station B, Ottawa, Ontario K1P 5R4, Canada.

Penetrator, an arcade-type game. Your mission is to carefully weave your way into an enemy base and destroy a neutron bomb cache. The enemies’ defenses are composed of four increasingly difficult rings, with missiles, radar bases, and para troopers abounding. This program features graphics, sound, and a customizing option. For the TRS-80 Models I and III; floppy disk or cassette, $24.95. Melbourne House, c/o Braverman, Gordon Co., 233 South Beverly Dr., Beverly Hills, CA 90212.

Property Management System, an income and expense tracking system for rental property (see description above). For the TRS-80 Models I and III; floppy disk, $375. Realty Software Co., 1116 F 8th St., Manhattan Beach, CA 90266.

Ricochet, an arcade-type game (see description above). For the TRS-80 Models I and III; disk or cassette, $19.95. Automated Simulations, POB 4247, Mountain View, CA 94040.

W9AV Morse Code Trainer, a Morse code training program. For the TRS-80 Models I and III; cassette, $9.95. J. C. Sprott (see address above).

VIC-20
Astroids, an arcade-type game (see description above). For the Commodore VIC-20; cassette, $6.65. MFJ Electro Enterprises, POB 13076, Kanata, Ontario, K2K 1X3, Canada.

Type-Test, a program to help you increase your typing speed. It includes a five-line speed test, where typing errors are subtracted and your speed is displayed. For the Commodore VIC-20; cassette, $9.85. MFJ Electro Enterprises (see address above).

ZX80/81
ZX81 Classics, Lunar Lander, K-Trek, Life, and Mastermind, games. For the ZX-81 and ZX-80 (8K ROM); cassette, $9.95. Lamo-Lem Laboratories, POB 2382, La Jolla, CA 92038.

Logic Systems has made a number of changes to LDOS operating system since it was reviewed in BYTE. (See “LDOS-Disk Operating System for the TRS-80,” page 372.) One change is that the price lowered to $129. Another change involves the extended Support Package (available for $25 per year), a subscription to a quarterly newsletter, access to a bulletin board on Micronet, and updates for only $10 to elect to purchase the Extended Support Package. Contact Logical Systems Inc., 11520 North 1 Rd., Mequon, WI 53092, (414) 241-3066.
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Color Forth consists of the standard FORTH Interest Group (FIG) implementation of the language plus most of FORTH-79. It has a super `screen` editor with split screen display. Mass storage is on cassette. Color Forth also contains a decompiler and other aids for learning the inner workings of this fascinating language. It will run on 4K, 16K, and 32K computers. Color Forth contains 10K of ROM, leaving your RAM for your programs! There are simple words to effectively use the Hi-Res Color Computer graphics, joysticks, and sound. The 112-page manual includes a glossary of the system-specific words, a full standard FIG glossary and complete source listing. COLOR FORTH ... THE BEST!! From the leader in Forth, Talbot Microsystems. Price: $109.95

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Bye August 1982 427
Ohio Scientific Systems. The change newsletters with other users groups anywhere in the Ohio Scientific systems. The meetings are held on the first Thursday of each month at 656 Northeast 164 St., North Miami Beach, Florida. A software library is being set up. Membership fees are $5 per year. Contact the Miami Special Interest Group: OSI, 656 Northeast 164 St., North Miami Beach, FL 33162.

Pocket Computer Group Formed

A club for TRS-80 Pocket Computer and Sharp PC-1211 users has been formed. For a $10 annual fee you will receive two free games, Draw Poker and Tic-Tac-Toe, and a year's subscription to the Pocket Programming newsletter. For details, write to John Riggs, 1114 Elaine, Livermore, CA 94550.

National Personal Computer Organization

Autumn Revolution '81 is a national organization of IBM Personal Computer owners, users, and interested parties. A $30 annual membership fee provides you with access to a toll-free technical hot line staffed with specialists who can answer most of your software and hardware questions, a newsletter, and software and technical libraries. Local chapters of Autumn Revolution '81 are being formed throughout the country. In the Chicago area, the local chapter, Neobyte, can be reached by contacting James L. Szafranski, 5195 Castaway Lane, Barrington, IL 60010, (312) 934-8133. In Utah, contact Nancy Williamson, Computerland Store, 161 East 200 South, Salt Lake City, UT 84111.

Complete details are available from Autumn Revolution '81, 10981 East 23rd St., Tulsa, OK 74129, (918) 438-4582.

Professional Newsletter

Computers in Psychiatry/Psychology is a clinical-resource newsletter for professionals interested in the use of computers in psychiatry and psychology. Each issue has descriptions of the computer-related activities of subscribers in such diverse fields as neuropsychiatric and MMPI (Minnesota multiphasic personality inventory) testing, problem assessment, biofeedback, computer psychopharmacology consultation, and electroencephalogram (EEG) analysis. Other features include summaries, reviews, original articles, and an ongoing bibliography and program catalog.

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Books Received


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.

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Continuing Engineering Education, North Campus, University of Michigan, Ann Arbor, MI. Among the conferences being offered are "Computers Image Analysis" and "Database Technology." For complete details, contact Engineering Summer Conferences, 200 Chrysler Center, North Campus, University of Michigan, Ann Arbor, MI 48109, (313) 764-8490.

August
Introduction to Microcomputing, various sites throughout the Midwest. Each participant in this three-day seminar will receive a Rockwell International AIM-65 computer and learn to program in machine language. Applications for instrumentation and process control will be emphasized. The seminar fee is $895, which includes the AIM-65; in-house presentations can be arranged. Details are available from the Foundation for Computer Education, POB 668, Ogden, IA 50212, (712) 843-2000.

August
Professional Development Seminars, various sites throughout the U.S. These seminars are presented by the Institute for Advanced Technology, a part of Control Data Corporation. Seminar topics include "Computer Operations Management," "Data and Site Security," and "Effective Management of Software Projects." Complete outlines can be obtained from the Registrar, Institute for Advanced Technology, Control Data Corp., 6003 Executive Blvd., Rockville, MD 20852. To register, call (800) 638-6590; in Maryland, (301) 468-8576. Information on in-house presentations is available from Pam Gallos at the address above.

August-September
Courses from Boeing Computer Services Company, various sites throughout the U.S. Among the topics to be covered are programming languages and aids, operating system facilities, and conversational systems. A complete catalog of courses, locations, and fees is available from Boeing Computer Services Co., Education and Training Division, POB 24346, Seattle, WA 98124, (206) 575-7700.

August-December
Courses from Fairchild Camera and Instrument Corporation, Santa Clara, CA. Among the courses being offered are "FM445 Family Introduction," "Pascal for Microprocessors," and "Fe680 Microprocessor Family." For more information, contact Fairchild Camera and Instrument Corp., Education Center, 3420 Central Expressway, Santa Clara, CA 95051, (408) 773-2161.

August-December

August-December
IEEE Computer Society Conferences and Meetings, various sites throughout the U.S., Europe, and Asia. Among the events scheduled are "Computer Vision: Representation and Control" and "The Annual Workshop on Computing to Aid the Handicapped." For a complete listing of conferences and meetings, contact the Executive Secretary, IEEE Computer Society, POB 639, Silver Spring, MD 20901, (301) 589-3386.

August-December
Institute for Coordinator of Academic Computing, Potsdam, NY. Among the topics to be covered are user education, hardware planning, software location, conversion and adaptation, and exposure to instructional software and utility. For details, contact Dr. Fritz H. Grupe, Associated Colleges of the St. Lawrence Valley, Potsdam, NY 13676.

August
Computers—Can You Afford Not to Understand?, New York, NY. The fee for this executive briefing is $500. Further information can be obtained from the Registrar, Arthur Andersen & Co., Center for Professional Education, 1405 North Fifth Ave., St. Charles, IL 60174, (800) 323-0815; in Illinois, (800) 942-0851.

August-11
The Uncommon Carrier: New Opportunities in Carrier Services, New York, NY. For details, contact the Yankee Group, POB 43, Harvard Square, Cambridge, MA 02138, (617) 542-0100.

August-12
Microcomputers in Vocational Education Conference, Sheraton Inn, Madison, WI. Attendees will have access to both computer information for beginners and advanced applications of vocational education-related software.
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The registration fee is $35. For more information, contact Judy Rodenstein or Roger Lambert, Vocational Studies Center, 944 Educational Sciences Building, 1025 West Johnson St., Madison, WI 53706, (608) 263-4367 or (608) 263-2704, respectively.

August 15-19
The Second International Computer Engineering Conference and Exhibition, Sherton Harbor Island Hotel, San Diego, CA. This conference is sponsored by the Computer Engineering Division of the ASME (American Society of Mechanical Engineers). More than 50 exhibitors will display computer-engineering products, information, and services. The conference will feature technical sessions on more than 60 topics ranging from interactive graphics, personal computing by means of programmable calculators, computer-aided design and manufacturing, and robots. For complete details, contact the ASME, 345 East 47th St., New York, NY 10017, (212) 644-7100.

August 16-20
The National Conference on Artificial Intelligence, Carnegie-Mellon University and the University of Pittsburgh, Pittsburgh, PA. Among the topics to be addressed are expert systems, robotics, computational vision, programmable automation, game playing, and knowledge representation. Other features include an exhibition program and a two-day tutorial program providing a nontechnical look at key areas of artificial-intelligence research. Complete conference details are available from the American Association for Artificial Intelligence, 445 Burgess Dr., Menlo Park, CA 94025, (415) 328-3123.

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September 1982

September 1-3
European Conference on Integrated Interactive Computing Systems (ECICS '82), Stresa, Italy. Among the topics to be covered are software architecture, user interfaces, system software and hardware, knowledge support, activities management, office information systems, and computer-aided design systems. For details, contact Maria Simi or Pierpaolo Degano, Istituto di Scienze dell'Informazione, Corso Italia 40, I-56100 Pisa, Italy, (50) 40862; Telex, 500371 CNUCE.

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exhibits of computer software and computer-related materials and services. Show details are available from Ernie Kerns & Associates, Suite 201, 2555 East 55th Place, Indianapolis, IN 46220, (317) 259-8111.

September 5-9
Euromicro 1982, Haifa, Israel. This conference is made up of scientific sessions, tutorials, panel discussions, industrial programs, and exhibits. Among the topics to be addressed are system architecture, hardware and software tools, network structure, and education. Highlighting this event is the international Euromouse competition for maze-solving mobile robots. For details, contact Euromicro, 4, Place Félix Eboé, 75012 Paris, France, (1) 341-08-46; Telex 211801.

September 9-11
The First Annual Meeting of the Microcomputer Users Group of the University System of Georgia (MUG/USG), Georgia Southern, Statesboro, GA. This meeting will feature demonstrations, talks, tutorials, and panel discussions on various applications of microcomputers in the classroom, laboratory, and office. Other features include vendor demonstrations and displays. For further details, contact Fred Henneke, Georgia State University, Atlanta, GA 30303, (404) 658-3120, or Richard Stracke, Augusta College, Augusta, GA 30910, (404) 868-3706.

September 9-12
The Fifth Personal Computer World Show, Barbican Centre, London, England. This is the largest computer show held in the United Kingdom. For complete details, contact Personal Computer World, 14 Rathbone Place, London W1P 1DE, England, 01-631 1433.

September 12-15

September 13
Knowledge Engineering in the 1980s, Chicago, IL. This executive briefing provides an overview of the power and potential of artificial intelligence. It is designed to introduce executives and senior technical personnel to the concepts of knowledge engineering and knowledge systems. Topics to be covered will assist participants in assessing the utility of knowledge engineering, pinpointing areas of impact, and outlining costs and strategies for initiating knowledge-engineering projects. The fee is $750, which includes materials, luncheon, and a reception. For further information, contact Dina Barr, Teknowledge, 151 University Ave., Palo Alto, CA 94301, (415) 327-6600.

September 13-15
Advanced Electronic Data Processing Auditing Concepts, Phoenix, AZ. This course is designed for experienced computer auditors. Topics to be studied include advanced computer systems control concepts and methods of evaluating controls and techniques for testing integrity and application controls for online systems, database management systems, and distributed-processing networks. This course is presented by Coopers & Lybrand. Information is available from Marge Unlor, EDP Auditors Foundation, 373 South Schmalle Rd., Carol Stream, IL 60187, (312) 682-1200.

September 13-24
Computer Science at UCLA, University of California, Los Angeles, CA. Sponsored by the Continuing Education in Engineering and Mathematics (CEEM), this UCLA Extension program is designed for engineers, managers, and other professionals needing a concentrated overview of an up-to-date, master's level computer-science curriculum. Participants may enroll in six minicourses from a total of 18. Each unit is based on a course presented by UCLA's Computer Science Department during regular academic sessions. Each course runs for one week, two hours per day, for a total of 10 lecture hours. Hands-on experience is not provided. The fee is $1750 for the complete two-week program. Full details may be obtained from UCLA Extension, CEEM Special Programs, POB 24901, Los Angeles, CA 90024, (213) 825-5010.

September 14-15

September 14-16

September 14-16
Wesccon/82 High-Technology Electronics Exhibition and Convention, Anaheim Convention Center, Anaheim, CA. Among the topics to be
ECT Building Blocks for Microcomputer Systems, Dedicated Controllers and Test Equipment

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Event Queue

covered are analog and digital signal processing, office automation, and semiconductor technology. For more details, contact Electronic Conventions Inc., Suite 410, 999 North Sepulveda Blvd., El Segundo, CA 90245, (213) 772-2965.

September 20-24
COMPCON Fall '82, Capital Hilton Hotel, Washington, DC. This conference will focus on the principles behind work-station technology, including local area networks, operating systems, and new concepts in user interfaces. Topics of interest include reliability and availability techniques, network-wide databases, distributed architectures, network user environments, and standards. For information, contact COMPCON Fall '82, POB 639, Silver Spring, MD 20901, (301) 589-3386.

September 20-24
Auditing in the Contemporary Computer Environment, Oklahoma City, OK. This course is designed for internal auditors and financial and data-processing professionals. A comprehensive audit approach for computer-based systems will be presented. Topics on the agenda include how to evaluate controls, how to prepare an audit report, and how to design a program of tests using questionnaires, checklists, software tools, and flowcharts. Contact Marge Umlor, EDP Auditors Foundation, 373 South Schmale Rd., Carol Stream, IL 60187.

September 21-22
Word Processing/Information Systems Expo, Sheraton Washington Hotel, Washington, DC. This conference and exposition will address the trends and advances in the word-processing industry. Among the topics to be covered are word processing and office integration, productivity measurement, and levels of managing an organization. Further details are available from National Trade Productions Inc., Suite 206, 9418 Annapolis Rd., Lanham, MD 20706, (301) 459-8383.

September 21-23
Software/Expo—National, Ex- pocenter, Chicago, IL. This show is sponsored by Infosystems magazine. For complete details, contact Software/Expo, Suite 400, 222 West Adams St., Chicago, IL 60606, (312) 263-3131.

September 23-25
The First International Conference and Exhibition on Medical Computer Science (Medcomp '82), Hilton Hotel and the University of Pennsylvania, Philadelphia, PA. This conference is sponsored by the IEEE (Institute of Electrical and Electronics Engineers) Computer Society's Technical Committee on Computational Medicine. It is a transdisciplinary forum for engineers, medical professionals, and biomedical and computer scientists. Papers and exhibits will focus on topics such as the history and evolution of computers in medicine, artificial intelligence, software and systems evaluation, and signal and image processing. For additional information, contact the IEEE Computer Society, POB 639, Silver Spring, MD 20901, (301) 589-3386.

September 28-29
The Future Factory, Sunnyvale, CA. For details, contact the Yankee Group, POB 43, Harvard Square, Cambridge, MA 02138, (617) 542-0100.

September 28-October 1
Computer Trade Forum, National Exhibition Centre, Birmingham, England. This
The SA2 is a robot developed for the educational market, and has been designed to meet a requirement for a robot which will emulate, in behaviour and physical attributes, larger industrial robots.

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October 1982

October 4-8
Knowledge Engineering in the 1980s, Boston, MA. For details, see September 13.

October 4-8
Auditing in the Contemporary Computer Environment, Hartford, CT. For details, see September 20-24.

October 5-7
The Third Annual Southwest Semiconductor Exposition, Civic Plaza Convention Center, Phoenix, AZ. "Automation/Automania?" is the theme for this year's technical conference. Suppliers of equipment and materials dedicated to the semiconductor, printed-circuit board, and hybrid industries will attend. Among the issues to be explored are the latest trends in general wafer processing and printed-circuit board manufacturing, hybrids, automation, robotics, and automatic testing. Highlighting this conference will be a preventative-maintenance training forum. Contact Cartridge & Associates Inc., Suite 1014, 491 Macara Ave., Sunnyvale, CA 94086, (408) 245-6870.

October 7-8
Workshop on Automotive Applications of Microprocessors, Hyatt Regency Hotel, Dearborn, MI. This workshop is a forum on applications of microprocessors to automobiles, trucks, vans, allied automotive products, plants, and processors. Topics of interest include engine control, engine and vehicle diagnostics, instrumentation and display, safety systems, drive train control, plant process and quality control, and test equipment. For further details, contact S. Murtuza, Department of Electrical Engineering, University of Michigan, 4901 Evergreen

trade show will bring together vendors, original equipment manufacturers, dealers, distributors, retailers, service companies, and independent sales organizations. For complete details, contact Clapp & Poliak Inc., 245 Park Ave., New York, NY 10167, (212) 661-8410. In England, contact Clapp & Poliak Europe Ltd., 232 Acton Lane, London W4 5DL, 01-747-3131.

October 1-2
The Third Annual Fall Conference on Classroom Applications of Computers, San Jose, CA. This conference is sponsored by Computer-Using Educators, a nonprofit corporation. Topics will cover all areas of curricula from preschool through post-secondary school. Workshops, field trips, school visits, commercial exhibits, and a banquet dinner with a keynote speaker will be featured. Participation in all events is by preregistration only. Conference information is available by writing to Don McKell, Computer-Using Educators, POB 18547, San Jose, CA 95158.

October 3-7
Electronics 82, Bella Center, Copenhagen, Denmark. This will be the largest electronics fair in Scandinavia this year. It will feature demonstrations, conferences, talks, seminars, and commercial exhibits ranging from automation equipment to technical magazines. Approximately 250 exhibitors, representing almost 1000 firms, are expected. For particulars, contact Bella Center A/S, Center Blvd., DK-2300 Copenhagen S, Denmark, (01) 51 88 11; Telex: 31188 bella dk.

October 5-7
The Third Annual Southwest Semiconductor Exposition, Civic Plaza Convention Center, Phoenix, AZ. "Automation/Automania?" is the theme for this year's technical conference. Suppliers of equipment and materials dedicated to the semiconductor, printed-circuit board, and hybrid industries will attend. Among the issues to be explored are the latest trends in general wafer processing and printed-circuit board manufacturing, hybrids, automation, robotics, and automatic testing. Highlighting this conference will be a preventative-maintenance training forum. Contact Cartridge & Associates Inc., Suite 1014, 491 Macara Ave., Sunnyvale, CA 94086, (408) 245-6870.

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October 8-11
Electronica, Hynes Auditorium, Boston, MA. This show will feature a wide variety of personal electronics equipment, including computers, electronic games, ham radios, and projection TV. For more information, contact Northeast Expositions, 824 Boylston St., Chestnut Hill, MA 02167, (617) 739-2000.

October 10-14
Association of Records Managers and Administrators (ARMA) Annual Conference and Exposition, Atlanta, GA. This is ARMA's twenty-seventh annual meeting. Word processing, data communication, and other aspects of information storage and retrieval will be examined. Additional information can be obtained from National Trade Productions Inc., 9418 Annapolis Rd., Lanham, MD 20706, (301) 459-8383.

