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11 megabytes of hard disk and 64 kilobytes of fast RAM in a Z80A computer for under $10K. Two floppy drives, too.

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EXPANDABILITY

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PRESENT CROMEMCO USERS

We’ve kept you in mind, too. Ask about the new Model HDD Disk Drive which can combine with your present Cromemco computer to give you up to 22 megabytes of disk storage.
**Forefront**

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Controlling appliances in your home is one of the many chores that may be delegated to a personal computer. One product that is readily available is the Sears Home Control System used in this month's Garcia's Circuit Cellar.

**56 A COMPUTER-CONTROLLED LIGHT DIMMER, PART 1: DESIGN by John H Gibson**
You can use your computer in conjunction with programmable timers to easily control a light dimmer. Since programmable timers simplify both hardware and software in such applications, you may think of other applications.

**74 A FURNACE WATCHDOG by Theron Wierenga**
January is a month in which most of us show a greater than average concern for the state of our own home heating systems. After moving into a new house Theron decided to let his computer keep track of the furnace.

**122 TELEPHONE DIALING BY COMPUTER by Edward Joyce**
Your computer can ease the burden of remembering and dialing telephone numbers. This computer-controlled interface can dial your most frequently used numbers on Touch Tone telephone systems.

**129 ANALYSIS OF POLYNOMIAL FUNCTIONS WITH THE TI-59 CALCULATOR, PART 2 by Pierre Chance**
This article describes the operation of the polynomial evaluation programs for the TI-59 given in part 1. One program calculates the roots of a sixth-order polynomial, while the other produces a plot of the function on the TI PC-100C printer.

**156 ALPHA LOCK FOR YOUR ASCII KEYBOARD by Terry Conboy**
This article presents a method to produce only uppercase letters from a keyboard capable of both uppercase and lowercase operation. Control and special characters are not shifted, and the shift lock can be easily turned off.

**180 RELOCATING 8080 SYSTEM SOFTWARE by John Lipham**
The ability to relocate programs in memory space is often helpful when you are changing from one system to another, or adding a new program to your present system. John discusses some of the problems that are encountered during relocation on the 8080 microprocessor and gives two programs that perform most of the work.

**212 EIGHTEEN WITH A DIE, A LEARNING GAME PLAYER by Russell R Yost**
People learn from their mistakes. Computers can too, if given the right program. Russell enabled his personal computer to learn how to win a simple game by writing the program described in this article.

**Background**

**20 MAKING COLOR SLIDES WITH AN INTECOLOR MICROCOMPUTER by Alan W Grogono**
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**100 WHAT COMPUTERS CANNOT DO by T G Lewis**
Designers constantly try to build better and faster computers. Recent technology has produced many advances, but the question remains, "Is computing qualitatively better than when it first began?" T G Lewis discusses this issue.

**118 INDIRECT ADDRESSING FOR THE 6502 by Kenneth Skier**
The 6502 processor allows the user to perform certain indirect addressing operations. However, indirect addressing is not available for all instructions. Kenneth informs us of an easy way to perform indirect addressing on the 6502 when it is not normally available.

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The plotter described in this article is capable of being run by hardware and software drivers and gets around some of the physical difficulties, such as large torque and wobble factors, that confront some plotter designs.

**160 A COMPUTER-GENERATED REMINDER MESSAGE by E M Pass**
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ON THE COVER

The theme of this issue's cover illustration is "the domesticated computer." Robert Timney has taken the idea of the remote controlled appliances suggested by Steve Ciarcia's article on page 28 and combined it with some imaginative cabinetry in a household setting. In the process, Robert used his artistic license to employ radio imagery with antennae and aetheric airbrushing as an alternative to ultrasonic techniques described by Steve. Either way, practical means of safely controlling 110V appliances from the computer with total electrical isolation now exist—both for the homebrewer and as practical products advertised in this issue.
HIGH RESOLUTION INTELLIGENT GRAPHICS

Graphics boards have come and graphics boards have gone. None have really given you all the features at a competitive price that you've wanted—UNTIL NOW!

HIGH RESOLUTION 512 x 484 pixel display, from its own 32K random access memory.

INTELLIGENT Resident software emulates a terminal and also accepts high level commands for point, line, region, and variably sized and oriented character generation.

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EXTENSIBLE Room for up to 8K of PROM.

TIMELY 60 Hertz interrupting real time clock.

EASY TO USE Drop it into any S-100 host and you're up and running.

VERSATILE Composite or direct drive output; provision for external sync for a 512 x 512 display.

AFFORDABLE $95 dollars brings you the creative genius of MicroAngelo.

MicroAngelo is available now. Call Jim Mother at (703) 827-0888 or write us at Micro Diversions, Inc., 8455-D Tyco Road, Vienna, Virginia, 22180 and get creative!
The Era of Off-the-Shelf Personal Computers Has Arrived

Carl Helmers

This issue marks the beginning of a new decade: the 1980s. It may be appropriate at this time to pause and see how technology has progressed. At the turn of a previous decade, the only computers I could get my hands on were those large and expensive behemoths of the 1960s, the IBM 360s, Univa 1108s, and DEC PDP-6s, which I used during my occasional employments while an undergraduate physics student. Those machines represented such large capital investments that there was no way I could possibly own one.

At the time I knew that minicomputers existed. But they too were quite expensive. The minicomputer of late 1969 was also very limited in peripherals and systems software. At that time minicomputers were usually made by Digital Equipment Corporation, used a Teletype with paper tape for mass storage, and they may have had all of 8 K words of memory with 12 bits per word. It was an era in small computers when $30,000 might have purchased the hardware equivalent of today's $500 single-board engineering system; for example, a Rockwell AIM-65 with some added memory and a power supply. (This single-board 6502-based computer includes printer, tape interface, systems software and keyboard. With all required purchases, it costs about $500 to $600. A system such as this is equivalent to (if not better than) one of the typical minicomputer "installations" of the late 1960s.)

As we entered the 1970s, the beginnings of the large-scale integration microcomputer technology had been made. In existence at that time were 4-bit computers in high-technology calculator products, as well as such great accomplishments as 1024-bit shift register memories (slow) and high-speed 64-bit transistor-transistor logic (TTL) memories (power hungry). Mass storage on small machines in 1969, if it was electronic, was done on various randomly or serially addressable tape devices. These tape units were sold at prices comparable to the present-day retail price of a dedicated Winchester technology 10-million-byte hard disk drive. But the more common mass storage was mechanical, eg: the paper-tape reader and punch on a Model ASR-33 Teletype. As we enter the next decade, we find a much different picture.

The 64-bit memory part of late 1969 has increased in size to today's latest technology 64 K bit dynamic memories. This is an increase in density of just over 3 decimal orders of magnitude (1024 = 10^3). The primitive 4-bit architectures of then current calculators have become the 32-bit architectures of current machines such as the Motorola 68000, which is now seeing its first limited deliveries to prototype laboratories. At the end product level, smart machines have taken off in myriad directions, ranging from the dedicated controllers of computerized toys and microwave ovens, to the modern personal computer.

With the new extremely large-scale integration devices, the era of the 32-bit personal computer with high-resolution graphics display, main memory of 256 K bytes and from 10 to 50 million bytes of hard disk capacity on line is nearly here. In 1980, such a system can be built with the central computer consisting of just 33 major parts: 32 memory chips and a 68000 microcomputer.
"After working all day with the computer at work, it's a kick to get down to Basic at home. And one thing that makes it more fun is my Shugart minifloppy™. We use Shugart drives at work, so when I bought my own system I made sure it had a minifloppy drive.

"Why? Shugart invented the minifloppy. The guys who designed our system at work tell me that Shugart is the leader in floppy design and has more drives in use than any other manufacturer. If Shugart drives are reliable enough for hard-working business computers, they've got to be a good value for my home system.

"When I'm working on my programs late at night, I can't wait for cassette storage. My minifloppy gives me fast random access and data transfer. The little minidiskettes™ store plenty of data and file easily too.

"I made the right decision when I bought a system with the minifloppy. When you lay out your own hard-earned cash, you want reliability and performance. Do what I did. Get a system with the minifloppy."

If it isn't Shugart, it isn't minifloppy.

Shugart
435 Oakmead Parkway, Sunnyvale, California 94086

See opposite page for list of manufacturers featuring Shugart's minifloppy in their systems.
Ancillaries, such as buffers and read-only memories, might double that count to 66. In a very approximate systems sense, the manufacturing cost of an electronic system is proportional to the number of parts involved. This is exclusive of intangibles like software and aesthetics. So the manufacturing cost of such a device two years from now will make it the typical personal computer.

But what of right now? Where would we stand if there were to be no technological improvements in off-the-shelf personal computers? What is the state of today’s technology? I am going to describe some of the criteria that make up the design of a good modern personal computer system — and then I will make some comments about a particular system I just purchased and upon which I am creating this editorial. The fact that I have made a particular choice reflects the necessity for choice and not necessarily that other machines might not have served me as well. I will leave comments about this particular machine until later while I go into more details about what I see as the state of the art in small computers at the beginning of the 1980s.

The Personal Computer Circa 1980...

As of this writing, October 1979, the state of the art in personal computing is such that the user is king. It is possible to enter a computer store and witness the operation of a typical modern system, try it out, then purchase one just like it to take home and use. The discriminating user must pay attention to a number of technical points relevant to the function of systems: areas of hardware, systems software, applications software, and plain old-fashioned idiosyncracies such as aesthetics and programming styles enter into a decision about which computer to purchase. But there is a core of minimum function which must be met in the contemporary small computer.

Starting this tour of function at the level of system design, what are the characteristics of the processor and memory required? First, remember the often overlooked point that the particular processor used is an arbitrary consideration within a broad range. This is especially so in an era when high-level languages and systems software can insulate the programmer from needless details of low-level code.

In present-day personal computers the processors which are typically used are 8-bit devices: 8080s, 6502s, Z80s, 8085s, 6800s, and 6809s. In raw performance statistics, all of these are comparable within a factor of 2 or 3 depending upon the benchmark chosen. Each has its own strengths and weaknesses. The basic limitation of present-era computers is the 8-bit bus, which cycles at only a several megahertz rate (a typical system memory access time is 200 to 500 nanoseconds). Transferring a byte at a time is often the most significant speed limitation.

Thus the processor choice is relatively unconstrained among the various off-the-shelf computers available today. What of memory? Whatever the processor, the more memory available, the better the system. I believe that the convenient and pleasurable use of the small computer as it exists today requires a bare minimum of 32 K (ie: 32,768) bytes. Of the computers I use regularly, two have 64 K bytes and one has 53 K bytes. The primary criterion for selecting memory technologies for a user of a
At Intersystems, “dump” is an instruction. Not a way of life.
(Or, when you’re ready for IEEE S-100, will your computer be ready for you?)

We’re about to be gadflies again. While everyone’s been busy trying to convince you that large buses housed in strong metal boxes will guarantee versatility and ward off obsolescence, we’ve been busy with something better. Solving the real problem with the first line of computer products built from the ground up to conform to the new IEEE 5-700 Bus Standard. Offering you extra versatility in 8-bit applications today. And a full 16 bits tomorrow.

We call our new line Series II! And even if you don’t need the full 24-bit address for up to 16 megabytes (!) of memory right now, they’re something to think about. Because of all the performance, flexibility and economy they offer. Whether you’re looking at a new mainframe, expanding your present one or upgrading your system with an eye to the future. (Series II boards are compatible with most existing S-100 systems and all IEEE S-100 Standard cards as other manufacturers get around to building them.)

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

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Whatever your needs, why dump your money into obsolete products labelled “IEEE timing compatible” or other words people use to make up for a lack of product. See the future now, at your Intersystems dealer or call/write for our new catalog. We’ll tell you all about Series II and the new IEEE S-100 Bus we helped pioneer. Because it doesn’t make sense to buy yesterday’s products when tomorrow’s are already here.

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modern computer is that it be in the system, competently engineered, and reliable. Engineering jargon terms like “static” versus “dynamic” are meaningless once a product has passed the design stage and becomes a reliable mass-produced product. The fact that nearly all mass-produced computers use dynamic memory is a statement about the costs of various semiconductor engineering technologies. When I buy a computer off the shelf, I care only about the quantity of main memory available for use as a resource.

In addition to the need for adequate main memory, the next question is, what of magnetic mass storage? At a bare minimum, the personal computer should have on the order of 500 K bytes of on-line storage, preferably in two or more drives. In today’s technology, the most prevalent magnetic medium is the 5- or 8-inch floppy disk, with single-, double- or quad-density recording. Although recently introduced in personal computers, the hard disk technology based on drive products, from firms like Shugart, IML and Micromation, is not nearly as prevalent as it will be in 1980 and beyond; the standard configuration for most small computers is two or more floppy disk drives as 1979 draws to a close.

At the level of user interfaces, the standard display hardware of a usable small computer is the 24 (or 25) line by 80-character video display. In some machines this is built in as a board in the system itself; on others it is provided in the form of a high-speed serial link (typically 19.2 kbps) to a video terminal. In either design, the terminal interface has a standard keyboard similar to a typewriter, and both upper and lowercase text are supported. In this era, when the marginal cost of a full upper and lowercase text capability is low compared to system cost, there is no excuse for perpetuating primitive computers’ use of only uppercase text. Still remaining at a hardware level, it is necessary to have a hard copy device for most effective use of a small computer (or a large computer for that matter). Rare is the person who can remember all the details of a program without hard copy; and rare is the computer system with sufficient redundant displays so that multiple independent pages of text can be conveniently viewed simultaneously. In a personal computer at prices within reason today, hard copy is a necessity.

What about the options and their availability? Does the computer in question have a de facto standard bus design which is used by independent companies to design compatible peripherals? At the present time, the personal computer world has four principal bus systems available — two that are represented by multiple computer manufacturers (S-100 and SS-50), and two that are represented by one computer manufacturer and many independent compatible peripherals manufacturers (Apple II and Radio Shack TRS-80). These bus designs allow owners of small computers to mix and match peripherals beyond those of the standard variety every manufacturer provides. Thus we can find music boards, modem boards, real-time clocks, and even hard disk memories which plug into the bus definitions of one or more of the widely used de facto standards.

Going on to the issue of software and its specifications,
New from SSM.

80 Character Video

With 80 characters per line our VB3 is the perfect video interface for processing. It produces a standard 80x24 display of upper and lower case characters or as much as 80x51 for a full page of text. The matrix for graphic display goes up to 16x204. And with optional EPROM, as many as 256 user programmed characters or symbols can be produced.

VB3 is memory mapped for rapid screen updating. But it occupies memory only when activated. So one or more VB3s can be located at the same address with a full 65K of memory still available to the user.

It generates both U.S. and European TV rates and meets the new IEEE S-100 standard. Other features include keyboard input, black on white or white on black, one level of grey, underline, strike thru, blinking char., blank-out char., and programmable cursor. Software includes a CP/M compatible driver and a powerful terminal simulator.

VB3 is available in several configurations. Retail prices start at $375 kit, $440 assembled.

Z-80 CPU

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

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

CB2 also features an MWRITE signal, firmware vector jump, and an output port to control 8 extended address lines (allowing use of more than 65K of memory). Jumper options generate the new IEEE S-100 signals to insure future S-100 compatibility.

Retail price — $210 kit, $275, assembled.

8080 CPU

Our new CB1A is identical to our popular CBI with the exception that the on-board RAM has been increased from 256 bytes to a full 1K.

It also features an optional 2K of 2708 EPROMs, power-on/ reset vector jump, MWRITE, parallel input port with status and DIP switch addressing.

Retail price — $159 kit, $219 assembled.

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Microcomputing comes of age.

Ohio Scientific's OS-65U Level 3 operating system software brings new networking and distributed processing capabilities to microprocessor based computer systems.

Until now, the only alternative for low cost multiple-user computer applications was time-shared systems. However, a serious drawback of microcomputer or mini-computer multi-user time-share systems is the fact that under heavy work loads they slow down to a crawl since the central processor time in such a system is shared by all of the users.

In a microprocessor based distributed processing system, using floppy based microcomputers as intelligent terminals (local systems) most of the work load is handled locally. Overall system performance does not degrade under heavy job loads. Each local system performs entry, editing and execution while utilizing the central data base for disk storage, printer output, and other shared resources.

For more demanding applications it is desirable to have several data bases, each with its own collection of local systems. Such an inter-connected set of data bases is called a network. Each data base and its local intelligent and dumb terminals is called a cluster.

Level III

OS-65U Level 3 now supports this advanced networking and distributed processing capability as well as conventional single user operation and time-sharing. Level 3 now supports local clusters of intelligent microcomputer systems as well as dumb terminals for the purpose of utilizing a central Winchester disk data base and other shared resources. The system also has full communications capability with other Level 3 data bases providing full network capability. The system utilizes Ohio Scientific's low cost, ultra high performance computer systems throughout for intelligent terminals as well as data bases. This general systems configuration provides a cost/ performance ratio never before attained in this class of computer power.

Level 3 resides in each network data base. A subset system resides in each intelligent terminal. Each data base supports up to 16 intelligent systems and up to 16 dumb terminals. However, since dumb terminals can heavily load the system, they should be kept to a minimum. Level 3 also supports a real time clock, printer management, and other shared peripherals.

Data Base Requirements

Minimal requirements for a Level 3 network data base are a C3-C or C3-B computer system with 23 or 74 megabytes respectively, console terminal, 100K bytes RAM and a CA-10X 16 port I/O board for network and cluster communications.

Intelligent Terminal Requirements

Any Ohio Scientific 8" floppy based computer with 56K RAM and one data base communications port.

Connections

Intelligent terminals and networked data bases are connected by low-cost cabling. Each link can be up to 10,000 feet long at a transfer rate of 500K bits per second, and will cost typically $30 a foot (plus installation).

Syntax

Existing OS-65U based software can be directly installed on the network with only one statement change! Level 3 has the most elegantly simple programming syntax ever offered on a computer network.

File syntax is as follows:

```
DEV A B C D Local Floppies
DEV E Local hard disks
DEV K Z Specific network
{ Data Bases

Each of up to 8 open files per user can be from 8 separate origins. Specific file and shared peripheral contentions are handled by 256 network semaphores with the syntax Wait N

Waite N, close.
```

The network automatically prioritizes multiple resource requests and each user can specify a time out on resource requests. Semaphores are automatically reset on errors and program completion providing the system with a high degree of automatic recovery.

A Typical System

A typical system with two network data bases will have 148 megabytes of disk, four intelligent subsystems equipped with dual floppies, two dumb terminals, a word processing printer, a fast line printer, network data base manager software and 1000 ft. of interconnecting cable. Utilizing .7 MIPS processors throughout it will cost less than $50,000 plus installation. GT option computers (1.2 MIPS) can be utilized at a slightly higher cost.

One Step at a Time

Best of all, Ohio Scientific users can develop distributed processing systems economically one step at a time. A user can start with a single user floppy system, add a hard disk, then time-sharing, then a second Winchester data base for backup and finally cluster intelligent terminals to achieve a full network configuration.

For literature and the name of your local dealer, CALL 1-800-321-6850 TOLL FREE.

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The Challenger III Series is the microcomputer family with the hardware features, high level software and application programs that serious users in business and industry demand from a computer system, no matter what its size.

Since its introduction in August, 1977, the Challenger III has become one of the most successful microcomputer systems in small business, educational and industrial development applications. Tens of thousands of Challenger III's have been delivered and today hundreds of demonstrator units are set up at systems dealers around the country.

The Challenger III systems offer features which make their performance comparable with today's most powerful mini-based systems. Some of these features are:

Three processors today, more tomorrow.
The Challenger III Series is the only computer system with the three most popular processors— the 6502A, 68000 and Z-80. This allows you to take maximum advantage of the Ohio Scientific software library and programs offered by independent suppliers and publishers. And all Challenger III's have provisions for the next generation of 16 bit micros via their 16 bit data BUS, 20 address bits, and unused processor select codes. This means you'll be able to plug a CPU expander card with two or more 16 bit micros right in to your existing Challenger III computer.

Systems Software for three processors.
Five DOS options including development, end user, and virtual data file single user systems, real time, time share, and networkable multi-user systems.
The three most popular computer languages including three types of BASIC plus FORTRAN and COBOL with more languages available from independent suppliers. And, of course, complete assembler, editor, debugger and run time packages for each of the system's microprocessors.

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Ready made factory supported small business software including Accounts Receivable, Payables, Cash Receipts, Disbursements, General Ledger, Balance Sheet, P & L Statements, Payroll, Personnel Files, Inventory and Order Entry as stand alone packages or integrated systems. A complete word processor system with full editing and output formatting including justification, proportional spacing and hyphenation.

OS-OMS, the software star.
Ohio Scientific offers an Information Management system which provides end user intelligence far beyond what you would expect from even the most powerful mini-systems. Basically, it allows end users to store any collection of information under a Data Base Manager and then instantly obtain information, lists, reports, statistical analysis and even answers to conventional "English" questions pertinent to information in the Data Base. OS-DMS allows many applications to be computerized without any programming!

The "GT" option yields sub-microsecond microcomputing.
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Tic Tac Rebuttal

In his letter to BYTE (October 1979, page 175), Mr. Miller raises some interesting points. However, his comments about my Tic-Tac-Toe program (BYTE May 1979, page 196) do require further examination.

Apparently, aesthetics in programming is in the eye of the beholder; Mr. Miller found my table-lookup method unappealing. It is more aesthetically pleasing to me to compute a move only once, then use it, rather than to recompute the same move each time it is used. Since a Tic-Tac-Toe game is readily represented as a decision tree, I felt that a table-lookup algorithm was the most natural implementation, and regretted the necessity of using more clumsy methods for the special cases.

A further advantage of a table-lookup method is its modularity; one move-logic block may be readily changed without affecting other parts. You may recall that there was a logic bug in the published program (see “BYTE’s Bugs,” August 1979, page 194). This was easily corrected by changing only five numbers in the data table.

The concept is similar to that of a chess program; the better ones use a table-lookup for the early moves of the game, before things get too complicated. As for taking advantage of the microprocessor’s capabilities, it is more natural for it to increment an address to find a prestored number than to compute; its built-in computing power is limited to addition. More complicated computing must be done by “brute force and awkwardness” in the machine-language programming of the BASIC interpreter.

Mr. Miller did not like for the computer to always move first. As I stated in the article, I wanted the computer to play an aggressive game. It is readily apparent that the computer cannot play an aggressive game if the user moves first; it can then play only a defensive game, and wait for the user to blunder. Actually, I do have a user-first Tic-Tac-Toe program that uses a similar table-lookup method of play. While it plays the best possible game within the limits of a user-first game, it is still “curiously limited” and I felt that its inclusion would detract from the performance of the published program.

To play a rational Tic-Tac-Toe game, it is necessary but not sufficient for the program to be unbeatable. A rational program must not just respond to the current situation, but it must be goal-oriented. To set a “trap” requires three moves in the proper sequence. This planning ahead is readily done with a table-lookup method, but I suspect that it would be difficult to do by following Mr. Miller’s proposed system.

I suggest that Mr. Miller submit a Tic-Tac-Toe program based upon his 9-step strategy. It is much more meaningful to compare the performance of working programs than to compare a working program with a theoretical one.

Delmer D Hinrichs
2116 S E 377th Ave
Washougal WA 98671

UNIX-type File Available

We applaud Jim Howell’s plea (“Operating Systems: Let’s Have Some UNIX-Inspired Software,” September 1979 BYTE, page 82) for more sophisticated system software on microcomputers.

We would like to point out that UNIX-style file systems are, however, available already for microprocessors (at least the 6800s) in our SOOS product.

The SOOS file system supports files which may be randomly addressed to the byte; as many bytes as desired may be read or written in a single system call. Sector sizes of the disk hardware underlying the file system are completely invisible to the application program. Disks with different capacities and sector sizes can even be mixed on the same system. Regular I/O devices such as terminals and printers are treated identically, with the result being that applications object programs move unchanged from one SOOS hardware configuration to another.
There's been a lot of talk lately about intelligent terminals with small systems capability. And, it's always the same. The systems which make the grade in performance usually flunk the test in price. At least that was the case until the SuperBrain graduated with the highest PPR (Price/Performance Ratio) in the history of the industry.

For less than $3,000*, SuperBrain users get exceptional performance for just a fraction of what they'd expect to pay. Standard features include: two dual-density mini-floppies with 320K bytes of disk storage, up to 64K of RAM to handle even the most sophisticated programs, a CP/M Disk Operating System with a high-powered text editor, assempler and debugger. And, with SuperBrain's S-100 bus adapter, you can even add a 10 megabyte disk!

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

*Quantity one. Dealer inquiries invited.
Also, like UNIX, SDOS is completely interrupt-driven.

SDOS currently runs on seven manufacturers' systems, handling over ten different types of drives, including floppy, Winchester, and 10 M byte cartridge drives.

We point out the obvious disadvantages of systems such as FLEX and CP/M, they are tied (and thus tie the application) irrevocably to the floppy disk hardware to which they were originally attached. Further, file I/O under these systems requires a lot of knowledge (ie: code) in the application to perform random access.

Yes, the industry does generally need more sophisticated system software.

Ira D Baxter
Software Dynamics
2111 W Crescent, Suite G
Anahiem CA 92801

A Stitch in Time?

Karen Wolfe's article in October BYTE "Power Helps Analyze Electric Bills," (page 48) led me to analyze Karen's sewing power. With the assistance of a sewing machine and a pocket calculator, neither of them programmable, I reached the following conclusions: For 100 hours running time on the sewing machine she probably spends close to eight hours a day sewing, including cutting, pinning, etc.

In a month Karen sews about 21 miles — that's 25,000 double seams the full length of the kid's jeans. 50 miles of thread speed through denim. Enough to weave 400 square feet of new cloth.

If Karen is ahead of the game and is in fact getting her stitches in on time, she is saving 189 miles of sewing each month. If she is not in time, she is wasting 18.9 miles of stitches, 45 miles of thread, and $1.38 of electricity.

Ken Bramham
apt 160, 15 rue Leon Bloy
92260 Fontenay-aux-Roses
FRANCE

Willard Irwin Nico
1928 - 1979

Personal computing pioneer and author Bill Nico passed away recently in Houston, Texas. Bill died of cancer July 2, 1979 at the age of 50.

Bill Nico is perhaps most widely known for his writing. He wrote several articles for BYTE ("Shooting Stars,"


Not so well known is the fact that Bill Nico was one of the first real computer hobbyists in the US. Bill's homebrew 8080 computer built in 1974 had to be one of the first in the country.

Bill was also one of the best BASIC and 8080 programmers around. He could get more out of his disk-based IMSAI than anyone. He could write systems software and languages, but felt just at home with a small business package or a real-time industrial control program.

Bill was also pretty good at hardware. He was a professional logic designer and did a fair amount of consulting in this field. His home was perhaps one of the most fully automated in existence. It was a virtual electronic showplace. Bill was also an active amateur radio operator (WSPRZ).

It was only in recent years that Bill discovered his talent for teaching. Bill taught frequently in Heath's computer classes. His great empathy and personal awareness made him a gem of a teacher. His practical nature and down-to-earth approach made him the favorite of every student. It was hard not to learn in his classes.

Bill Nico was born August 30, 1928 in Los Angeles. He graduated from Burbank High in 1946 and served in the Army from 1950 to 1953. His electronics training came from Pierce College in Los Angeles. Bill worked in a variety of electronic engineering and sales jobs in California and Texas from 1953 to 1969.

He was manager of the Heathkit Electronic Center in Houston from its opening in 1969 until 1975 when he left to form his own company. From 1975 to 1979 he operated as a consultant and writer from his Houston-based firm, Delta-t.

Those of us who knew and worked with Bill will miss him greatly.

Lou Frenzel
1586 Oak Ter
St Joseph MI 49085

Marsport Forces Resurface

Mr Reiland made some comments about my "Marsport" article (April 1979, page 84) in his letter to BYTE (October 1979, page 209). While I appreciate his compliments, I do differ with him on
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one point; he objected to my statement about a circular orbit, "The attraction of gravity is exactly balanced by the centrifugal force at all times." All that I can say is, if this is "confusion," I am in good company. In the NASA book *Space Mathematics* (January 1972, page 119), two forces are defined:

\[
F_1 = \frac{mv^2}{r}
\]

where:
- \(F_1\) = Centripetal force
- \(m\) = Mass
- \(v\) = Velocity
- \(r\) = Radius from center

\[
F_2 = \frac{GMm}{r^2}
\]

where:
- \(F_2\) = Gravitational force
- \(G\) = Universal gravitational constant
- \(M\) & \(m\) = Masses of the two bodies
- \(r\) = Radius between centers

They then say, "The physical situation, if these two forces are equal, is represented in . . . (a circular orbit)." (Emphasis added.) They further show how, by setting these two forces equal, one can solve algebraically for the circular orbit velocity. While their terminology is slightly different from mine, their meaning is obviously the same as I expressed.

One further point: Mr Reiland seemed surprised that a three-dimensional landing simulation could be programmed on a programmable calculator. This program is far from the limit! I have since programmed a similar three-dimensional rendezvous simulation, that keeps track of two objects in their orbits simultaneously. In it, the spaceship is initially at rest on the surface of the primary, while a target satellite is in a random elliptical orbit. The user waits until the satellite is in the best position, lifts off, matches orbits with the satellite, and rendezvous with it. To try this more difficult exercise, send $1 to cover my copying and postage costs for a 12-page write-up and listing for the HP-67/97 (as submitted to the Hewlett-Packard Users' Library). Include two blank magnetic cards and I can record the program on them.

Delmer D Hinrichs
2116 S E 377th Ave
Washougal WA 98671

**It Happened Again**

It has happened again. Every time I decide to let my BYTE subscription lapse because of the high price of the magazine, along comes an issue so jam-packed with well-written, informative, readable articles, that I am forced to renew my subscription again. The most recent issue, the one on LISP (August 1979), just did it again.

The LISP articles simply covered almost everything one would want to know in an introduction, and did it well. In addition, there were excellent articles on more advanced subjects — symbolic math systems and pattern-directed languages being the prime cases to point to — for those who want to delve deeper, or who already knew LISP and its implications and implementations. All of these articles were well-written, too.

Amazing is the only word.

Dave Mellinger, LISP hacker
c/o Datek Inc
2336 Wilson Blvd
Arlington VA 22201

**Elegant Input Recognizer**

While working on a Star Trek program, I came across the problem of command mnemonics. I wanted the user to be able to type commands as alphabetic mnemonics, not numbers (for example, TRP for torpedo). Also, I wanted him or her to be able to type in the initial of the mnemonic, also for expediency.

However, I did not want the remaining letters to be arbitrary (having the computer recognize only the first letter would mean that THE PHASERS would work for TRP). It's not easy to memorize the mnemonics, so users could easily make mistakes in typing in commands, thereby moving two quadrants west when they wanted to fire the photon torpedo banks. I have seen this happen on many occasions. So, I did a little brainstorming, and came up with this:

```
IF LEFT$("TRP",LEN(A$)) = A$ THEN PRINT "TRP"
```

This works just as well for YES. This one-line comparison will allow "Y," "YE," or "YES," but not "YEAH," "ALYESKA," or even "YESNO." I agree that it is really not necessary to put all that user-input protection in a computer-assisted instruction (CAI) program, but if you want to use it, you can implement it very easily in any BASIC with LEFT$ and LEN. It's also useful for other applications, such as my Star Trek problem.

Mits Hadeishi
1460 W 182nd St
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Making Color Slides with an Intecolor Microcomputer

Alan W. Grogono
State University of New York
Upstate Medical Center
750 E Adams St
Syracuse NY 13210

Slides are required for many demonstrations and lectures. Instructional slides often consist of a few words or a simple diagram or graph which the lecturer wishes to discuss. In recent years such slides have commonly been prepared as a blue diazo (white writing on a blue ground). Even the simplest slide is subject to about twelve processes: rough drafting, typing, checking, type setting, rechecking, photography, developing negatives, brushing out imperfections, diazo exposure, pickling, cutting, and mounting. Misunderstandings and interpretations mean that it is not uncommon for one or more stages to be repeated; the process is moderately expensive, and a diazo slide tends to fade with time. This article describes a quick, convenient method of preparing color slides using a computer.

Equipment

The computer employed is an Intecolor eight-color intelligent terminal equipped with BASIC and dual floppy disk. The choice of camera and film may depend on individual circumstances, but the author suggests the following: a single-lens reflex (SLR) 35 mm camera, mounted on a tripod, with telephoto lens (to reduce barrel distortion). Close-up lenses or close focusing attachments are essential.

The computer allows images to be formed on a high-resolution screen offering eighty characters per line and either forty-eight lines of small letters or twenty-four lines of double-height letters. Lines, bar graphs, vector graphics, and simple drawings can also be constructed. The color for the background and for the foreground (the character or line) can be separately selected from the eight available colors.

Software

A program called Menu is used to:
- prepare a new floppy disk for saving images,
- prepare images,

About the Author

Dr. Grogono is an Associate Professor of Anesthesiology at the State University of New York, Upstate Medical Center, in Syracuse New York. He trained in London, England, and emigrated to the United States in 1974. He uses microcomputers with graphics for teaching, for recreation, and as described in the accompanying article, for color slide making. He has written many scientific papers in his specialty, anesthesiology, and is author and/or editor of several books. He is an active member of the American Heart Association and directs the Advanced Cardiac Life-Support Instructor's Course in Syracuse NY. For the New York State Society of Anesthesiologists annual meeting in New York, he runs the panel "Research by New Investigators." He is also a member of the Icarus high-speed hydrofoil sailing project which set a B-Class, World Sailing speed record in Weymouth, England, in 1976.

Photo 1: Two examples of computer-generated slides containing color text material.
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The program also places the computer into a suitable mode. The scroll mode is replaced by the page mode, and the screen image is made to correspond with the appropriate memory locations.

Image Preparation

Simple word slides are best prepared in CRT mode (a mode which allows direct user interaction with the graphics display). The keyboard allows letters to be positioned anywhere on the screen. Colored text, borders, and backgrounds are used for effect. Considerable rearrangement and adjustment is possible using the delete and insert keys for characters and lines. When the image is complete, the disk is inserted and the AUTO key is pressed to run the storage program. The image is automatically transferred to the disk to be photographed later. Examples of text slides prepared in this way are shown in photos 1a and 1b.

More complicated slides may be produced by employing a program to prepare the display (e.g., to generate a graph or a histogram). Examples of slides prepared in this way are shown in photos 2a and 2b. When such a program is being written, it is important to remember that the process of transferring the image to disk uses a BASIC program that will replace the preparation program in memory.

Color Selection

Color slides are usually most successful when the image or letters are brighter than the background. With the bright foreground image, any spreading due to light-scatter on the cathode-ray tube, the film or the projection screen tends to enlarge a line or a character instead of extinguishing it. Therefore, of the sixty-four color combinations available, only about twenty are useful for slides.

If the alignment of the red, blue, and green electron beams in the cathode-ray tube is imperfect, the focus of the screen image may suffer. This problem may be minimized by judicious choice of foreground color. In such cases, use a color scheme in which the image is formed by turning only a single beam on and off as it sweeps across the tube. For example, with white text on a magenta background, only the green electron beam is modulated, and a good image can be obtained even if the beam alignment is poor.

Photography

The images are recalled for photography using the same program. The program recalls the images one by one. Photographs must be made in ambient darkness to avoid unwanted reflections. Certain colors tend to require more exposure than others (e.g., red and blue on black backgrounds).

Color film does not always reproduce television images perfectly. Red, in particular, may appear somewhat brown. A Kodak CC40R filter is supposed to correct this, but the exposure time required is doubled. I have prepared slides with and without the filter. I currently use Kodak Ektachrome 64 (ER-135) with no filter. The films, filters, and exposures I used are shown in table 1.

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films to the manufacturer for developing and mounting; if slides have a black background, an automatic film cutter may be unable to recognize the frame boundaries. Several films have been returned irreparably damaged, sometimes with half of a slide in one mount and the other half in the next mount. The use of colored backgrounds is recommended for visual pleasure as well as preservation of your work. If you are in doubt, it is probably wise to ask for your film to be returned uncut.

**Discussion**

Slide preparation using a small computer and color-transparency film has a number of advantages; several colors can be used on a single slide, the photography is simplified, and the color slides are more durable. In addition, when the computer is suitably located, the drafting and checking are more convenient and may even be reduced to a single step. I now find it easy to design a slide at the keyboard. Decisions about spacing, positioning, and color can be made, revised, and implemented as the image is being prepared. This has reduced the first five steps to two, namely drafting the image and saving it on disk. The photographic process is reduced to making the exposures, developing the film, and mounting the slides — a considerable saving in steps and labor.

---

**Table 1: Exposures and films used to photograph displays on the Intecolor microcomputer.**

<table>
<thead>
<tr>
<th>Film</th>
<th>Speed (ASA)</th>
<th>Filter</th>
<th>Exposure Seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kodak Ektachrome ER 135</td>
<td>64</td>
<td>None</td>
<td>0.5</td>
</tr>
<tr>
<td>Kodak Ektachrome ER 135</td>
<td>64</td>
<td>CC40R</td>
<td>1</td>
</tr>
<tr>
<td>Kodak Ektachrome KM 135</td>
<td>25</td>
<td>None</td>
<td>1</td>
</tr>
<tr>
<td>Kodak Ektachrome KM 135</td>
<td>25</td>
<td>CC40R</td>
<td>2</td>
</tr>
</tbody>
</table>

---

The quality of slides produced in this way is very pleasing. Audience members inquire how the slides are made and express appreciation of the color and the technique. Distortion is negligible, and the quality of curved and oblique graph lines is adequate for lecture slides (for the graphs the resolution is 1 in 160 on the X axis and 1 in 192 on the Y axis).

The cost of making slides is hard to evaluate. The lecturer's time and the time spent fetching, carrying, and checking are often assumed by the organization. However, even those costs that remain are significant. Between $6 and $10 is probably the minimum cost of laying out the simplest text and preparing a diazo slide. Slides for a one-hour lecture may cost approximately $500.

Preparing slides on the computer simplifies the photographic process. This alone represents a saving of about $2 per slide. The time spent designing the slide and arranging the layout can be reduced as well. However, any time spent employing the additional choices of colors and layouts may offset this potential savings to some extent. The disks used for storing the images cost $5, or about 50 cents per slide. However, the disks are reusable and should therefore not represent an appreciable cost per presentation.

The greatest savings would be realized by those illustration departments that are frequently expected to prepare histograms, regression graphs, scatter diagrams and graphs of functions. A few appropriate programs would allow numerical data or mathematical functions to be directly converted to color images. A final advantage is that Ektachrome processing is commonly available commercially on a same-day basis. Slides can be prepared, photographed and reviewed in twenty-four hours.

The computing equipment described in this article costs about $6000. Any illustration department handling much slide preparation, particularly that involving slides of graphs, should find it worthwhile to review the type of material they handle and its cost. The Intecolor computer has now been used to prepare hundreds of slides. A similar program will also work on the Compucolor II with only slight sacrifice in definition, resolution, and color rendition.

---

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I anxiously glanced around the Circuit Cellar. Devoid of the usual sounds of the stereo or television, the equipment fans imparted a distinctly uneasy sensation of mechanical presence.

The room was totally dark except for a few pilot lights and a video display. There were no games, no fast-moving program listings; only a single line was written on the screen. In the dim luminescence I could barely distinguish the furniture from the bookcases. A little experience navigating in the dark would have been useful, but I opted for modern technology and reassuringly patted the flashlight in my pocket.

I pushed the button on my digital watch and noted the time. As it neared the prearranged hour, I turned instinctively to the terminal. Soon I'd know which of us was in control!

Almost immediately the display changed and printed out "AUTOMATIC CONTROL INITIATED." Simultaneously I could hear a high-pitched noise. It sounded almost like an insect chirp. There are no crickets down here; it must be a subharmonic. So far so good, but did it work?

"Steve, did you just blow a fuse?" My wife stood in the doorway and called down the stairs. It didn't bother her that there weren't any lights on. After all, if you blow a fuse, shouldn't the lights be off?

"The kitchen light went off and the bedroom light came on. Wait! The bedroom light just went off and the kitchen light came back on. Now they're both off."

I grinned in a way that only a Cheshire cat could appreciate. "Sorry, Joyce, just experimenting on the latest article." Chuckling softly, I continued. "I hope you don't mind, but the computer seems to have taken over."

"Can it make beds?" she replied.

I should have known that she wouldn't be taken in that easily. "OK, I'll tell the computer to keep its sphere of influence to the cellar. I'll let you know what the password is later."

As if by magic, the Circuit Cellar lights were activated. The test was successful.

Security Versus Control

Even though it may seem true at times, our house has not been taken over by a computer. I was simply testing the latest addition to my home control system.

In previous issues of BYTE, I presented a series of articles on the construction of a home security system. (See "Build a Computer Controlled Security System for your Home": Part 1, January 1979 BYTE, page 56; Part 2, February 1979 BYTE, page 162; Part 3, March 1979 BYTE, page 150.) This was not a theoretical dissertation. It was, in fact, an overview of the system installed in my house. The original concept was configured around a single-board 8085 system and designed primarily as an alarm controller. Even though it works, it has definite limitations.

Eventually I became dissatisfied with just having a super burglar alarm. It seemed a shame to dedicate all that hardware and expense to a function with such a limited capacity. The obvious step was to expand the concept to be a "home control" system where security is but one of many possible applications. To do this requires more memory; the single board has been replaced by a 26 K byte Z80-based computer with a video display. Operating in either high-level or assembly language, it is as adept at keeping the checking account straight as it is at scanning input ports searching for an intruder. Add to it the ability to activate and communicate with my large disk-based development system, and it is indeed a powerful tool.

The major difference between the two system concepts is the output control structure. As an alarm, the computer is strictly configured to scan and analyze a multitude of event inputs, such as door switches and motion sensors. Its decision process is immediate, but its output control is relatively limited. These generally consist of several lights, a siren, and an automatic phone dialer. Even in
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Circle 18 on inquiry card.
the sophisticated system I presented, these hardwired outputs were kept to a minimum to reduce costs.

Generalized home control extends computer control capability far beyond the few outputs of the original system. It is conceivable that all of the lights and AC outlets in the house could be affected. A few lights outside are barely enough. Lighting in the bedrooms, kitchen, and garage should be included, with the stereo and television thrown in for good measure. If you live in a cold climate and use an automobile engine-block heater, why not turn it on automatically before you get up in the morning? Tired of searching around in the dark for the light switch? Let the door sensor from the alarm system trigger the lights as you walk into a room. How about some soft music ten minutes after you enter? The list is endless.

This expansion seems to be a contradiction considering my previous concern over wiring costs. To accomplish this feat, either every AC outlet must be directly wired to the computer through relays as in the original system or the control capability must be added remotely to each light and appliance.

AC Remote Control

This latter suggestion is not as farfetched as it might seem. There have been many technological advances in the past year. One of the more significant achievements comes from BSR (USA) Ltd—specifically in the area of AC remote control. The BSR X-10 control system is shown in photo 1. Clockwise from the center, the five components are: command console, appliance module, cordless controller, lamp module, and wall-switch module. With these units, low-cost AC control is a reality.

The BSR X-10, also marketed by Sears as the Sears Home Control System, operates through carrier current transmission from the command console to the receivers. When a button is pushed on the command console to activate a remote receiver, a coded signal is sent through the house wiring. Each receiver monitors these transmissions and responds only when its particular code is sent.

Figure 1a is a block diagram of the $39 command module and photo 2 shows its internal electronics. The heart of this, as well as the other system components, consists of custom large-scale integration (LSI) chips manufactured for BSR by General Instrument Corp. In normal operation the twenty-two-button keypad is continuously scanned. When a key is pressed, this designated function and a house code (previously set by a thumbwheel switch on the bottom of the command console) are combined into a single message. The digital message is directed to the transmitter section, where it modulates a 120 kHz carrier. The control signal appears on an oscilloscope as a series of pulse bursts. This is shown in photo 3.

There is a second method where the command console designates a control function and transmits a message. Each control console contains an ultrasonic receiver. In the picture this is the metallic cylindrical component with the two protruding pins and shielded cable soldered on them. The BSR X-10 system facilitates
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Photo 3: Oscilloscope picture of command-control console transmission on the AC line. (Photo courtesy of Mark Schefler.)

Photo 4: Handheld cordless controller showing top and internal circuitry.

remote channel and function selection through a handheld ultrasonic transmitter. This unit is shown in photo 4 and diagrammed in figure 1c.

When a key is pressed, it is encoded and transmitted as a series of 40 kHz tone bursts. The command console, receiving this information through its ultrasonic receiver section, takes this data as if a button had been pushed on the command console. It then adds the house code and simultaneously transmits the command message over the house wiring.

The receiver part of the system is also quite sophisticated, considering that each receiver costs less than $15. These receivers, shown in photos 5 and 6, can be placed virtually anywhere. An overhead light can be accommodated by replacing the standard on/off wall switch with a wall-switch module. An appliance such as a dehumidifier is controlled through an appliance module.

All receivers are basically the same. A block diagram of an appliance module is shown in figure 1b. The receiver section monitors the AC line waiting for a coded message corresponding to its unique house (A thru P) and unit device (1 of 16) code.

To turn on channel 10, simply press “10” and then the “ON” button sequentially. When the appliance module activates, it sounds like a relay engaging. In actuality, BSR uses an inexpensive solenoid to operate a 15 A push-button Microswitch.