October 13-15

October 15-17
The Second Annual Symposium on Small Computers in the Arts, Philadelphia, PA. Papers, tutorials, workshops, a gallery display of computer-generated prints and plots, films and video tapes, and computer-generated music performances are parts of this event. Topics of interest include computer graphics and animation, computer-automated sculpture, choreography, design, and computer-generated music. The Annual Philadelphia Computer Music Concert is the featured attraction of this symposium. Address inquiries to the Symposium on Small Computers in the Arts, POB 1954, Philadelphia, PA 19105.

October 11-14

October 12-13

October 19-20
The Future: Home, Palo Alto, CA. For information, contact the Yankee Group, POB 43, Harvard Square, Cambridge, MA 02138, (617) 542-0100.

October 20-22
Auditing in the Contemporary Computer Environment, Tulsa, OK. For details, see September 20-24.

October 21-22
Maintainability and Availability Engineering of Equipment and Systems, University of California, Los Angeles, CA. This short course is for upper-level and product managers, designers, salespeople, field-service personnel, and for those involved in the management, conception, design, operation, and maintenance of equipment. Topics to be covered include distribution of times-to-repair components and times-to-restore equipment, the equipment mean-time-to-repair, and optimum preventive maintenance schedules for minimum total corrective and preventive maintenance cost. The fee is $825, which includes notes. A complete course outline is available from Continuing Education in Engineering and Mathematics, UCLA Extension, POB 24901, Los Angeles, CA 90024, (213) 825-4100.

October 23-24
The Future: Home, New Orleans, LA. This is the sixth annual conference of Issue, an independent nonprofit organization of SPSS Inc. software users and coordinators. Papers will address such topics as data analysis, research training, computer graphics, and training materials and documentation. Contact the Executive Coordinator of Issue Inc., POB 11385, Chicago, IL 60611, (312) 329-2400.

October 11-12
Personal Computer Peripherals Market Analysis, The Anatole, Dallas, TX. The fee for this seminar is $495. Further details are available from Future Computing Inc., 900 Canyon Creek Square, Richardson, TX 75080, (214) 783-9375.

October 14-15
The Thirty-first Annual Data Processing Management Association (DPMA) International Conference and Exposition, Chicago Marriott Hotel, Chicago, IL. This will be the largest show in the DPMA's history. More than 85 companies will exhibit office automation technologies and data- and word-processing equipment. A full conference program is planned. Contact National Trade Productions Inc., 9418 Annapolis Rd., Lanham, MD 20706, (301) 459-8383.

October 25-26
October 21-24
EdCOM '82—The National Computer Conference and Expo for Educators, Los Angeles Convention Center, Los Angeles, CA. More than 200 seminars, workshops, demonstrations, and exhibits are planned. In-depth tutorials and hands-on sessions will be held. Topics of interest include computer-aided instruction, administrative uses of microcomputers, classroom management, programming, research applications, computer literacy, and authoring languages. Information is available from Jayne LaFontain, EdCOM '82, 2629 North Scottsdale Rd., Scottsdale, AZ 85257, (800) 528-2355.

October 24-26
Texas Association for Educational Data Systems (TAEDS)

Eighteenth Annual Convention, Villa Capri Hotel, Austin, TX. The conference theme is “Computer Literacy for Education, Industry, and the Community.” Contact Dr. Terry Bishop, Austin ISD, 6100 Guadalupe St., Austin, TX 78752.

October 25-27

October 25-27
The 1982 ACM (Association for Computing Machinery) Annual Conference, ACM '82, Dallas Hilton Hotel, Dallas, TX. Among the topics to be addressed are programming languages, artificial intelligence, office automation, networks, graphics, computers and the handicapped, and operating, database, and distributed systems. General conference information is available from William Burns, ACM '82 Chairman, E-Systems Inc., POB 226118, Dallas, TX 75266, (214) 272-0515, ext. 3916.

October 26-28
The First IEEE Computer Society International Symposium on Medical Imaging and Image Interpretation, ISMII '82, International Congress Center, Berlin, West Germany. This symposium is sponsored by the IEEE (Institute of Electrical and Electronics Engineers) Computer Society's Technical Committee on Computational Medicine. It will provide a transdisciplinary forum for biomedical and computer scientists, engineers, medical physicists, and physicians from universities, medical centers, industry, and government. Papers and panel discussions will examine a variety of topics including microscope imaging, medical computer graphics, medical device regulation, computer-aided diagnosis, and image analysis systems. Equipment will be displayed. A thorough description of ISMII '82 is available from the IEEE Computer Society, POB 639, Silver Spring, MD 20901, (301) 589-3386.

October 26-31
The Fourth International Office Trade Fair, Orgatechnik '82, Cologne, West Germany. More than 1300 companies from 25 countries will exhibit the complete spectrum of office and information system products. Among the concurrent events planned are the KTV—Congress for Text Processing, Data '82—Data Protection Conference, and Telecom '82 Germany—Congress for Telecommunications in Business and Industry. For further information, contact Messe- und Ausstellungs-Gес.m.b.H Köln, Box 21 07 60, D-5000 Cologne 21, West Germany; Telex: 8 873 426 a m u a d.

October 30-November 2
The Sixth Annual Symposium on Computer Applications in Medical Care (SCAMC), Sheraton Washington Hotel, Washington, DC. Topics to be addressed include medical informatics, health-care administration, information systems in health care, and artificial intelligence in medicine. Panel discussions, workshops, applications and methods demonstrations, and commercial exhibits are on the agenda. Highlighting this show will be the final round of the student paper competition. Information is available from Bruce L. Blum, SCAMC—Office of Continuing Medical Education, George Washington University Medical Center, 2300 K St. NW, Washington, DC 20037, (202) 676-4285.

In order to gain optimal coverage of your organization's computer conferences, seminars, workshops, courses, etc. notice should reach our office at least three months in advance of the date of the event. Entries should be sent to: Event Queue, BYTE Publications, POB 372, Hancock NH 03449. Each month we publish the current contents of the queue for the month of the cover date and the two following calendar months. Thus a given event may appear as many as three times in this section if it is sent to us far enough in advance.
Using the LOOKUP Function in Visicalc

Robert E. Ramsdell, C.P.A.
Pansophics Ltd.
Whistlestop Mall
POB 59
Rockport, MA 01966

According to feedback I get from users, the most difficult operation to understand in the Visicalc software package is the @LOOKUP function. In this article, I'll explain that function using as an example calculation of the 1980 federal income tax form 1040 for a joint return (see table 1).

The LOOKUP function in Visicalc is designed to take a value and compare it to a table of increasing values. This operation can be performed either across a row or down a column. When the program finds an amount greater than the value being tested, the LOOKUP function displays the entry immediately to the right (in column order) or immediately below (in row order) the value that appears just before the amount greater than the value being tested. In our example, the initial value is the taxable income and the range of values is defined by the income-level break-points in the tax-rate schedule.

In BASIC, the @LOOKUP function would be represented by the following formula:

\[
\text{IF (value) } \leq \text{(number in range) THEN (result)}
\]

In Visicalc the result can be a fixed value or a calculated amount based on certain other information.

Let's see how the LOOKUP table is created (see table 2). First a title for the model is placed in columns A to D, row 1. Next a value of 0 is placed in column A, row 2 and a title is placed in columns B and C, row 2. The value at A2 will become the amount that is looked up in the table. Columns A, B, C, and D in row 3 all contain 0 values.

### Table 1: Schedule Y from the 1980 federal income tax form 1040.

<table>
<thead>
<tr>
<th>Over</th>
<th>But not over</th>
<th>% of the amount over</th>
<th>Over</th>
<th>But not over</th>
<th>% of the amount over</th>
</tr>
</thead>
<tbody>
<tr>
<td>$3,400</td>
<td>$5,500</td>
<td>14%</td>
<td>$2,100</td>
<td>$1,700</td>
<td>14%</td>
</tr>
<tr>
<td>$5,500</td>
<td>$7,600</td>
<td>$2,100+14%</td>
<td>$5,500</td>
<td>$2,100</td>
<td>$1,700+14%</td>
</tr>
<tr>
<td>$7,600</td>
<td>$11,900</td>
<td>$4,300+18%</td>
<td>$7,600</td>
<td>$2,100</td>
<td>$1,700+18%</td>
</tr>
<tr>
<td>$11,900</td>
<td>$16,000</td>
<td>$4,400+21%</td>
<td>$11,900</td>
<td>$2,100</td>
<td>$1,700+21%</td>
</tr>
<tr>
<td>$16,000</td>
<td>$20,200</td>
<td>$4,200+24%</td>
<td>$16,000</td>
<td>$2,100</td>
<td>$1,700+24%</td>
</tr>
<tr>
<td>$20,200</td>
<td>$25,400</td>
<td>$5,200+27%</td>
<td>$20,200</td>
<td>$2,100</td>
<td>$1,700+27%</td>
</tr>
<tr>
<td>$25,400</td>
<td>$30,600</td>
<td>$5,200+30%</td>
<td>$25,400</td>
<td>$2,100</td>
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<td>$1,700+39%</td>
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<td>$1,700+42%</td>
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<tr>
<td>$52,000</td>
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<td>$52,000</td>
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<td>$57,400</td>
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<td>$2,100</td>
<td>$1,700+51%</td>
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<tr>
<td>$70,200</td>
<td>$76,600</td>
<td>$5,200+54%</td>
<td>$70,200</td>
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<td>$83,000</td>
<td>$2,100</td>
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</tr>
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<td>$89,400</td>
<td>$95,800</td>
<td>$5,200+63%</td>
<td>$89,400</td>
<td>$2,100</td>
<td>$1,700+63%</td>
</tr>
<tr>
<td>$95,800</td>
<td>$102,200</td>
<td>$5,200+66%</td>
<td>$95,800</td>
<td>$2,100</td>
<td>$1,700+66%</td>
</tr>
</tbody>
</table>

Table 2: Schedule Y—Married Taxpayers and Qualifying Widows and Widowers

<table>
<thead>
<tr>
<th>Over</th>
<th>But not over</th>
<th>% of the amount over</th>
<th>Over</th>
<th>But not over</th>
<th>% of the amount over</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1,700</td>
<td>$2,100</td>
<td>$1,700</td>
<td>$2,100</td>
<td>$1,700+14%</td>
<td>$2,100</td>
</tr>
<tr>
<td>$2,100</td>
<td>$3,600</td>
<td>$1,500</td>
<td>$2,100</td>
<td>$1,700+18%</td>
<td>$2,100</td>
</tr>
<tr>
<td>$3,600</td>
<td>$5,100</td>
<td>$1,500</td>
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<td>$1,700+21%</td>
<td>$2,100</td>
</tr>
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<td>$1,700+24%</td>
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<td>$1,700+27%</td>
<td>$2,100</td>
</tr>
<tr>
<td>$8,100</td>
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<td>$1,500</td>
<td>$2,100</td>
<td>$1,700+30%</td>
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<td>$1,500</td>
<td>$2,100</td>
<td>$1,700+33%</td>
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<td>$1,700+36%</td>
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<td>$1,500</td>
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<td>$1,700+48%</td>
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<td>$1,700+51%</td>
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<td>$1,500</td>
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<td>$1,700+54%</td>
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<td>$2,100</td>
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<td>$2,100</td>
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<td>$32,100</td>
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<td>$2,100</td>
<td>$1,700+78%</td>
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<td>$35,100</td>
<td>$1,500</td>
<td>$2,100</td>
<td>$1,700+81%</td>
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</tr>
<tr>
<td>$35,100</td>
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<td>$1,500</td>
<td>$2,100</td>
<td>$1,700+84%</td>
<td>$2,100</td>
</tr>
<tr>
<td>$36,600</td>
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<td>$1,500</td>
<td>$2,100</td>
<td>$1,700+87%</td>
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<td>$38,100</td>
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<td>$1,500</td>
<td>$2,100</td>
<td>$1,700+90%</td>
<td>$2,100</td>
</tr>
</tbody>
</table>

About the Author
Robert E. Ramsdell, C.P.A., is a microcomputer consultant who lives and works in Rockport, Massachusetts.
WANTED:  
SD SYSTEMS USERS  
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1-800-327-5567  

---  

Table 2: LOOKUP table using column format.  

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1980 JOINT TAX LOOKUP</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0 TAXABLE INCOME</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0 0 0 0</td>
<td>0 0</td>
<td>0 0</td>
</tr>
<tr>
<td>4</td>
<td>0 .14 3400</td>
<td>-476 4</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>294 .16 5500</td>
<td>-586 5</td>
<td></td>
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<tr>
<td>6</td>
<td>630 .18 7600</td>
<td>-758 6</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>1404 .21 11900</td>
<td>-1095 7</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>2265 .24 16000</td>
<td>-1575 8</td>
<td></td>
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<td>9</td>
<td>3273 .28 20200</td>
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<td>10</td>
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<td>13</td>
<td>12720 .49 45800</td>
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</tr>
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<td>14</td>
<td>19678 .54 60000</td>
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<td></td>
</tr>
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<td>33902 .59 85600</td>
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<td></td>
</tr>
<tr>
<td>16</td>
<td>47544 .64 109400</td>
<td>-22472 16</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>81464 .68 162400</td>
<td>-28968 17</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>117504 .7 215400</td>
<td>-33276 18</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>1512 .15 600</td>
<td>-22472 16</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>TOTAL TAX 0.00 20</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Column A will now have the cumulative tax amounts typed in; column B, the tax percentages; and column C, the income-level break-points (see table 1). One additional amount (at location C19) must be entered, representing the highest possible taxable income. I have arbitrarily chosen 1E12 for this amount, because the majority of my clients don't have taxable income exceeding a trillion dollars.

Now the actual tax calculations can be entered into column D. At location D4 the following formula could be typed:

\[ +B4 \times (A2 - C4) + A4 \]

This formula states: take the taxable income (A2) and subtract the income-level break-point (C4), multiply it by the tax rate (B4) and add the cumulative tax amount (A4). This formula may now be replicated with the following commands:

/R (return), D5 , D18 (return), R N R R

Finally, the @LOOKUP function is inserted at location D20 with the following formula:

@LOOKUP (A2, C3 . C19)

This formula states: take the taxable income (A2) and compare it to the values shown in the table (C3 to C19). When a value greater than A2 is found, back up one amount and print the result found in the column immediately to the right.

An important point to remember concerning a Visicalc idiosyncrasy is that determinant (or forward) references require recalculation, and to avoid this requires an awareness of Visicalc's calculation methods. The value to be looked up (in this case the taxable income) must appear before the LOOKUP table, and the @LOOKUP...
function after the table has been seen in the calculation order. Remember that column calculations begin at location A1 and proceed downward to location n, then back to B1 and down to n, etc. Row calculations begin at A1 and proceed across to n, then back to A2 and across to n, etc. (see table 3).

Now let's take a look at table 4 to see how the calculation works. A taxable income of $26,000 has been entered at location A2. The @LOOKUP function at D20 takes this value and compares it to the table from C3 to C19. The first number greater than 26,000 in the table is 29,900, so the function drops back one value (to 24,600) and prints the calculation shown immediately to the right of that value, 4953. Table 5 shows how to accomplish these same calculations using row lookups instead of columns.

The @LOOKUP function has many more uses, and when used with the @MIN and @MAX functions it can be used to solve most problems involving conditional relationships.
Random Rumors: Commodore International is said to have working prototypes of its new family of 16/32 microprocessors. The devices are expected to be upwardly compatible with the 6500 series microprocessors, and the company may begin shipping samples before year-end. However, expect to see an Intel 8088 or 8086 in the new 16-bit personal computer Commodore is expected to introduce soon. You can expect Sears to expand the number of its Business Systems Centers to over 200 within the next few years. IBM is rumored to be working on several new microcomputer projects: a second-generation personal computer, a portable personal computer, a low-cost consumer personal computer, and a professional workstation. Microsoft is expected to release version 2.0 of its MS-DOS (used on the IBM Personal Computer) this fall. Expect it to contain features such as multiple screen windows, string system commands, and stress networking. Portia Isaacson predicts that we will soon see robot stores in addition to our current computer stores and software stores. She also predicts that software stores will follow a growth curve similar to that of computer stores, sharing a $1.5 billion market by 1989. ... Intel is said to be negotiating with Microsoft to put Xenix in its software line as an option. In the meantime Intel is readying release 5 of its RMX operating system, which will be upgraded to a multituser system. ... Zenith is reportedly dubbing its new 16-bit system the Z-100; it may use the 68000 microprocessor and may also be available in kit form from Heath. A 16-bit microprocessor trainer might also be in the works. Heath, which already has 60 stores, is expected to open 10 more this year. Microcomputers are now approaching 50 percent of Heath sales. ... The Arc operating system for Z80-based computers, which contains many Unix-like features, is expected to reach the market finally in the fall. It is from Vortex Technology, Culver City, California. Digital Research is rumored to be working on 68000 versions of CP/M, MP/M and CP/Net. These versions are all currently running in-house and are expected to be released before year-end. ... Univa and Control Data Corporation are expected to soon introduce Z80-based personal computers running CP/M, with communications facilities.

Word has it that Osborne Computer is readying a $500 personal computer, complete with software, for introduction possibly this year. In the meantime, the company expects to have 150,000 Osborne 1s installed by the end of this year.

IBM Rumblings: From disclosures of disk contracts being signed by IBM it is estimated that IBM expects to sell close to 1 million IBM Personal Computer systems by the end of 1984. The company has also just added 500 more employees to its Boca Raton, Florida, facility, which assembles the Personal Computers. ... IBM reported worldwide net earnings of $768 million for the first quarter of 1982; that's up $38 million from the same quarter last year. Gross income for the period was over $7 billion, compared to $6.46 billion last year.

Apple Doings: Apple Computer Inc. reported that earnings for the first quarter of this year rose 50 percent while revenue rose 70 percent. A.C. "Mike" Markkula, Apple president, forecasted earnings of close to $14 million, as opposed to $9.2 million for the same period last year.

Apple is beginning to feel the effects of recent marketing decisions (e.g., Apple's controversial ban on mail-order sales) and competition from new entries into the field (most notably IBM). Revenue was fractionally below the previous quarter ($133.6 million). Most industry analysts feel that sales of the Apple II have finally hit a plateau at an estimated 20,000 systems per month. It is also estimated that there are about 400,000 such systems presently in use. It is expected that Apple will finally announce a new version of the Apple II this summer. The new computer is expected to be compatible with the Apple II and have a standard 80-character by 24-line display, with lowercase letters, plus several other enhancements; and it will be priced lower than the current version.

In the meantime, Apple has made another major marketing change that should have a considerable effect on its sales. Apple has terminated its central buying agreement with Computerland, the nation's largest chain of computer stores, in an attempt to gain control over the geographic locations of its retail outlets. Computerland wanted all of its current and future outlets to be able to sell Apples from any location and Apple wanted to be able to specify which new franchises could or could not sell Apples. Independent Apple dealers have long been asking Apple to reduce the competition from so-called low-support dealers and many Computerland dealers were guilty of low-support discount sales. Apple already has agreements to sell directly to most Computerland dealers, however, these dealers will now have to pay a higher cost than under their previous central purchasing agreement. Since Computerland undertook to sell IBM's systems, the chain's contribution to Apple's sales has declined.

Apple is also cracking down on dealers who have been "transshipping" to mail-order and telephone sellers. Reportedly, at least six Apple dealerships have been terminated for this reason. Apple has been discreetly purchasing systems from unauthorized dealers to track serial numbers and identify the transshippers.

The sum and substance of these policy changes is that Apple is attempting to build loyalty into its dealer base to offset existing and anticipated competition from IBM, Osborne, Digital Equipment Corporation (DEC), and several Japanese makers.

The $99.95 Personal Computer: Timex, well known around the world as a leading supplier of low-cost watches, has entered the personal computer market with a blockbuster. The company will be mass-merchandising an improved version of the Sinclair ZX81, to be called the Timex Sinclair 1000, at a list price of $99.95, and it's likely that we'll eventually see these machines discounted in chain department stores, drugstores, jewelry stores, and consumer electronics outlets at prices ranging down to $75. Timex has been manufacturing the ZX81 for Sinclair and is currently pushing units...
At last, full feature general business software for micro-computers.

Officially authorized derivations from the popular MCBA® mini-computer packages, these packages have been eased down to micros and made even more user friendly.

The mini versions of these packages are distributed by over 900 OEMs and dealers, and are in use at over 9,000 end user sites worldwide.

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Written in RM/COBOL™, these packages run under CP/M®, OASIS®, UNIX®, COS-990® and other operating systems.

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*Computer Dealer* magazine

January, 1982
off the production line at a rate of 1 every 10 seconds. The Timex Sinclair 1000 will be distributed through over 100,000 retail outlets, starting with computer stores. Timex will also be offering a wide selection of game, educational, personal, VisiCalc-like, and business software for the system. Predictions are that there may be as many as 1 million of these units out by the end of next year.

The Timex Sinclair 1000 contains 2K bytes of memory, compared to the ZX81's 1K bytes, and Timex expects to introduce shortly a communications interface and a thermal printer ($99.95 each). A 16K-byte memory module will be available for $49.95. Timex also disclosed that a more powerful computer is in the works. Could it possibly use the new flat video screen that Sinclair is developing?

**The Sony System:** Sony has finally decided to take the plunge and enter the personal computer market with a Z80-based CP/M system. In a cabinet roughly the same size as that of an Apple II, it contains two of Sony's new 3½-inch floppy-disk drives, 64K bytes of memory, and 32K bytes of ROM (read-only memory) containing Sony-BASIC, which will be very similar to Microsoft BASIC. The basic unit without the drives will cost $1475. It will have 4 different graphics modes that range from 640 by 400 black-and-white pixels to 640 by 200 color pixels. It will have five slots for optional plug-in accessory cards and numerous other optional features. There will be plug-in options such as a cache, 8-inch floppy-disk controller, an IEEE-488 interface, a plug-in ROM and keypad interfaces, an 8086 card with 256K bytes of memory (to run either CP/M-80 or CP/M-86), a printer, a clock/calendar, and a cassette interface.

**Commodore Unveils New Units:** Commodore has disclosed that it will soon introduce three new microcomputers: a 16-bit system and two "very low-cost" 8-bit systems. The 16-bit computer will be a dual-processor system using Commodore's new 6509 8-bit microprocessor and Intel's 16-bit 8086. It will have multiprocessing ability, an 80-column display screen, 256K bytes of memory, and dual floppy-disk drives with 800K bytes of storage. All three systems will accept plug-in 8080 or 8088 processors, enabling users to run CP/M-80 or CP/M-86. Prices of these systems should be significantly less than comparable machines currently on the market.

Commodore also disclosed that sales for the first quarter of this year rose to $82 million, up from $50 million for the same period last year.

**Unix Where Art Thou?:** Despite advertisements in magazines, publicity releases and articles maintaining that Unix or Unix-like operating systems are available for microcomputers, I have yet to see any multituser microcomputer systems being shipped (although I have received samples of single-user Unix-like systems and am aware that two or three companies have begun shipping these systems). Just what is the problem? It appears that, although it is written in the C language, Unix is still very difficult to convert for use on other systems. Because Unix was written to run on large minicomputer systems such as the DEC PDP-11, it is not easy to make multituser versions run with decent speed on microcomputers. Therefore, many companies are spending an inordinate amount of time on refinement and optimization of the code.

The result is that we can expect Unix versions with various levels of implementation. The likelihood is that few of the microcomputer versions will be full implementations of Unix. Keep in mind also that there are several different versions of Unix currently in use in the minicomputer world. Thus there is the question of software compatibility between these different implementations, and application software transportability may turn out to be a serious problem.

It is interesting to note that, until last year, the overwhelming number of Unix users were internal to the Bell System; however, since last year, the number of commercial users granted binary licenses and the number of universities granted source licenses have increased. It has been estimated that over 90 percent of the universities in this country have Unix source code licenses.

**Software Suppliers Doing Well:** To a large extent the software industry is still a cottage industry, but things are changing. Just a few short years ago companies such as Digital Research, Microsoft, Micropro, and VisiCorp were "basement" and "spare-room" operations. Today they are large corporations. Digital Research, creator of CP/M, MP/M, CP/Net, PL/I-80 and more, now has over 150 employees and will probably do over $20 million in gross business this year. Micropro, creator of Wordstar, last year earned $5.2 million and this year should earn well over $12 million.

Microsoft, which did not incorporate until July of last year, now has over 125 employees and anticipates a gross revenue of close to $30 million this year, up from $15 million last year. VisiCorp (previously known as Personal Software Inc.) last year had revenues of more than $3 million, mostly from its VisiCalc program.

Digital Research and Microsoft have already gotten venture capital money, which is usually a precursor to "going public" (offering stock for sale to the public) a la Apple Computer. Micropro plans to go public before this year is out.

**Race for Space:** Shelf space is the key to merchandising low-cost personal computer systems, and a battle is developing as personal computer vendors vie for that precious shelf space among mass merchandisers. Texas Instruments (TI), Atari, Commodore, and Nippon Electric Company (NEC) are currently fighting for acceptance by mass-merchandising chains such as J. C. Penney, K-Mart, Sears Roebuck, Woolco, and Montgomery Ward for machines such as the TI 99/4A, Atari 400, Commodore VIC, and NEC PC-6001. Apple is expected to enter the low-cost marketplace this year, and there are even rumors that IBM is developing a low-cost unit. However, Timex with its $99.95 machine may pull the rug out from under these companies.

The personal computer vendors estimate that over a million machines will be sold in 1983. TI has already had limited success selling systems through J. C. Penney, and Atari through Sears. Other consumer discount chains such as Tech Hi-Fi, Crazy Eddie, and Shack Electronics are also jumping onto the personal computer bandwagon.

The mass merchandisers are looking to use the hardware to draw traffic to sell software and peripherals. They think it might work out like the razor/razor-blade and record-player/record markets, where the profits are in the big aftermarket sales. In the meantime the traditional computer stores have dropped these low-cost products and are concentrating on the business marketplace, where performance, training, and support are important.

**Who's on Top?** In the traditional personal computer marketplace, the question is frequently asked,
Changing Disk Scene: Prices of 5¼-inch Winchester drives are dropping drastically in a price war that is shaking up the industry. Leaders in this battle are Seagate Technology and Tandon Corp., which are quoting large-volume order prices of as low as $650 per unit. The result is that retail prices are dropping. For example, Apple originally priced its hard-disk option for the Apple III at $4000. It is now selling for $2500, and the price should be under $2000 by year-end.

The first 5¼-inch disk drives typically stored 6 megabytes. Now, however, 10 and 20 megabytes are routine and capacities are expected to be pushed to over 60 megabytes next year. In fact, Micropolis introduced drives storing 25 and 38 megabytes at the recent National Computer Conference show. The company also introduced an 8-inch Winchester hard-disk drive with a capacity of 110 megabytes.

The Japanese are attempting to crack the U.S. hard-disk drive market. They have already shown drives at trade shows and are expected to start shipping units in large quantities soon. It is of real concern to U.S. disk vendors who fear that the Japanese may take over this market as they have the low-cost printer market. The Winchester disk market is expected to be threatened as early as 1984 by the optical disk, which will offer spectacular price and performance advantages.

Personal Robotics: Last year Jerome Hamlin constructed a robot "butler" at home. He named it Comro I and persuaded Neiman-Marcus to feature the robot, priced at $15,000, in its Christmas catalog. The store sold three. Hamlin is now working on a robot kit that he plans to sell for under $2000.

Heath has already demonstrated a prototype robot kit that it plans to introduce either later this year or next for between $1500 and $3000.

Several companies are already selling computer-controlled arms and bodies in kit form that range in price from $700 to $2500, and there are rumors that some toy companies have developed prototypes of true robotic toys that will sell in the $300 to $500 price range.

So far, the personal robotics products and projects that have been built are awkward and not very useful, reminiscent of the early personal computers. But more and more experimenters are getting involved in robotics projects, and the likelihood is that we will soon see the fruits of these labors translated into a mushrooming new market.

Quote of the Month: "Software suppliers are trying to make their software packages more 'user friendly.' The best approach, so far, has been to take all the old brochures and just rubber stamp them with 'user-friendly' on the front cover." Bill Gates, President, Microsoft

Random News Bits: There's a new game out called Tax Man in which an IRS agent chases a taxpayer through a maze that looks very much like a 1040 form. . . Bible Research Systems, Austin, Texas, has released "THE WORDprocessor," consisting of eight floppy disks containing the entire King James version of the Bible. An Apple or TRS-80 user can scan and locate biblical references through a series of indexes. . . Did you know that each year Japan graduates more engineers than the U.S., even though it has half the population?
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eye protection

The only screen shield made with lead to stop x-rays from computer VDT's!

Fact: Current Federal Regulations permit computer terminals, at a distance of 6 cm. from the screen, to emit .5 millirads x-ray radiation per hour... the old black & white TV standard.

Fact: Computed on a 35 hour work week, that can be the equivalent of a chest x-ray every 12 days, (or 30 chest x-rays each year). A single chest x-ray is 30 millirads... and radiation is cumulative.

Fact: The I-Protect™ Screen Shield, a slightly tinted sheet of leaded acrylic, gives 100% protection from x-rays and most u.v. radiation.

You and your fellow workers may be joining the growing number of computer users complaining of eye fatigue and other problems that seem to be caused by video display terminals used in word processors, stock reporting machines, home computers and video games. If the increase in health problems related to the extended use of VDT's concerns you, LSI offers the solution.

Developed by a physician who was troubled by the amount of radiation his son was absorbing from their home computer, I-Protect is made from leaded hi-impact acrylic, similar to that used to shield x-ray machines and protect workers in experimental laboratories.

I-Protect is available from Langley-St. Clair, a leader in video enhancement systems for the computer industry. It has the lead equivalency of 0.15mm, is slightly tinted to increase contrast and effectively prevents 100% of the x-rays and most of the u.v. radiation from reaching you.

In a recent FDA study,* nearly 10% of the monitors tested showed x-radiation at levels above the current limits of .5 millirads per hour, or 30 chest x-rays per year. While it may be true that when sitting 6 feet from a television screen, very little radiation actually reaches the viewer, daily close work on a video computer terminal can be subjecting you to constant radiation. So, for your protection and your peace of mind, equip your computer with an I-Protect screen shield.

Order an I-Protect Screen Shield now... direct from LSI. Call (800) 221-7070. (Be sure to inquire about our "Anti-Flicker Slow-Phosphor" Replacement CRT Tubes for TRS 80 Microcomputers... and about our new leaded screen shield with an exclusive anti-glare polarized surface.)

I-Protect... in two sizes, complete with velcro fasteners for easy attachment to most monitor screens. 81/2"x11" - $49.95
10"x13" - $59.95. Add $2.00 for shipping and handling. $3.00 for C.O.D. New York State residents, add 8.25% sales tax. Allow 2-6 weeks for delivery.

U.S. Public Law 90-602: J.E.D.E.C. Publ. 64
For technical information and far West Coast Distributors: (800) 882-9450
In New York state, to order call
(212) 989-6876.

Circle 470 on inquiry card.
**What's New?**

**SYSTEMS**

### Desktop Unit for Business and Science

The MT500, a desktop computer with data- and word-processing capabilities for business and science applications, is a Multi-Tech Systems product. It features a full DMA [direct memory access] video display, a Z80A microprocessor, the CP/M operating system, 64K bytes of RAM [random-access read/write memory], and a single-board central processing unit with built-in S-100 expansion capabilities. The MT500 has two integral 5½-inch disk drives with floppy-disk storage capacity of up to 900K bytes and 5½-inch Winchester disk-storage capacity of 5 megabytes.

Optional equipment for the MT500 includes letter-quality or high-speed printers and Bell 103- or 212A-compatible modems. The price for the MT500 ranges from $4795 to $7995, depending on storage options; dealer discounts are available. Multi-Tech Systems Inc. is located at 82 Second Ave. SE, New Brighton, MN 55112. (612) 631-3550. Circle 550 on inquiry card.

### Development System

Sys-1 from Octagon Systems Corporation is a single-board microprocessor development system and process controller. It operates in BASIC and employs National Semiconductor's INS8073 chip with integral control BASIC interpreter. Sys-1 features 4K bytes of static RAM [random-access read/write memory], up to 4K bytes of EPROM [erasable programmable read-only memory] in 2K-byte increments, hardware-interrupt vectored in BASIC, a 2K-byte system-utilities library, 24 programmable input/output [I/O] lines, 2 flags, 1 sense input, a decoded peripheral-select line, and a large breadboard area with ten 16-pin DIP [dual-inline pin] sockets. Other standard features include an EPROM programmer, a serial RS-232C I/O port that operates at data rates from 110 to 4800 bps [bits per second], and the ability to address 8K bytes of external memory.

An individual Sys-1 costs $245; OEM [original equipment manufacturer] inquiries are invited. Complete details are available from Octagon Systems Corp., 2849 West 35th Ave., Denver, CO 80211, (303) 458-1705. Circle 551 on inquiry card.

### 6502 Board Is AIM-Compatible

The Model SBC651 is an AIM-compatible single-board computer from Industrial Micro-Systems. Based on the 8-bit 6502 microprocessor, the 4½-by 6½-inch SBC651 features 40 lines of parallel input/output [I/O], eight channels of 8-bit analog input, an onboard 20 mA current loop, TTL [transistor-transistor logic], and RS-232C serial I/O. Intended for controller and OEM [original equipment manufacturer] applications, the SBC651 has such standard features as four programmable 8-bit parallel ports, eight auxiliary control lines, four 16-bit counter/timers with 1-µs [microsecond] resolution, and a crystal-controlled clock that provides 1 MHz operation. The SBC651 can accommodate from 1K to 3K bytes of RAM [random-access read/write memory] and up to 10K bytes of ROM [read-only memory] and EPROM [erasable programmable ROM].

Peripheral equipment available for the SBC651 includes a device that allows Rockwell International's AIM-65 to fully emulate the SBC651 and provide low-cost development support. Another option is an EPROM burner [programmer] that is used with the AIM-65 as a program-development system. In single units, the board costs $154.50. Full product specifications are available from Industrial Micro-Systems Inc., POB 306, Plantsville, CT 06479, (203) 628-4844. Circle 552 on inquiry card.

### Super Computer

The Super Computer from the Mega Company is a single-board Z80A-based
unit that's guaranteed to run at 5 MHz. It features a 4K-byte system monitor in EPROM (erasable programmable read-only memory), 64K bytes of dynamic RAM (random-access read/write memory), and memory parity checking. Super Computer has a single- or double-density, single- or double-sided 5 1/4- or 8-inch floppy-disk controller, a hard-disk interface that connects directly to Priam Corporation's intelligent hard-disk controller, and a DMA (direct memory access) controller for the floppy disks, serial ports, and general input/output (I/O) interface. Super Computer's two serial ports operate at data rates from 150 to 19,200 bps (bits per second) and are controlled by two Z80A SIOs (serial I/Os) with drivers for full RS-232C handshaking. Other standard features include a Z80A-based counter/timer circuit, sockets for expandability, and CP/M and MP/M operating system compatibility.

Optional equipment for Super Computer includes two 8-bit bidirectional parallel ports with Z80A PIO (parallel I/O), four serial ports with two SIOs and handshaking, 448K bytes of onboard dynamic RAM with a PAL (programmable array logic) chip for either fast RAM disk or bank-switching for multituser applications under MP/M, and a 9511A mathematics processor. The basic Super Computer system costs $1099. A full system, including the 9511A, costs $2199. Dealer inquiries and purchase orders will be accepted by the Mega Co., 2318 South Park St., Madison, WI 53713, (608) 255-7400. Circle 553 on inquiry card.

**Basis for Expansion**

The Basis 200 series of modular microcomputers offers true upward expandability, because the same bus structure supports either 8- or 16-bit plug-in processors. At this time, two models are available: Basis 208 and Basis 216. The 8-bit Basis 208 features the Z80B processor, a 6-MHz clock, and the CP/M operating system. Its minimum configuration has 128K bytes of RAM (random-access read/write memory) expandable to more than 1 megabyte, dual 5 1/4-inch floppy-disk drives, an 8-bit parallel printer interface, a serial RS-232C interface, and a 10-slot card cage with room for additional memory, high-resolution graphics, and other equipment.

The Basis 216 is currently offered equipped with the Z8001 processor, but the 68000 and others are in development. This 16-bit machine features Microsoft's Xenix operating system and the ability to support up to 16 workstations for multitasking and multiuser environments. Approximate prices are $6000 for the Basis 208 and $9000 for the Basis 216. Further information is available from Basis Inc., 23116 Summit Rd., Los Gatos, CA 95030, (408) 438-5804. Circle 554 on inquiry card.

**Multiuser, Multitasking Microcomputer**

The SB-80/4 microcomputer from Colonial Data Services allows up to four users to share floppy-disk and hard-disk storage, while maintaining separate 4-MHz Z80A microprocessors with 64K bytes of RAM (random-access read/write memory) for each user. This is accomplished by placing all four computers on a single printed-circuit board, connected to a master Z80A multiuser input/output (I/O) controller. The system is CP/M compatible, uses 5 1/4- or 8-inch floppy disks, supports a 10- to 104-megabyte hard disk, takes up to 320K bytes of 200-nanosecond dynamic RAM, and has four Centronics-type parallel ports and six serial ports, two programmable real-time clocks, a switching power supply (115V 60 Hz or 220V 50Hz), and a 50-pin expansion connector. The system is designed to run business software under the CP/M operating system. The multiuser supervisor allows simultaneous users to share the same database and off-line memory.

For more information on the SB-80/4, contact Colonial Data Services Corp., 105 Sanford St., Hamden, CT 06514, (203) 288-2524. Circle 555 on inquiry card.

**TMS9995-based Computer**

The SBC 95/1 is an STD bus single-board computer using Texas Instruments' TMS9995 processor, which is fully object-code-compatible with the TMS990 and 9900 families. The board has two independently configurable asynchronous communications ports for RS-232C and RS-422 interfaces. Also provided are a 5-bit parallel output port, an 8-bit input port, and two software-selectable memory maps. Capable of operating as a stand-alone unit, the 16-bit SBC 95/1 can be equipped with up to 16K bytes of onboard EPROM (erasable programmable read-only memory) and up to 4K bytes of RAM (random-access read/write memory).
One option available for the SBC 95/1 is Eyring Research Institute's PDOS program development tool, which consists of a real-time multitasking, multiuser DOS (disk operating system), and PDOS BASIC. Floppy-, mini-floppy-, and hard-disk storage options are supported. In lots of one to nine, the SBC 95/1 costs $349. An evaluation kit that includes 4K bytes of RAM and EPROM debugging monitor, connection hardware, and documentation can be purchased for $562.4. Contact GW3, 7239 Bealing Court, Springfield, VA 22150, (703) 451-2043. Circle 556 on inquiry card.

Versatile System
Thomas Engineering Company has introduced the TEC MZ-80, a microprocessor-based computer system suitable for communications, word processing, and small-business applications. Built upon Intel's Multibus architecture, the MZ-80 is configured around separate processor, memory, input/output (I/O), and DMA (direct memory access) disk-controller boards that mount on the chassis with four or eight slots. The processor board contains a 6-MHz 280B microprocessor, 32K bytes of 150-ns (nanosecond) dynamic RAM (random-access read/write memory), 4K bytes of ROM (read-only memory) or EPROM (erasable programmable ROM) control memory, a 30-millisecond timer, and a serial I/O port. Each additional memory board provides the MZ-80 with 32K bytes of 50-ns static RAM and allows bank switching. The I/O boards have eight independent RS-232C channels and are engineered with an onboard crystal-controlled clock to assure proper timing reference. The DMA disk controller can handle up to four standard single- or double-density 8-inch drives or two 3½-inch mini-floppy drives. Sector size can be as large as 8K bytes.

The list price for a typical ROM-based MZ-80 is $743.50, including software license. The price for a disk-based configuration for use as a local processing system is $733.0. Contact Thomas Engineering Co., Suite 106, 1040 Oak Grove Rd., Concord, CA 94518, (415) 680-8640. Circle 557 on inquiry card.