The lamp and wall-switch modules use a triac instead of this pseudo-relay. Unlike the appliance module, which only operates as an on/off switch, these units have the additional ability to automatically brighten or dim when the corresponding function buttons are pressed on the command console. Finally, all receivers can be locally activated without the command console. To turn on a light or motor, simply flip the power switch from on to off and
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Controlling the BSR X-10

When I first started using the BSR X-10, I could hardly believe its versatility and low cost. The only problem is that operation of the BSR X-10 is completely manual. The only way to use the control receivers is through the command console or ultrasonic transmitter and by physically pressing the buttons. I would not say that I have a never-say-die attitude, but considering my original security system, with an average cost of $250 per AC output channel, my future computer-controlled house depended heavily on less expensive input/output (I/O). It was absolutely necessary to find some method of utilizing the control receivers.

Three possible solutions came to mind:

- Directly synthesize the command-console waveform and transmit it directly onto the AC line.
- Brute force contact closure—attach either relays or complementary-metal-oxide semiconductor (CMOS) switches in parallel with the push buttons and activate the relays from the computer.
- Synthesize the waveform from the ultrasonic controller and let the computer “talk” to the command console.

Simulating the command-console output sounds simple in theory. (This is somewhat like estimating software costs.) Simulating the device-control code and using it to modulate a 120 kHz carrier frequency leads to contact with a hostile environment. The output from the computer must be attached to the AC line. This requires isolation through either transformers or optoisolators, plus many discrete components to properly match impedances. It is a shame to reinvent the wheel when BSR has already designed such an effective transmission system. Although possible in theory, this approach is too messy to warrant further consideration.

The second alternative is brute force. This can usually work, but you must be careful. In essence this method entails wiring relays or CMOS switches across the push buttons and remotely, but still mechanically or electronically, closing the contacts corresponding to a particular button. Figure 2a illustrates the keypad connections for both the command console and cordless controller. The configuration is a 3 by 8 scanning matrix. To turn on channel 6, simply short pins 28 and 18 together. Likewise, “dim” would be pins 25 and 23. While twenty-two separate single-pole, single-throw switches could be used, figure 2b demonstrates an easier alternative.

Two CMOS switches can be used in combination with the ultrasonic controller to provide this capability. Connected to 5 bits of a latched parallel output port, the two integrated circuits channel the appropriate lines together. To turn on channel 12, a row-select code of binary 001 would be set on B2, B1,
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and B0, respectively, and a columnselect code of binary 10 would be set on B4 and B3. The ON key would be a code of 11100 for bits B4 thru B0, for example.

The circuit of figure 2b will work only with the handheld battery-controlled unit. The command-console electronics, which run on -20 V, can use the same logical concept, but relays must be substituted for the CMOS switches. The command-console is not isolated and its electronics are floating at 120 VAC. To be totally safe, it is best not to bother with it.

Hardwiring to the handheld unit keyboard will work, but it also has some detrimental features. In operation, the ultrasonic unit consumes an average of 30 mA, while peak currents are about 100 mA. Alkaline batteries are a must. Short of direct connection to the computer’s power supply through a 9 V regulator, there is always the hazard of battery brown-out. If I were depending upon this system, I would not have a critical component powered by battery.

**Talking to the BSR X-10**

The sensible alternative is to construct an interface that facilitates cordless communication between the computer and the BSR X-10 command controller. Safety is the primary consideration. There is no hazard in using the controller or receivers as long as their cases are intact. The BSR X-10 is Underwriters’ Laboratories listed. Attachments between the computer and the command module must be done carefully and only by experienced people. By maintaining the structural integrity of the components, you are not limited to use with the computer. The command console can be moved around the house, and it is placed within range of the computer only when automatic control is desired.

Practical accomplishment of this goal is achieved using the ultrasonic receiver found within the command module. An interface is constructed that formats function codes into message strings; these strings are transmitted to the command console as 40 kHz pulses. In essence, the interface simulates the activity of a cordless-controller unit.

Figure 3 describes in detail the communication between the two subsystem components. Each of the twenty-two buttons has a unique 5-bit code (listed in table 1). For example, channel 5 has a code of 00010 with respect to bits D1, D2, D3, and D4. The ALL LIGHTS ON key generates the code 00011.

The actual message that communicates this selection is approximately 100 ms long and is composed of thirteen 8 ms segments. Each segment consists of a burst of 40 kHz directed to an ultrasonic transducer. Data is pulse-width modulated. A logic 1 is a 4 ms burst and a logic 0 is a 1.2 ms burst.

To signify channel 5, the interface first sends a start bit to alert the receiver of the pending message transmission. This is a 40 kHz tone for 4 ms. Next, the 5-bit selection code is sequentially transmitted as a series of 1.2 and 4 ms bursts of 40 kHz. This is followed by transmission of the logical inversion of the 5-bit selection code and a 16 ms end-of-message tone. All messages use the same format; only the 5-bit selection code varies.

Figure 4 is an interface specifically designed to send this message and facilitate wireless remote control. Incorporating complete circuitry for address decoding and data storage, it appears to the computer as a single output port. Turning on the table lamp is as simple as sending a 1-byte output to the interface port. As with
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Figure 3: Description of coded message sent from the cordless controller to the command console via ultrasonic communication. The necessary codes are shown in Table 1.

The majority of my designs, it is both processor and speed independent. It works equally well in BASIC or assembly language programs. Connected to port 9 (as in my example software), turning on a table lamp or the hall lights in BASIC is a one-line command: OUT 9,5 (from the code list of Table 1). Turning it off is simply OUT 9,7.

The circuit will work on virtually any computer, although the pin designations in Figure 4 refer specifically to the Radio Shack TRS-80 Model I. All connections are made directly to the computer address and data buses. In the TRS-80 this is done through the expansion connector. In a computer such as an Apple II, the circuit could be built to plug directly into the back-plane connector or to be connected by a ribbon cable.

The electronics can be divided into three subsystems: port latch and address decoding, pseudo pulse-width modulator, and message serializer. Photo 7 illustrates the prototype of Figure 4.

Table 1: Cordless controller push-button codes and decimal equivalents.
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Bits 0 thru 4 will contain the function code (from table 1) and bit 7 is used to turn the transmitter output on and off. For further information on address decoding and output ports, I refer you to Ciarcia's Circuit Cellar from BYTE Books and the article entitled "Memory Mapped I/O," which first appeared in the November 1977 BYTE, page 10.

In figure 4, the 5-bit function code, as well as its logical inversion, are attached to a 16-to-1 multiplexer, IC1. As the 4-bit counter IC7 increments, each of the input lines of the multiplexer is sequentially routed to the output, pin 10. With address position 0 permanently tied high and the next ten addresses wired as function-code inputs, the output of IC1 will reflect the first eleven 8 ms message segments.

ICs 3, 5, 6, and 8 act as a digital modulator. If the output of IC1 pin 10 is a logic 1 (such as the start bit), a 4 ms burst of 40 kHz will be routed through IC5 and appear at pin 6. A logic 0 on pin 10 results in a 1.2 ms burst. The timing of these events is rather critical. The rate of clock one (IC8d) should be as close to 125 Hz as possible (8 ms period), and clock two (IC8e and IC8f) should be similarly set to 40 kHz. Use potentiometer R1

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**As of the writing of this article, Mountain Hardware Inc (300 Harvey West Blvd, Santa Cruz CA 95060) has announced a plug-in card for the Apple II that, like the control card described in this article, transmits to the BSR X-10 Command Console. In addition, the company offers control software tailored to the Apple II with at least 32 K bytes of programable memory. Cost of the unit is $189 for the controller board alone and $279 for the controller board, the X-10 Command Console, and three remote modules.**

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Figure 4: An interface between the computer and the wireless remote control. Control of AC appliances is as simple as a single BASIC command. Potentiometer R1 is set for 4 ms, R2 is set for 1.2 ms, and R3 is set for 40 kHz. The output transducer is typically a MASSA Products TR-89 set for 40 kHz center frequency. A 23 kHz transducer should not be used. The effective range is 20 feet. The circuit requires approximately 300 mA at +5 V. Pin designations are for the TRS-80.
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Figure 5: A typical application of the wireless remote control. All of the modules are connected over the house wiring.

to set the monostable multivibrator (or one-shot) IC6a to a period of 4 ms. Use R2 to set the one-shot IC6b to 1.2 ms.

The output of IC5 should generate the first eleven segments of the message. IC2, using the same technique as IC1, adds a 16 ms end-of-message tone burst as segments 12 and 13. The message is repeated in 24 ms as the counter (IC7) loops to 0. It will send the same data as long as the contents of ICs 11 and 12 have not changed and the output-enable line has not been brought high.

All of the components (except possibly the 40 kHz transducers) are readily available. Low-power Schottky transistor-transistor logic (TTL) devices should be used where specified to properly interface with the TRS-80 or similar low-power bus systems.

One further note for prospective TRS-80 circuit builders. To use this

Text continued on page 48
Listing 1 on page 46
Fully compatible with the SS-50 bus—requiring no modification of the motherboard, memory or I/O slots—the SBC/9™ is also a complete, single-board control computer with its own ROM operating system—BAM, peripheral ports and a full-range baud clock generator.

Make the SBC/9™ the heart of your computer and put to work the most outstanding microprocessor available, the 6809.

The Mighty 6809

Featuring more addressing modes than any other eight-bit processor, position-independent coding, special 16-bit instructions, efficient argument-passing calls, autodecrement/ autodecrement and more, it’s no wonder the 6809 has been called the “programmers dream machine.”

Moreover, with the 6809 you get a microprocessor whose programs typically use only one-half to two-thirds as much RAM space as required for 6800 systems, and run faster besides.

And to complement the extraordinary 6809, the Percom design team has developed PSYMON™, an extraordinary 6809 operating system for the SBC/9™.

PSYMON™ — Percom System Monitor

Although PSYMON™ includes a full complement of operating system commands and 15 externally callabale utilities, what really sets PSYMON™ apart is its easy hardware adaptability and command extensibility.

For hardware interfacing, you merely use simple, specific device driver routines that reference a table of parameters called a Device Control Block (DCB). Using this technique, interfacing routines are independent of the operating system.

The basic PSYMON™ command repertoire may be readily enhanced or modified. When PSYMON™ first receives system control, it initializes its RAM area, configures its console and then "looks ahead" for an optional second ROM which you install in a socket provided on the SBC/9™ card. This ROM contains your own routines that may alter PSYMON™ pointers and either subtly or radically modify the PSYMON™ command set. If a second ROM is not installed, control returns immediately to PSYMON™

- Provision for multi-address, 8-bit bidirectional parallel I/O data lines for interfacing to devices such as an encoded keyboard.
- A serial interface Reader Control output for a cassette, tape punch/reader or similar device.
- An intelligent data bus: multi-level data bus decoding that allows multiprocessing and bus multiplexing of other bus masters.
- Extended address line capability — accommodating up to 16 megabytes of memory — that does not disable the onboard baud rate clock or require additional hardware I/O slots.
- On-board devices which are fully decoded so that off-card devices may use adjoining memory space.
- Fully buffered address, control and data lines.

The SBC/9™, complete with PSYMON™ in ROM, 1K of RAM and a comprehensive user’s manual costs just $199.95.

To place an order or request additional literature call toll-free 1-800-527-1592. For technical information call (214) 272-3421. Orders may be paid by check, money order, COD or charged to a VISA or Master Charge account. Texas residents must add 5% sales tax.

Circle 26 on inquiry card.

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SS-50 Bus LFD-400™ and LFD-800™ Systems

Each LFD mini-disk storage system includes:

- drives with integral power supplies in an enamel-finished enclosure
- a controller/interface with ROM operating system plus extra ROM capacity
- an interconnecting cable
- a comprehensive 80-page users manual

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Low-Cost Mini-Disk Storage in the Size You Want.

Percom LFD mini-disk drive systems are supplied complete and ready to plug in the moment they arrive. You don't even have to buy extra memory. Moreover, software support ranges from assembly language program development aids to high-speed disk operating systems and business application programs.

Mini-disk storage system prices:

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<th>1-DRIVE SYSTEM</th>
<th>2-DRIVE SYSTEM</th>
<th>3-DRIVE SYSTEM</th>
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<td>599.95</td>
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<td>LFD-800™</td>
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<td>LFD-1000™ (dual)</td>
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<td>(quad) $4950.00</td>
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</tr>
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Data Terminal & Two-Cassette Interface — the CIS-30+

- Interface to data terminal and two cassette recorders with a unit only 1/10 the size of SWTP's AC-30.
- Select 30, 60 or 120 bytes per second cassette interfacing; 300, 600 or 1200 baud data terminal interfacing.
- Optional mod kits make CIS-30+ work with any microcomputer. (For MITS 6800, ask for Tech Memo TM-CIS-30-09.)
- KC Standard/Bl-Phase-M (double frequency) cassette data encoding. Dependable self-clocking operation.
- Ordinary functions may be accomplished with 6800 Micbug monitor.

Prices: Kit, $79.95; assembled, $99.95. Prices include a comprehensive instruction manual. Also available: Test Cassette, Remote Control Kit (for program control of recorders), IC Socket Kit, MITS 6800 mod documentation and Universal Adapter Kit (converts CIS-30+ for use with any computer).

Although designed with the SWTP 6800 owner in mind, this upgrade adapter may also be used with most other 6800 and 6802 MPUs. The adapter is supplied assembled and tested, and includes the 6809 IC, a crystal, other essential components and user instructions. Restore your original system by merely unplugging the adapter and a wire-jumpered DIP header, and re-inserting the original components. Also available for your upgraded system is PSYMON® (Percom SYstem MONitor), the operating system for the Percom 6809 single-board computer. PSYMON® on 2716 ROM costs only $69.95. On diskette (source and object files), only $29.95.
**6800/6809 SOFTWARE**

**System Software**

6800 Symbolic Assembler — Specify assembly options at time of assembly with this symbolic assembler. Source listing on diskette.

Super BASIC — A 12K extended random access disk BASIC for the 6800 and 6809. Supports 44 commands and 31 functions. Interprets programs written in both SWTP 9K BASIC (versions 2.0, 2.2 & 2.3) and Super BASIC. Features: 9-digil BCD arithmetic, Print Using and Linput commands, and much more. Price $49.95.

TOUCHUP™ — Modifies TSC's Text Editor and Text Processor for Percom mini-disk drive operation. Supplied on diskette complete with source listing. Price $17.95.

**Operating Systems**

INDEX™ — This easy-to-use disk-operating and file management system for 6800 microcomputers is fast. I/O devices are serviced by interrupt request. INDEX™ accesses peripherals the same as real disk files — new devices may be added without changing the operating system. Other features: unlimited number of DOS commands may be added — over 60 system entry points — display only those files at or above user-specified file activity level. Versions available for SWTP MF-68, Smoke's BFD-68 and Motorola's EXORCISE. Price $99.95.

MINIDOS-PLUS™ — An extension of the original MINIDOS™ for LFD-400™ mini-disk systems, MINIDOS-PLUS™ manipulates files by six-character names. Supports up to 31 files. Resident commands include Initialize, Save, Allocata, Load, Files (directory list), Rename and Delete. Supplied on 2708 ROM with a minidiskette that includes transient utility libraries such as Copy, Backup, Create, Pack, Rename, and Print Directory. Price $34.95.

PSYMON™ — Percom System Monitor for the Percom single-board/SS-50 bus-compatible 6800 computer accommodates user's application program with any mix of peripherals without modifying programs. PSYMON™ also features character echoing to devices other than the communicating device, sophisticated register and memory dump routines and more. Price (on 2716 ROM) $99.95.

FINDER™ — This general purpose data base manager is written in Percom Super BASIC. Works with 6800/6809 computers using Percom LFD mini-disk storage systems. Short runs or knowledge of bookkeeping because the operator is prompted with non-technical questions during data entry. General Ledger updates account balances immediately — in real-time and will print financial statements immediately after journal entries. User selects and assigns account numbers; tailors financial statements to specific needs. Provides audit trail. Runs under Percom Super BASIC. Requires 24K bytes of RAM. Supplied on minidiskette with a comprehensive users manual. Price $199.95.

WINDEX™ — Described in detail elsewhere on this page.

**Business Programs**

General Ledger — For 6800/6809 computers using Percom LFD mini-disk storage systems. Requires little or no knowledge of bookkeeping because the operator is prompted with non-technical questions during data entry. General Ledger updates account balances immediately — in real time, and will print financial statements immediately after journal entries. User selects and assigns account numbers; tailors financial statements to specific needs. Provides audit trail. Runs under Percom Super BASIC. Requires 24K bytes of RAM. Supplied on minidiskette with a comprehensive users manual. Price $199.95.

FINDER™ — This general purpose data base manager is written in Percom Super BASIC. Works with 6800/6809 computers using Percom LFD-400™ mini-disk drive storage systems. FINDER™ allows user to define and access records using his own terminology — customize file structures to specific needs. Basic commands are New, Change, Delete, Find and Pack. Add on as many user-defined commands as necessary. FINDER plus Super BASIC require 24K bytes of RAM. Supplied on minidiskette with a users manual. Price $99.95.

Mailing List Processor — Powerful search, sort, create and update lists of files for all 6800 and 6809 computers. Supplied on diskette complete with source listing. Price $29.95.

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Development and debugging programs for 6800 µCs on diskette:

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**SS-50 Bus Card: $24.95**

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**Now Available! the SBC/9® MPU/Control Computer**

(Single-Board-Computer/6809) — stands alone as a control computer, but also compatible with the SS-50 bus for use as an MPU card. Includes PSYMON™ (Percom System Monitor) in a 1K ROM and provides for additional 1K of RAM. Also includes 1K of RAM. Features: Super Port — provision for multi-address, 8-bit bidirectional data lines • an intelligent data bus for multi-level data bus decoding • an on-board 110-baud to 19.2 baud clock generator • extended address capability — to 16 megabytes without disabling baud clock or adding hardware. And much more. Supplied with PSYMON™ and comprehensive users manual. Price $199.95.

**The Electric Window.®**

WINDEX™ is a fast video display driver program for the Electric Window®. WINDEX™ also features: program and keyboard control of character generators, displayable control characters — under program control; automatic scrolling; a driver routine for the parallel input keyboard feature of the Percom 6809 Single-Board Computer, the SBC/9® • auto-linking to PSYMON™, the ROM operating system for the SBC/9® • Prices: ROM version $99.95; LFD-400™ compatible diskette (source and object files): $29.95.

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All of the features needed for rapid, straightforward circuit prototyping. Use 14-, 16-, 24- and 40-pin DIP sockets • SS-50 bus card accommodates 34- and 50-pin ribbon connectors on top edge, 10-pin Molex connector on side edge • I/O card accommodates 34-pin ribbon connector and 12-pin Molex on top edge.

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**PERCOM DATA COM COMPANY INC.**

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Listing 1: Demonstration program for the Sears Home Control System.

Listing 1 continued on page 48
WHY CUT? WHY STRIP? WHY SLIT? WHY NOT...

NEW

JUST WRAP™
WIRE WRAPPING TOOL

- AWG 30 Wire
- .025” Square Posts
- Daisy Chain or Point To Point
- No Stripping or Slitting Required

JUST WRAP™
- Built In Cut Off
- Easy Loading of Wire
- Available Wire Colors:
  Blue, White, Red & Yellow

U.S.A., FOREIGN PATENTS PENDING

<table>
<thead>
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<th>JUST WRAP TOOL WITH ONE 50 FT ROLL OF WIRE</th>
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<td>YELLOW</td>
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</tr>
<tr>
<td>----------</td>
</tr>
<tr>
<td>JWU-1</td>
</tr>
</tbody>
</table>

OK MACHINE & TOOL CORPORATION 3455 CONNER ST., BRONX, N.Y. 10475 (212) 994-6600/TELEX 125091

*MINIMUM BILLING $ 25.00/ADD SHIPPING CHARGE $2.00/NEW YORK CITY/STATE RESIDENTS ADD APPLICABLE TAX.

Circle 27 on Inquiry card.

BYTE January 1980 47
Listing 1 continued:

13. AT 16 HOURS 0 MINUTES TURN CHANNEL 1 ON
14. AT 22 HOURS 0 MINUTES TURN CHANNEL 1 OFF
15. AT 23 HOURS 0 MINUTES TURN CHANNEL 4 ON
16. AT 0 HOURS 30 MINUTES TURN CHANNEL 4 OFF
17. AT 19 HOURS 30 MINUTES TURN CHANNEL 5 ON
18. AT 21 HOURS 20 MINUTES TURN CHANNEL 5 OFF
19. AT 22 HOURS 0 MINUTES TURN CHANNEL 5 ON
20. AT 1 HOURS 0 MINUTES TURN CHANNEL 5 OFF

1. CHANGE LIST
2. ADD TO LIST
3. EXIT TO MENU

ENTER TIME, CHANNEL, AND FUNCTION
ENTRY NO. 21 ? 23:30, 3, ON
ENTRY NO. 22 ? 0:0:0

1. CHANGE LIST
2. ADD TO LIST
3. EXIT TO MENU

CHOOSE ONE OF THE FOLLOWING:

1. AUTOMATIC CONTROL SYSTEM ON
2. MANUAL CONTROL / CURRENT STATUS
3. PRINT THE CURRENT TIME
4. REVIEW DEFAULT SETTINGS AND ADD TO CONTROL LIST

YOUR CHOICE ? 1
AUTOMATIC CONTROL INITIATED
23 HOURS 43 MINUTES

Listing 2: Program to compare the time from a real-time clock against a list of operations to be performed at specific times. A sample run of the program demonstrates how the entries may be varied.

RUN
CURRENT STATUS IS:
CHANNEL 1 IS OFF
CHANNEL 2 IS OFF
CHANNEL 3 IS OFF
CHANNEL 4 IS OFF
CHANNEL 5 IS OFF
CHANNEL 6 IS OFF
CHANNEL 7 IS OFF
CHANNEL 8 IS OFF
CHANNEL 9 IS OFF
CHANNEL 10 IS OFF
CHANNEL 11 IS OFF
CHANNEL 12 IS OFF
CHANNEL 13 IS OFF
CHANNEL 14 IS OFF
CHANNEL 15 IS OFF
CHANNEL 16 IS OFF
DO YOU WANT TO CLEAR ALL OUTPUTS TO START?
YES
SET CONTROLLER OUTPUTS BY ENTERING CHANNEL NO. AND FUNCTION
ENTER CHANNEL NO. (O TO EXIT) ? 2
CHANNEL 2 IS OFF
ON+OFF+NEXT, OR REVIEW ?
ON
CURRENT STATUS IS:
CHANNEL 1 IS OFF

Text continued from page 42:
interface properly, you must have Level 2 BASIC to address output ports. Also, in most Level 2 systems, +5 V on the expansion connector has been disconnected at the factory. It will be necessary, therefore, to provide a separate 5 V 300 mA power supply for the interface electronics.

Using the Interface
A typical application is demonstrated in figure 5. The receivers can be placed around the home to control a variety of appliances and lights. With the addition of the real-time clock outlined in a previous Circuit Cellar article ("Anyone Know the Real Time?" August 1979 BYTE, page 50) you can add timed activation of these control functions as well.

Listing 1 shows a simple BASIC program that demonstrates the interface capabilities. The command console is plugged in and positioned within 20 feet on a direct unobstructed line with the interface output transducer. The program starts by asking if you want to clear all outputs and start fresh. Since the BSR X-10 is an open-loop control system, and the entries may be varied.

To turn on channel 6, simply answer the appropriate questions with "6" and "ON". The status of all channels can be reviewed at any time.

The program responds by calling a control output routine. Turning channel 6 on requires two outputs to the command console. One sets channel 6 (as if pressing the 6 button), and the other sets the "on" function (as if pressing the ON button). To allow enough time for the command console to respond, delay loops are inserted. The result is a 2-second message that tells it to turn on.

Listing 2 is the logical extension of this basic concept. Using a real-time clock, you can create a list of precisely timed events. It can be used to control house lighting during vacations or to turn the coffee maker on at 6:30 AM. The program incorporates a default list of data statements. Each statement is formatted as time, channel, and function.

Listing 2: Program to compare the time from a real-time clock against a list of operations to be performed at specific times. A sample run of the program demonstrates how the entries may be varied.

RUN
CURRENT STATUS IS:
CHANNEL 1 IS OFF
CHANNEL 2 IS OFF
CHANNEL 3 IS OFF
CHANNEL 4 IS OFF
CHANNEL 5 IS OFF
CHANNEL 6 IS OFF
CHANNEL 7 IS OFF
CHANNEL 8 IS OFF
CHANNEL 9 IS OFF
CHANNEL 10 IS OFF
CHANNEL 11 IS OFF
CHANNEL 12 IS OFF
CHANNEL 13 IS OFF
CHANNEL 14 IS OFF
CHANNEL 15 IS OFF
CHANNEL 16 IS OFF
DO YOU WANT TO CLEAR ALL OUTPUTS TO START?
YES

SET CONTROLLER OUTPUTS BY ENTERING CHANNEL NO. AND FUNCTION
ENTER CHANNEL NO. (O TO EXIT) ? 2
CHANNEL 2 IS OFF
ON+OFF+NEXT, OR REVIEW ?
ON
CURRENT STATUS IS:
CHANNEL 1 IS OFF

Listing 2 continued on page 50

Text continued on page 54
THE BEST GETS BETTER! Yes, in just a few months, thousands of users now know that WORD-STAR™ is the word processing product that truly transforms the performance of Z-80, 8085, and 8080 microcomputers into a class with systems costing far more. Look at these recent enhancements: Print spooling; directory; foreign language adaptability; microspace justification; mailing list merge; CP/M*1.4, 2.0 & MPM compatible, and more. Examine our features and order yours now!

MicroPro Price List:

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<thead>
<tr>
<th>Software/Manual</th>
<th>Software/Manual</th>
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<tr>
<td>Word-Star™</td>
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<td>$250 /25</td>
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<tr>
<td>Super-Sort II™</td>
<td>$200 /25</td>
</tr>
<tr>
<td>Super-Sort III™</td>
<td>$150 /25</td>
</tr>
</tbody>
</table>

For more information and the name of your nearest dealer, contact MicroPro International Corporation.

MICROPRO INTERNATIONAL CORPORATION
1299 4th Street, San Rafael, California 94901
Telephone (415) 457-8990 Telex 340388
Listing 2 continued:

```
CHANNEL 2 IS ON
CHANNEL 3 IS OFF
CHANNEL 4 IS OFF
CHANNEL 5 IS ON
CHANNEL 6 IS OFF
CHANNEL 7 IS OFF
CHANNEL 8 IS OFF
CHANNEL 9 IS OFF
CHANNEL 10 IS OFF
CHANNEL 11 IS OFF
CHANNEL 12 IS OFF
CHANNEL 13 IS OFF
CHANNEL 14 IS OFF
CHANNEL 15 IS OFF
CHANNEL 16 IS OFF

ENTER CHANNEL NO. (0 TO EXIT) ?

LIST

100 REM THIS PROGRAM PROVIDES REAL TIME CONTROL OF AC APPLIANCES
110 REM BY CONNECTING THE SEARS HOME CONTROL SYSTEM AND A REAL TIME CLOCK
120 REM TOGETHER.
130 REM
140 REM COPYRIGHT 1979 STEVEN CIARCIA
150 REM
160 REM
170 REM
180 GOSUB 350 :REM LOAD DATA TABLES
190 REM PROGRAM OPTIONS ARE MADE THROUGH MENU SELECTIONS
200 PRINT :PRINT :PRINT 'CHOOSE ONE OF THE FOLLOWING :
210 PRINT
220 PRINT '1. AUTOMATIC CONTROL SYSTEM ON'
230 PRINT '2. MANUAL CONTROL / CURRENT STATUS
240 PRINT '3. PRINT THE CURRENT TIME'
250 PRINT '4. REVIEW DEFAULT SETTINGS AND ADD TO CONTROL LIST'
260 PRINT
270 PRINT 'YOUR CHOICE '; INPUT Z1
280 IF Z1 = 1 THEN PRINT 'AUTOMATIC CONTROL INITIATED' : GOTO 1190
290 IF Z1 = 2 THEN GOSUB 740 : GOTO 810
300 IF Z1 = 3 THEN GOSUB 1470 : PRINT 'THE PRESENT TIME IS '; GOSUB 1130 : PRINT 200
310 IF Z1 = 4 THEN GOTO 940
320 GOTO 200
330 REM
340 REM
350 REM SET UP TABLE OF CHANNEL/OUTPUT CODES
360 DIM CC:20J, SC:5OL
370 DATA 12.2a, 4, 20.2, 1e, 10.2.6, 14.J0
380 DATA 6,22,0,16,8,24
390 FOR X = 1 TO 16
400 READ CC(X):REM CC(X) IS CHANNEL NUMBER
410 NEXT X
420 REM WHEN PROGRAM IS INITIATED THE FOLLOWING DATA TABLE CONSTITUTES THE DEFAULT CONTROL SETPOINTS
430 REM SETPOINTS ARE STORED AS DATA STATEMENTS IN THE FORM OF TIME,CHANNEL, AND FUNCTION
440 REM W=TOTAL NUMBER OF DATA STATEMENTS
450 REM
460 DIM W:50), A(50), B(50), A*(50) + L(50)
470 W = 20 : REM W=TOTAL NUMBER OF DEFAULTS
480 DATA 0200,10,'ON' : REM DEHUMIDIFIER
490 DATA 1700,10,'OFF'
500 DATA 1830,6,'ON' : REM SPARE BEDROOM LIGHTS
510 DATA 1925,6,'OFF'
520 DATA 1940,6,'ON'
530 DATA 2020,6,'OFF'
540 DATA 2035,6,'ON'
550 DATA 2150,6,'OFF'
560 DATA 2200,6,'ON'
570 DATA 2350,6,'OFF'
580 DATA 0150,6,'ON'
590 DATA 0245,6,'OFF'
600 DATA 1600,1,'ON' : REM CIRCUIT CELLAR ACCESS PLUG
610 DATA 2200,1,'OFF'
620 DATA 2300,4,'ON' : REM CELLAR HALL
630 DATA 0030,4,'OFF'
640 DATA 1930,5,'ON' : REM MASTER BEDROOM
650 DATA 2120,5,'OFF'
660 DATA 2200,5,'ON'
670 DATA 0100,5,'OFF'
680 FOR L = 1 TO W :READ A(L), B(L), A*(L) : REM SET TIME, CHANNEL, FUNCTION
```

Listing 2 continued on page 52
OLIVETTI PRINTERS
AVAILABLE NOW!

For years we have been our own biggest customer. Until now you couldn’t buy an Olivetti printer unless you bought a complete Olivetti calculator. Now, for the first time, our complete line of OEM printers is available for immediate shipment in any quantity. For use in calculators, electronic scales, cash registers, mini computers, CRT hard copy output, data loggers, medical and scientific instruments, or any application where a paper tape printout is desired. Olivetti has a quality OEM printer for you.

Features:
- High Speed
- Low Cost—The Best Really Can Cost Less!
- Fewer Moving Parts
- Proven High Reliability and Long Life
- Over 3 Million In Use by Olivetti Alone
- Lightweight and Compact—Extremely Versatile
- Available With 6V or 18V Motor
- Low Power Usage
- Graphic Capabilities (PU1828 and PU1840)
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20370 Town Center Lane
Cupertino, California 95014
Telephone: 408/996/3867

PU1840 —
40 Column Thermal, 240 L.P.M.
Dot Matrix, Plotter

PU1808 —
16 Column Thermal, 120 L.P.M.

PU1100 —
20 Column Impact, 120 L.P.M.

PU1828 —
28 Column Thermal, 240 L.P.M.
Dot Matrix, Plotter

Coming Soon:
80 Column Thermal, 240 L.P.M.
Dot Matrix, Plotter

olivetti
Circle 28 on Inquiry card.
Listing 2 continued:

690 NEXT L
760 RETURN
770 STOP
720 REM
730 KE197 REM
740 PRINT "CURRENT STATUS IS:"
750 FOR X=1 TO 16
760 PRINT "CHANNEL "; X; " IS " ; IF S(X)=1 THEN PRINT "ON" ELSE PRINT "OFF"
770 NEXT X
780 RETURN
790 REM
800 REM
810 PRINT "DO YOU WANT TO CLEAR ALL OUTPUTS TO START?" ; INPUT A$";
820 IF A$="YES" THEN F=1 : GOSUB 1380 : FOR Z=1 TO 16 : S(Z)=0 : NEXT Z : REM CLEAR BSR OUTPUTS
830 PRINT "SET CONTROLLER OUTPUTS BY ENTERING CHANNEL NO. AND FUNCTION"
840 PRINT "ENTER CHANNEL NO. TO EXIT:" ; INPUT C
850 IF C=0 THEN GOTO 200
860 PRINT "CHANNEL " ; C; " IS " ; IF S(C)=1 THEN PRINT "ON" ELSE PRINT "OFF"
870 PRINT "DO YOU WANT TO CLEAR ALL OUTPUTS TO START?" ; INPUT A$";
880 IF A$="YES" THEN F=1 : GOSUB 1380 : FOR Z=1 TO 16 : S(Z)=0 : NEXT Z : REM CLEAR BSR OUTPUTS
890 IF A$="OFF" THEN S(C)=0 : GOSUB 1380 : GOTO 840 : REM CLEAR BSR OUTPUTS
900 IF A$="NEXT" THEN C=C+1 : GOTO 860
910 GOSUB 740 : GOTO 840
920 REM
930 REM
940 PRINT "DO YOU WANT TO REVIEW THE DEFAULT SETTINGS (Y/N)" ; INPUT B$";
950 IF B$="Y" THEN GOTO 1000
960 FOR L=1 TO W
970 L=INT(A(L)/100)
980 PRINT L; "HOURS " ; A(L)-L*100; " MINUTES " ; TURN CHANNEL " ; B(L); " ; "A$(L)
990 NEXT L
1000 PRINT "CHANGE LIST" ; PRINT "ADD TO LIST" ; PRINT "EXIT TO MENU" ; INPUT Z2
1010 PRINT "0.....EXIT TO MENU" ; INPUT Z2
1020 IF Z2=0 THEN GOTO 200
1030 IF Z2=1 THEN PRINT "RECORD ENTRY TO BE CHANGED" ; ELSE 1080
1040 INPUT Z1
1050 PRINT "PRESENTLY " ; A(Z1) ; P(Z1) ; A$(Z1)
1060 INPUT "TIME CHANNEL AND ON OR OFF " ; A(Z1) ; P(Z1) ; A$(Z1) ; IF A(Z1)=0 THEN 1000
1070 PRINT "CHANGE ANOTHER Y/N " ; INPUT Z$ ; IF Z$="Y" THEN GOTO 1030 ELSE 1000
1080 IF Z2<>2 THEN GOTO 1000
1090 REM START ADDITIONS AT END OF DEFAULT LIST
1100 PRINT "ENTER TIME CHANNEL AND FUNCTION"
1110 W=W+1 ; PRINT "ENTRY NO. " ; W ; " ; INPUT A(W) ; B(W) ; A$(W) ; IF A(W)=0 THEN W=W-1 : GOTO 1000
1120 GOTO 1110
1130 REM 4 DIGIT FORMAT ROUTINE
1140 T2=HI*1000+LO
1150 PRINT T2; "HOURS " ; T3; "MINUTES" ; RETURN
1160 REM
1170 REM
1180 REM
1190 REM CONTROL OUTPUT SUBROUTINE----SETPOINT MONITOR
1200 L=0
1210 GOSUB 1470 : REM GET TIME
1220 IF T1<T5 THEN GOSUB 1130 ; T5=T1 : REM PRINT TIME
1230 FOR L=1 TO W
1240 IF T1=A(L) THEN X=B(L) : GOSUB 1330 : GOSUB 1280
1250 NEXT L
1260 IF INP(0)<0 THEN GOTO 200 : REM CHECK KEYBOARD FOR INTERRUPT INPUT
1270 GOTO 1210
1280 IF A(L)="ON" THEN F=SIS(B(L))=1 : GOSUB 1400
1290 IF A(L)="OFF" THEN F=S7; S(B(L))=0 : GOSUB 1400
1300 RETURN
1310 REM
1320 REM
1330 REM BSR HOME CONTROL DRIVER
1340 REM C(X) IS CHANNEL CODE
1350 OUT 9;C (X) ; REM SET CHANNEL
1360 GOSUB 1460
1370 RETURN
1380 REM FUNCTION DRIVER
1390 REM F=FUNCTION CODE
1400 OUT 9;F
1410 GOSUB 1460
1420 OUT 9;128 ; REM BIT 7 SHUTS OFF TRANSDUCER OUTPUT
1430 RETURN
1440 REM
1450 REM
1460 FOR D=0 TO 900 : GOTO 0 : RETURN : REM DELAY TIMER

Listing 2 continued on page 54
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1490 REM IT READS IN 2400 HR. FORMAT AND IS CONNECTED TO PORT B
1500 RO=O :O U T 3,254 :REM TURN ON PANEL LIGHT
1480 REM HARDWARE DESCRIBED IN AUG, '79 BYTE
1470 REM THIS ROUTINE IS THE REAL TIME CLOCK INTERFACE DRIVER
1580 IF RO = 16 THEN 1530 ELSE 1510
1530 MO = r AND 15 !GOSUB 1630
1610 REM Ti = TIME Hl = TEN S OF HOURS HO • HOURS
1540 M1 • T AND 15 !GOSUB 1630
1590 OUT 3,255 !REM TURN OFF PANEL LIGHT
1580 IF RO = rl THEN 1590 ELSE RO = T1 !GOTO 1510
1570 Ti = (H1+100)+1000+M1 HO = Ti 1590 OUT 3,255 REM TURN OFF PANEL LIGHT
1600 RETURN
1610 REM Tl=TIME Hl=TENS OF HOURS HO=HOURS
1620 REM Ml=TENS OF MINUTES MO=MINUTES
1630 OUT 8,1 :OUT BrO :T = INP(8) :RETURN
1580 IF RO = rl THEN 1590 ELSE RO = T1 !GOTO 1510
1570 Ti = (H1+100)+1000+M1 HO = Ti 1590 OUT 3,255 REM TURN OFF PANEL LIGHT
1600 RETURN
1610 REM Tl=TIME Hl=TENS OF HOURS HO=HOURS
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1610 REM Tl=TIME Hl=TENS OF HOURS HO=HOURS
1620 REM Ml=TENS OF MINUTES MO=MINUTES
1630 OUT 8,1 :OUT BrO :T = INP(8) :RETURN

Listing 2 continued:

Conclusion

I always try to present interfaces and applications that I think will interest BYTE readers. I consider this one is particularly significant considering the cost advantages over earlier technology. I will not replace the relay-controlled lighting in my home, but further expansion of AC control will use the hardware from this article. There are, of course, many situations where the BSR X-10 is inappropriate, but considering the sophistication when it is connected to a computer, I am going to look a lot harder for ones that apply.

Next Month:

It is getting a little cold in Connecticut, and Venezuela is our oil connection. As a result, I have installed a wood stove and have eight cords of wood piled up in the backyard. Realize that not just any stove can be put in the Circuit Cellar, so next month I will discuss my "Computer-Controlled Wood Stove."
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And may the juiciest application win.
A Computer-Controlled
Light Dimmer

Part 1: Design

John H Gibson
Physics Department
Alma College
Alma MI 48801

Microcomputer hobbyists are generally and loosely classified as either software or hardware types, depending on where their dominant interests and fascinations lie. Software types find data manipulation a satisfying end in itself. They dream of ever-expanding memories, and they use their computers to organize their finances, keep kitchen records, and play complex video games. Hardware types look for ever more interesting ways to interface their microcomputers with the outside world. They lie awake at night devising new ways of making their computers control lights, appliances, and mechanical devices. Their homes are filled with wires, relays, and remote sensors.

I am a hardware type. I love to make electrical and mechanical devices respond to automatic control. My most recent interest, which I would like to share with you, has been in using a very simple microcomputer for lighting control.

Of all the control techniques developed by the microcomputer hobbyist, lighting control has remained the most primitive. Until recently, lighting control with a microcomputer was usually restricted to simple on and off switching. Proportional control, the controlled dimming of lights, required either expensive hardware or an impractically large software overhead and was therefore beyond the reach of most microcomputer hobbyists.

The recent appearance of peripheral programmable timers for microcomputers has changed all of this. Proportional lighting control with a microcomputer is now both inexpensive and easy to achieve.

Introduction to AC Phase Control

In traditional designs, lamp dimmers used either a rheostat to regulate the current through the lamp, or an autotransformer to adjust the voltage across it. Either of these inherently analog devices requires that a knob be turned to change the lamp brightness, and neither device is amenable to microcomputer control.

Modern lamp dimmers use the technique of proportional AC phase control. A semiconductor switch in series with the lamp is opened and closed 120 times per second. The switch's operation is timed to permit a current to flow through the lamp only during a controlled fraction of each half cycle of the 60 Hz alternating voltage supplied by the power line. Because this is a switching process, it is inherently digital, and it is therefore a ready candidate for microcomputer control.

The switching device most commonly used for AC phase control is the triac. A triac is a semiconductor device that functions as a latching switch. Once turned on, the triac remains on and cannot be turned off until the current through it drops to zero.

Figure 1a is a drawing of a triac, and figure 1b shows its schematic symbol. The terminals through which the switched current flows are labeled MT1 (main terminal 1) and MT2 (main terminal 2). A third terminal, called the gate, is used to turn on the triac, that is, to establish conduction between main terminal 1 and main terminal 2. Because of its latching property, once the triac is turned on by the gate, it remains on until the current through main terminal 1 and main terminal 2 drops to zero.

Figure 2 illustrates the basic switching arrangement for AC phase control. A triac and a lamp are connected in series with the 120 V, 60 Hz AC power line. A mechanical push-button switch in series with the triac's gate is pushed and released 120 times per second, or once during each half cycle of the 60 Hz alternating voltage applied to the triac and lamp.
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Because the triac is a latching switch, it then remains on (even though the push button is released) until the end of the AC half cycle, when the current through it drops to zero. The triac then turns off and remains off until the next momentary closure of the push-button switch.

The 380 ohm resistor limits the gate current pulse to a value that will not damage the triac's gate.

Figure 3 illustrates when the current does and does not flow through the lamp during each AC half cycle. In this illustration, the push-button switch is open (and the triac off) for the first 5 ms of the 8.33 ms (1/120 second) positive half cycle. The push button is then momentarily closed.

At this time the triac turns on, and current flows through it and the lamp until the end of the positive half cycle, when the current drops to zero. The triac then turns off and remains off until the next momentary closure of the push button. The next push-button closure occurs during the negative half cycle, when the triac again turns on and remains on until the negative half cycle ends.

Current therefore flows through the lamp for only a fraction of each AC half cycle. The size of that fraction depends on how late in each half cycle the push button is momentarily closed and the triac turned on. The longer the delay in turning on the triac during each half cycle, the less power will be supplied to the lamp.

The simplified switching arrangement of figure 2 is for illustration only. Obviously, no mechanical switch can be pushed and released with the speed and timing accuracy needed to make this a reliable way of achieving proportional phase control of the power supplied to the lamp.

This does not mean that it is difficult to design circuits that will deliver properly timed trigger pulses to a triac. Many analog circuits that do this can and have been designed. They range in complexity from simple, manually adjusted resistor/capacitor phase-shift networks used in household lamp dimmers to sophisticated ramp-and-pedestal circuits that provide AC phase con-
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viders the silicon bilateral switch into momentary conduction. This sends a current pulse into the triac's gate, turning on the triac for the rest of that AC half cycle. The circuit operates just like the push-button circuit described earlier, except that the push button has been replaced by the silicon bilateral switch, and the triac is now turned on by each microcomputer-generated current pulse.

Electrical isolation is an important feature of this circuit. The MOC3011 permits the microcomputer to control the 120-VAC lamp circuit while remaining electrically insulated from it.

How is the microcomputer to generate the properly timed pulses needed to control the triac? Proportional AC phase control requires 120 pulses per second, with each pulse occurring at a controlled delay interval after the beginning of an AC half cycle. Part of this pulse generation can be performed by software, but there is also an important hardware requirement. The microcomputer can produce properly timed pulses only if it knows when each AC half cycle begins. That is, the microcomputer must be synchronized to the AC power line.

This design problem has a two-step solution. The steps are:

1. Design a circuit that generates a pulsed logic-level change at the beginning of each AC half cycle.
2. Use this pulsed logic-level change to signal the microcomputer at the beginning of each AC half cycle.

Photo 1: Output of the synchronizer. The waveform was recorded with a vertical scale factor of 1V per division and a horizontal time base of 100µs per division. Its zero is at the bottom line of the screen.

Figure 5 shows a synchronizing circuit that achieves the goal of step 1. The circuit's output remains at logic 1 (5 V), except when it goes to logic 0 for about 0.4 ms at the beginning of each AC half cycle. This output is the
put the pieces together!

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pulsed logic-level change required.

How is the microcomputer signaled, as required by step 27? The answer to that question depends on how you plan to complete the design of the AC phase control.

One method is to connect the synchronizing signal to one of the microcomputer’s interrupt inputs. Upon receipt of each interrupt, the computer enters a program-timing loop to count off the desired delay. At the end of the delay, the program generates an output pulse to trigger the triac and then waits for the next synchronizing interrupt.

An interrupt-driven microcomputer using program-timing loops can handle very simple AC phase control applications, but this scheme becomes unworkable for even moderately sophisticated programs. This is because a wide-range power control capable of adjusting a lamp from complete darkness to full brightness requires a timing loop that runs nearly the full duration of each AC half cycle, leaving almost no time to execute the rest of the program.

It would be much easier to let the microcomputer simply compute a number representing the delay time required and leave it to a peripheral timing device to actually count off each delay time and trigger the triac.