What's New?

Free Business Graphics Guide
A free guide to business computer-graphics software, systems, and services is available from The Harvard Newsletter on Computer Graphics; Stanley Klein, publisher and editor. The guide contains concise descriptions of source materials and the name, address, and telephone number of each supplier, including contact person. Information on foreign sources is also provided.


Power of Visicalc
Management Information Source has announced the availability of Robert Williams and Bruce Taylor's book The Power of Visicalc. Written in plain English, this book has seven easy-to-follow exercises that are designed to show you how to expand your applications usage of Visicorp's Visicalc program. The Power of Visicalc uses specific examples to illustrate the logic of each step in designing an applications program and step-by-step instructions that help you understand the basic concepts behind Visicalc function and command uses.


PUBLICATIONS

Microprocessor Software Databook
D.A.T.A. Inc. has introduced a new subscription service: Microprocessor Software D.A.T.A. Book. Published biannually, the D.A.T.A. Book is organized by general type of software package, by the microprocessor upon which it will operate, and by the manufacturer's title. The information covers language and extensions, ANSI (American National Standards Institute) standard, date of introduction, number of in-
What's New?

Newsletter for Pascal Users

Pascal Market News is aimed at current and prospective Pascal language users. This bimonthly newsletter is packed with Pascal hardware and software information, commercial notices, and interviews with personalities in the news. In a recent issue, Pascal Market News explored the use of Pascal in real-time chemical analysis of blood samples at Yale-New Haven Hospital.

Subscribing to Pascal Market News entitles you to discounts on many Pascal-related books and software publications. A year's subscription costs $20 in North America. Foreign prepaid airmail subscriptions are $29, and invoiced subscriptions are $4 higher. Order from Pascal Market News, POB 5314, Mount Carmel, CT 06518.
Circle 561 on inquiry card.

Database Management Tool Explained

A free 12-page brochure describing Micro Data Base Systems' MDBS II microcomputer database-management application development tool is available from ISE-USA. MDBS II innovations, advantages, features, and capabilities, including its flexible query system, are described.

Typical applications are discussed, and a company profile is provided. Obtain your copy from ISE-USA, 350 West Sagamore Parkway, West Lafayette, IN 47906, (317) 463-2581.
Circle 564 on inquiry card.

Consumer Newsletter Tests TRS-80 Software

Software Review is a bi-monthly newsletter that tests and evaluates programs for Radio Shack TRS-80 Model I and III users. Software Review reports on a program's performance, advantages, and limitations from the user's point of view to help consumers select the products that are best for them. In each issue a wide range of materials are evaluated, including games, business programs, operating systems, utilities, educational programs, and languages. One special feature, the Bug Killer column, provides advice, operating and programming tips, short cuts, fixes, hardware reviews, modifications, and so on.

For a sample copy of the Software Review, send a self-addressed envelope with $0.37 postage to Software Review, 92 Washington Ave., Cedarhurst, NY 11516. Retailers or computer clubs interested in selling the Software Review can call (516) 374-5193.
Circle 564 on inquiry card.

Three-Dimensional Graphics Tablet

Micro Control Systems and Penguin Software have joined together to create Space Tablet, a hardware/software three-dimensional graphics input device for the Apple II. Space Tablet's hardware is made up of a clear 16-by-13-inch two-dimensional workspace and an arm with an elbow that enables it to swivel on the two-dimensional space or rotate above the tablet. Information on the position of the tip of the arm is converted by the computer to X,Y,Z coordinates, making it possible to trace three-dimensional objects, both real and imaginary. The tablet, which connects to the Apple by means of the paddle port, also has two buttons for additional inputs.

Space Tablet's software allows it to be used as a standard two-dimensional tablet or in three dimensions. Its two-dimensional programs include the high-resolution drawing, text, and shape routines available in the Apple Tablet and paddle/stick ver-
The 8882 data-acquisition and control system for the TRS-80 costs less than $200, including software. Complete product and purchasing information is available from Starbuck Data Co., POB 24, Newton Lower Falls, MA 02162, (617) 237-7695. Circle 566 on inquiry card.

Apple PROM Development System

A PROM (programmable read-only memory) development system for the Apple II is available from Vista Computer Company. This system simulates PROM in RAM (random-access read/write memory), allowing new code to be tested and modified within the computer before the PROM is burned in. Supplied with a disk-based, menu-driven program-development monitor, the system has onboard memory that can be directly loaded from assembler or disk. Other standard features include a data and address interface for operator location and control. The Vista Computer PROM development system simulates and programs most standard PROMs, including 2K- and 4K-byte EPROMs (erasable PROMs) such as 2708, 2716, and 2532 types. The system costs $495. Further details are available from Vista Computer Co., 1317 East Edinger, Santa Ana, CA 92705, (714) 953-0523. Circle 567 on inquiry card.

Acoustic Data Coupler

The Anderson Jacobson AJ 1233 acoustic data coupler is capable of communicating with Bell 212-type modems. The AJ 1233 is an originate-only full-duplex acoustic coupler with switch-selectable data rates of 1200 bps (bits per second) for synchronous or asynchronous communications and from 0 to 450 bps for asynchronous communications. It can be used either as an acoustic coupler or as a modem, and it can communicate with VA 3400 and AJ 1200 series modems and in Bell 103 or 113 modes. The microprocessor-controlled, Federal Communications Commission-approved AJ 1233 costs $995. Complete details are available from Anderson Jacobson Inc., 521 Charcot Ave., San Jose, CA 95131, (408) 263-8520. Circle 568 on inquiry card.

Analog I/O Interface

International Aerospace Products' Model ADA 8/4 AP analog input/output (I/O) interface board is designed for the Apple II. It is equipped with eight A/D (analog-to-digital) input channels, four D/A (digital-to-analog) output channels, screw-activated terminal strips for I/O connections, voltage-follower buffers on A/D inputs, VREF output for ratiometric transducers, and buffers on D/A outputs. It's compatible with any language, such...
as BASIC, that allows direct addressing of specific memory locations.

The ADA 8/4 AP plugs in any Apple II I/O slot except slot 0. Complete specifications are available upon request from International Aerospace Products Inc., POB 166, White Marsh, VA 23183.

Circle 569 on inquiry card.

Color Port

The Color Port from Maple Leaf Systems gives your Radio Shack TRS-80 Color Computer powerful input/output capabilities. The plug-in cartridge Color Port gives the Color Computer two fully programmable 8-bit bidirectional parallel ports with full handshaking. It supports full interrupt capability and computer voltage and logic control lines are brought out to the standard edge connector. Additionally, the cartridge has a socket for 2K bytes of RAM (random-access read/write memory) or EPROM (erasable programmable read-only memory).

Optional equipment for the Color Port includes 2K-byte RAMs and 2K-byte EPROMs. With documentation, the Color Port cartridge without memory costs $129.95. The optional RAM is available for $19.95, and the EPROM costs $12.95. All can be purchased from Maple Leaf Systems, POB 2190, Station C, Downsview, Ontario M2N 2S9, Canada.

Circle 570 on inquiry card.

Glitch Sentinel Has Built-in Printer

The Model GS-2 Glitch Sentinel power-line monitor from Billings McEachern diagnoses power problems for microcomputers, disk drives, and other sensitive electronic equipment. The Sentinel checks for power failures, low and high line voltages, spikes, voltage drops, high-frequency noise, and high and low line frequencies. Built-in features include a clock/calendar, a user-enabled audible alarm, latched LEDs (light-emitting diodes) for each alarm type, and a printer that prints alarm messages in English.

In addition to the Model GS-2, Billings McEachern offers the GS-1 and the GS-3 Glitch Sentry power-line monitors. The GS-1 is similar to the GS-2, but it does not have the printer, clock/calendar, and the line-frequency monitoring capabilities. The GS-3 is designed for three-phase power monitoring.

In single units, the Model GS-2 Glitch Sentinel and the Model GS-3 cost $900; in lots of two to ten, the price is $750. A single GS-1 costs $300, and two to ten units are available for $250 each. Order directly from the manufacturer, Billings McEachern Inc., Suite 106, 333 Cobalt Way, Sunnyvale, CA 94086, (408) 746-0830.

Circle 571 on inquiry card.

Apple Time II

Time II, an Applied Engineering product, is a real-time clock/calendar for the Apple II computer. Time II tells time in hours, minutes, and seconds with program-selectable 24-hour military or 12-hour [with a.m. and p.m. indication] formats. It tells you the date with year, month, date, day of week, and leap year information. Standard features include rapid date and time setting, crystal-control for 0.0005% accuracy, latched input/output ports for easy PEEK and POKE BASIC programming, and an onboard battery backup that provides power-off operation for more than four months. With Time II, you can call up schedules, time events, and date listings and other printouts because its DIP-(dual-inline package) switch-selectable interrupts permit foreground and background operation of two programs simultaneously.

Time II is supplied with a 16-sector DOS 3.3 disk with Time II programs and a 23-page operating manual that contains many example programs to use with your Apple II. The price is $129. Contact Applied Engineering, POB 470301, Dallas, TX 75247, (214) 492-2027.

Circle 572 on inquiry card.

SOFTWARE

Stock and Commodities Messenger

George Arndt's Investors' Micro Messenger (IMM) is made up of a group of investors who pool their expertise to develop stock- and commodities-management software for the Apple II. As an IMM
What's New?

member, you receive annually four packages containing floppy disk-based software, updated commodity database, a detailed instruction book written in nontechnical language, complete documentation and reports, and graphics software that allows you to see buy-and-sell calls with daily open, high, low, and close. Opportunities to purchase technical trade books are also offered.

The IMM membership fee is $995 for the first year and $350 for the second year. Members receive $100 for each program donated to IMM. Complete details are available from George Arndt, CTGA, Investors’ Micro Messenger, POB 319, Harvard, MA 01451, (617) 456-8830.

Atari BASIC Tutorials
Santa Cruz Educational Software’s Tricky Tutorials are designed to help sharpen your Atari BASIC programming skills. Each tutorial in the six-disk package consists of a discussion in plain language and examples already entered and running. The topics covered are Display Lists, Horizontal and Vertical Scrolling, Page Flipping, Basics of Animation, Player Missile Graphics, and Sounds and Music.

Tricky Tutorials are available on tape or disk in a single package for $99.95 plus $3 for shipping and handling. They require 16K- to 32K-byte tape-based Ataris or 24K- or 32K-byte Ataris with disk drives. Order Tricky Tutorials from Santa Cruz Educational Software, 5425 Jigger Dr., Soquel, CA 95073, (408) 476-4901. Circle 574 on inquiry card.

Strategy Game
Automated Simulations’ Ricochet is a strategy game combined with fast-action graphics. It can be played with another player or any of four different computer opponents. Here’s how it works: players maneuver blocks to set up a shot at the opposing goal and to protect their own goal. Each contestant has two launchers to fire. Shots ricochet off the blocks, earning points for each hit plus bonus points for hitting the opponent’s goal. Before victory can be claimed, a player must win two of three (or three of five) games.

Ricochet is available on cassette for 16K-byte Atari 400/800s equipped with the BASIC ROM [read-only memory] cartridge and 16K-byte Level II TRS-80s. On disk, the game can be enjoyed on 32K-byte Atari 400/800s, 32K TRS-80s with the TRS-80 operating system, and 48K-byte Apples with Applesoft in ROM. The suggested retail price is $19.95. Contact Automated Simulations, POB 4247, Mountain View, CA 94040.

Solar Design Programs
Version 2.0 of Solarsoft’s Sunpas, Sunop, and Tswing interactive solar-analysis programs for 48K-byte Apple II Plus computers is now available. Given both the solar input and the load on the building, Sunpas and Sunop estimate the yearly auxiliary heating requirements of a passive solar building.

Both programs are based on Los Alamos National Laboratory’s Solar Load Ratio Method, which is described in volume two of the Passive Solar Design Handbook [available for $30.50 from National Technical Information Service, 5285 Port Royal Rd., Springfield, VA 22161]. With documentation, Sunpas and Sunop cost $250 each or $400, if purchased together.

Tswing is a nodal-analysis thermal-simulation program that helps predict temperature swings in a building. It is useful for sizing mass and glazing areas to prevent overheating. Tswing makes extensive use of graphs to supplement hard-copy printouts of data. Provided with Tswing is Solgain, a clear-day solar-insolation routine to calculate incident and transmitted hourly solar gains. Tswing costs $395, including a 60-page manual.

Sunpas, Sunop, and Tswing can be purchased as a three-program package for $700. Yearly subscriptions to an updating service are available for $75, and users manuals without software may be obtained for $25. Get additional details on these programs from Solarsoft Inc., POB 124, Snowmass, CO 81654, (303) 927-4411. Circle 576 on inquiry card.

PILOT for CP/M
Owners of CP/M-based computers can now run the Nevada PILOT language, thanks to Ellis Computing. A string-oriented language, Nevada PILOT is designed for interactive applications such as data entry, programmed instruction, and testing. Among its many features are an integrated full-screen text editor and the ability to drive video-tape recorders, voice-response units, and other optional equipment. With Nevada PILOT, someone with no prior computer experience can develop dialog programs in an hour or so. Nevada PILOT meets all PILOT-73 standards.

Nevada PILOT requires 32K bytes of RAM [random-access read/write memory], one disk drive, a video display and keyboard. It will run on TRS-80, North Star, Superbrain, Micropolis, Vector, Softcard-equipped Apples, and many other CP/M-based systems. Nevada PILOT costs $149.95, which includes a floppy disk and a manual, and is available from Ellis Computing, 600 41st Ave., San Francisco, CA 94121, (415) 751-1522. Circle 577 on inquiry card.
Flexible Changes
The Flex 9.0 DOS (disk operating system) for Radio Shack's TRS-80 Color Computer is available from Technical Systems Consultants (TSC), 111 Providence Rd., Chapel Hill, NC 27514. Occasionally, changes to TSC-supplied utility programs are required to avoid memory conflicts with the BASIC ROMs (read-only memories). These changes and an implementation guide can be obtained from South East Media, POB 794, Chattanooga, TN 37443.
Circle 578 on inquiry card.

Wiremaster 4.02
Afterthought Engineering has released version 4.02 of its Wiremaster software tool for the design, layout, and construction of electronics hardware. Wiremaster generates network maps, wire lists, cross-references, and checklists. It can handle large industrial jobs as well as small prototypes and hobby projects. Version 4.02 enhancements include location accuracy of 0.001 inch, provisions for twisted-pair and coaxial wiring, and input language expansions that handle special components such as connectors.

Wiremaster version 4.02 costs $200; computer club members are eligible for a 50% discount. Updates to earlier versions are priced at $25. Complete details can be obtained from Afterthought Engineering, 7266 Courtney Dr., San Diego, CA 92111, (714) 279-2868.
Circle 579 on inquiry card.

TRS-80 Game System
The Adventure System has all the necessary ingredients you need to cook up adventure-type games on your Radio Shack TRS-80 Model I or III. Offered by The Alternate Source, the Adventure System consists of an editor that compiles a command language into an adventure database and a driver program that executes the database. A manual documenting the Adventure Language syntax and a complete analysis of a small adventure is provided. Two full adventures are also supplied with the System.

The Adventure System requires a 48K-byte TRS-80 Model I or III with disk drives. It is available on formatted disks for $39.95. Purchase orders are being fulfilled by The Alternate Source, 1806 Ada St., Lansing, MI 48910, (517) 487-3358.
Circle 580 on inquiry card.

Disk Recovery System
DPatch 1.3 is a CP/M- and MP/M-based disk recovery and reliability system from Advanced Micro Techniques. It gives you the ability to recover files that contain input/output errors and to regain the use of disks that have error tracks. With DPatch, files that have been erased from the disk directory may be recovered. Additionally, you can extract data from files that are no longer readable under normal circumstances. Damaged or unreadable disks can be returned to normal using DPatch's Surface Analysis, which analyzes and locks out damaged areas.

DPatch is distributed in most popular disk formats and has a suggested retail price of $195. The manufacturer invites dealer and OEM (original equipment manufacturer) inquiries. Complete specifications are available from Advanced Micro Techniques, Suite 209, 1291 East Hillsdale Blvd., Foster City, CA 94404, (415) 349-9336.
Circle 581 on inquiry card.

Bigbug Squashes Debugging Delays
Future Project Corporation has developed Bigbug, a Z80 monitor for controlling Radio Shack TRS-80 Model I Level II assembly-language programming. The device features a ROM- (read-only memory) based monitor that doesn't need a backup, direct access of input/output, a hexadecimal calculator, built-in RS-232C driver software, up to eight user-selectable breakpoints, and the ability to produce hard-copy printouts for debugging history.

Bigbug can be treated as a subroutine from your programs, and its hardware can accept your own EPROM (erasable programmable ROM), which can save you loading time. Other features include 3K bytes of memory that permit a target program to be resident anywhere in memory.

Bigbug costs $75. Further details are available from Future Project Corp., POB 11, Hawleyville, CT 06440, (203) 775-3062.
Circle 582 on inquiry card.

Superfile System
FYI Inc. has introduced Superfile, an indexing and file-retrieval system for text entries of any size. The system can handle more than 7000 entries per database on 8-inch single-density disks or 2500 entries per database on 80K-byte 5¼-inch disks. Superfile can search as many as 100 entries per second, and up to 65 keywords can be combined with AND, OR, and NOT in a single search. Superfile lets you direct output to the screen, printer, or disk, and it does not limit the amount of text per entry or the number of data disks per database. Additionally, Superfile can access up to 16 floppy- or hard-disk drives.

Superfile runs under the CP/M operating system on Z80-based processors. Available on 8-inch and most 5¼-inch disks, Superfile costs $195, which includes a demonstration database, installation pro-
What's New?

MISCELLANEOUS

Monolithic Dual 8-Bit D/A Converter

Analog Devices has introduced the AD7528, a monolithic dual 8-bit D/A (digital-to-analog) converter. With both converters on the same chip, and with the use of a common data bus to load D/A register, Analog Devices engineered the dual D/A converter in a 20-pin DIP (dual-inline package). The AD7528 has onboard data latches and a microprocessor interface. Each of the AD7528's D/A converters has its own reference input, which eliminates the need to test and select D/A converters in most applications where precise matching is required.

The AD7528 monolithic dual 8-bit D/A converter is available in various grades for industrial and military applications. Complete grade descriptions and product information can be obtained from Analog Devices, Route 1 Industrial Park, POB 280, Norwood, MA 02062.

Micromonitor

MK Enterprises’ Micromonitor MX2100 Teleprocessor is a 3½ by 5½-inch device that can connect your microcomputer to the Bell Telephone Network. The Micromonitor is a DTMF (dual-tone multifrequency) transmitter/coupler outfitted with parallel input/output, two 600-ohm audio channels, ring and off-hook signaling circuitry, a retriggerable circuit that signals the presence of a conversation, and circuitry that monitors the status of the telephone trunk (i.e., dial tone, ringing, busy, etc.). Two onboard optoisolators can control your equipment by means of Touch-Tone (a registered trademark of AT&T) commands. The Micromonitor’s Touch-Tone transmitter allows outward dialing in PABX (private automatic branch exchange) applications, including automatic redial and speed dialing, while its companion Touch-Tone receiver permits end-to-end signaling for remote data entry. When used with a microprocessor or an intelligent controller, the Micromonitor is capable of performing sophisticated functions such as telephone call accounting, information retrieval, radio-telephone paging, and remote security monitoring.

Certified by the Federal Communications Commission, the Micromonitor is compatible with Apple, STD bus, and many single-board computers. It costs $495, including a manual. Additional operating specifications are available from MK Enterprises, 8911 Norwick Rd., POB 29654, Richmond, VA 23229, (804) 740-8380.

Data Line Tester

Warren Instrotech's portable W-DLT (data-line tester) can identify seven commonly used RS-232C data lines and show the likely cause of a connection problem. It’s provided with a switch that enables it to function as a Null Modem, which is used to interconnect two terminals, modems, or com-

...
What's New?

S-100-based Dynamic RAM Board
Sonics Research Corporation recently introduced a low-cost S-100-based 64K-byte bank-selectable dynamic RAM (random-access read/write memory) board. The board provides continuous memory refresh during system resets and long wait states, true bank-selectability in 16K-byte levels, switch-selectable port assignments, and compatibility with most 280-based S-100 systems, including Cromemco, North Star, Vector Graphic, TDL, and SD Systems. Other features include the ability to assign 16K-byte banks to any of four locations within the 64K-byte address space and the ability to enable and disable 16K-byte banks under software control. Power requirements are 6½ watts.

The Sonics Research 64K-byte dynamic memory board has a suggested retail price of $450, assembled and tested. Further information is available from Sonics Research Corp., Suite 505, 1500 Northwest 62nd St., Fort Lauderdale, FL 33309, (305) 776-7177. Circle 588 on inquiry card.

Hug Your Office Equipment
The Huggy System can protect your office equipment from theft. Conventional tools cannot remove the Huggy System’s “Tufnut,” yet removal does not require special tools. The Huggy System number 101 will secure a single piece of equipment. It’s available in kit form for $10.95. The master Huggy System service kit, number 1020, secures up to 12 machines and is available for $89.50. Contact the Huggy System, 2660 West Chester Pike, Broomall, PA 19008, (800) 345-1280, in Pennsylvania, (215) 359-1004. Circle S89 on inquiry card.

Hide Your Cables and Wires
Designatron’s Organizer places your Radio Shack TRS-80 Model 7’s components into a single desktop package, hiding the wires and cables. The Organizer is made up of two wood-grain cabinets. The first cabinet, which has a removable front panel for easy rebooting, holds the monitor, expansion interface, power supplies, line filters, power strip, and fan. The second cabinet can hold up to four disk drives, a tape recorder, fan, floppy disks, and cassettes. The Organizer costs $87.50, plus $8.75 shipping and handling. Orders are being accepted by Designatron, 2794 Hume Rd., Malibu, CA 90265, (213) 456-9023. Circle S90 on inquiry card.

Align Disk Drives Without a Scope
The Lynx-300 from Lynx Design & Technology lets your field-service personnel make all necessary floppy-disk alignment adjustments without an oscilloscope. The Lynx-300 comes with a color-coded set of probes, which attach directly to a drive’s printed-circuit board, and with a series of LEDs (light-emitting diodes) to indicate the proper settings for radial and index/sector adjustments and to indicate if the adjustment is not within specifications. The Lynx-300 is powered directly from the drive. The Lynx-300 comes with a zippered leatherette case and is priced at $394...
What's New?

[US. funds] and [Canadian funds]. For complete specifications, contact Lynx Design & Technology Inc., 3880 Chesswood Dr., Downsview, Ontario M3J 2W6, Canada, (416) 638-4875.

Circle 591 on inquiry card.

Products for HP Users

The Hand Held Products Division of F.M. Weaver Associates produces a wide range of products and services for HP (Hewlett-Packard) users. The HHP-16K EPROM (erasable programmable read-only memory) is one such product. It gives HP-41C and -41CV calculator users cost-effective application program storage. The HHP-16K, basically a ROM (read-only memory) emulator, can hold 4K- or 8K-byte programs for storage, or it can hold up to 16K-byte programs, depending on the selection of EPROMs. The HHP-16K costs $241.

Other products offered include the HHP-41DS user development system and the BURN software program for the HP-85 SDS-11 computer. The BURN program is available for a one-time lease fee of $495. The Hand Held Products Division will convert to EPROM storage programs stored on magnetic cards or Hewlett-Packard development system tape or disk. The price for this service ranges from $50 for a 4K-byte program to $100 for a 16K-byte program. For more information, contact F.M. Weaver Associates Inc., Hand Held Products Division, 6201 Fair Valley Dr., Charlotte, NC 28211, (704) 377-3841.

Circle 592 on inquiry card.

Floppy-Disk Controllers

Western Digital Corporation has introduced the FD176X family of 5¼-inch floppy-disk controllers that provides all the features of its industry-standard FD179X family. The FD176X family operates at 1 MHz and is fully compatible with existing mini floppy-disk designs using the FD179X standard. Aimed at soft-sectored systems equipped with automatic track seek with verification and providing DMA (direct memory access) or programmed data bus transfers, the FD176X family supports single- or multiple-sector reads or writes with automatic sector search in both modes, or it can read and write an entire track. Currently, Western Digital has four members in the family: the FD1761, -63, -65, and -67, which cover all combinations of single- or double-density, true or inverted data bus, and single- or double-sided drives. The FD176X family can be used with single-density IBM 3740 or double-density IBM System/34 formats.

In production quantities, the FD176X family is available in ceramic or plastic packages for 40-pin devices for $36 and $25.30, respectively. Full product information and applications assistance can be obtained from Western Digital Corp., 2445 McCabe Way, Irvine, CA 92714, (714) 557-3550.

Circle 593 on inquiry card.

Keyboard Guard

Plexa-Lok from Last Electronics guards your Apple II keyboard from contaminants and curious fingers. Made of clear 0.080-inch-thick acrylic, Plexa-Lok slips up and over the keyboard, then snaps into position. It does not affect air circulation.

Plexa-Lok comes with a 60-day warranty and costs $19.95, postpaid. Contact Last Electronics, POB 1300, San Andreas, CA 95249, (209) 754-1800.

Circle 594 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.

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CC-2422 w/CP/M 22 $625

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Goodbout Disk 1 $895

DIGITAL RESEARCH
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MAMA MXX-21 LS/11 controller (RX-01, RX-92 compatible) $1050

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Cable Kits 2 drives $35

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INTELLIGENT VIDEO I/O FOR S-100 BUS

VIO-X

The VIO-X Video I/O Interface for the S-100 bus provides features equal to most intelligent terminals both efficiently and economically. It allows the use of standard keyboards and CRT monitors in conjunction with existing hardware and software. It will operate with no additional overhead in S-100 systems regardless of processor or system speed.

Through the use of the Intel 8275 CRT controller and an onboard 6808 processor and six memory, the VIO-X I/O interface operates independently of the host system and communicates via two ports, thus eliminating the need for host memory space. The screen display rate is effectively 80,000 baud.

The VIO-X interface provides an 80 character by 25 line format (24 lines plus status line) using a 5 x 7 character set in a 7 x 10 dot matrix to display the full upper and lower case ASCII alphanumeric 96 printable characters set (including true descenders) with 33 special characters for escape and control characters. An optional 2572 character generator is available which allows an alternate 7 x 10 contiguous character set.

VIO-X2

The VIO-X2 also offers an 80 character by 25 line format but uses a 7 x 7 character set in a 9 x 10 dot matrix allowing high-resolution characters to be used. This model also includes expanded firmware for block mode editing and light pen location. Contiguous graphics characters are not supported.

Both models support a full set of control characters and escape sequences, including controls for video attributes, cursor location and positioning, cursor toggle, and scroll speed. An onboard Real Time Clock (RTC) is displayed in the status line and may be read or set from the host system. A checksum test is performed on power-up on the firmware EPROM.

Video attributes provided by the 8275 in the VIO-X include:
- FLASH CHARACTER
- INVERSE CHARACTER
- UNDERLINE CHARACTER or
- ALT CHARACTER SET
- DIM CHARACTER

The above functions may be toggled off on and on separately, The board may be addressed at any port pair in the IEEE 696 (S-100) host system. Status and data ports may be swapped if necessary. Inputs are provided for parallel keyboard and for light pen as well as an output for audio signalling. The interrupt structure is completely compatible with Digital Research's MP/M.

Additional features include:
- HIGH SPEED OPERATION
- PORT MAPPED IEEE 5-100 INTERFACE
- FORWARD-REVERSE SCROLL or PROTECTED SCREEN FIELDS
- CONVERSATIONAL or BLOCK MODE (opt)
- INTERRUPT OPERATION
- CUSTOM CHARACTER SET
- CONTROL CHARACTERS
- ESCAPE CHARACTER or
- INVERSE CHARACTER
- INTERRUPT TERMINAL EMULATION
- TWO PAGE SCREEN MEMORY

The VIO-X1 is priced at $295.00 and the VIO-X2 is priced at $345.00.

64K STATIC RAM BOARD FOR S-100 BUS

NEW: Additional Features

FEATURES
- Conforms to IEEE 696 standard
- 8 or 16 bit data transfers
- 12 bit addressing
- Bank select in 32K-32K or 48-16K
- Bank selectable/deselectable on DMA
- Responds to phantom pin 67 or 16
- 2K & 8 static rams with 27C02 pin out
- Power consumption is typically 600 ma.
- Banks on or off on power up
- Bank addressable to any of 5125 possible ports
- BMX with 150ns parts standard faster speeds available on request
- Available partially loaded as a 32K board
- Multiple bank residence

NEW FEATURES
- Phantoms read only, or read and write
- Generates onboard M-WRITE or uses bus M-WRITE
- Two separate banks, independently addressable on 16K boundaries. Banks may be overlapped.

OMNIRAM INTRODUCTION:
The Fulcrum Computer Products OMNIRAM for the IEEE 696 (S-100) bus provides 64 kilobytes of fast static random access memory. Provision is made for 8 or 16 bit transfers, extended 24 bit addressing, and for control via the bus phantom line. In addition, a number of features are included to make the OMNIRAM compatible with systems designed before the IEEE 696 standard was developed. These include bank selection and provision for operation with IMSAI-type front panels. When the bank select option is activated, the board is divided into two parts which can reside in separate banks. The division of the board may be into two 32K sections or into one 16K section and one 48K section. 2K blocks may be disabled in the upper 16K, or 4K blocks in the upper 32K, of memory. Provision is made for DMA override of bank select if needed. The board is also compatible with IEEE 696 or IMSAI-type extended addressing.
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Circle 226 on Inquiry card.
### 16K Apple RAM CARD

Upgrade your 48K Apple II to full 64K

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### MICROSOPOR

REAL-TIME CLOCK

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### CMOS

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### LINEAR

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<th>Component</th>
<th>Price</th>
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<tr>
<td>4MHz, Z-80, 64K RAM, Disk Controller, C/PM 2.2 w/dual 5&quot; DD DD</td>
<td>$2349</td>
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<tr>
<td>w/dual 5&quot; DD DD</td>
<td>$2599</td>
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<tr>
<td>w/dual 8&quot; DD DD</td>
<td>$2999</td>
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<tr>
<td>w/dual 8&quot; DD DD</td>
<td>$3699</td>
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#### VIDEO TERMINALS

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<tr>
<td>INTERTEC SUPERBRAIN II</td>
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<tr>
<td>ZENITH Z-19</td>
<td>$729</td>
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<td>SOGOC 120</td>
<td>$649</td>
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<td>SOGOC 130</td>
<td>$599</td>
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<td>920C</td>
<td>$999</td>
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<td>950C</td>
<td>$1195</td>
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<td>TEXAS INST. 940 BASIC</td>
<td>$1599</td>
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<tr>
<td>948 Package</td>
<td>$2097</td>
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<tr>
<td>745 Portable Terminal</td>
<td>$1399</td>
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<tr>
<td>745 Portable Terminal w/U/L/Case</td>
<td>$1495</td>
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#### PRINTERS

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<td>ANADEX DP-9600</td>
<td>$1249</td>
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<td>DP-9501</td>
<td>$1349</td>
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<tr>
<td>PAPER TIGER 1DS-560G</td>
<td>$1199</td>
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<tr>
<td>PRISM PRINTER IDS-80 w/o color</td>
<td>$1899</td>
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<tr>
<td>IDS-80 w/o color</td>
<td>$1899</td>
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<tr>
<td>IDS-132, w/color</td>
<td>$1695</td>
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<tr>
<td>NEC 3510, no RS232 55CPS</td>
<td>$1945</td>
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<tr>
<td>NEC 3530, 20, Cent. Int. 35CPS</td>
<td>$1945</td>
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<tr>
<td>NEC 7110, no RS232 55CPS</td>
<td>$2325</td>
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<tr>
<td>NEC 7720, dsr, RS232 55CPS</td>
<td>$2599</td>
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<tr>
<td>NEC 7725, dsr, Int. RS232 55CPS</td>
<td>$2599</td>
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<tr>
<td>OUME</td>
<td>$629</td>
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<tr>
<td>Sprint 9/45, ltc, 40 CPS</td>
<td>$2119</td>
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<tr>
<td>C17, Pro Win i/o Parallel</td>
<td>$3049</td>
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<tr>
<td>DIABLO 630, rs232 55 CPS</td>
<td>$2299</td>
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<tr>
<td>CENTRONICS R3-265, Parallel</td>
<td>$399</td>
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<td>783-2, w/Graphics, RS232C</td>
<td>$638</td>
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<td>704-11, Parallel</td>
<td>$1695</td>
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<td>704-9, RS232C</td>
<td>$1595</td>
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<td>122C, Parallel, 120 CPS</td>
<td>$949</td>
</tr>
</tbody>
</table>

#### RAM

<table>
<thead>
<tr>
<th>Model</th>
<th>Price</th>
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<tbody>
<tr>
<td>EPSON MX-80</td>
<td>$488</td>
</tr>
<tr>
<td>MX80FT</td>
<td>$549</td>
</tr>
<tr>
<td>MX100FT</td>
<td>$1099</td>
</tr>
<tr>
<td>RS232 Serial Interface</td>
<td>$65</td>
</tr>
<tr>
<td>RS232/2K BufferInterFace</td>
<td>$125</td>
</tr>
<tr>
<td>Graftrix X</td>
<td>$29</td>
</tr>
<tr>
<td>Apple Printer Interface</td>
<td>$75</td>
</tr>
<tr>
<td>TI810 Basic</td>
<td>$1349</td>
</tr>
<tr>
<td>80 Basic, RS232 &amp; Parallel</td>
<td>$1399</td>
</tr>
<tr>
<td>80 w/full ASCII, vertical forms</td>
<td>$1599</td>
</tr>
<tr>
<td>Video uncompressed print</td>
<td>$1645</td>
</tr>
<tr>
<td>820 RO, Basic</td>
<td>$1839</td>
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</tbody>
</table>

#### OKIDATA

<table>
<thead>
<tr>
<th>Component</th>
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<tbody>
<tr>
<td>Microline 80</td>
<td>$465</td>
</tr>
<tr>
<td>Tractor-feed option</td>
<td>$56</td>
</tr>
<tr>
<td>Microline 82A</td>
<td>$519</td>
</tr>
<tr>
<td>Microline 83A</td>
<td>$849</td>
</tr>
<tr>
<td>Microline 84</td>
<td>$1199</td>
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#### MONITORS

<table>
<thead>
<tr>
<th>Component</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZENITH-ZYM-12, 12&quot; Green Phosphor</td>
<td>$125</td>
</tr>
<tr>
<td>AMDEK 100, 12&quot;</td>
<td>$193</td>
</tr>
<tr>
<td>100G, 12&quot; Green Phosphor</td>
<td>$143</td>
</tr>
<tr>
<td>300, &quot;12&quot; Green Phosphor KH Res</td>
<td>$193</td>
</tr>
<tr>
<td>Color, 13&quot;</td>
<td>$359</td>
</tr>
<tr>
<td>Color II, 15&quot; R.G.B. HR Res.</td>
<td>$799</td>
</tr>
<tr>
<td>Apple adapter for Thermos</td>
<td>$193</td>
</tr>
<tr>
<td>BM/C, 12&quot; Green Phosphor</td>
<td>$169</td>
</tr>
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</table>

#### FLOPPY DISK SYSTEMS

<table>
<thead>
<tr>
<th>Component</th>
<th>Price</th>
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<tbody>
<tr>
<td>MCDORROW DESIGNS</td>
<td>$51849</td>
</tr>
<tr>
<td>Disc M-5 5 Meg.</td>
<td>$51849</td>
</tr>
<tr>
<td>Disc M-10 10 Meg.</td>
<td>$3095</td>
</tr>
<tr>
<td>Disc M-20 20 Meg.</td>
<td>$4068</td>
</tr>
<tr>
<td>Disc M-26, 26 Meg.</td>
<td>$3795</td>
</tr>
<tr>
<td>CORIVUS 5 Meg.</td>
<td>$540</td>
</tr>
<tr>
<td>10 Meg.</td>
<td>$540</td>
</tr>
<tr>
<td>15 Meg.</td>
<td>$540</td>
</tr>
<tr>
<td>INTERTEC 10 Meg. w/2 Microsoft Basic</td>
<td>$5195</td>
</tr>
</tbody>
</table>

#### CALIFORNIA COMPUTER SYSTEMS

<table>
<thead>
<tr>
<th>Component</th>
<th>Price</th>
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<tbody>
<tr>
<td>Z80 CPU Board</td>
<td>$269</td>
</tr>
<tr>
<td>Disk Controller 2422, w/CP/M</td>
<td>$359</td>
</tr>
<tr>
<td>16K Static, A/B 7</td>
<td>$399</td>
</tr>
<tr>
<td>32K Static, A/T 7</td>
<td>$399</td>
</tr>
<tr>
<td>64K Dynamic RAM</td>
<td>$335</td>
</tr>
<tr>
<td>System 2210 w/56K, CP/M 2.2</td>
<td>$1495</td>
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</table>

### CPU BOARDS

(assembled unless noted)

<table>
<thead>
<tr>
<th>Component</th>
<th>Price</th>
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</thead>
<tbody>
<tr>
<td>NORTSTAR Z-80A (Z-80A/A-A)</td>
<td>$269</td>
</tr>
<tr>
<td>INTERSYSTEMS (56K-60)</td>
<td>$369</td>
</tr>
<tr>
<td>SSM CB1 8000, A/B7</td>
<td>$214</td>
</tr>
<tr>
<td>CBZ, Z-80, A/B7</td>
<td>$289</td>
</tr>
<tr>
<td>CBZ, Z-80, Kit</td>
<td>$219</td>
</tr>
<tr>
<td>SD SYSTEMS, SBC-100, A/B7</td>
<td>$349</td>
</tr>
<tr>
<td>SBC-200, A/B7</td>
<td>$399</td>
</tr>
<tr>
<td>SYSTEMS GROUP 2-89 w/1D0</td>
<td>$419</td>
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</table>

### MEMORY BOARDS

<table>
<thead>
<tr>
<th>Component</th>
<th>Price</th>
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</thead>
<tbody>
<tr>
<td>NORTSTAR 16K RAM</td>
<td>$259</td>
</tr>
<tr>
<td>HRAM 64K</td>
<td>$589</td>
</tr>
<tr>
<td>HRAM 32K</td>
<td>$419</td>
</tr>
<tr>
<td>DPMEM 16K, 16K</td>
<td>$419</td>
</tr>
<tr>
<td>CROMEMCO 64K2</td>
<td>$595</td>
</tr>
<tr>
<td>MEMORY MERCHANT</td>
<td>$159</td>
</tr>
<tr>
<td>64K Static, 4MHz</td>
<td>$549</td>
</tr>
<tr>
<td>SYSTEMS GROUP</td>
<td>$419</td>
</tr>
</tbody>
</table>

### VIDEO SYSTEMS

<table>
<thead>
<tr>
<th>Component</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>OKI DATA BMC, 12&quot;, Green Phosphor</td>
<td>$2099</td>
</tr>
<tr>
<td>12&quot;, Green Phosphor</td>
<td>$2099</td>
</tr>
<tr>
<td>&quot;CP/M 2+ and Microsoft Basic</td>
<td>$2099</td>
</tr>
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</table>