Now such a peripheral timing device will be discussed.

The Programmable Timer

A programmable timer is a peripheral device designed for connection to the microcomputer bus. It can be configured (by software) so that, driven by an external signal (i.e., the synchronizing signal discussed earlier), it generates an output pulse after each input pulse. It accomplishes this with the interval between input and output pulses equal to a programmed delay.

This is just what is necessary for an AC phase control. A programmable timer can relieve the microcomputer of all the processing required for delay timing and output pulse generation. With a programmable timer attached, the microcomputer is free to run sophisticated programs that need only load the timer with a new delay number each time a changed delay time is required.

To gain a closer look at the timer’s operation, a simplified model will now be examined.

Figure 6 is a diagram of such a timer. In addition to its connections to the microcomputer bus, this timer also has a gate input \( G \) and an output \( O \). Inside the timer are three addressable registers. They are:

- an 8-bit, write-only control register used to establish the timer’s operating mode (much as a control register configures the operation of a peripheral interface adapter (PIA));
- a 16-bit, write-only latch. Its contents are divided into two 8-bit bytes, called \( M \), for the most significant byte, and \( L \), for the least significant byte. These two bytes are placed in the latch by the program running in the microcomputer, and they may be changed by the program at any time;

![Diagram of Programmable Timer](image)

**Figure 6:** Model of the programmable timer, showing gate input \( G \), output \( O \), the connection to the microcomputer bus, and the addressable registers. The arrows pointing from the latch to the counting register indicate the data transfer that takes place at the beginning of each count.

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**ANALOG SYSTEMS FOR MICROPROCESSORS AND MINICOMPUTERS.** By Patrick H. Garrett. 249 pp., illus. Explores all possibilities for analog systems in one applications oriented volume—with many specific examples.
• a 16-bit, read-only counting register. A momentary logic 0 at the timer's gate input causes this register to be loaded with bytes M and L from the latch. The counting register then decrements on each cycle of the microprocessor clock. When the count reaches zero, a voltage pulse is delivered to the timer's output. Details of this operation will be described shortly.

For this application, the synchronizing signal should be connected to the timer's gate, and the timer's output used to trigger the triac.

Now examine the timer in detail by stepping through one cycle of its operation:

1. Upon receipt of a momentary logic 0 at its gate, the timer loads its counting register from the latch (without changing the number stored in the latch). If it is not already low (logic 0), the timer's output goes low.

2. The output remains low for an interval equal to \((M+1)L + 1\) periods of the microprocessor's clock. At the end of this interval, the timer's output goes high (logic 1).

3. The output remains high for L periods of the microprocessor's clock. At the end of this time, the output again goes low.

4. The output remains low until another momentary logic 0 at the gate starts the cycle again.

This timing sequence is illustrated in figure 7 and example outputs are shown in the photo 2 sequence.

For this application, it is convenient to make \(L\) a fixed quantity and let \(M\) range from hexadecimal 00 to FF. This choice allows you (1) a fixed output pulse width \(LT\), regardless of the delay chosen, and (2) program control of the timed delay by specification of a single 8-bit byte \(M\).

How is the size of \(L\) chosen? The time for one complete cycle of the timer is:

\[
\text{Timer cycle} = \text{Delay time} + \text{Output pulse width} = (M+1)L + 1 + LT = (M+1)(L+1)T
\]

![Photo 2: This series of photos shows how the timer's output pulses lag behind those from the synchronizer and how the alternating voltage across the lamp is determined by the delay value contained in the timer latch. The numbers indicate the hexadecimal value. The top row of photos shows how the timer's output pulses lag those from the synchronizer by a time proportional to the delay value. The synchronizer's output is the series of negative pulses across the top half of the screen, while the timer's output is the series of brief positive pulses (blips) across the bottom half. Both waveforms were recorded with a vertical scale factor of 2V per division and a horizontal time base of 2ms per division. The synchronizer's output has its zero at the screen's horizontal center line, while the timer's zero is at the bottom line. The bottom row of photos shows the alternating voltage across the lamp as determined by the delay value in the timer's latch. The waveforms were recorded with a vertical scale factor of 50V per division and a horizontal time base of 2ms per division.]

![Figure 7: Timer input and output pulses in the single-shot, dual 8-bit operating mode. The output pulse begins at time \(t = \frac{(M+1)L + 1}{T}\) after the input gate pulse, where:

\(M\) = most significant byte loaded from the timer latch into the counting register

\(L\) = least significant byte loaded from the timer latch into the counting register

\(T\) = period of microprocessor clock]
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If the maximum value of M is hexadecimal FF or decimal 255, then the maximum time for one cycle of the timer is:

$$[\text{Timer cycle}]_{\text{max}} = 256 (L+1) T$$

Each AC half cycle has a duration of 8333 µs. If you wish one cycle of the timer at maximum delay to just equal one AC half cycle, you must have:

$$8333 \mu s = 256 (L+1) T$$

which requires that:

$$L = \frac{8333 \mu s}{256 (2.5 \mu s)} - 1$$

The value picked for L clearly depends on the period T of the microprocessor clock. For example, if the clock period is 2.5 µs (for a 400 kHz clock), the computed value for L is:

$$L = \frac{8333 \mu s}{256 (2.5 \mu s)} - 1 = 12 = \text{hexadecimal } \text{OC}$$

Using this computed value for L does not work in practice. This is because an intentional, small delay in the synchronizer causes the timed cycle actually to begin about 100 µs after the start of each AC half cycle, thus slightly reducing the time remaining in the half cycle for the timer to operate. However, for this particular example, a value of L = 11 = hexadecimal 0B does work well.

For this example, the timer’s output pulse width therefore is:

$$LT = 11 \times 2.5\mu s = 27.5\mu s$$

---

**Programmable Timer Module**

Up to now you have been examining a slightly simplified model of the programmable timer. Now concern yourself with a real device, the Motorola MC6840 programmable timer module. Figure 8 is a pin-assignment diagram for the MC6840.

Each timer in the MC6840 has its own gate input (pins G1, G2 and G3) and its own output (pins O1, O2 and O3). For this application, the synchronizing signal should be connected to all three gate inputs, and the individual timer outputs used to trigger three separate triacs. Figure 9 shows how each timer output should be connected to the AC circuit it controls. With the MC6840’s three inde-

---

**Figure 8: Pin-assignment diagram for the Motorola MC6840 programmable timer module.**

---

**Figure 9: Circuit for connecting one timer output to the AC circuit it controls. The AC phase-control circuit contained within the dotted lines should be built into a metal box, and the triac’s isolated mounting tab securely fastened to the inside wall of the box. (Substitution of a different triac without the isolated mounting feature will require the use of special mounting hardware to electrically isolate the triac from the wall of the enclosure.)**
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pendent timers, it is possible to control three different AC circuits.

Each timer in the MC6840 also has its own external-clock input (pins C1, C2 and C3) for use when timer-counting frequencies different from that of the microprocessor clock are needed. The external-clock inputs are not needed in this application.

Table 1 describes register selection in the MC6840. The MC6840 contains ten addressable registers. Nine of these are the control registers, timer latches, and counting registers for the three timers. The tenth is a status register containing interrupt flags. The status register will not be used.

The three register-select inputs RS0, RS1, and RS2 should normally be connected to the microcomputer's low-order address lines A0, A1, and A2 respectively. Because the control registers and the timer latches are all write-only registers, while the counting registers and the status register are all read-only registers, the R/W input in effect serves as a fourth register select line. This feature precludes the use on MC6840 registers of any MC6800 processor instructions that operate directly on memory. Examples of such instructions are INC (increment), DEC (decrement), and CLR (clear).

The next section examines in detail how the MC6840 is programmed for proportional AC phase control.

System Power-Up
A system power-up or a momentary low-logic level on the MC6840's RESET line causes the following actions:

- All three timer outputs are set low.
- All three timer latches are preset to hexadecimal FFFF, and the three counting registers are loaded from the latches.
- All three control registers are cleared, except that bit 0 of control register 1 is set. Setting this bit causes all three counting registers to be held in their preset state, so that the timers do not run.

Timer Initialization
The MC6840 is a versatile device with several operating modes. This application requires that each timer in the MC6840 be configured for single-shot dual 8-bit operation. The MC6840 is initialized for this application by loading hexadecimal B6 into control register 3 (CR3), hexadecimal B7 into control register 2 (CR2), and hexadecimal B6 into control register 1 (CR1).

The order in which these registers are loaded is important. Control registers CR3 and CR1 share a single address space, with bit 0 of CR2 selecting whether control register CR3 or CR1 is accessed (CR2 bit 0 cleared selects CR3; CR2 bit 0 set selects CR1).

For example, if control registers CR3 and CR1 share address hexadecimal 8000 and CR2 occupies address 8001, then (recall that CR2 bit 0 is cleared on system power-up or RESET) an appropriate initialization sequence is the following sequence of MC6800 instructions:

```
LDA A #$B6 Control word for CR3 and CR1
LDA B #$B7 Control word for CR2
STA A $8000 Configure timer 3
STA B $8001 Configure timer 2
STA A $8000 Configure timer 1
```

Loading the Timer Latches
With the MC6840 initialized and the program running, the brightness of each lamp is controlled by the number stored in its associated timer latch. If not disturbed, these numbers remain unchanged, and the lamps glow with constant brightness. To change the brightness of any lamp, it is necessary only to load a new number into its timer's latch.

It is important that the two bytes of each timer latch be loaded in the proper order. Although table 1 may lead you to believe that the most significant bytes of the three latches have three different addresses, in reality these three addresses lead to a single 8-bit buffer. To load a particular latch, this buffer register must first be loaded with the most significant byte. Then, when the least significant byte is loaded into space L of the latch, the buffer's contents are automatically transferred to the latch's space M.
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For example, suppose the three timer latches occupy hexadecimal addresses 8002 through 8007, and are assigned as follows:

- M1: 8002
- L1: 8003
- M2: 8004
- L2: 8005
- M3: 8006
- L3: 8007

If you wish to load M1, M2, and M3 with new delay numbers DELAY1, DELAY2, and DELAY3 but leave L1, L2, and L3 unchanged with hexadecimal 1E stored in each, the program sequence that would accomplish this is:

```
LDA A DELAY1  
LDA B #1E     
STA A $8002   
STA B $8003   

LDA A DELAY2  
STA A $8004   
STA B $8005   

LDA A DELAY3  
STA A $8006   
STA B $8007   
```

It is important to understand that, even though L1, L2, and L3 remain constant, it is not possible to avoid reloading a latch's least significant byte each time you want to change its most significant byte. There is no other way to access the most significant bytes of the timer latches.

**Controlled Fading**

Proportional AC phase control is most interesting when it is used to fade lamps on and off at controlled rates. This has application to theatrical lighting control, planetarium operation, and control of multiple projectors in a slide show.

Controlled fading may be accomplished by using a program-timing loop to slowly increment or decrement a delay number toward some final value set by the program. The fading stops when the final value is reached. Fading up or down resumes when the program sets a new final value.

The basic timing element can be either the microprocessor's clock or a 120 Hz interrupt signal produced by the synchronizer. Of these two choices, I prefer the latter, simply because it is much slower and therefore easily used to achieve slow fading rates.

But even 120 Hz is too fast. If the delay number is decremented 120 times per second, a lamp fading from complete darkness (DELAY = FF) to full brightness (DELAY = 00) will do so in only 2.1 seconds.

An intermediate register is needed, one which may be incremented or decremented 120 times per second and the carry or borrow generated is used to increment or decrement the delay number.

**Summary**

You have been introduced to the basic principles of proportional AC phase control; seen how a triac is used for this purpose and how a programmable timer may be used to drive the triac; and looked closely at the Motorola MC6840 programmable timer module configured for this application. A method of using a program timing loop to slowly fade a lamp up and down in brightness has been outlined. You now have all the information necessary to try this on your own.

In part 2 of this article I shall create a program and circuit example on the Heathkit ET-3400 microprocessor trainer that will perform the lighting control functions discussed so far.
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Having recently moved into a new home and being a home computer enthusiast, I naturally began looking for an application for my homebrew microcomputer. During the big snowstorm of January 26, 1978, I was snowed in for four days. This situation encouraged the development of several ideas.

With forty-eight km (thirty mile) per hour winds producing 1.8 to 2.4 m (six to eight foot) snowdrifts alongside of the house, and with emergency food source information being broadcast on the local radio station, it was natural that I began to think about the heating system in the house. During a conversation with my wife several questions arose, and we dug out an information booklet that had been supplied with the furnace. We also began to record the furnace on-off cycles.

More questions arose. How long was the burner on? What were the cycle times? How much gas did it burn per cycle, and what was the cost of this gas? What would be the effect if I used my fireplaces for heating? How much would additional insulation help, and did it really help to turn the thermostat down at night?

It became obvious that the only way to answer these questions would be to monitor the burner cycles of the furnace on a continual basis. This seemed to be an ideal task for my homebrew 8080A microcomputer. By the time the storm had ended, my notebook contained schematic diagrams of all the additional circuitry that would be needed to interface the furnace burner to the computer, and the first drafts of the necessary software were written.

Photo 1: Interior of the gas furnace. The computer interface circuit board is at the lower left, just to the right of the light green paper tag. The gas solenoid is slightly above the center of the photograph.

Photo 2: The author’s homebrew 8080A-based microcomputer system. Two circuit boards of interest have been removed from the card cage and are displayed in the foreground. The real-time clock and cassette interface board is on the left; the programmable read-only memory board is on the right.
Computer

The microcomputer which was used is unique. It was assembled between May 1977 and January 1978, and uses the 8080A microprocessor. The circuitry was packaged on four 4½ by 6 inch (11.43 by 21.24 cm) wire-wrap boards joined by a motherboard using standard 44-pin double readout edge connectors on 0.156 inch (0.402 cm) centers. The four boards consist of:

- 8080A central processor, bus drivers, and a serial I/O (input/output) port using the Intel 8251 programmable communication interface.
- 4 K byte programmable memory using 21L02-type static memory devices.
- 8 K byte programmable read-only memory using Intel 2708 circuits.
- Real-time clock, Kansas City format cassette interface, and a parallel I/O port.

After some effort and a little hair pulling, it was possible for me to squeeze a copy of Processor Technology's 5K BASIC into six 2708-type programmable read-only memories. A monitor (which resides in another 2708) contains routines to load memory, display memory, jump to a specified address, and begin program execution. The monitor can also fill blocks of memory, move blocks of memory, set the real-time clock, read the real-time clock, print the current time on the terminal, record programs on cassette, and play back programs from cassette.
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The only additional necessary hardware was a simple interface to the furnace that the computer could read to determine whether the burner was on or off.

Monitoring Hardware
The only information from the furnace needed by the computer is whether the burner is on or off. This could be supplied to the processor through 1 bit of a parallel input port. Since the computer has a real-time clock, it can then calculate the length of time the burner is on and the amount of gas used. I timed the gas meter over several long periods and found that the furnace took seventeen seconds to burn a cubic foot (28.32 liters) of gas. This measurement was confirmed by figures supplied by the manufacturer of the furnace.

Figure 1 shows how I obtained the one logical bit of information (on or off) from the furnace circuitry. The gas solenoid is connected to a 28 V AC source by the mercury switch in the thermostat. The bimetallic coil in the thermostat tips the switch on as the room temperature decreases, and tips it off as the temperature increases. The contacts of the mercury switch show 28 VAC when open (furnace burner off) and 0 VAC when closed (burner on).

When the burner is off, the 28 V AC signal is passed to a bridge rectifier made of diodes D1 thru D4. The pulsated DC current is smoothed by capacitor C1 and flows through the LED, and the phototransistor. When the mercury switch closes, no current flows through the LED, and the phototransistor will be in the nonconducting state.

If you have a parallel input port available (actually only one bit of an 8-bit port is needed), you need only connect point A of the circuit to the input of the least-significant bit (LSB) of the port and point B to the system ground. A 1000 ohm pull-up resistor to the +5 V supply should also be connected to the input. A twisted pair of wires can be used to connect the circuitry in the furnace with the input port on the computer.

My computer did not originally have a parallel input port, so I had to construct a simple one with a minimum of parts. Referring to figure 2, an 8T95 three-state buffer was
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Figure 2: A simple input port that can be used to transfer one bit of information concerning the furnace status to the computer. The address of this input port is hexadecimal OD, determined by the eight-input NAND gate and the inverter.

<table>
<thead>
<tr>
<th>Number Type</th>
<th>+5V</th>
<th>GND</th>
</tr>
</thead>
<tbody>
<tr>
<td>IC1 8795</td>
<td>16</td>
<td>8</td>
</tr>
<tr>
<td>IC2 74LS30</td>
<td>14</td>
<td>7</td>
</tr>
<tr>
<td>IC3 74LS00</td>
<td>14</td>
<td>7</td>
</tr>
<tr>
<td>IC4 74LS04</td>
<td>14</td>
<td>7</td>
</tr>
<tr>
<td>IC5 74LS02</td>
<td>14</td>
<td>7</td>
</tr>
</tbody>
</table>

Used, as the data bus in the computer is bidirectional. A 74LS30 8-input NAND gate and a single inverter decode the input port address, which is OD hexadecimal or thirteen decimal. The I/O R signal from the Intel 8228 bus driver gates the input signal onto the bus. This I/O R signal can be duplicated in an S-100 bus machine by NANDing the input instruction (INP) signal from pin 46 together with the DBIN signal on pin 78.

Real-Time Clock

Before I begin to describe the software used, a few words about the real-time clock will be useful. The real-time clock that is used is my own design, and is unique to this computer. Any type of real-time clock could be used in the system. It makes no difference whether or not it uses extensive hardware, software timing loops, interrupts, etc—as long as the processor can obtain the time upon request and be able to convert this into the time of day in absolute daily elapsed seconds (ie: time of day 00:00:00 equals 0 seconds, time 02:03:04 equals 2 x 3600 + 3 x 60 + 4 = 7384 seconds and time 23:59:59 equals 86,399 seconds). A subroutine is used in the BASIC program (in listing 1) beginning at line 600 to derive the absolute time in seconds from the twenty-four-hour real-time clock. Regardless of the type of real-time clock you use, some sort of subroutine will be necessary to calculate the time in absolute seconds. It is also very convenient to have a routine that prints out the current time in traditional form on your terminal.

Software

The main program used by this system (listing 1) is written in BASIC. The BASIC interpreter used is Processor Technology's 5K BASIC. Simply stated, the program continually monitors the furnace burner's state, and each time it shuts off, the computer prints out a line of information on the furnace's last burn cycle. A burn cycle is defined as the interval between two burner-off events.

To eliminate errors induced by switch bounce, ten read operations are done in sequence from the input port. If all of the ten inputs represent the same on or off state, then the pro-

Listing 1: The "watchdog" program, written in Processor Technology 5K BASIC. Once started, this program loops continuously, monitoring the status of the furnace and printing summary data as required. A flowchart is shown in figure 3.

```basic
10 REM = FURNACE WATCHDOG
12 REM - TO BE STARTED WITH FURNACE OFF
20 DIM M2(12)
22 I9=0; J9=0; G2=.21149
24 PRINT"INPUT MONTH,DAY"
28 INPUT N9,D9
30 PRINT"LAST DOLLAR TOTAL"
35 INPUT K
40 PRINT;PRINT
41 REM - GET TIME
42 GOSUB 600
43 S2=S
44 REM - STORE # DAYS IN MONTHS
45 FOR C=1 TO 12
46 READ M2(C)
48 DATA 31,28,31,30,31,30,31,31,30,31,30,31
49 NEXT C
50 L=0
55 REM - LOOP TO READ INPUT PORT 14
60 T=0
70 FOR C=1 TO 10
80 Z=CALL(12074)
Listing 1 continued on page 80
```

```basic
80 Z=CALL(12074)
```

This generates the I/O R on the S-100 bus used, as the data bus in the computer is bidirectional. A 74LS30 8-input NAND gate and a single inverter decode the input port address, which is OD hexadecimal or thirteen decimal. The I/O R signal from the Intel 8228 bus driver gates the input signal onto the bus. This I/O R signal can be duplicated in an S-100 bus machine by NANDing the input instruction (INP) signal from pin 46 together with the DBIN signal on pin 78.

Real-Time Clock

Before I begin to describe the software used, a few words about the real-time clock will be useful. The real-time clock that is used is my own design, and is unique to this computer. Any type of real-time clock could be used in the system. It makes no difference whether or not it uses extensive hardware, software timing loops, interrupts, etc—as long as the processor can obtain the time upon request and be able to convert this into the time of day in absolute daily elapsed seconds (ie: time of day 00:00:00 equals 0 seconds, time 02:03:04 equals 2 x 3600 + 3 x 60 + 4 = 7384 seconds and time 23:59:59 equals 86,399 seconds). A subroutine is used in the BASIC program (in listing 1) beginning at line 600 to derive the absolute time in seconds from the twenty-four-hour real-time clock. Regardless of the type of real-time clock you use, some sort of subroutine will be necessary to calculate the time in absolute seconds. It is also very convenient to have a routine that prints out the current time in traditional form on your terminal.

Software

The main program used by this system (listing 1) is written in BASIC. The BASIC interpreter used is Processor Technology's 5K BASIC. Simply stated, the program continually monitors the furnace burner's state, and each time it shuts off, the computer prints out a line of information on the furnace's last burn cycle. A burn cycle is defined as the interval between two burner-off events.

To eliminate errors induced by switch bounce, ten read operations are done in sequence from the input port. If all of the ten inputs represent the same on or off state, then the pro-
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Listing 1 continued:

90 T=T+Z
100 NEXT C
110 IF T=L THEN 60
120 IF T=10 THEN 160
130 IF T=0 THEN 210
140 GOTO 60
150 REM - GAS ON ROUTINE
160 GOSUB 600
170 G=S
180 L=10
190 GOTO 60
200 REM - GAS OFF ROUTINE
210 REM - DO CALCULATIONS AND PRINT OUT LAST BURN CYCLE
215 REM - HAS TIME CROSSED MIDNIGHT
220 IF G<S THEN 250
230 I=B6400-G+S
240 GOTO 260
250 I=S-G
260 J=(I/1700)*S2
262 I9=I9+I
264 J9=J9+J
265 K=K+J
266 REM - HAS TIME CROSSED MIDNIGHT
268 IF S2<S THEN 274
270 D=B6400-S2+S
272 GOSUB 500
273 GOTO 275
274 D=S-S2
275 R=(I/170)*100
280 Q=CALL(6262)
288 PRINT TAB(1),M9,",","D9,
290 PRINT TAB(1),"On",INT((I/60)*100)/100,"Min."
292 PRINT TAB(27),INT(R*10)/10,"% of",INT((B/60)*100)/100
294 PRINT TAB(43),"Min. cycle ",INT((J+0.005)*100)/100
296 PRINT TAB(65),"",INT((K+.005)*100)/100
298 S2=S
300 GOTO 50
499 REM - MON/DAY UPDATE
500 D9=D9+1
510 IF D9=M2(M9) THEN 560
520 D9=1
530 M9=M9+1
540 IF M9<13 THEN 560
550 M9=1
560 PRINT;PRINT;PRINT
565 PRINT"DAILY TOTALS -- On",INT((I9/B64)*10)/10,"%"
568 I9=I9/1700
570 PRINT TAB(16),"Cost is ",INT((I8*G2)*100)/100
575 PRINT TAB(16),INT((IB*10)/10),"CCF Used"
580 PRINT;PRINT;PRINT
585 I9=0;J9=0
590 RETURN
599 REM - FETCH TIME IN SEC.
600 D1=CALL(12032)
610 D2=CALL(12041)
620 D3=CALL(12047)
630 D4=CALL(12053)
640 D5=CALL(12059)
650 D6=CALL(12065)
660 M=(10*D1+D2)*60+(10*D3+D4)
670 S=M+60+(10*D5+D6)
680 RETURN

Figure 3: Simplified flowchart of the watchdog program given in listing 1. Once started, the program loops continuously, checking the status of the furnace and printing summary data as required.