### GROBOD (A/B7)

<table>
<thead>
<tr>
<th>Component</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU Z</td>
<td>$1429</td>
</tr>
<tr>
<td>CPU 8838-88.</td>
<td>$359</td>
</tr>
<tr>
<td>RAM 2800</td>
<td>$359</td>
</tr>
<tr>
<td>RAM 17-84</td>
<td>$675</td>
</tr>
<tr>
<td>RAM 21</td>
<td>$1439</td>
</tr>
<tr>
<td>Interface</td>
<td>$210</td>
</tr>
<tr>
<td>Interface 2</td>
<td>$210</td>
</tr>
<tr>
<td>Disk 1</td>
<td>$419</td>
</tr>
<tr>
<td>System Support 1</td>
<td>$335</td>
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<tr>
<td>Enclosure 1 (Desk)</td>
<td>$699</td>
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<tr>
<td>Enclosure 2 (Rack)</td>
<td>$760</td>
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### VIDEO SYSTEMS I/O Mapped

<table>
<thead>
<tr>
<th>Component</th>
<th>Price</th>
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<tbody>
<tr>
<td>SD SYSTEMS</td>
<td>$1469</td>
</tr>
<tr>
<td>VDB-9024, A/B7</td>
<td>$169</td>
</tr>
<tr>
<td>VBB-11/0, A/B7</td>
<td>$219</td>
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</table>

### MEMORY MAPPED

<table>
<thead>
<tr>
<th>Component</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>VB1C, 16x64, Kit</td>
<td>$152</td>
</tr>
<tr>
<td>VB1C, 16x64, A/B7</td>
<td>$206</td>
</tr>
<tr>
<td>VBB, 80 Char, 4MHz, A/B7</td>
<td>$359</td>
</tr>
<tr>
<td>VBB, 80 Char, 4MHz, A/B7</td>
<td>$419</td>
</tr>
</tbody>
</table>

### APPLE BOARDS

<table>
<thead>
<tr>
<th>Component</th>
<th>Price</th>
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<tbody>
<tr>
<td>CALIFORNIA COMPUTER</td>
<td></td>
</tr>
<tr>
<td>7710A Asynchronous Ser Interface</td>
<td>$129</td>
</tr>
<tr>
<td>7712A Synchronous Par Interface</td>
<td>$149</td>
</tr>
<tr>
<td>7424A Casemate Disk</td>
<td>$99</td>
</tr>
<tr>
<td>7728A Centronics Printer Interface</td>
<td>$99</td>
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</table>

### MOUNTAIN HARDWARE

<table>
<thead>
<tr>
<th>Component</th>
<th>Price</th>
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<tbody>
<tr>
<td>CPS Multifunction Board</td>
<td>$189</td>
</tr>
<tr>
<td>SuperTalk 2000</td>
<td>$259</td>
</tr>
<tr>
<td>Rompus w/ keyboard filter</td>
<td>$179</td>
</tr>
<tr>
<td>Rompus w/ keyboard filter</td>
<td>$130</td>
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<tr>
<td>Keyboard filter ROM</td>
<td>$49</td>
</tr>
<tr>
<td>COPY ROM</td>
<td>$49</td>
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<tr>
<td>Music System</td>
<td>$459</td>
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<tr>
<td>ROM WRITER</td>
<td>$149</td>
</tr>
<tr>
<td>Apple Clock</td>
<td>$239</td>
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<tr>
<td>A/D-Y/A</td>
<td>$295</td>
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<tr>
<td>Expansion Card</td>
<td>$116</td>
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### VISTA

<table>
<thead>
<tr>
<th>Component</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>8&quot; Disk Controller (Apple III)</td>
<td>$5495</td>
</tr>
</tbody>
</table>
Electronic Circuit Analysis

- DC and AC analysis
- Very fast, machine language
- Infinite circuits on multiple pages
- Worst case sensitivity analysis
- Dynamic modification
- 64 Nodes, 127 branches
- Compare circuits
- Log or linear sweep
- Full file handling
- Frequency response, magnitude and phase
- Complete manual with examples
- TRS-80 (TRSDOS) $90.00
- CP/M $180.00

Tatum Labs
P.O. Box 722
Hawleyville, CT
06440
(203) 426-2184

5 1/4" Floppy Disk Drives
(Direct IBM Plug in)

TANDON Model TM 100-1 $219.95 ea.
2 or more $214.95 ea.
Floppy Drive Power Connector Kit $2.00
Tandon Manual and Schematic $3.00
12" Green Phosphor Zenith Monitor $119.95
We also stock TM 6025, 6035.
2 or more - $214.95 ea.

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ENGINEERING & BUSINESS SYSTEMS

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- PLOT & GRAPH SOFTWARE ON CP/M
- FOR ENGINEERING & BUSINESS SYSTEMS
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- SOFTWARE FOR CP/M SYSTEMS
- COMPLETE DOCUMENTATION AND SCHEMATICS
- ALL FOR $325.00

EDGE-86
AN INDUSTRIAL QUALITY
8086 OEM SYSTEM

- HARDWARE
  - A Multibus/CP/M compatible 8086 CPU BOARD
  - With DMA floppy controller, interrupt controller, programmable timers, serial ports, two parallel I/O ports, and all standard I/O.
  - With 1MB hard disk drive. SOFTWARE:

  - CMPIB O/S WITH COMPLETE UTILITIES - $250.00
  - OFF THE SHELF DELIVERY

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195 W. EL CAMINO REAL, SUNNYVALE, CA 94086
TELEPHONE: 408-729-4725

Circle 70 on inquiry card.
Circle 395 on inquiry card.

SAVE 40% Write for our complete list.
5 1/4" Specify soft, 10 or 16 sector
#744 1 side/sgl dens. $26.70
#745 1 side/dbl dens. $31.20
#746 2 sided/dbl dens. $43.60

8" Specify soft or 32 sector
#740 1 side/sgl dens. $27.30
#741 1 side/dbl dens. $35.80
#743 2 sided/dbl dens. $43.60

Circle 239 on inquiry card.
Dot Matrix Printers

NEW EPSONS with Graftrax-plus

Epson has improved and upgraded their best selling line of printers to include new Graftrax-plus graphics package. Features now include: 9 x 9 matrix, bi-directional/logic seeking, line spacing to 5/26, programmable forms length and horizontal tabs, skip over, italicized fonts, international symbols, superscript/subscript, normal, emphasized, double-strike, and double-emphasized print. Underlining, line drawing graphics, 60/120 DPI bitmap, software raster, adjustable right margin, and true back space.

MX-80 with Graftrax-plus +80/123 column, 120 CPS, forms up to 15".

NEC-8023A and NEC-8023A-01 with Graftrax-plus +80/123 column, 120 CPS, forms up to 15".

PRA-99700

Desk top printer stand and continuous form paper holder.

PRA-43081

Friction feed, paper tear bar, NEC-8023-01 interlaces included, front panel switch handles 4 part forms up to 10.

PRM-43082

Head, bi-directional/logic seeking, both preset graphics built in, plus all the features of the 83A.

TSX-200A

Double-high friction feed and pin feed.

MX-100 with Graftrax-plus +132/232 column, 120 CPS, adjustable pin feed, parallel interface.

PRA-27081

FR-1000 with GRAFTRAX-plus MX-100, 2K hi-speed serial card, parallel interface.

PRA-27087

FX-12251051M

80 CPS LETTER QUALITY - Fujitsu

New 40 CPS daisy wheel printer with full serial interlaces included.

PRD-86200

10 CPS daisy wheel printer from Smith Corona.

PRD-45011

Centronics parallel.

PRD-45022

Les 232C parallel.

LETTER QUALITY PRINTER - Jade

Uses standard daisy wheels and ribbon cartridges, 16 CPS bi-directional printing, semi-automatic paper loader (single sheet or fan fold), 10/1215 pitch, up to 16" paper, built-in noise suppression, 1 Megabyte back-up drive is also available.

PRD-11001

Centronics parallel.

PRD-11002

Les 232C serial model.

STARWRITER F-10 - C. Ihoh

New 40 CPS daisy wheel printer with full 15" carriage, uses standard Diablo print wheels and ribbons, both parallel and serial interfaces included.

PRD-22010

Starwriter F-10.

80 CPS LETTER QUALITY - Fujitsu

High speed daisy wheel printer with both RS-232C serial & Centronics parallel interfaces, uses NEC 550, Mitsubishi 600, Qume, and will interface to the IBM Personal Computer, features include Z-80 CPU, 16K buffer (4K optional), bidirectional printing, & baud rates up to 12X2.

PRD-86103

Fujitsu with 16K.

PRD-86200

Fujitsu with 48K.

PRD-86300

Adjustable tractor.

Software

PLANNER CALC - Target Software

Spread sheet (what if ?) program designed with the user in mind, user oriented (simple english) commands allow you to quickly master this powerful software package, supplied on disk for most CP/M based systems.

SFA-12251052

Apple II by CP/M.

SFC-12251055

SS SD 8" CP/M.

SFC-12251056

Xerox 8" CP/M.

SFC-12251057

Xerox 5", CP/M.

SFC-12251058

NEC 5", CP/M.

PAC MAN - Atari

Atari's best selling game for your 800 or 400 computer.

SFI-31254022E

Pac Man cartridge.

$37.95

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Printer & Disk Drive Sales

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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 8% sales tax. No minimum shipping & handling charge. 5% Pricing & availability subject to change. Circle 216 on inquiry card.
## Disk Drive for Apple $319.95

**PREMIUM DISKETTES - Jade**
We proudly put our name on these high quality diskettes.

<table>
<thead>
<tr>
<th>Model</th>
<th>Details</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>MMD-5110103</td>
<td>SS, SD, 01S</td>
<td>$29.00</td>
</tr>
<tr>
<td>MMD-5111003</td>
<td>SS, SD, 10S</td>
<td>$29.00</td>
</tr>
<tr>
<td>MMD-5112003</td>
<td>SS, DD, 01S</td>
<td>$31.00</td>
</tr>
<tr>
<td>MMD-5113003</td>
<td>SS, DD, 10S</td>
<td>$31.00</td>
</tr>
<tr>
<td>MMD-5221003</td>
<td>SS, SD, 01S</td>
<td>$48.00</td>
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</table>

### BARGAIN DISKETTES

<table>
<thead>
<tr>
<th>Model</th>
<th>Details</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>MMD-5110106</td>
<td>5¼&quot; SS, DD, 01S</td>
<td>$31.00</td>
</tr>
<tr>
<td>MMD-5220106</td>
<td>5¼&quot; SS, DD, 10S</td>
<td>$32.95</td>
</tr>
<tr>
<td>MMD-5222106</td>
<td>8&quot; SS, SD, 01S</td>
<td>$35.05</td>
</tr>
<tr>
<td>MMD-5223106</td>
<td>8&quot; SS, DD, 10S</td>
<td>$35.05</td>
</tr>
</tbody>
</table>

## Single User System

### THREE BOARD SET - SD Systems
4 MHz Z 80A CPU, 64K RAM (optional 256K), serial I/O port, parallel I/O port, double density disk controller, CP/M 2.2 & manual set, system monitor, utility & diagnostic software. Includes SBC-300, 64K ExpandableRAM II, Versatolopy II, & CP/M 2.2 - all boards are assembled & tested.

<table>
<thead>
<tr>
<th>Model</th>
<th>Details</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Board set with 64K of RAM</td>
<td>$1095.00</td>
<td></td>
</tr>
<tr>
<td>Board set with 256K of RAM</td>
<td>$1295.00</td>
<td></td>
</tr>
</tbody>
</table>

### Apple II Accessories

- **16K RAM CARD** - for Apple II
  - Expand your Apple to 64K, 1 year warranty
  - MEX-16700A Save $125.00!!! $69.95

### ADD-ON DISK DRIVE** - for Apple II
- Inexpensive direct replacement for Apple Disk II, works with Apple II controller as first or second drive.
  - MMD-122200 Add On Drive $319.95

### Video Monitors

- **HI-RES 12" GREEN - Zenith**
  - 15 MHz bandwidth, P31 green phosphor, switchable 40 or 80 columns, small, light-weight & portable.
  - VDM-20101 List price $299.95

- **12" GREEN SCREEN - NEC**
  - 20 MHz bandwidth, P31 phosphor ultra-high resolution video monitor with audio.
  - VDM-20501 List price $289.95

- **12" COLOR MONITOR - NEC**
  - High resolution color monitor with audio.
  - VDC-62112 Color monitor $399.95
  - NEC-1202D RGB color monitor $999.95

- **13" COLOR MONITORS - BMC**
  - 18 MHz RGB & composite video color monitors.
  - VDC-423210 13" RGB Color $329.95
  - VDC-421310 13" Composite video $149.95

- **COLOR MONITORS - Amdek**
  - Reasonably priced color video monitors.
  - VDC-80210 13" Color I $379.95
  - VDC-80220 13" Color II $484.95
  - IOV-2300A DVM board for Apple $799.95

- **AMBER or GREEN MONITORS - Jade**
  - High resolution 18 MHz compact video monitors.
  - VDM-751210 12" Amber phosphor $149.95
  - VDM-751220 12" Green phosphor $139.95
  - VDM-751230 12" Silver phosphor $149.95
  - VDM-759220 9" Green phosphor $139.95

## Modems

- **SIGNALMAN - Anchor**
  - Direct-connect automatic answer/originate selection, 300 Baud full duplex, Bell 103, includes RS-232 cable.
  - IOM-5600A Signalman $98.50

- **SMARTMODEM - Hayes**
  - Sophisticated direct-connect auto-answer/auto-dial modem, touch-tone or pulse dialing, 3200/332 interface, programmable.
  - IOM-0400A Smartmodem $248.95
  - IOM-1000A Hayes Color modem $199.85
  - IOM-2010A Micromodem II $328.95
  - IOM-1100A Micromodem 100 $368.95

## EMROM Epasers

- **ULTRA-VIOLET EMROM ERASERS**
  - Inexpensive erasea for industry or home.
  - XME-3100A Spectronics w/o timer $69.95
  - XME-3101A Spectronics with timer $84.95
  - XME-3200A Economy model $129.95

## Specials

- **SUPERQUAD - Adv. Micro Digital**
  - Single board, standard size S-100 computer system, 4 MHz Z-80A, single or double density disk controller for 9½" or 8" drives, 54K RAM, extended addressing, up to 4K of EPROM, 2 serial & parallel I/O ports, real time interrupt clock, CP/M compatible.
  - CPC-3200A A & T $729.95
  - IOX-4223A Serial I/O adapter $29.85

- **Z-80 STARTER KIT - SD Systems**
  - Complete Z-80 microcomputer with RAM, ROM, I/O, keyboard, display,基辅ea, manual, & workbook.
  - CPS-3201KA Kit with workbook $499.95

### Single Board Computer

- **AIM-65 - Rockwell International**
  - Complete 6502 microcomputer with alphanumeric display, printer, keyboard, & instruction manual.
  - CPK-50165A 1K AIM-65 $420.95
  - CPK-50465A 4K AIM-65 $474.95
  - SFK-7460008E 8K BASIC ROM $64.95
  - SFK-7490002E 64K assembler $129.95
  - SFK-7490002E PL/65 ROM $84.95
  - SFK-7490009E Forth ROM $129.95
  - SFK-6500003E Interc Pascal $99.95
  - PSX-030A Power supply $46.95
  - ENX-00002A Enclosure $54.95

### Special Package

- **SPECIAL PACKAGE**
  - 4K AIM-65, 8K basic, power supply, & enclosure
  - Special Package Price $949.95

## S-100 EPROM Boards

- **PROM-100 - SD Systems**
  - 2708, 2716, 2732 EPROM programmer with software.
  - PROM-100K 208 PROM programmer with software $189.95
  - PROM-100A A & T with software $249.95

### PB-1 - SSM Microcomputer

- **PB-1 - SSM Microcomputer**
  - 2716 EPROM board with on-board programmer.
  - PB-1100K Kit with manual $154.95
  - PB-1100A A & T with manual $219.95

### EPROM BOARD - Jade

- **16K or 32K PROM BOARD**
  - 2708 or 2716 EPROM PROMs, 1K boundary.
  - MEM-19230K Kit with PROMs $299.95
  - MEM-19230A A & T with PROMs $219.95

### Video Monitors

- **VISION 80 - Vista Computer**
  - 80 column x 24 line video card for Apple II, 128 ASCII characters, up to 4K memory, 8" display, parallel 110 port, real time interrupt clock, CP/M compatible.
  - IOV-2400A Vista Vision 80 $399.95

### APPLET-CAT - National

- Software selectable 1200 or 300 baud, direct connect, auto-answer/auto-dial, auxiliary 3-wire RS232C serial port for printer.
  - IOM-5232A Save $50.00!!! $235.95

### MPS MULTICARD - Mtn. Computer

- Three cards in one! Real time clock/calendar, serial interface, & parallel interface - all on one card.
  - IOX-2300A A & T $179.95

### HI-RES GRAPHICS CARD - Genie

- Intelligent printer interface and control card allows full high resolution graphics and alphanumeric printer.
- IOP-2405A Genie for Epson $119.95
- IOP-2410A Genie for Okidata $119.95
- IOP-2415A Genie for NEC/C. Iital $119.95

### Power Strips

- **ISOBAR - GSC**
  - Isolates & protects your valuable equipment from high voltage spikes & AC line noise, induc.tive isolated ground, 15 amp circuit breaker, U.L. listed.
  - EME-111510 G socket $39.95
  - EME-111510 4 socket $49.95
  - EME-111510 9 socket $54.95
  - EME-111510 12 socket $74.95

### S-100 Motherboards

- **ISO-BUS - Jade**
  - Silent, simple, and on sale - a better motherboard.
  - MBS-061B Bare board $10.95
  - MBS-061K Kit $20.95
  - MBS-061A A & T $36.95
  - MBS-121B Bare board $25.95
  - MBS-121K Kit $49.95
  - MBS-121A A & T $129.95

### ACTIVE TERMINATOR - CompuPro

- A true mother's helper.
  - TXS-100A A & T $59.45

---

Prices may be slightly higher at our retail locations. Please call the store nearest you for local price and availability. Circle #1 in inquiry card.
S-100 CPU Boards

8086/8087 CPU

16 bit, 8 or 10 MHz 8086 CPU with provisions for 8087 & 80387
CPU-70520A 8 MHz 8086 A & T $624.95
CPU-70520C 8 MHz 8086 CSC $764.95
CPU-70520 with 8078735 $1242.95
CPU-70530C with 8087 CSC $1455.95

8086/8087 CPU

Both 8 & 16 bit CPUs, standard 8-bit S-100 bus, up to 8 MHz, access 16 Megabytes of memory.
CPU-205/2A 6 MHz A & T $398.95
CPU-205/1C 6/8 MHz CSC $497.95

CPU-Z - CompuPro

2/4 MHz Z80A CPU, 24 bit addressing.
CPU-30500A 2/4 MHz A & T $279.95
CPU-30500C 3/6 MHz CSC $374.95

SBC-200 - S/0 Systems

4 MHz 286A CPU with serial & parallel I/O, 1 K RAM, 8K ROM space, monitor PROM included.
CPC-30200A A & T $399.95

THE BIG Z - Jade

2 or 4 MHz switchable Z-80 CPU board with serial I/O, accommodates 2708, 2712, or 2732 EPROM, baud rates from 75 to 10000.
CPU-30201B Bare board w/manual $35.00
CPU-30201K Kit with manual $149.95
CPU-30210A A & T with manual $192.95

CB-2 - SSM Microcomputer

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 550, front panel compatible.
CPU-30300K Kit with manual $229.95
CPU-30300A A & T with manual $274.95

2810 Z-80 CPU - C.C.S.

2 or 4 MHz Z-80CPUC with serial I/O port & on-board monitor PROM, front panel compatible.
CPU-30400A A &T with PROM $289.95

2820 Z-80 DMA CPU - C.C.S.

4 MHz 286A CPU board with 2 serial I/O ports & Centronics parallel I/O port, separate data & status ports, DMA delay chain. 
CPU-30420A A &T with manual $569.95

S-100 Disk Controllers

DISK 1 - CompuPro

8" or 5¼" DMC disk controller, single or double density, single or double sided, 10 MHz.
IOD-1910A A & T $449.95
IOD-1910C CSC $544.95
SFC-5250565F 8" CP/M 2.2 for Z-80 $174.95
SFC-5250565 8" CP/M 2.2 for 8086 $299.95
SFG-84195080F Oasis single user $495.95
SFG-84195090F Oasis multi-user $849.95

VERSAFLOPPY II - S/0 Systems

Double density disk controller for any combination of 5¼" or 8" single or double sided, analog phase-locked loop data separator, vectored interrupts, CP/M 2.2 & Oasis compatible, control/diagnostic software PROM included.
IOD-1900A A & T with PROM $529.95
SFC-55008047F CP/M 2.2 with VIC II $90.95

2242 DISK CONTROLLER - C.C.S.

5¼" or 8" double density disk controller with on-board boot loader ROM, trap CP/M 2.2 & manual test.
IOD-1300A A & T with CP/M 2.2 $399.95

DOUBLe D - Jade

High reliability double density disk controller with on-board boot loader ROM option, floppy disk drive for IEEE S-100, can function in multi-user interrupt driven bus.
IOD-1225B Bare board & loader man $59.95
IOD-1225K Kit with CP/M 2.2 $299.95
IOD-1200A A & T with CP/M 2.2 $399.95
SFC-59005019F CP/M 2.2 with Double D $99.95

S-100 Memory Boards

256K RAMDISK - S/0 Systems

Expandable RAM Disk from 64K to 256K using 64K x 1 RAM chips, compatible with CP/M, MP/M, Oasis, Cromemco, & most other Z-80 based systems, functions as ultra high-speed disk drive when used with optional RAMDisk software.
MEM-64064A 64K A & T $496.75
MEM-65128A 128K A & T $597.45
MEM-65168A 256K A & T $877.45
MEM-55256A 512K A & T $974.95
SFSC-55000000F RAMDisk w/CP/M 2.2 $44.95
SFSC-55000000F RAMDisk w/EXRAM III $24.95

128K RAM 21 - CompuPro

128K x 8 or 16 bit static RAM board, 12 MHz, 24 bit addressing.
MEM-12810A A & T $1609.95
MEM-12820C A & T $1794.95

64K RAM 17 - CompuPro

64K CMOS static RAM board, 10 MHz, low power less than 4 watts, DMA compatible, 24 bit addressing.
MEM-64144C A & T $549.95
MEM-64164C A & T $698.95

64K RAM 16 - CompuPro

32K x 6 or 8 bit low power static RAM board, 10 MHz, 24 bit addressing.
MEM-32100A A & T $598.95
MEM-32100C A & T $669.95

64K STATIC RAM - SSM

IEEE 6688-100 standard, up to 6MHZ/8 bit 12MHZ/16Bit 24 bit addressing, disableable in 2K increments.
MEM-64300A A &T $499.95

64K STATIC RAM - Mem Merchant

64K static S-100 RAM card, 4 to 16K banks up to 8 MHz.
MEM-64400A A & T $499.95

64K EXPANDORAM II - S/0 Systems

Expandable RAM board from 16K to 64K using 4115 RAM chips.
MEM-16630A 16K A & T $344.95
MEM-32631A 32K A & T $364.95
MEM-48632A 48K A & T $384.95
MEM-64633A 64K A & T $424.95

MEMORY BANK - Jade

4 MHz S-100 bank selectable expandable to 64K.
MEM-99730B Bare board w/manual $495.95
MEM-99730K Kit with no RAM $179.95
MEM-32731K 32K kit $199.95
MEM-64733K 64K kit $249.95
Assembled & Tested add $50.00

32K RAM 20 - CompuPro

32K static RAM, up to 10 MHz, disableable in 4K banks, bank selectable or 24 bit addressing.
MEM-16100A 16K A & T $259.95
MEM-16180C 16K CSC $324.95
MEM-24180A 24K A & T $324.95
MEM-24180C 24K CSC $324.95
MEM-32185A 32K A & T $384.95
MEM-32185C 32K CSC $449.95

16K STATIC RAM - Mem Merchant

4MHz low-power static RAM board, IEEE S-100, bank selectable, addressable in 4K blocks, disableable in 1K segments extended addressing.
MEM-16711A 16K A & T $149.95

Prices may be slightly higher at our retail locations. Please call the store nearest you for local price and availability. Circle 217 on inquiry card.
**KEYBOARDS — POWER SUPPLIES**

**JE610 ASCII Keyboard Kit**

The JE610 ASCII Keyboard Kit is perfect for any computer user. The kit includes a 32-key push-button ASCII keyboard assembly (51 keys), a 5V supply, connector, and everything pictured. Includes bezel trim and everything pictured. Two leads for hook-up. Includes all instructions for easy installation. Cut-out dimensions: 7"W x 1"H x 6"D.

Model 5VW3901 — $49.95

**JE600 Hexadecimal Encoder Kit**

FULL 8-BIT LATCHED OUTPUT
19-KY KEYBOARD

The JE600 encoder keyboard kit provides two separate hexadecimal digit outputs from 0 to F. Each digit contains separate leads for high and low outputs. Includes all instructions for easy installation. Cut-out dimensions: 3½"W x 6¾"D x 4¾"H.

Model 800DTE-HK (kit as pictured above) — $99.95

**JE600 Kit**

19-12 Hexadecimal Keyboard, PC Board & Components (no case) — $99.95

K19 12-Key Keyboard (keypad only) — $14.95

DTE-HK (cassette) — $44.95

**POWER SUPPLIES**

**Power Supply — 5V DC @ 500mA (each)**

* Includes kit for 5V TTL logic, 12V CMOS, and 5V DC @ 500mA. Complete instructions for easy installation. Cut-out dimensions: 7"W x 1"H x 4"D.

Model UV-11E1 Replacement Bulb — $16.95

**DE-4 UV-EPROM Eraser** — $79.95

**JOYSTICKS**

**JS-4K**

9-W Lineal Taper Pots — $5.25

100W Lineal Taper Pots — $4.95

**JVC-40**

40K 2 Video Controller in case — $4.95

**5% Mini-Floppy Disc Drive**

* Includes kit for 5% mini-disk drive. Instructions for easy installation. Cut-out dimensions: 7"W x 1"H x 4"D.

Part No. P51194 — $59.95

**Jumper and Cable Assemblies**

**Standard DIP Jumpers**

* Also available in 2, 3, 4, 5, 6, and 7 pin styles. Contact for details.

**Standard DB-3 Series Cables**

* Also available in 2, 3, 4, 5, 6, and 7 pin styles. Contact for details.

**Jameco Catalog**

* 3,500 pages) 15,000 products. Includes everything from ICs to PC boards. Complete instructions for easy installation.

**FREE 1983 Jameco Catalog**

* 3,500 pages) 15,000 products. Includes everything from ICs to PC boards. Complete instructions for easy installation.

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**FOR VOLKSWAGEN SCIROCCO, RABBIT, AUDI 5000 AND FOX**

**I/TIC Mini Stereo AM/FM Receiver**

**JE215 Adjustable Dual Power Supply**

* General Description: The JE215 is a Dual Power Supply with independent adjustable positive and negative output voltages. A separate adjustment for each of the output voltages is provided. The supply can also be used as a general purpose variable power supply.

**Features:**

* Independent voltage adjustable 0-12VDC P + and 0-5VDC N.

**JE215 Adjustable Dual Power Supply Kit (as shown) — $74.95**

* Includes kit for 12VDC and 5VDC. Instructions for easy installation. Cut-out dimensions: 7"W x 1"H x 4"D.

**JE200 Bag, Power Supply Kit (12VDC, 5VDC), 2 amp.** — $14.95

**JE200 Bag, Power Supply Kit (12VDC, 5VDC), 1 amp.** — $12.95

**JE215 Var. Pwr. Stream Kit, 5VDC @ 5 amp.** — $16.95

**JE501TDE-AK (Intermount Board Only) — $124.95**

**JE610 Kit of 6-Key Keyboard, PCB & Components (no case) — $79.95**

K62 6-Key Keyboard (keypad only) — $34.95

DTE-AK (card only) — $49.95

**JE610/DE-AK (Intermount Board Only) — $124.95**

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** 生命周期函数 August 1982**

**JE610 ASCII Keyboard Kit**

The JE610 ASCII Keyboard Kit is perfect for any computer user. The kit includes a 32-key push-button ASCII keyboard assembly (51 keys), a 5V supply, connector, and everything pictured. Includes bezel trim and everything pictured. Two leads for hook-up. Includes all instructions for easy installation. Cut-out dimensions: 7"W x 1"H x 6"D.

Part No. Price

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Price</th>
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<tbody>
<tr>
<td>SF-2E</td>
<td>$6.25</td>
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<tr>
<td>SF-5B010</td>
<td>$13.99</td>
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<tr>
<td>SF-5B020</td>
<td>$12.93</td>
</tr>
</tbody>
</table>

**Motorola AM/FM Stereo Push Button Car Radio**

FOR VOLKSWAGEN SCIROCCO, RABBIT, AUDI 5000 AND FOX

**(with minor adjustments, can be used in any automobile)**

includes basic trim and everything pictured. Two each: 62-tone switches and 10 AM/FM crystals. 24V supply, connects and leads for hook-up. Includes all instruction manuals for easy installation. Cut-out dimensions: 7"W x 1"H x 6"D.

Model TVW3901 — $49.95

**UV-EPROM Eraser**

Erase 2764, 2716, 27256, 2764, 2716, 2048, 256. Erase up to 6 chips within the same erasing cycle (6 to 60 minutes). Maintains commutation performance of DIP switches. Low voltage indicators (for visual confirmation only). Fast in 10 sec. at 9VDC. Contacts — 22VAC, 20mA. Amperes at 120VAC. Includes all instruction manuals for easy installation. Cut-out dimensions: 7"W x 1"H x 4"D.

UV-11E1 Replacement Bulb — $16.95

**DE-4 UV-EPROM Eraser** — $79.95

**Joysticks**

**JS-4K**

9-W Lineal Taper Pots — $5.25

100W Lineal Taper Pots — $4.95

**JVC-40**

40K 2 Video Controller in case — $4.95

**(5% Mini-Floppy Disc Drive)**

* Includes kit for 5% mini-disk drive. Instructions for easy installation. Cut-out dimensions: 7"W x 1"H x 4"D.

Part No. P51194 — $179.95

**Specs:**

* Double-sided. 16 tracks, 66K bytes capacity

**Circle 218 on Inquiry card.**
## MICROPROCESSOR COMPONENTS

### STATIC RAMS

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Function</th>
<th>Price</th>
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<tr>
<td>SN54137N</td>
<td>Static RAM</td>
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<tr>
<td>SN54137N</td>
<td>512x8</td>
<td>0.50</td>
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<tr>
<td>SN54137N</td>
<td>1024x8</td>
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<tr>
<td>SN54137N</td>
<td>2048x8</td>
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### DYNAMIC RAMS

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<tr>
<th>Part No.</th>
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<tr>
<td>M27C512</td>
<td>Dynamic RAM</td>
<td>5.00</td>
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<tr>
<td>M27C1024</td>
<td>1024x8</td>
<td>5.00</td>
</tr>
<tr>
<td>M27C2048</td>
<td>2048x8</td>
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<td>M27C4096</td>
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### PROMS

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<th>Part No.</th>
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<tr>
<td>SN7412</td>
<td>PROM</td>
<td>0.25</td>
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<td>SN7412</td>
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### EPROMS

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<th>Part No.</th>
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<tr>
<td>M27C128</td>
<td>EPROM</td>
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<td>M27C256</td>
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### MICROPROCESSOR CHIPS

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<th>Part No.</th>
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<tr>
<td>M48C15</td>
<td>Microprocessor</td>
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<td>M48C30</td>
<td>30x15</td>
<td>1.00</td>
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### RON'S

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<tr>
<td>M48C15</td>
<td>Ron's</td>
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<td>M48C30</td>
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### DATA ACQUISITION

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<td>M48C15</td>
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### SPECIAL FUNCTION

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<td>M48C15</td>
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### IC SOCKETS

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<th>Part No.</th>
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<tr>
<td>M48C15</td>
<td>IC Sockets</td>
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<td>M48C30</td>
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### CAPACITOR CORNER

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<tr>
<td>10uF</td>
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<td>0.25</td>
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<tr>
<td>1nF</td>
<td>0.50</td>
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</table>

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DIGITAL RESEARCH COMPUTERS
(214) 271-3538

32K S-100 EPROM CARD
NEW!
$79.95 KIT
USES 2716's
Blank PC Board - $34
ASSEMBLED & TESTED ADD $30

SPECIAL: 2716 EPROM's (450 NS) Are $9.95 Ea. With Above Kit.

KIT FEATURES:
1. Uses +5V only 2716 (2Kx8) EPROM's
2. Allowing equipment up to 32K of software on line
3. Uses 2714 (450NS) 8K Static Rams
4. Blank PC Board Selectable Wait States
5. Pulls out of Board with socket mask and silk screen layout. Gold plated contact fingers
6. All addresses and data lines fully buffered
7. Kit includes all parts and sockets
8. Prototype Kit
9. 2716's with 12A Typ-Amp. From the +15 Volt Buss
10. Blank PC Board can be populated as any multiple of 4K
11. Fully buffered and bypassed
12. Easy and quick to assemble

64K S-100 STATIC RAM
$349.00 KIT
NEW!
LOW POWER!
RAM OR EPROM
BLANK PC BOARD
WITH DOCUMENTATION
$55

FEATURES:
- Uses new 2K x 8 (TMM 2010 or HM 61316) Rambus.
- Completely compatible and independent RAM or EPROM on the same board.
- Fully supports all 48K of memory.

FOR 56K KIT $299
ASSEMBLED AND TESTED ADD $40

64K SS-50 STATIC RAM
$259.00 (48K KIT)
NEW!
LOW POWER!
RAM OR EPROM
BLANK PC BOARD
WITH DOCUMENTATION
$55

FEATURES:
- Uses new 2K x 8 (TMM 2010 or HM 61316) Rambus.
- Fully supports all 48K of memory.

SPECIAL PURCHASE!
UART SALE!
TR1602B - SAME AS TMS6011, AY5-1013, ETC. 40 PIN DIP
$2.95 EACH
4 For $10.00

TR1602B

CRT CONTROLLER CHIP
SMC #CRT 5037, PROGRAMMABLE FOR 80 X 24, ETC. VERY RARE
SURPLUS FIND. WITH PIN OUT. $12.95 EACH.

NEW! G.J. COMPUTER SOUND CHIP
AY3-8910. As featured in July, 1979 BYTE! A fantastically powerful Sound & Music Generator. Perfect for use with any 8 Bit Microprocessor. Contains: 3 Tone Channels, Noise Generator, 3 Channels of Analog to Digital Control, 16-Bit Envelope Control. ($85 Envelope Control). 2-8 Bit Parallel 1/0, DDA to A Converters, plus much more! All in one 40 Pin DIP. $11.93 PRICE CUT!

SPECIAL OFFER: $44.95 each. Add $5 for 60 page Data Manual.

TERMS: Add $2.00 postage. We pay balance. Orders under $15 add 75¢ handling. No C.O.D. We accept Visa and MasterCharge. Tex. Res. add 5% Tax. Foreign orders (except Canada) add 20% P & H. Orders over $50, add $1.50 for insurance.

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*TRADEMARK OF DIGITAL RESEARCH. WE ARE NOT ASSOCIATED WITH DIGITAL RESEARCH OF CALIFORNIA, THE SUPPLIERS OF CPM SOFTWARE.
THE BIG BOARD PROJECT: Three years in the works, and maybe too good to be true. A tribute to hard headed, no compromise, high performance American engineering! The Big Board gives you all the most needed computing features on one board at a very reasonable cost. The Big Board was designed from scratch to run the latest version of CP/M. Just imagine all the off-the-shelf software that can be run on the Big Board without any modifications needed! Take a Big Board, add a couple of 8 inch disc drives, power supply, an enclosure, CRT, and you have a total Business System for about 1/3 the cost you might expect to pay.

FEATURES: (Remember, all this on one board!)

- **64K RAM**
  - Uses industry standard 4116 RAM's. All 64K is available to the user. Our VIDEO and EPROM sections do not make holes in system RAM. Also, very special care was taken in the RAM array PC layout to eliminate potential noise and glitches.

- **Z-80 CPU**
  - Running at 2.5 MHZ. Handles all 4116 RAM refresh and supports Mode 2 INTERRUPTS. Fully buffered and runs 8080 software.

- **SERIAL I/O (OPTIONAL)**
  - Full 2 channels using the Z80 SIO and the SMC 8116 Baud Rate Generator. FULL RS232! For synchronous or asynchronous communication. In synchronous mode, the clocks can be transmitted or received by a modem. Both channels can be set up for either data-communication or data-terminals. Supports mode 2 INT.
  - Price for all parts and connectors: $49

- **BLANK PC BOARD — $149**
  - Consists of a separate parallel port (Z80 PIO) for use with an ASCII encoded keyboard for input. Output would be on the 80 x 24 Video Display.

- **24 x 80 CHARACTER VIDEO**
  - With a crisp, flicker-free display that looks extremely sharp even on small monitors. Hardware scroll and full cursor control. Composite video or split video and sync. Character set is supplied on a 2716 style ROM, making customized fonts easy. Sync pulses can be any desired length or polarity. Video may be inverted or true. 5 x 7 Matrix - Upper & Lower Case.

- **FLOPPY DISC CONTROLLER**
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<td>2102-L-1</td>
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### DYNAMIC RAMS

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<tr>
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<td>4116-200 16384 x 20</td>
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<tr>
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### EPROMS

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### DYNAMIC RAMS

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<td>MM5200 8192 x 1</td>
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<td>1.05</td>
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<tr>
<td>4116-120 16384 x 12</td>
<td>(200ns)</td>
<td>8/26</td>
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<td>4116-150 16384 x 15</td>
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<tr>
<td>4116-200 16384 x 20</td>
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<td>4232P 16384 x 32</td>
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### AUGUST SPECIALS

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<tr>
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### CALL US FOR VOLUME QUOTES

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<td>8008 7.25</td>
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<td>8039 7.95</td>
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<td>8168 9.95</td>
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### ORDER TOLL FREE

800-538-5000
800-662-6279
(CALIFORNIA RESIDENTS)

### AUGUST SPECIALS

<table>
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<tr>
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### CRYSRTALS

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### JDR MICRODEVICES, INC.

1224 S. Bascom Avenue
San Jose, CA 95128
800-538-5000 • 800-662-6279 (CA)
(408) 995-5430 • Telex 171-110

**PLEASE USE YOUR CUSTOMER NUMBER WHEN ORDERING TERMS:** For shipping include $2 for UPS Ground or $2 for UPS Blue Label Air. Items over 5 pounds require additional shipping charges. Foreign orders, due to high freight costs, are shipped at their 15% minimum order. Bay Area and Los Angeles Counties add 6% Sales Tax. Other California residents add 5% Sales Tax. We reserve the right to substitute manufacturers if the item is temporarily out of stock. Prices are subject to change without notice. We will match or beat any competitor's price provided it is not below our cost.

**HOURS:**
M-F 9-5; Sat. 11-3

**VISIT OUR RETAIL STORE**

**Circle 221 on inquiry card.**
# ALL MERCHANDISE 100% GUARANTEED!

## CALL US FOR VOLUME QUOTES

### IC SOCKETS

| Part Number | Quantity | Price
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### HOURS:

M-F. 9-5; Sat. 11-3

VISIT OUR

RETAIL STORE

800-549-5000 • 800-662-6779 (CA)

San Jose, CA 95128

BYTE August 1992

499

Circle 221 on inquiry card.
Just Arrived!

**COMRITER**

**CR-1 Daisy Wheel**

Typewriter quality printing for your word processing computer system. Wide 16.5" paper width, serial or parallel interface. Full control panel. MTBF 2,500 hours. Designed with few mechanical parts so high reliability. 17 CPS, 10, 12 and 15 CPI. Bidirectional 132, 150, 198 col. Incredibly low priced.