GRAM accepts this as a true indication of the burner's status. Figure 3 is a simplified flowchart of the program. Essentially the program loops continually, looking for a change in the burner status. If there is a change, there are two different flow paths depending on whether the burner has just turned on or turned off. If the burner has just turned on, the current time is stored in the variable G. If it has just shut off, the current time and the value stored in G are used to calculate how long the burner was on and the percentage of time the burner

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Table 1: Use of variables in the BASIC program of listing 1. The physical items of data represented by each variable are shown here. During leap years (such as 1980), the array M2 must be modified to reflect the greater number of days in the month of February.

D Number of total seconds in the previous burner cycle, from last burner-off event to current burner-off event.
D1 Most significant digit (MSD) of current time; number of tens of hours.
D2 One digit of current time; number of units of hours.
D3 One digit of current time; number of tens of minutes.
D4 One digit of current time; number of units of minutes.
D5 One digit of current time; number of tens of seconds.
D6 Least significant digit (LSD) of current time; number of units of seconds.
D9 The current day of the month.
G Absolute daily elapsed time in seconds that the burner was on in the current cycle.
G2 Cost of gas in dollars for 100 cubic feet (2832 liters).
H Number of seconds the burner was on in the previous cycle.
I Total number of units of gas used for the day, one unit = 100 cubic feet (2832 liters).
J Cost, in dollars, for the previous burner cycle.
J9 Accumulated number of seconds the burner has been on during the day.
K Accumulated total cost of gas since the program was started.
L Set to zero if the burner is currently off, set to ten if the burner is currently on.
M Current time in minutes from 00:00:00.
M2 A subscripted array of twelve values containing the number of days in each month, ignoring leap years.
M9 The current month.
R Percentage of time the burner was on during the previous cycle.
S Absolute daily elapsed time in seconds from 00:00:00.
S2 Time, in absolute daily elapsed seconds, that the burner was off in the previous cycle.
Z The value returned by a machine language subroutine, set to zero if the burner is off and to one if on.

The CALL at line 80 simply reads input port hexadecimal OD and returns either a logical zero or one to denote whether the burner is off or on, respectively.

The CALL at line 280 transfers control to a machine language routine that reads the real-time clock and prints the current time on the terminal in standard form. The variable Q is not used for any calculations, but rather just supplies the necessary syntax for the BASIC interpreter. A subroutine called TTOP, which resides at hexadecimal address 18 FD in the monitor, is used within this routine as well as in the machine language routines that begin at hexadecimal memory location 2F00. TTOP reads the real-time clock and stores the 6-digit time (as ASCII characters) beginning at hexadecimal memory location 2254.

The six CALLs beginning at line 600 are used to retrieve the individual digits of the current time of day from the real-time clock. The six digits are then used to calculate the absolute time of day in seconds.

The machine language subroutines are shown in listing 2 and are quite straightforward. The subroutines S1 through S6 each read a single digit of the time and return it to the BASIC program in the HL register pair. Subroutine S1 is always the first called, and the actual clock-read operation is done here just once. MASK is used to strip high-order bits from the ASCII character representation of
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Listing 2: Machine language subroutines that are called by the BASIC program of listing 1, shown here in assembler for the 8080 processor. Routines S1 through S6 each read a single digit of the time from the real-time clock. The digit value is returned to the BASIC program in the HL register pair. S1 is always the first to be called, and the actual clock read operation is done only once. MASK strips the high-order bits from the ASCII character representation of the digit.

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

; FURNACE WATCHDOG
; WRITTEN BY T. WIERENGA, FEB. 1978
;
; READ HOURS,MINUTES,SECONDS
;
189D  TTOP EQU 189DH
2F00 ORG 2F00H
2F00 CD9D18 S1: CALL TTOP ; READ CLOCK
2F03 3A5422 LDA 2254H ; STORE IN MEMORY
2F06 C3242F JMP MASK ; GET TENS HOURS
2F09 3A5522 S2: LDA 2255H ; GET UNITS HOURS
2F0C C3242F JMP MASK ; GET TENS MINUTES
2F0F 3A5622 S3: LDA 2256H ; GET TENS SECONDS
2F12 C3242F JMP MASK
2F15 3A5722 S4: LDA 2257H ; GET UNITS MINUTES
2F18 C3242F JMP MASK
2F1B 3A5822 S5: LDA 2258H ; GET UNITS SECONDS
2F1E C3242F JMP MASK
2F21 3A5922 S6: LDA 2259H ; GET UNITS SECONDS
2F24 E60F MASK: ANI 00FH
2F26 6F MOV L,A ; RETURN VALUE IN H,L
2F27 2600 MVI H,0
2F29 C9 RET
;
; READ INPUT PORT 13 (ODH)
; 0=FURNACE OFF, 1=ON
;
2F2A DBOD IN 13
2F2C E601 ANI 1 ; LSB ONLY USED
2F2E 6F MOV L,A
2F2F 2600 MVI H,0
2F31 C9 RET
;
END

NO PROGRAM ERRORS

1
8080 MACRO ASSEMBLER, VER 2.0 ERRORS = 0 PAGE 2

SYMBOL TABLE

* 01

A 0007 B 0000 C 0001 D 0002
E 0003 H 0004 L 0005 M 0006
MASK 2F24 PSW 0006 S1 2F00 * S2 2F09 *
S3 2F0F * S4 2F15 * S5 2F1B * S6 2F21 *
SP 0006 TTOP 189D

!C B1B0

:102F0000CD9D183A5422C3242F3A5522C3242F3A78
:102F10005622C3242F3A5722C3242F3A5822C3242F
:102F20002F3A5922E60F6F2600C9DB0DE6016F2606
:022F300000C9D6
:000000000

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Table 2: Example of the output produced by the BASIC watchdog program of listing 1.

<table>
<thead>
<tr>
<th>Time</th>
<th>H</th>
<th>M</th>
<th>T</th>
<th>Cost</th>
<th>28% Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>01:50:25</td>
<td>2</td>
<td>22</td>
<td>On 9.78 Min., 34.8 % of 285.41 Min. cycle</td>
<td>.07</td>
<td>$ 3.27</td>
</tr>
<tr>
<td>02:25:42</td>
<td>2</td>
<td>22</td>
<td>On 11.23 Min., 31.7 % of 35.43 Min. cycle</td>
<td>.08</td>
<td>$ 3.36</td>
</tr>
<tr>
<td>03:00:15</td>
<td>2</td>
<td>22</td>
<td>On 11.31 Min., 32.2 % of 35.06 Min. cycle</td>
<td>.08</td>
<td>$ 3.44</td>
</tr>
<tr>
<td>03:34:40</td>
<td>2</td>
<td>22</td>
<td>On 11.51 Min., 33.9 % of 33.91 Min. cycle</td>
<td>.09</td>
<td>$ 3.53</td>
</tr>
<tr>
<td>04:08:46</td>
<td>2</td>
<td>22</td>
<td>On 11.45 Min., 33.5 % of 34.1 Min. cycle</td>
<td>.09</td>
<td>$ 3.61</td>
</tr>
<tr>
<td>04:43:22</td>
<td>2</td>
<td>22</td>
<td>On 11.65 Min., 33.6 % of 34.58 Min. cycle</td>
<td>.09</td>
<td>$ 3.7</td>
</tr>
<tr>
<td>05:18:22</td>
<td>2</td>
<td>22</td>
<td>On 11.5 Min., 32.8 % of 35.01 Min. cycle</td>
<td>.09</td>
<td>$ 3.79</td>
</tr>
<tr>
<td>05:53:31</td>
<td>2</td>
<td>22</td>
<td>On 12.33 Min., 35.1 % of 35.13 Min. cycle</td>
<td>.09</td>
<td>$ 3.88</td>
</tr>
<tr>
<td>07:23:36</td>
<td>2</td>
<td>22</td>
<td>On 65.9 Min., 73.1 % of 90.08 Min. cycle</td>
<td>.49</td>
<td>$ 4.37</td>
</tr>
<tr>
<td>09:56:08</td>
<td>2</td>
<td>22</td>
<td>On 10.1 Min., 6.6 % of 152.53 Min. cycle</td>
<td>.08</td>
<td>$ 4.45</td>
</tr>
<tr>
<td>10:35:23</td>
<td>2</td>
<td>22</td>
<td>On 11.88 Min., 30.2 % of 39.26 Min. cycle</td>
<td>.09</td>
<td>$ 4.54</td>
</tr>
<tr>
<td>11:16:10</td>
<td>2</td>
<td>22</td>
<td>On 11.26 Min., 27.6 % of 40.78 Min. cycle</td>
<td>.08</td>
<td>$ 4.62</td>
</tr>
<tr>
<td>12:00:01</td>
<td>2</td>
<td>22</td>
<td>On 10.88 Min., 24.8 % of 43.83 Min. cycle</td>
<td>.08</td>
<td>$ 4.7</td>
</tr>
<tr>
<td>12:44:40</td>
<td>2</td>
<td>22</td>
<td>On 10.5 Min., 23.5 % of 44.66 Min. cycle</td>
<td>.08</td>
<td>$ 4.78</td>
</tr>
<tr>
<td>13:33:57</td>
<td>2</td>
<td>22</td>
<td>On 10.03 Min., 20.3 % of 49.28 Min. cycle</td>
<td>.07</td>
<td>$ 4.85</td>
</tr>
<tr>
<td>14:25:37</td>
<td>2</td>
<td>22</td>
<td>On 9.7 Min., 18.7 % of 51.66 Min. cycle</td>
<td>.07</td>
<td>$ 4.93</td>
</tr>
<tr>
<td>15:27:48</td>
<td>2</td>
<td>22</td>
<td>On 9.28 Min., 14.9 % of 62.16 Min. cycle</td>
<td>.07</td>
<td>$ 5</td>
</tr>
<tr>
<td>16:32:27</td>
<td>2</td>
<td>22</td>
<td>On 9.21 Min., 14.2 % of 64.66 Min. cycle</td>
<td>.07</td>
<td>$ 5.06</td>
</tr>
<tr>
<td>17:27:30</td>
<td>2</td>
<td>22</td>
<td>On 10.53 Min., 19.1 % of 55.03 Min. cycle</td>
<td>.08</td>
<td>$ 5.14</td>
</tr>
<tr>
<td>18:17:55</td>
<td>2</td>
<td>22</td>
<td>On 11.48 Min., 22.7 % of 50.43 Min. cycle</td>
<td>.09</td>
<td>$ 5.23</td>
</tr>
<tr>
<td>20:43:56</td>
<td>2</td>
<td>22</td>
<td>On 11.7 Min., 80.3 % of 146.01 Min. cycle</td>
<td>.88</td>
<td>$ 6.1</td>
</tr>
<tr>
<td>21:19:56</td>
<td>2</td>
<td>22</td>
<td>On 14.43 Min., 40 % of 36 Min. cycle</td>
<td>.11</td>
<td>$ 6.21</td>
</tr>
</tbody>
</table>

DAILY TOTALS -- On 28% Cost is $3

14.2 CCF Used

each number to yield the binary value before it is returned to the BASIC program.

The input subroutine begins at hexadecimal memory address 2F2A. Only the least significant bit (LSB) of the byte input from input port 0D is used.

Some sample output from the mainline program is shown in table 2. Although a large amount of data is supplied by this program, it is difficult to visualize the trends in the daily consumption of gas without some additional analysis of the data. Therefore, a second BASIC program is used to produce a simple bar chart of daily gas consumption.

The bar chart program appears as listing 3. Several sets of data, each consisting of three numeric values, are obtained from the "watchdog" program of listing 1. These data sets are entered into the DATA statements beginning at line 500. Each set is read as the variables H, M, and T, which are the hour and minute the burner shut off after each cycle, and the length of time it was on. The number of data sets should correspond to the number of burner cycles in the day being charted.

An array D of 144 entries is created. Each entry represents ten
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Listing 3: BASIC program that prints bar graphs from data accumulated by the watchdog program of listing 1. An example of the output of this program is shown in figure 4.

100 REM - BAR CHART PRINTOUT FOR
110 REM - FURNACE WATCHDOG
120 REM
130 DIM D(144)
135 REM - SET ARRAY TO ZERO
140 FOR I = 1 TO 144
150 D(I) = 0
160 NEXT I
165 REM - READ TIMES
170 READ H, M, T
175 IF T = 0 THEN 250
177 REM - CALCULATE PLACE IN ARRAY
178 REM - AND LENGTH OF TIME ON
180 X = H * 6 + INT((M / 10) + .5)
190 T = INT((T / 10) + .5)
200 IF T > 0 THEN 220
210 T = 1
212 REM - FILL ARRAY WHEN ON
220 FOR I = X TO X - T + 1 STEP -1
225 D(I) = 1
230 NEXT I
240 GOTO 170
250 RESTORE
252 GOSUB 400
254 REM - PRINT OUT ARRAY AS 144 BARS
255 FOR J = 1 TO 144
258 REM - CR IF = 0
269 REM - BAR IF = 1
260 IF D(J) = 0 THEN 300
270 IF D(J) = 1 THEN 300
280 PRINT X
290 NEXT K
291 REM - PRINT TIME ON LAST BAR
292 IF D(J+1) = 1 THEN 300
294 READ H, M, T
296 PRINT H, HRS., M, MIN.
300 PRINT
310 NEXT J
315 GOSUB 400
320 STOP
399 REM - PRINT LINE OF DASHES ROUTINE
400 FOR Z = 1 TO 40
402 PRINT -
404 RETURN
500 DATA 1, 50, 9, 78, 2, 26, 11.23, 3, 11.31, 3, 11.35, 11.51, 11.45
510 DATA 4, 43, 11.65, 5, 18, 11.55, 11.53, 12.33, 7, 24, 65, 99, 9, 56, 10.1
520 DATA 10, 35, 11.88, 11, 16, 11.26, 12, 0, 10.88, 12, 45, 10.5, 13, 34, 10.03
530 DATA 14, 26, 9.7, 15.28, 9.28, 16, 32, 9.21, 17, 28, 10.53, 18, 18, 11.48
540 DATA 20, 44, 11.13, 21.20, 14.43
599 DATA 0, 0, 0
600 RETURN

minutes of time during the day. A value of one is assigned to an array entry if the furnace was on during the major part of the corresponding ten minute interval, otherwise the value is left at zero. This array is then printed as 144 lines, which are blank if the array value is equal to zero and filled in with Xs if the value is equal to one. The time is printed alongside the filled-in bar corresponding to the time interval in which the burner shut off. A sample output of the program is shown in figure 4.
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<tr>
<td>FLEX for SSB</td>
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<td>90</td>
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<tr>
<td>Extended BASIC</td>
<td>100</td>
<td>100</td>
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<tr>
<td>Extended BASIC Precompiler</td>
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<td>BASIC Precompiler</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>FLEX Sort/Merge</td>
<td>75</td>
<td>75</td>
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<tr>
<td>Text Editing System</td>
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<td>Debug Package</td>
<td>100</td>
<td>60</td>
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<tr>
<td>FLEX Utilities</td>
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These packages are available on either 8" or 5" soft-sector FLEX diskettes (5" 6800 is FLEX 2.0). Price includes user's manual and object code diskette. Certain programs are available on cassette. Contact Technical Systems Consultants for pricing. All orders should include 3 percent for postage and handling (8 percent on foreign orders). Master Charge and Visa are welcome.

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The particular day shown in figure 4 is February 22, 1978. Several interesting features can be determined from the output. The thermostat was turned down sharply before midnight, and the furnace did not come on again until 1:50 AM. The furnace cycled smoothly about every half hour until 5:53 AM. At about 6:30 AM when we arose for the morning, the thermostat was turned up. The burner was on for about one hour. The heat accumulated during this hour was not completely wasted when we left for work at about 7:30 AM, and the thermostat was again turned down. Notice that the burner did not cycle again for about 2½ hours. Between 9:56 AM and 6:18 PM (18:18 in 24-hour style), the cycle time lengthened as the outdoor temperature rose, and less energy was needed to maintain a constant temperature. At about 7:00 PM (19:00) we returned home and turned the thermostat up. The furnace ran for about one hour and fifty minutes. After this time it cycled once more before the thermostat was turned down for the evening. The furnace did not cycle again until after midnight.

The burner was on twenty-eight percent of the time during this particular day, and 40,210 liters (1420 cubic feet) of gas was burned at a cost of $3. The weather was quite harsh. A low temperature of \(-18^\circ C (0^\circ F)\) and a high of \(-3^\circ C (29^\circ F)\) were recorded, and the winds were sixteen to twenty-five km per hour (ten to fifteen miles per hour).

A secondary fact that came out of the data concerns the use of a fireplace in our home. This fireplace is located in the living room, about six meters (twenty feet) around a corner from the thermostat. Whenever the fireplace is burning, even moderately, the living room area and nearby thermostat are kept warm enough that the furnace does not run at all. This encourages a considerable savings, since we use the fireplace often on evenings that we are home.

Conclusion

This system provides an excellent starting point for an individual interested in monitoring the consumption of energy used for heating. An extension of this system might be useful to a homeowner who adds a supplemental solar heating system to the conventional heating system already present in the home. Aside from monitoring the energy used, the computer in this situation could also monitor the solar energy generated. In addition, the computer could also operate the two heating systems, turning on the conventional furnace when there is not enough available solar energy.

Individuals may desire different specific information from the furnace watchdog, therefore they may have to write their own software for a systematic analysis of the data obtained.
Bob admits he thought his computer had reached the limit of its capabilities. Then he discovered the BASIC Compiler from Microsoft.

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Bob believes in giving credit where credit is due. "Microsoft turned my BASIC computer into a genius for $395, but I was smart enough to recognize a good thing immediately."

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Editorial continued from page 10:

what are the typical criteria expected in the modern personal computer? For one thing, systems software is required to use the rich hardware capabilities of the small system. The days of an integer subset of high-level language X with a disk operating system capable of only simple data transfer operations are gone. The modern personal computer user at a minimum requires an extended disk BASIC with files and strings and an operating system with all the appropriate filing, editing and utility amenities. Nearly all the widely advertised systems have this kind of capability.

In what I consider to be the ultimate in usefulness for current computers, we find the high-level language orientation of computers with manufacturer-independent Pascal, C, ANSI standard FORTRAN, and BASIC languages.

The particular case of the UCSD Pascal system is pioneering a machine independence never before seen in computing. Users are driving the mass-produced computer market, with no single company having dominance enough to dictate styles of languages. The success of UCSD Pascal over the past two years as a machine-independent package available from numerous manufacturers is one of the joys of present-day computing. I can edit, compile, and use the operating system on one machine in a manner identical with my interactions on another machine. I use three different computers with totally different hardware processor designs — yet, with UCSD Pascal, the operating systems are functionally identical, so I do not have to switch personalities constantly.

I have demonstrated with friends that it is possible to send object code produced by the UCSD Pascal compiler to other machines where it will execute and behave the same way. The manner of transportation at the hardware level is sometimes via disk media where compatibility exists, and, where different disk formats are involved, we have transferred files through the means of serial RS-232C compatible data connections.

This Pascal-based system is actively supported by a number of manufacturers, now prominently including personal computer manufacturers Apple and North Star as well as the integrated circuit manufacturer Western Digital. UCSD Pascal is available in versions for DEC PDP-11 minicomputer systems (upon which it was originally developed), CP/M-based 8080 and Z80 systems, Motorola 6800-based systems, and even the Radio Shack TRS-80. On all these diverse hardware configurations — with a working useful criterion of 500 K bytes mass storage, 50 K or more bytes of memory — the same operating system and compilers run, can pass files compatibly between each other, and achieve systems performance sometimes missing from the minicomputers and behemoth computers of today and yesterday.

So with this in mind as the ultimate in off-the-shelf technology, let's summarize: A desirable contemporary personal computer has 64 K bytes of memory, about 500 K bytes of mass storage on line, any old competent designed computer architecture, upper and lowercase video terminal, printer, and high-level languages such as that provided by the UCSD Pascal software system. This is the state of the art in small computing as it stands to date.
A Particular System

The previous discussion of the glowing generalities of our entry into the 1980s with personal computing technologies is only part of the information you need when contemplating a purchase. To provide a concrete example of a particular case, I shall describe the new computer I just bought. First, why did I need a new one? The computer I have been using until recently (a Northwest Microcomputer Systems Model 85/P) executes the UCSD Pascal system, meets all the minimum requirements, and had served me well for nearly a year.

But no computer, however competently engineered, is immune to dumb users like yours truly. As an attempt to get around a relatively minor hardware problem, I managed to plug a terminal into the wrong socket and fry a power supply, possibly worse. After a month of withdrawal symptoms, my frustration level reached such a peak that I had to get another computer. . . . NOW! . . . INSTANTLY! Thus the genesis of this month’s editorial celebrating the existence of off-the-shelf personal computers — when I had the need to get one, a computer was available from a local retailer, and purchased with cash over the counter.

To be sure, I had been contemplating a new computer for some time. I had also been looking into a possible small UCSD Pascal facility for a good friend of mine who desires a computer to handle his local political campaign data processing activities. Thus I had actually priced out a system that was available off the shelf at Bob McGuffie’s Computerland store in Nashua, New Hampshire. The system was an Apple II with UCSD Pascal and assorted peripherals. Then, the frustration level rose to exceed my threshold of action during the weekend of the Philadelphia Personal Computing ’79 show. On Saturday of that week, I called Bob at his store in New Hampshire to firm up an order for a slightly expanded system. The order for the system was placed on October 6. I picked up the system on October 11, with all items except an extra set of read-only memories for a second pair of floppy disk drives. Here is what I am now using to write editorials, write various memos involved with my everyday work, explore miscellaneous uses of personal computing, etc:

Apple II Plus Computer with . . .
UCSD Pascal Option (64 K total memory),
Serial Communications Interface,
Four 5-inch floppy disk drives (2 controllers,
520 K bytes on line),
Parallel Printer Interface,
D C Hayes Micromodem II, and extra phone line.

To this list of equipment should be added an Integral Data Systems Model 440 “Paper Tiger” printer which I had ordered a month earlier with the intention of using as a scratch printer. Also added to this list is a COPS-10 terminal which was manufactured by the Computer Peripheral Corp, of which several were already owned by BYTE. This set of equipment (including the printer but omitting the cost of the COPS-10 terminal) cost only $6000 and, except for two read-only memory parts which arrived ten days later, was delivered off the shelf.

As the Apple Pascal comes delivered, it is oriented
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toward use of the Apple II video display, a 24-line by 40-character display built into the computer. Because of the short line width and uppercase only characteristics of the built-in Apple II display, I do not prefer to use it as a primary UCSD Pascal terminal. This is no great problem because the clever hardware design of the Apple Pascal option and the documentation which comes with the system make it fairly trivial to reconfigure the UCSD Pascal system for operation via any typical terminal. At bootstrap time, the Apple II Pascal system simply checks to see if a Serial Communications card is plugged into slot number 3 of the Apple peripheral bus. If so, it uses that card as the system terminal instead of the built-in Apple display. It of course makes default assumptions about the terminal, but these proved to be adequate to check some major points about the interface. The major technical problem was discovering that my terminal generated a default bit in the wrong state when parity was suppressed, and that its cursor addressing feature did not seem to work. The parity default problem was solved by changing a jumper option in the terminal. The cursor addressing problem was solved by a GOTOXY kludge.

Using the Apple II built-in display as a bootstrapping tool, I was able to run the UCSD system's SETUP program to create a SYSTEM.MISCINFO file for the COPS-10 terminal. This mode of operation also enabled me to write a custom Pascal "GOTOXY" procedure which is used by the UCSD Pascal system to do cursor addressing with the particular terminal involved. It turned out that, as a kludge, I had to do cursor addressing with a "home" followed by a sequence of "cursor down" and "cursor right" operations — a technical point I have not yet resolved. The problem that keeps me from using direct cursor addressing is either the inability of the terminal to understand its documented addressing sequences, or the inability of the compiled GOTOXY procedure to emit the cursor escape character. The kludge gets around the problem temporarily at the price of some cursor movement delays. Listing 1 shows the Pascal code which resulted. Since the program was edited and compiled before I had the terminal attached, it uses uppercase only. As I write these notes the cursor addressing kludge remains in the system, slowing down operation of the UCSD system's screen editor during deletions and cursor positioning.

After getting the terminal to work with default parameters I was able to write a Pascal procedure which is compiled and saved as SYSTEM.STARTUP. When

**Listing 1:** This GOTOXY procedure meets the requirements of cursor control for the UCSD Pascal system, given an Apple II driving a COPS-10 terminal. It uses an inelegant kludge for cursor positioning, one which requires a total of 105 character times to reach the worst case position. Sooner or later it will be replaced when direct cursor control's subtleties are mastered using my terminal. This listing (and listing 2) was produced on the Integral Data Systems Model 440 "Paper Tiger" printer that is attached to the Apple via a parallel printer port. A custom Pascal print utility program is used to transfer files to the printer in formatted form instead of using the system's Filer program.

```
PROGRAM GOTOXY;

PROCEDURE GOTOXY(X,Y:INTEGER);
(# COPS 10 - GOTOXY #)

CONST
HOME = 25;
DOWN = 10;
ACROSS = 12;

VAR
SEND: PACKED ARRAYCO..OJ OF o..2ss;
J, I : INTEGER;

BEGIN
SENDCOJ := HOHE;
UNITWRITEC2,SEND,1J;
IF X>79 THEN X: =79
ELSE IF X<0 THEN x:=o;
IF Y>23 THEN Y:=23
ELSE IF Y<0 THEN Y:=o;
IF Y<>O THEN
BEGIN
SENDCOJ := DOWN;
FOR I := 0 TO Y-1 DO
UNITWRITE(2,SEND,1)
END;
IF X<>O THEN
BEGIN
SENDCOJ := ACROSS;
FOR I := 0 TO X-1 DO
UNITWRITE(2,SEND,1)
END
END

BEGIN ( # DUMMY MAIN # )
END.
```
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Listing 2: This is a first cut at the program SYSTEM.STARTUP, which is executed every time UCSD Pascal wakes up on the Apple II with the COPS-10 terminal. It uses direct addressing of memory through a standard Pascal variant record technique isolated in the procedure “set_memory.” The memory locations directly addressed from procedure “set_up_cops” are the addresses described for various parameters of the Apple II Serial Communications Interface card.

```
PROCEDURE set_up_cops;

CONST
  slot=31
  data_rate_address=1144
  stop_bits_address=1272
  parity_address=1400
  linewidth_address=1784
  data_bits_address=1912
  op_modes_address=2040;

PROCEDURE set_memory(value,address:INTEGER); TYPE
  ptr = INTEGER;
  memory_access=RECORD
    pointer : (a Pointer) ;
    number : (a Number:INTEGER)
  END;
VAR
  anybyte : memory;
BEGIN (set_memory)
  anybyte.a_number := address+slot;
  anybyte.a_pointer := CHR(value)
END;

BEGIN (set_up_cops)
  (...
```

executed, this procedure manipulates the Apple II serial communications port through absolute memory addresses. SYSTEM.STARTUP changes defaults so that the terminal will run at 19,200 bps, its maximum rate. In listing 2, the procedure “set_memory” is used to place arbitrary information in arbitrary memory locations; the procedure “set_up_cops” references “set_memory” in order to set up the hardware specific control locations of the serial port in slot number 3 of the Apple. Reading and learning about these system configuration details took about a weekend of work.

As my deadline for this editorial approaches, I have yet to try out the D C Hayes Micromodem with the system, although I expect it will be quite controllable from Pascal programs — perhaps with a link to a short 6502 assembly-language program if I use the read-only memory routines of the modem card.

The printer quite obviously works, as seen by the sample listings. One of my first application tasks was typing in my 1025-line Pascal print utility program as I had used it on my previous UCSD-based system. Only two language related points worked differently on the UCSD version II.0 Apple as compared to the UCSD version I.5 booted through CP/M. First, I found that the intrinsic procedure PAGE(OUTPUT) did not work on my Apple, possibly due to some problem in my use of the SETUP utility to configure the system for my terminal. Second, I received a syntax error for a statement which had compiled just fine in UCSD Pascal version I.5 and which the version II.0 documentation of Apple implies should work; READ(KEYBOARD, anychar) where “anychar” is a variable declared CHAR. I got around both these problems by using the UCSD-specific intrinsic procedure UNITWRITE and UNITREAD, respectively.

This Apple II system with UCSD Pascal demonstrates that the state of the art in small computers is powerful indeed. I was able to walk into a computer store and purchase a full-fledged machine with mass storage, lots of memory, a good high-level language, operating system, and printer. At $6000 this fits the bill of being personally affordable yet possessed of those features which make for a complete computer system. Of course there are other computers which are functionally equivalent to this Apple II system. I use its purchase as an example of what the state of the art is at present — a concrete example of my “ideal” abstraction of a personal computer cast into a specific and eminently useful form as a mass-produced product.

**Note:**

You may have noticed that the familiar “In This BYTE” page is missing from this issue. We have integrated the information from that page into the “In The Queue” page so that readers do not have to repeatedly flip between these corresponding pages.
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What Computers Cannot Do

T. G. Lewis
Computer Science Department
Oregon State University
Corvallis OR 97331

Rapid advances in computing, resulting from the microcomputer revolution, are surprising even experienced computer professionals. A single integrated circuit microprocessor can perform the same number of computations per second as the expensive, large-scale computer of ten years ago. Yet, in a technical sense, both the type of computer and the things that computers are used for seem to have changed very little in the last ten years.

Ten years ago, BASIC was used in a manner similar to that of today, except that more people are now using it. Ten years ago computers had registers and memories to perform calculations; today register and memory costs have decreased fantastically. The cost of computing has declined, making it available to almost everyone. But has computing itself changed?

Can computers do any more today than they could ten years ago? Has there actually been any progress made in computing since Babbage’s Analytic Engine, one hundred years ago?

What is meant by progress, and what is meant by computing? If progress is measured by the number of computers sold, the impact on society, or the size of the computer industry, then something has certainly increased and something else has decreased. What effect computers have had on our society is a moot question indeed, but one that I leave for another philosopher.

If computing is measured in terms of the number of machine cycles executed this year as compared to last year, or in terms of the number of programs written, then something has again increased and perhaps something else has decreased (like size or cost). But this kind of reasoning misses the point.

The essence of computing centers on two fundamental questions: (1) what exactly is computable, and (2) is it possible to compute more today than ten years ago? If these two questions can be answered, I believe that we can determine if progress has been made, whether this progress is due to microcomputers or their dinosaur ancestors, the maincomputers.

Back to Games

Suppose a simple game called Look is played. Look is so trivial that it is easily played by any low intelligence animal. In fact, Look may be played by a simple machine.

A 4 by 4 grid of squares is arranged as shown in figure 1. A piece of cheese is placed in one of the squares and a mechanical mouse robot (R) is placed in any other square. The object of the game is for R to find C.

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A 4 by 4 grid of squares is arranged as shown in figure 1. A piece of cheese is placed in one of the squares and a mechanical mouse is placed in any other square. The mouse is a robot designated by “R”; the cheese is represented by “C.” The objective is for robot R to find cheese C. The game immediately poses a problem for robot designers, for they must program R to find C without outside help. How is R instructed to locate C?

The first area of concern is the simplest program for R. If it is impossible to solve the robot programming problem in a simple manner, a sophisticated solution will probably fail.

Suppose R is designed to move one step in any of directions North, South, East and West. This is called a step action, and the direction is designated by writing STEP W for a single step in the western direction, for example.

Clearly, the robot must know when it has encountered a barrier (wall) and when it has found the cheese. Hence, mouse R is also empowered with a sensor that sets a condition code. Codes Barrier and Found are set by sensors on board R.

The STEP and condition code designs are a start toward a working mouse. They allow the robot to move

About the Author

Dr. Lewis is an Associate Professor of Computer Science at Oregon State University, where he lectures on software engineering and personal computer systems. He is the author of How to Profit from Your Personal Computer and The Mind Appliance: Home Computer Applications.
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one square in any compass direction, detect a barrier, or locate the cheese. Surely radar or any other sophisticated tool is not needed to solve the Look problem.

Sit back and watch R move one square at a time after each command it is given. Recall, however, that Look is a game played only by a mechanical mouse without human intervention; R is a robot. A robot can be defined as follows:

Robot: Any device that operates without direct human control.

By this definition, a wall clock is a robot because it keeps time independently of direct human instruction. An automobile, however, must have direct contact with a human in order to operate.

The Look mouse must be given a brain with enough intelligence to find its own way from one square to another. This is where the concept of computing arises.

The Concept of Computing

A robot that acts without direct human guidance must possess two types of control: (1) basic actions and (2) intrinsic control for sequencing basic actions. The following two sets are chosen in keeping with the simplest possible design:

**ACTIONS:**
- STEP X, set condition code, BARRIER, FOUND, NOT FOUND, and START, STOP, where X is N, W, E, S.

**CONTROL:**
- simple sequence of a collection of actions, looping of actions, decision (branch) capability.

These actions and control are programmed into R through some yet to be determined mechanism. A pseudolanguage will be used to illustrate the programs in this article, but it is important to remember that every programming language for every computer known to the author has at least the three control constructs listed above; that is, it is conjectured that the intelligence being given R is no more than the intelligence of very simple computers. This leads to the following hypothesis:

**Hypothesis 1:** Any robot mouse with the actions and control given to R can be programmed to solve the Look problem.

It is possible to go even further with this hypothesis and claim that the solution to the Look problem is indeed possible. Possible means that a path from the starting location of R to the square occupied by C exists and is computable:

**Hypothesis 2:** Any path leading to C from R is a computation, and furthermore, any machine with the properties of R is able to perform such a computation.

There is now a concept of computing. For the game of Look, a computation involves finding a path. A function is a set of operations that tries to calculate a computation.
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"... but the really impressive stuff is in the back room."
A function is computable if R can get to C, and a function is undecidable if there is a possibility that R will fail to reach C.

Programming a Function in Look

Now an attempt is made to build a robot R that finds its way to C. The first attempt is again a simple approach to the problem. Suppose R is instructed to go West until reaching a barrier, then another direction is chosen and it continues to travel in that direction until reaching a barrier, and so on. Such a program might look like the pseudolanguage program shown in listing 1.

Of course, this program does not solve the Look puzzle. It may correctly locate the cheese C if C is in a boundary square (see figure 2). The problem is that C may or may not be in a square along the circular path established by program CIRCLE. Hence, it is undecidable whether or not CIRCLE computes a path leading to C.

The intelligence of R must be increased in order to guarantee a computable path (as opposed to an undecidable path). Clearly, the problem with CIRCLE is that it fails to cover every possible square. How can no square be left uncovered?

A second simple program (see listing 2) is attempted that exhaustively scans every possible square until it locates C. Lines 200 thru 220 move R to a left side square. The program must cover every square, but since R may be initially placed anywhere within Look, a starting point must be established that guarantees an exhaustive scan of the sixteen squares. This is done in lines 230 thru 250.
R is now in the proper lower left position to begin looking for C by systematically visiting every square. This is done by moving N after every E or W BARRIER is found as shown in figure 3.

This version of the program for R illustrates two conceptually important features. Indeed, this program is called an **algorithm** because (1) it will systematically carry out the basic actions in a deterministic (predictable) manner every time it is executed, and (2) it will reach a STOP statement every time it is run. The question remains, however: will this program (algorithm) find C every time?

**Looking for C**

The program for exhaustive search lacks a certain elegance. For example, the sophistication of R could be increased to add subroutine capability:

```
SUBROUTINE MOVE: (X, Y)
1000   REPEAT LOOP
1010   STEP X; IF FOUND THEN STOP;
1020   UNTIL Y BARRIER;
1030   RETURN
```

This would reduce program size and complexity by using pieces of the program iteratively. Such an improvement may benefit a programmer or reduce the cost of building robots, but does nothing to improve the concept of computing.

The EXHAUST program becomes easier to understand and write when additional control is supplied. However, the addition of subroutines, interrupts, and other sophisticated features does nothing to increase the computational power of robots. This is an important fundamental concept:

**Hypothesis 3:** Every function that can be computed, can be computed by a robot with only three control operations: (1) sequence, (2) looping, (3) conditional branching.

If true, this means that every solution to the Look puzzle is possible with the simple machine designed here. There is no path through Look that cannot be computed with the power of robot R. Does this mean that every computation in Look is computable by R? In this specific game, the answer is yes. We have not proven the above hypotheses, but they can be supported by evidence.

**What Are the Limits?**

What is not computable, if such a simple machine (R) is able to compute every function in Look? (This corresponds to finding every path from R to C.) If internal barriers are added to Look as shown in figure 4, does R need more power? The answer is no. A larger, more sophisticated program may be required, but it can be constructed from the same simple building blocks as before.

Suppose that an attempt is made to fool robot R by removing C entirely (see figure 5). What becomes of algorithm EXHAUST? Reexamination of the algorithm shows that the program eventually halts when every square has been searched by R at least once. The STOP action executed when C is located is a different STOP than the one executed when C is missing from the game.
Heuristics

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Figure 6: A heuristic technique for finding C. The programmer has assumed that C is more likely to be found in the center squares, and has thus accelerated the search at the expense of an occasional failure.

board. Can it be known which stop is executed when EXHAUST halts?

Suppose lines 210, 240, 280, 300, 320, 340, and 360 in listing 2 are modified to display the condition code setting when a STOP is executed. Then when the robot halts, the condition code can be examined to see if it says FOUND or NOT FOUND.

Indeed, R can be built cleverly enough so that it stops and informs you of its condition. This requires that R eventually stop. When it stops, it is asked whether or not it has found a path to C. This leads to another important concept in computing:

The Halting Problem: A robot that computes an algorithm must eventually halt. If a robot tries to compute a function (i.e., find a path) that does not guarantee the termination of its search, the robot is computing an undecidable function.

Normally, undecidable functions are avoided in computing. Often, however, the risk of encountering a non-terminating search is not great, and thus the rules can be relaxed to speed up the robot. For example, suppose that the EXHAUST algorithm is replaced by a faster heuristic. That is, the search strategy is changed as follows: the exhaustive search procedure is too slow. Its speed can be increased by increasing the robot’s speed (technological improvement in equipment), or by decreasing the search space (eliminating the number of squares considered). Perhaps the cheese is in the central squares most of the time. If so, a nearly perfect batting average can be obtained by searching the middle four squares only. Figure 6 suggests one possible heuristic for computing a path to C.

Perhaps the “four-square” heuristic will locate C, perhaps not. This approach may seem too casual, but interestingly enough, much of the software in contemporary systems is of this nature. That is, many programs are heuristic in nature rather than algorithmic, because they have reduced their search space to only the most probable paths. One way of defining a heuristic is as “a procedure for finding the solution most of the time.”
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Hypothesis 4: Many computer programs are heuristic in nature because they do not satisfy the halting problem, or do not cover the search space of solutions.

More has been required of the little robot than is required of real computer programs. Thus, R is a good model of what machines can do. Still, there must be something R cannot compute. In fact, there is: R cannot construct. GR is basically like R, except GR solves a problem called DECIDE. This new game is played as follows: the instructions for a program written in robot R’s language (eg: the EXHAUST problem) are given GR as its inputs. Thus, GR plays the DECIDE game on a program instead of a checkerboard. GR is smart enough to interpret the instructions directly and to determine the halting condition of R.

Let us assume that the EXHAUST program is given to GR. GR interprets EXHAUST and, when it reaches a STOP, announces that R has halted. Further, GR announces HALT NOT FOUND or HALT FOUND, depending on the condition code setting of R. In fact, GR is a general robot because it can interpret programs for other robots. In a sense, GR can simulate R because it can interpretively execute any program which can be written for R:

Hypothesis 5: Any machine GR that can simulate a robot of the power of R is a universal robot. A universal robot is limited in its power, being able to compute only computable functions.

Can a problem be found that is too difficult for GR? It would be interesting to discover if such an uncomputable function exists. GR is quite similar to real computers. For example, an Intel 8080 could be simulated on a Motorola 6800 to perform the functions of a universal robot. Thus, if problems too difficult for GR are discovered, they will also be too difficult for the Intel 8080, Motorola 6809, IBM 370, CDC 7600, or Cray-1!

The Halting Problem Revisited

It was stated earlier that the GR machine can interpret any program and decide whether or not it halts. To be more precise, however, a GR robot cannot in general decide whether an arbitrary program from R’s library of programs will halt or run forever. Notice the emphasis on any arbitrary program. A specific program can be examined and it can be determined that it will halt. This was done for the EXHAUST program. However, a decide algorithm is being sought that can be written before any program from R is tried. Thus, the DECIDE program must be smart enough to handle any program it is given. This is where the problem appears. Suppose a program is written in the language suggested earlier for R. This language made R powerful enough to compute anything that robots can compute. Thus, the DECIDE algorithm can be written in this language. The DECIDE algorithm is loaded into a mouse just like R, and it becomes super-mouse GR. Now GR can decide whether or not a given program halts and, if so, whether or not the arbitrary program being interpreted has found its solutions. If it is shown that at least one program exists for which GR fails, then the DECIDE algorithm is undecidable (ie: it is not an algorithm). In fact, there is such a program.

If the DECIDE program itself is input into GR, a paradox is created for GR. If it executes to a STOP action and announces a HALT FOUND termination, the DECIDE program has succeeded. If, on the other hand, GR reaches a STOP and announces HALT NOT FOUND, then GR must itself have reached a NOT FOUND condition. This, however, is impossible, because GR cannot reach a FOUND termination point within the loaded DECIDE algorithm at the same time it reaches a NOT FOUND termination point within the interpreted DECIDE algorithm. Therefore, the DECIDE problem is unsolvable and is, in short, a problem no computer can compute:

Hypothesis 6: The general halting problem is undecidable. This is an example of a problem computers cannot solve.

After that mind twister, it may be argued that such a problem is of no practical significance. Unfortunately, the halting problem is completely analogous to several important practical problems in computing. Here are a few:

Hypothesis 7: A robot GR that can test any other robot R to determine if R is malfunctioning is impossible to build.

Hypothesis 8: A robot GR that can examine any other robot and determine if R is secure (impenetrable by a team of spies) is impossible to build.

Hypothesis 9: A robot GR that can examine a programming language robot R and determine if it is without ambiguity is impossible to build.

In essence, it has been illustrated that computers have their limits regardless of their size, speed, number of registers, or sophisticated instruction sets. This notion is summarized in the next hypothesis:

Hypothesis 10: Progress in computing has led to microcomputers and circuits that still cannot solve the same problems that earlier computers could not solve.

In other words, computing has advanced in a technological sense only, and not in a conceptual sense. The limitations of computing remain the same: the power of computing is the same. All computers do essentially the same thing. Some are easier to program because they have high-level instructions. Some are faster because their organizations are more efficient. However, the fundamental problems of computing remain.

Difficult Problems

Fable: An old man was about to send his son into the world to travel. He bent over and wheezed into his proud son’s face, ‘Hear me well, son. The world has
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Can be applied to solving a problem that it is possible to solve. EXHAUST is a blunt approach to computing a path from R to C. The easiest way to compute the location of C at hand. Therefore, if the complexity of the problem can be determined, a program can be designed that is no more complex than the problem. Is this possible?

An algorithm need be only as complex as the problem at hand. Therefore, if the complexity of the problem can be determined, a program can be designed that is no more complex than the problem. Is this possible?

The EXHAUST problem is actually rather uncomplicated. Suppose that initially the cheese is in any square. If there are S squares, the cheese can be in any one of (S-1) squares with probability 1/(S-1). The average number of steps for R to compute along the EXHAUST trail is the average of 1 + 2 + 3 + ... + (S-1):

\[
\text{AVERAGE} = \sum_{i=1}^{S-1} \frac{\text{STEPS}}{i+1} = \frac{S}{2}
\]

Hence, the average number of steps to find C is half the total number of squares in Look.

The problem can be more difficult if C is located at the worst possible location (e.g., at (S-1) steps from robot R). This is called the worst case complexity of Look, or SWORST = (S-1). In either the average or worst case condition, the EXHAUST algorithm will complete in a number of steps proportional to S. The complexity of Look is O(S). Since S is a straight line when plotted on graph paper, the Look puzzle is called linear.

Hypothesis 11: Linear problems are easy, polynomial problems are more involved, and exponential problems are difficult.

Suppose the Look problem is modified to a more realistic situation. Try to trace the roots of your family tree back to 1600 AD. A great-great ... great-grandparent is given as a target (C). You must trace your father or mother first, then their father or mother, etc. If your ancestors never practiced incest, remarried, etc, you will have to compare at least 2^R ancestors to find the shortest path back to your roots, where R = number of generations.