CR-1C List: $1195

**OLYMPIA**

**Daisy Wheel**

Letter quality typewriter interfaces to Apple, Ikar, TRS-80 and RS-232 Serial ports. 17.5 CPS, 10, 12 CPI. ES 100KRO Computer printer List: $1950.00 SAVE: $500

Interface Card Only: $195

(seri/parallel) Apple Serial Card: $25

**SMITH-CORONA**

**TP-1 Daisy Wheel**

Letter quality price breakthrough! Serial or parallel data interface. 12 CPS, 10 or 12 CPI. Smith-Corona TP-1 List: $895

**NEC**

**Spinwriters**

Letter quality printers: 7700 serial print 5", 3500 series print 33 CPS. Both series offer up to 128 char, take paper up to 16 in. wide. 7700 series: 136 col. at 10 CPI, 163 col. at 12 CPI. Same for 3500 series plus 204 col. at 15 CPI.

7710/7730 RO w/tractor: $2475.

7720 KSR w/tractor: 2850.

3510/3530 RO: 195.

Bidirectional tractor: 200

Push tractor: 350.

**OKIDATA**

**Microline**

82A—80/132 col., 120 CPS. 9 x 9 dot matrix, friction, pin feed or tractor feed (optional) rear and bottom feed. Includes bidirectional/serial entry and parallel interface. Double width and condensed characters, true lowercase descendents and graphics.

82A: $59.

83A—132/232 col., 120 CPS, handles forms up to 15 in. wide, plus all features of the 82A.

83A: $745.

84SP—132/232 col., 200 CPS with full dot graphics built in. Takes forms up to 15 in. wide, plus all the features of the 83A. 84SP: $1150.

**C. ITOH**

**F10 Daisy Wheel**

Letter quality printer. Friction feed or bidirectional tractor. 40 or 55 CPS. 136, 163 and variable col.

F10 List: $1795

**ADLER**

**Printer Typewriter**

11 or 17.5 CPS, 10, 12, 15 CPI and proportional spacing. 2 line correcting memory, interchangeable print wheels.

SE 1010 List: $1295

Interface Card: $995.

Circle 315 on inquiry card.
**APPLE SOFTWARE**

**BUSINESS**

- **Financial Partner** $191
- **Pascal Tutor** $97
- **Pro Easy Writer** $137
- **Easy Writer 40 col.** $78
- **Word Star (Res. SC)** $241
- **SuperSort (Res. SC)** $129
- **Mail Packer** $379
- **Data Star (Res. SC)** $192
- **Spell Star (Res. SC)** $129
- **SuperText II** $117
- **Dictionary** $9
- **Android** $435
- **WordProcessor (Res. SC)** $255
- **PERSONAL HOME**
- **Tutor Typing** $191
- **Elementary Math** $31
- **Person-on-Filing System** $74
- **Algebra** $105
- **Compu-Math Arith. Skills** $39
- **Compu-Math Fractions** $31
- **Compu-Math Decimals** $31
- **Compu-Spell (Res. Data)** $99
- **Disk** $23

**GRAPHICS CARD**

- Dump Screen 1 or 2
- Double size Emphasize
- Inverse or normal Rotate
- Set left margin or center image.

**BI-ZCOMP**

Superlow introductory price. Save over other modems! Apple direct connect via game port. No serial card needed. Save $139 or more. Apple package includes software on disk. Apple direct connect via interface module and telelink cartridge. Each pkg. contains cable with connectors and phone T-adaptor.

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Vic Comm Pkg $99
Atari Comm Pkg $99

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- UDS 103 LP, direct $169
- UDS 103 JLP Auto Answer $209
- 202 LP 1200 BAUD $259
- NOVATION CAT, 115
- D-Cat, direct $135
- Auto Cat $219
- Apple Cat $275
- HAYES S100 Micromodem $349
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- Qume $45/Doz.
- Diablo $66/Doz.
- Anadex $135/6 ea.
- Trill $95/Doz.
- TI/DEC/TTY $45/Doz.
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- 80 character screen
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- PC-6031A Dual Mini-Disk Drive Unit $750

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Centronics to Centronics 6 ft. $30

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- 9 wire male-female $25

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- Ampex Dialog 30 $795
- Televideo 9200C $845
- Televideo 950 $995
- SOROC IQ 120 $499
- Zenith 12" Green $119
- NEC 12" Green $169

**SAVE $100s**

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- CR-6500 Color Display Monitor—13" inline color, Hi-Resolution 260H x 300V
- CR-6500 List $445
- CR-6600 Color Display Monitor—13" inline color with RGB signal for higher resolution graphics, 380H x 240V
- CR-6600 List $619

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Computer Products
BH6BT180A memory, see the "Product Description" on page 416 of the BH6BTM0256KA 256K of A&T memory & M-Drive Software.

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I/O BOARDS

SYSTEM SUPPORT 1 MULTIFUNCTION BOARD

Serial port (software prog. based), 4K EPROM or RAM provision, full level interrupt, real time clock, optional math processor.

New!

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110V 60Hz CVT Mainframe uses famous 20 slot COMPUPRO bus.

Circle 333 on Inquiry card.
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**Tandon 5/6/7 Drives**

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• Fully static design uses less power than dynamics (1.2 amps typical)
• 24 bit extended addressing
• 8 bit (128K) or 16 bit (64K) operation
• Addressable as one block
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• Switch selectable PHANTOM disable
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• 16K x 1 static RAM
• Thorough bypassing of all supply lines
• Capable of DMA processing
• 128K Static, 1.2 amps
• NMOS high speed low power memory ICS

SALE PRICE:

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In addition to a 6, 8, or 12 slot S-100 card cage, the mainframe is designed to support two 8” floppy or hard disk drives. It is ideal for the new generation of Single Board Computers and high density RAM cards that do not require many slots. Now you can have a complete dual floppy or hard disk system in one convenient enclosure at a remarkably low price.

FEATURES:
- Accommodates any combination of standard 8” floppy or hard disk drive (8010 A, D, E, F, G, H, J).
- Built in 15A circuit breaker, on/off switch, pilot light.
- Isolated • Circuit breaker protected at 15A.
- Two AC convenience outlets on rear panel for peripherals.
- 15-250V cut outs for inspecting I/O connectors.
- 2-50 plug cut outs.
- Dimensions: 9” x 5” x 1” (229 x 127 x 25.4 mm).
- Weight: 10 oz. w/batteries.
- Power Supply: +5V @ 120mA. +24V @ 0.7A. +8V @ 1.8A. ±16V @ 0.25A.
- Batteries: 6V 600mA NiCad.
- Function Test: • Switches:Originate/Off/Answer: Full Duplex/Test/Half Duplex • Indicators: Transmit Data, Receive Data, Carrier Ready Test

RS232 and “D” SUB-MINATURE CONNECTORS

<table>
<thead>
<tr>
<th>SOLDER TYPE</th>
<th>Plug, Male Type</th>
<th>D-Socket, Female Type</th>
<th>C-Cover, Hood</th>
</tr>
</thead>
<tbody>
<tr>
<td>BHCNOU6U6P</td>
<td>9 Pin Male</td>
<td>$2.10</td>
<td>$1.98</td>
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<tr>
<td>BHCNOEU6U6P</td>
<td>9 Pin Female</td>
<td>$2.70</td>
<td>$2.40</td>
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<tr>
<td>BHCNOE6U6C</td>
<td>9 Pin Cover</td>
<td>$1.50</td>
<td>$1.25</td>
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<tr>
<td>BHCNO30U6U6P</td>
<td>15 Pin Male</td>
<td>$2.75</td>
<td>$2.45</td>
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<td>BHCNO30U6U6S</td>
<td>15 Pin Female</td>
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<td>$2.65</td>
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<tr>
<td>BHCNO30U6C</td>
<td>15 Pin Cover</td>
<td>$1.30</td>
<td>$1.10</td>
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<tr>
<td>BHCNO30U6AP</td>
<td>25 Pin Male</td>
<td>$3.00</td>
<td>$2.75</td>
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<tr>
<td>BHCNO30U6AS</td>
<td>25 Pin Female</td>
<td>$4.00</td>
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<tr>
<td>BHCNO30U6P</td>
<td>1 Pc. Grey Hood</td>
<td>$1.50</td>
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<tr>
<td>BHCNO2EU6P</td>
<td>2 Pc. Grey Hood</td>
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<td>$1.40</td>
</tr>
<tr>
<td>BHCNO8EU6P</td>
<td>8 Pc. Black Hood</td>
<td>$1.60</td>
<td>$1.50</td>
</tr>
<tr>
<td>BHCNO37U6P</td>
<td>37 Pin Male</td>
<td>$6.70</td>
<td>$6.30</td>
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<tr>
<td>BHCNO37U6S</td>
<td>37 Pin Female</td>
<td>$1.80</td>
<td>$1.65</td>
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<tr>
<td>BHCNO85U6P</td>
<td>50 Pin Male</td>
<td>$1.80</td>
<td>$1.65</td>
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<td>BHCNO85U6S</td>
<td>50 Pin Female</td>
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<td>$1.65</td>
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<tr>
<td>BHCNO85U6C</td>
<td>50 Pin Cover</td>
<td>$1.00</td>
<td>$0.90</td>
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IBM PC PROTOTYPING BOARDS

<table>
<thead>
<tr>
<th>IBM PC</th>
<th>Description</th>
<th>List Price</th>
<th>Sale Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>BHTU4U4</td>
<td>3 Hole Solder Board</td>
<td>$58.00</td>
<td>$50.00</td>
</tr>
<tr>
<td>BHTU4U3</td>
<td>3 Hole Solder Board</td>
<td>$32.50</td>
<td>$28.50</td>
</tr>
<tr>
<td>BHTU4U3-2</td>
<td>Wire Wrapping Board</td>
<td>$58.00</td>
<td>$50.00</td>
</tr>
<tr>
<td>BHTU4U3-2x Extender</td>
<td>$22.35</td>
<td>$20.12</td>
<td></td>
</tr>
</tbody>
</table>

IBM “STAR” MAINFRAMES FOR DUAL 8” HARD AND FLOPPY DISKS

The D.T. MICO series mainframe is designed to be the most versatile and the most compact system enclosure on the market today. In addition to a 6, 8, or 12 slot 8” card cage, the mainframe is designed to support two floppy or hard disk drives. It is ideal for the new generation of Single Board Computers and high density RAM cards that do not require many slots. Now you can have a complete dual floppy or hard disk system in one convenient enclosure at a remarkably low price.

FEATURES:
- Accommodates any combination of standard 8” floppy or hard disk drive (8010 A, D, E, F, G, H, J).
- Built in 15A circuit breaker, on/off switch, pilot light.
- Isolated • Circuit breaker protected at 15A.
- Two AC convenience outlets on rear panel for peripherals.
- 15-250V cut outs for inspecting I/O connectors.
- 2-50 plug cut outs.
- Dimensions: 9” x 5” x 1” (229 x 127 x 25.4 mm).
- Weight: 10 oz. w/batteries.
- Power Supply: +5V @ 120mA. +24V @ 0.7A. +8V @ 1.8A. ±16V @ 0.25A.
- Batteries: 6V 600mA NiCad.
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TELEX: 12-5606 CABLE: WASHCOMP NYK

PRINTERS

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teletype 40</td>
<td>300 LPM-typewriter quality, RS-232 interface. This quality printer is available in many configurations including forms access, quieted case, etc.</td>
<td>from Only $2000</td>
</tr>
<tr>
<td>Teletype 43</td>
<td></td>
<td>from $995</td>
</tr>
<tr>
<td>Teletype AP-200</td>
<td>340 cps dot matrix (similar to Data Prod. M-200)</td>
<td>$2799</td>
</tr>
<tr>
<td>NEC Starwriter</td>
<td>55 cps, bidirectional, letter quality</td>
<td>$2560</td>
</tr>
<tr>
<td>DIABLO 630</td>
<td>40 cps, bidirectional, daisy wheel, plot/graph</td>
<td>$2349</td>
</tr>
<tr>
<td>QUME Sprint/35 cps, daisy wheel</td>
<td></td>
<td>$1944</td>
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<tr>
<td>C. ITOH Starwriter</td>
<td>40 cps, daisy wheel, F10</td>
<td>$1550</td>
</tr>
<tr>
<td>EPSON MX-80</td>
<td>80, 80 cps, 9x9 dot matrix</td>
<td>$987</td>
</tr>
<tr>
<td>ANADIA 9500/9501A</td>
<td>up to 200 cps, high resolution dot</td>
<td>$1451</td>
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<tr>
<td>OXIDATA Microline 82A</td>
<td>$525 Microline 83A</td>
<td>$799</td>
</tr>
<tr>
<td>Ti-610, 150 cps, Basic</td>
<td>$1449 Package-C/VFC</td>
<td>$1630</td>
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<tr>
<td>MANNESSMANN MT17B00 200 cps, 7x9, 132 col</td>
<td>$CALL</td>
<td></td>
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<tr>
<td>TALLY MT17B05 200 cps, 7x9, 132 col+NL0 40x18 matrix</td>
<td>$CALL</td>
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<tr>
<td>CENTRONICS 739 100 cps, 9x9 dot matrix, Full Graphics</td>
<td>$557</td>
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<td></td>
<td>122 120 international set, Full Graphics</td>
<td>$987</td>
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<tr>
<td>DEC LA-34</td>
<td></td>
<td>$1085</td>
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<tr>
<td>IDS PRISM, 132 col, color</td>
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<td>$785</td>
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TERMINALS

<table>
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<tr>
<th>Model</th>
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<tr>
<td>PMNI MODEM</td>
<td></td>
<td>$359</td>
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<tr>
<td>AMPLEX DIALOGUE 30, 80, 81</td>
<td>Lowest Prices</td>
<td>$CALL</td>
</tr>
<tr>
<td>AMPLEX DIALOGUE 910 C (multi-terminal)</td>
<td></td>
<td>$610</td>
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<tr>
<td>925C</td>
<td></td>
<td>$795</td>
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<tr>
<td>950C</td>
<td></td>
<td>$965</td>
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<tr>
<td>SOROC IQ 120</td>
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<td>$799</td>
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<td>HAZELTINE ESRT</td>
<td></td>
<td>$618</td>
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<tr>
<td>DEC VT-100</td>
<td></td>
<td>$1575</td>
</tr>
<tr>
<td>WYSE WY-100 (ALTOS 1)</td>
<td></td>
<td>NEW! $394</td>
</tr>
<tr>
<td>Zenith ZT-1 80x24, autodual modem VT-52</td>
<td></td>
<td>$669</td>
</tr>
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SOFTWARE

<table>
<thead>
<tr>
<th>Model</th>
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<tr>
<td>DBASE II</td>
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<td>$525</td>
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<tr>
<td>MBASIC-80</td>
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<td>$275</td>
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<td>MBASIC COMPILER</td>
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<td>$316</td>
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<td>FORTRAN-80</td>
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<td>COBOL-80</td>
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<td>PL/1-80</td>
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<td>$425</td>
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<tr>
<td>PASCAL MT+ V5.5</td>
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<td>$398</td>
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<tr>
<td>WHITESMITH'S C</td>
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<td>$650</td>
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<tr>
<td>CO-80</td>
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<td>$420</td>
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<tr>
<td>PEARL (LEVEL 3)</td>
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<td>$549</td>
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<tr>
<td>LIFEBOAT SOFTWARE</td>
<td>Call</td>
<td>$CALL</td>
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<tr>
<td>PEAChEE</td>
<td></td>
<td>$CALL</td>
</tr>
<tr>
<td>GRAHAM-DORIAN</td>
<td></td>
<td>$CALL</td>
</tr>
<tr>
<td>STRUCTURED SYST.</td>
<td>Call</td>
<td>$CALL</td>
</tr>
<tr>
<td>DBASE II</td>
<td></td>
<td>$525</td>
</tr>
</tbody>
</table>

8" DISK DRIVE SALE

- SHUGART SABUR $450
- SHUGART SA 85IR $669
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- DEC VFC $350
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WANTED: Software that will graphically display vectors in 3D. Vortex motion is like a smoke ring that moves circularly and crusies at 6 m. T. Johnson, Devondere 63, Marketo, NL 5600.

WANTED: IBM graphics board. Works fine with X or Y. $250.

FOR SALE: IBM Memoprint printer. $300.モデル 200 Es, 2 x 512K DRAM. 1 x 16M PROM. All working. $120. Heartland Informatics, POB 1627, Pleasant Hill, OR 97401.

WANTED: We are interested in solving high-resolution graphics problems. All programs will be written on an Apple II 48K. Joe Miller, Electronics Dept. Anne Arundel Community College, Arnold, MD 21012.

FOR SALE: All brand new and unused. Unopened with original guarantees. Apple Vocalec (retail $200), $140; Violee (retail $225), $175; Zonder-V镝ilicdead (retail $175), $175. Take all and I'll pay shipping and reduce the total price by $25. Desktop Top II (retail $200), $140; Visquel (retail $180), $175; Visquel (retail $180), $175. Take all and I'll pay shipping and reduce the total by $25. Violee (for Atari 800 or Commodore 2001, retail $100), $139.90. D. Solomon, 246 Overlook, Fremont, CA 94530.

WANTED: Programs, experiments, interfacing projects, games, etc., applicable to the Heathkit ET-3040 microcomputer trainer (not included) in the EE-3040 home-study course. Charles Miller, Electronic Design Dept., Arne Munske Community College, Arnold, MD 21012.
FOR SALE: Ohio Scientific hardware C2-8P with 20K ($500), 520, 1640/boards). Hard-slot backplane. 32 by 64 display, separate keyboard, and RS-232C. Also two 527 24K 2 MHz memory boards and 470 disk controller (New). Original prices were $999 for C2-8P, $450 for each memory board, and $100 for the disk controller. Make an offer for some or all. Mike Bissman, 39-65 52 St., Woodside, N.Y. 11377, (312) 679-3505 evenings.


FOR SALE: CBIA 8080 microcomputer with 4K RAM, 2K ROM monitor, and keyboard port. $100. 24K two parallel and two serial ports. 190. Both boards are for 5-100 systems, come with complete documentation, and work well. Steve Moore, 2541 Chestnut Court, Visalia, CA 93277, (209) 734-2965 after 6 p.m.


WANTED: A Datronics 280 board for a Processor Technology SCI-20 computer. The board and documentation are preferred, but I will accept just the documentation. I will pay a reasonable price. Richard Obermeyer, 2025 Hol, Santa Ana, Calif. 92704, (714) 730-2567 days.

FOR SALE: Two 16K 5A-400 boards. Both are in excellent physical condition. One operates, one does not. 375 for each or $650. D.M. Sander, 701 South 23rd St., Allentown, PA 18102, (717) 321-7800.

FOR SALE: Swtpc GT-6144 graphics terminal with power supply, enclosures, and documentation. I will sell or trade for two MP-A or equivalent parallel interfaces for 5150 bus. William E. Summner, 11 Homestead Ave., SouthINGTON, N.J. 08436, (701) 627-1903.

WANTED: Need documentation/manuals for a MITS Altair PROM programmer card (#800 PPROM/HEV), C. Lyons, 15620 North 24th Ave., Phoenix, AZ 85023, (602) 942-7724.

FOR SALE: A brand new UDS 103 direct connect router. I will sell it or trade for an originate modem of similar type. I am also interested in software and hardware for the TI-99/4A computer and would like to correspond with other users. Ralph Power, 2348 Circle Lane, South Daytona, Fl 32119.


FOR SALE: A-138 acoustic modem in good shape. $100. IBM 2660 with sound in good shape, New York City area preferred. $100. Mike Steckman, 215 West 91 St., New York, N.Y. 10024, (313) 457-0511.


FOR SALE: Do you need a TV camera interface? Here is a fast Video Graphic board that could do the job. Three boards make a set. AIO, DMA, and DIA. New, $900; sell for $500 or best offer. Deluxe camera also available. Dan Felker, 2512 Maryland, Topka, KS 66605, (913) 232-4977.

WANTED: Professional programmer to implement CPM for a Cromemco Z80 48K computer. Will pay reasonable charge. Bitty Matson, 33 West Strawbridge Ave, E9, Melbourne, Fl, 32901.
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