The roots problem is difficult because of the exponential growth in the computation. Thus, an exponential problem is hard.

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*Apple II is a trademark of Apple Computer, Inc.
The traveling salesperson problem. A salesperson wishes to visit all six cities in a given district, once every month. The problem is to compute the shortest path that goes through each city only once.

Figure 7: The traveling salesperson problem. A salesperson wishes to visit all six cities in a given district, once every month. The problem is to compute the shortest path that goes through each city only once.

This raises some philosophical questions for the future. For example, is the functioning of brain cells a complex problem? If so, is the path established by a thought process representable as a computable function? Even if thought is a computable function, it might also belong to the class of NP-complete problems, and thereby be difficult for computers to handle.

Conclusion

In summary, we must be realistic about the power of computers. There are functions that no computer can compute, and there are functions that require impressive performance to manage. The current crop of microcomputers is no more able to compute a solution to problems than computers of a decade ago. Programmers may, however, have learned new ways to apply computing power in the interim.

On the optimistic side, many practical problems remain to be solved in our society. Computers can help solve them and, due to the microcomputer revolution, there is an opportunity to economically apply this technology to the real world. Along the way, do not forget the limits to computing.
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INTEL 32-BIT MICROPROCESSOR RUMORED: As reported in this column last April, Intel was rumored to be working on a 32-bit microprocessor. The project is moving closer to reality as Intel has assigned a part number to the device. It will be called the 8800 (not to be confused with the Altair 8800 computer). The instruction set will not be compatible with Intel's 8-bit or 16-bit microprocessors. The device will be housed in the new 64-pin QUIP (quad-in-line package, see "BYTE News," June 1979) which is cheaper, smaller, and easier to test than dual-in-line packages. The 8800 is reportedly being developed at Intel's facility in Aloha OR. The first test prototypes are reported to have been produced.

TI RF MODULATOR FCC WAIVER GRANTED: The Federal Communications Commission (FCC) has granted Texas Instruments a waiver which permits TI to connect its personal computers to color television receivers using a radio frequency (RF) modulator. TI originally petitioned the FCC for approval of the RF modulator system in February 1979. The petition was rejected since the regulations required that the complete system be submitted for approval: TI submitted only the RF modulator for approval. Subsequently, Texas Instruments applied for a waiver, provided that the modulator unit met the standards.

The FCC asked other personal computer system manufacturers to comment on the TI request. Radio Shack, Apple Computer, Commodore, Mattel, and Atari responded negatively to the request. Apple, Atari, and Mattel went to great expense to comply with the FCC regulations. The Radio Shack and Commodore systems, which contain integral displays and do not use RF modulators, do not come under the FCC regulations.

The FCC decision further waives testing by the FCC and merely requires that the manufacturer provide the FCC with test results showing compliance. In a related action, the FCC relaxed the standards on RF interference generated by commercial and personal computer systems.

Several personal computer manufacturers that compete with TI have already stated that this waiver will give TI a competitive advantage. Furthermore, several firms publicly questioned the FCC's rule-making methods in making its decision. The likelihood now is that the other personal computer makers will offer systems with RF modulators. It will probably take these manufacturers at least a year to bring out such competing systems.

ULTRA MINI-FLOPPY DRIVE INTRODUCED: Sanyko Seiki Manufacturing Co, Tokyo, Japan, has begun producing samples of an ultra-small floppy disk drive and controller. Called the FMC-100, it uses a 2-inch floppy disk that stores 8 K bytes on one track. It is intended for use in word-processing typewriters and personal computer systems.

THWARTING COMPUTER SOFTWARE PIRATING: A patent (number 4,168,396) has been issued to Robert M Best, Seattle WA, for a "microprocessor which prevents the piracy of computer programs." The device reportedly uses cryptography to protect the software. It is called a crypto-microprocessor and stores software in cipher to prevent it from being copied, disassembled, or altered by unauthorized processes. Authorized users can decipher the software with special encryption keys. The patent states that the device is intended primarily for use in personal computer systems.

AC LINE TO TTL INTERFACE IC INTRODUCED: General Instrument Optoelectronics of Palo Alto CA has introduced a low-cost, 8-pin integrated circuit that can be used to directly monitor AC power line circuits and provide transistor-transistor logic (TTL) outputs. The device, therefore, can be used to interface your microprocessor inputs easily and directly to monitor AC power-line-operated devices such as motors, solenoids, relay contacts, and the like. It can also be used to detect power failure and other such applications.

FLAT PANEL TERMINAL DISPLAYS BECOMING AVAILABLE: Computer terminals using flat-screen video displays are getting close to the marketplace. The technology is based on the plasma panel developed by Owens-Illinois, Toledo OH, in the late 1960s. Currently, Interstate Electronics of Anaheim CA, IBM, and Fujitsu have these panels in production. Control Data and NCR are planning large-scale production. IBM now makes approximately 100,000 plasma panels annually, which...
are all used in-house. Interstate Electronics currently sells a plasma display terminal that has a 512 by 512 matrix of dots and can display alphanumeric characters and graphics.

Plasma panel makers are working on getting the cost down to the point where these displays can compete with cathode-ray tube (CRT) displays. This is still expected to take several more years.

**RANDOM RUMORS:** IBM will soon unveil small business (Model 5105) and multiterminal (Model 5130) computers in their 5100 line of microcomputers. The 5105 computer will begin at $4500 and the 5130 will range from $21,500 to $37,500. The basic 5105 will include 16 K bytes of programmable memory, a 960-character video display screen, a magnetic tape cartridge, and a thermal or electrostatic printer. Increasing memory up to 96 K bytes, adding a 1920-character screen, floppy disks, and high-speed printer, and including software packages will raise the 5105 price up to $20,000. It is expected that the 5105 will penetrate the personal computer market to some extent even though it is intended to be an entry-level business computer system . . . . IBM is also rumored to have an intensive research and development effort trying to develop a low-cost alternative to the cathode-ray tube (CRT) screen display. Reportedly they are currently investigating 24 different alternatives. At this time, the most promising is the multiplexed liquid-crystal display . . . . It is rumored that a Japanese electronics company will shortly introduce a $600 personal computer system that is hardware and software compatible with the Radio Shack TRS-80 (Level-II BASIC, 16 K version) . . . . By the end of 1979, over 2,500,000 floppy disk drives had been manufactured.

**64 K EPROMS AVAILABLE BY MID-YEAR:** Samples of 64 K bit erasable-programmable read-only memory (EPROM), organized as 8 K words by 8 bits, are currently being distributed to customers by Motorola, and production quantities are expected to be shipped by the end of the second quarter of 1980. Motorola has put their 64 K EPROM in a 24-pin package by multiplexing the program supply and chip-enable signals on the same pin. Intel and Texas Instruments, it is believed, will use 28-pin packages for their 64 K EPROMS.

In the meantime, the supply of 2708 EPROMS (1 K words by 8 bits) has caught up to demand and prices are now in the $6 range. The demand for the 2716 EPROM (2 K words by 8 bits) is still very strong, and hence the devices are selling in the $20 to $24 range.

Texas Instruments is currently the largest manufacturer of EPROMs with about 38% of sales. Intel is second with 29%. Fujitsu and Hitachi share third place with 8% each.

**AT&T RUNS INTO TROUBLE WITH UNIX:** The Association of Data Processing Service Organizations (ADAPSO) has petitioned the US Department of Justice to take action against AT&T's sale of software products, particularly the UNIX operating system. UNIX is one of the most popular software systems for larger Digital Equipment Corp (DEC) PDP-11 machines. Most users feel that UNIX is better than DEC's software.

ADAPSO maintains that AT&T is in violation of a 1956 consent decree. In 1978 the Justice Department authorized an investigation after a similar petition by the Computer and Communications Industry Association (CCIA).

Developed at Bell Laboratories in 1969, UNIX was offered to non-Bell organizations starting in 1973, for $20,000 per computer. In the first half of 1978, Bell reported $580,000 revenues from about 800 non-Bell users.

Whitesmiths Ltd, a New York software house, is currently working on an LSI-11 version of UNIX.

**IBM and MCA TO MARKET VIDEO DISK:** IBM and MCA Inc have formed a joint venture, called Discovision Associates, to develop, manufacture, and market video disks and players. Until now, MCA has been the sole manufacturer of optical video disks. It is hoped that this will broaden the use of video disk technology in the home entertainment, industrial education, and information fields. The optical disk technology, which uses a laser to record and play back the recorded material, shows promise for use in the computer field. It could be used to store large amounts of read-only digital data in much more compact form than presently is possible on magnetic disks. North American Philips is also marketing a video disk player and RCA plans to introduce a system soon.

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

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. . . Feel Free to Mix and Match

**SYSTEM 1**

<table>
<thead>
<tr>
<th>Item</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Twin Mini W/32K</td>
<td>$1750.00</td>
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<tr>
<td>Leadex Monitor</td>
<td>$139.00</td>
</tr>
<tr>
<td>Keyboard</td>
<td>$110.00</td>
</tr>
<tr>
<td>Base 2</td>
<td>$499.00</td>
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**SYSTEM 2**

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<td>32K S-100 Mainframe</td>
<td>$1650.00</td>
</tr>
<tr>
<td>T/V 912 Terminal</td>
<td>$775.00</td>
</tr>
<tr>
<td>Ti 810</td>
<td>$1750.00</td>
</tr>
<tr>
<td>1 Megabyte Double Density Storage</td>
<td>$1350.00</td>
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**SYSTEM 3**

<table>
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<td>64K S-100 Mainframe</td>
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<td>T/V 920 Terminal</td>
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</tr>
<tr>
<td>Diablo 1620</td>
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<tr>
<td>2 Megabyte Quad Density Storage</td>
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**SYSTEM 4**

<table>
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<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desk Enclosure</td>
<td></td>
</tr>
<tr>
<td>32 Megabyte Disk</td>
<td></td>
</tr>
<tr>
<td>AT&amp;T Model 300</td>
<td></td>
</tr>
</tbody>
</table>

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- CBASIC: $115.00
- MBASIC: $300.00
- FORTRAN: $395.00
- COBOL: $625.00
- PASCAL: $265.00
- WORDSTAR: $495.00
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Indirect Addressing for the 6502

Kenneth Skier
25 Myrtle Ave
Cambridge MA 02138

One of the most attractive features of the 6502 processor—in fact, of the entire 6500 series—is the flexibility offered by its thirteen addressing modes. Unfortunately, these addressing modes are not always available when you want them. Indirect indexed addressing, for example, is available for load and store instructions (and a few others), but not for jump to subroutine (JSR).

A structured approach to programming leads one to write many programs as nested subroutines, and it is not always desirable for the programmer to specify the addresses of those subroutines in advance. For a given application, you may want the user to choose the address of the next subroutine that the processor will execute, or you may want software to calculate or look up that address, perhaps in response to sampled input conditions. In either case, you need indirect addressing for the jump to subroutine instruction.

In the 6502, the jump to subroutine instruction has only one addressing mode: absolute. So how can you get what the 6502 does not have?

One solution is to use the jump to subroutine instruction (JSR, hexadecimal 20) in your program, and follow it with two reserved bytes (i.e., when you write the program, you do not care what is in those two bytes). The rest of your program follows those two bytes. When your program runs, it will ask the user to specify the address of the next subroutine, or else it will look up or calculate that address according to some algorithm. It will then store that address in the two reserved bytes mentioned earlier (low byte first). When the 6502 processor executes the JSR instruction, it will use the next two bytes for the address of the subroutine it is supposed to execute.

This technique will work, but I avoid it for several reasons. First, it requires writing a program that modifies itself, and a simple error in such a program can cause it to self-destruct or subtly deface itself, not something I would look forward to debugging. Second, such a program may work fine in programmable memory, but it cannot work in read-only memory. The third reason is the clincher: this technique is unnecessary. You can have a program execute a subroutine and calculate or look up its address without requiring that it modify itself.

What is the solution? Use the zero page.

Set aside four consecutive bytes in the zero page of memory. The first part of your program, which presumably initializes I/O (input/output) ports, variables, flags, table pointers, etc, will write a hexadecimal 20 (JSR) into the first of these zero-page bytes, and a hexadecimal 60 (RTS) into the fourth of these zero-page bytes. (It need not do anything to the second and third bytes.) When it is time for your program to select the address of a subroutine and then perform a subroutine jump to that address, have your program calculate or look up the subroutine’s address and then store it, low byte first, in the second and third zero-page bytes mentioned above.

Now your program can jump to a fixed address: the address of the first of these four zero-page bytes. Upon arrival at the zero page, the processor will perform a subroutine jump to a new address: the address it previously looked up or calculated. When it finishes executing that subroutine, it returns to the fourth of the zero-page bytes, which tells the processor to return to the program that called it. In practice your program jumps to a subroutine with a fixed address, whereupon it jumps to a subroutine with a calculated address. In effect, however, you get indirect addressing for the JSR instruction.

The effect can be impressive.

Using this technique, you can display an address, then let the user
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change that address or execute it as a subroutine. It is an effective way to give a GO function to a read-only memory monitor. I have discovered many other applications for this technique in system software and applications programs.

Using this technique, your program can jump to the Xth subroutine in a table: the table would simply be a list of the addresses of eligible subroutines. Assuming that the beginning of your program initialized the first and fourth of the zero-page bytes (to hexadecimal 20 and 60, respectively), your program might look like listing 2.

This technique works quite nicely, but why go to all of that trouble each time you want to call a subroutine? Listing 3 shows a subroutine named CALL SUBROUTINE (X). The programmer need only load the X register with the number of the desired subroutine, and call CALL SUBROUTINE (X). (See listing 4 for a program segment that does just that.)

In other words, you can call a subroutine by a name that you've given it, rather than by its explicit address. To relocate any such subroutine, you need only change its address in the table of subroutine addresses; the routines that call it need not be changed in any way.

Here is one last point. You do not have to put the four bytes (20, XX, XX, 60) in the zero page; you can put them anywhere in programmable memory. However, putting them in the zero page lets your program operate on the second and third of these bytes (that is, on the subroutine's address), with the zero-page addressing mode available on many other instructions. Thus, by putting those four bytes in the zero page, you can make your overall program shorter (and probably faster) than it would be if you put those bytes elsewhere in programmable memory.

Incidentally, this technique may be used for any instruction, not just for JSR. To achieve such indirect addressing for other instructions, do not write a hexadecimal 20 in the first byte; write the op code for the instruction you want to execute. (Be sure that your program follows that op code with the appropriate one or two byte operand, and that your program writes a return [RTS, hexadecimal 60] in the byte following that operand, or your program, like

Charlie on the MTA [a legendary subway passenger...RSS], may never return.) In any case, the program that calls this function must do so by executing a subroutine jump to the first of these zero-page bytes, even if those zero-page bytes do something other than call a subroutine.

Listing 1: A program to initialize the zero-page bytes.

<table>
<thead>
<tr>
<th>Instruction</th>
<th>Address</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LDA #520</td>
<td></td>
<td>Write JRS</td>
</tr>
<tr>
<td>STA zero page byte #1</td>
<td></td>
<td>RTS into zero page</td>
</tr>
<tr>
<td>LDA #60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>STA zero page byte #4</td>
<td></td>
<td>remainder of initialize routines</td>
</tr>
</tbody>
</table>

Listing 2: The indirect addressing method discussed can be used to jump to one subroutine in a table of subroutines. If the start of the program initializes the first and fourth of the zero-page reference to a jump to subroutine (JSR) command and a return (RTS) command, the coding for using the table might look as above. Note that "Zero Page Byte #3" does not mean address 0003; rather it means the address of the third of the zero-page bytes referred to in this article.

<table>
<thead>
<tr>
<th>Instruction</th>
<th>Address</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LDA TABLE, X</td>
<td></td>
<td>Look up address</td>
</tr>
<tr>
<td>STA zero page byte #2</td>
<td></td>
<td>of Xth subroutine</td>
</tr>
<tr>
<td>INX</td>
<td></td>
<td>and copy that</td>
</tr>
<tr>
<td>LDA TABLE, X</td>
<td></td>
<td>address into the</td>
</tr>
<tr>
<td>STA zero page byte #3</td>
<td></td>
<td>zero page</td>
</tr>
<tr>
<td>JSR zero page byte #1</td>
<td></td>
<td>Execute that subroutine</td>
</tr>
<tr>
<td>RTS</td>
<td></td>
<td>remainder of program</td>
</tr>
</tbody>
</table>

Listing 3: Routine to create subroutine call using zero-page addresses.

<table>
<thead>
<tr>
<th>Instruction</th>
<th>Address</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LDA TABLE, X</td>
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<td>STA zero page byte #2</td>
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</tr>
<tr>
<td>INX</td>
<td></td>
<td>and copy that</td>
</tr>
<tr>
<td>LDA TABLE, X</td>
<td></td>
<td>address into the</td>
</tr>
<tr>
<td>STA zero page byte #3</td>
<td></td>
<td>zero page</td>
</tr>
<tr>
<td>JSR zero page byte #1</td>
<td></td>
<td>Execute that subroutine.</td>
</tr>
<tr>
<td>RTS</td>
<td></td>
<td>Return to caller.</td>
</tr>
</tbody>
</table>

Listing 4: Shorter program segment to simulate an indirect subroutine jump.

<table>
<thead>
<tr>
<th>Instruction</th>
<th>Address</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LDX subroutine #</td>
<td></td>
<td></td>
</tr>
<tr>
<td>JSR CALL SUBROUTINE (X)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>remainder of program</td>
</tr>
</tbody>
</table>
These books will help you code, assemble, link, load, relocate, and debug your 6800 assembly language programs. Each book includes complete source code, object code in hexadecimal format, and machine readable (PAPERBYTE) bar code listings, to make entering and modifying the programs as easy as possible.

Tracer: A 6800 Debugging Program is for the programmer looking for good debugging software. Tracer features single step execution using dynamic break points, register examination and modification, and memory examination and modification. This book includes detailed Tracer program notes and a reprint of "Jack and the Machine Debug" (from the December 1977 issue of BYTE magazine).
Authors: Robert D. Grappel & Jack E. Hemenway

MONDEB: An Advanced M6800 Monitor-Debugger has all the general features of Motorola's MIKBUG monitor as well as numerous other capabilities. Some of the command capabilities of MONDEB include displaying and setting the contents of registers, setting interrupts for debugging, testing a programmable memory range for bad memory locations, changing the display and input base of numbers, displaying the contents of memory, searching for a specified string, copying a range of bytes from one location in memory to another, and defining the location to which control will transfer upon receipt of an interrupt.
ISBN 0-931718-09-0 Pages: 72 Price: $8
Authors: Robert D. Grappel & Jack E. Hemenway

Tiny Assembler 6800, Version 3.1 is a small (4K) but sophisticated and useful assembler for a large subset of the Motorola 6800 assembly language. The book includes detailed notes on the design and implementation of Version 3.0 of the assembler, a complete description of the enhancements upgrading the Tiny Assembler to Version 3.1, an updated user's guide, and complete listings for both versions, making this book the most complete documentation possible for Jack Emmrich's Tiny Assembler.
Author: Jack Emmrichs

RA6800ML: An M6800 Relocatable Macro Assembler is a two pass assembler for the Motorola 6800 microprocessor. The Assembler can produce a program listing, a sorted Symbol Table listing and relocatable object code. The object code is loaded and linked with other assembled modules using the Linking Loader LINK68. There is a complete description of the 6800 Assembly language and its components. Each major routine of the Assembler is described in detail, complete with flow charts and a cross reference showing all calling and called-by routines, pointers, flags, and temporary variables. In addition, details on interfacing and using the Assembler and error messages generated by the Assembler are included. This book provides the necessary background for coding programs in the 6800 assembly language, and for understanding innermost operations of the Assembler.
Author: Jack E. Hemenway

LINK68: An M6800 Linking Loader is a one pass linking loader which allows separately translated relocatable object modules to be loaded and linked together to form a single executable load module, and to relocate modules in memory. It produces a load map and a load module in Motorola MIKBUG loader format. This book provides everything necessary for the user to easily learn about the system, including a detailed description of the major routines of the Linking Loader, including flow charts. While implementing the system, the user has an opportunity to learn about the nature of linking loader design as well as simply acquiring a useful software tool.
ISBN 0-931718-09-0 Pages: 72 Price: $8
Authors: Robert D. Grappel & Jack E. Hemenway

Circle 35 on inquiry card.
How would you like to have your computer dial a seven-digit telephone number in about 3/4 of a second? For a small investment in hardware components and construction time, your personal computer can dial a telephone number faster than you can say that number. This article describes the construction and operation of a dual-tone multiple-frequency (Touch Tone) dialing device that interfaces with an ASCII computer terminal and can be used for automatic telephone dialing.

Many practical applications can be designed around an automatic dial feature, but the most obvious is a personal telephone directory. In such a system, a list of frequently dialed telephone numbers and associated names is displayed on the computer terminal. The user selects the number to be dialed by entering a single corresponding character on the computer keyboard (see table 1). A feature that could be incorporated is an option to redial the last number dialed, which would be useful for reaching busy numbers.

Assuming that you have a microprocessor and an ASCII terminal, the additional hardware that is required can be constructed for less than $20. Furthermore, this Touch Tone interface does not require its own I/O (input/output) port, the telephone can be used both automatically and manually, the programming is relatively simple, and either a Touch Tone or rotary-dial telephone can be utilized. \[Note that the telephone exchange to which the line is connected must be capable of interpreting Touch Tones. Some telephone systems (such as those in Peterborough NH) still cannot use Touch Tone dialing....RSS\]

**Touch Tone Interface**

A block diagram of the hardware is shown in figure 1. Note that communication with the Touch Tone device is established through the terminal. Specifically, the computer generates tones by sending certain characters to the terminal. Since most ASCII codes have predesignated meanings (for example, hexadecimal 30 is the digit 0, hexadecimal 41 is the letter A, etc.), it is necessary to assign the Touch Tone controls to ASCII codes not used by your terminal. A logical choice for these assignments is among the thirty-two ASCII control codes (hexadecimal 00 thru hexadecimal 68).
### System Specifications

#### CPU
- **Microprocessors:** Twin Z80A's with MMX clock frequency. One Z80A (the host processor) performs all processor and screen related functions. The second Z80A is "down-loaded" by the host to the extension processor (E-P). When dual processing data, the second Z80A may be programmed by the host for other processor related functions.

#### Word Size
- 8-bit

#### Execution Time
- 1 microsecond required to register

#### Machine Instructions
- 150K

#### Memory Storage Capacity
- 320K bytes formatted on two double density drives. Optional external 10 300 megabyte hard disk storage is available using optional 5-100 bus adapter.

#### Data Transfer Rate
- 255K bit/second

#### Average Access Time
- 250 milliseconds, 35 milliseconds track to track

#### Media
- 5 1/4 inch disk

#### Disk Rotation
- 360 rpm

#### Internal Memory
- Dynamic RAM
- Static RAM
- 256 bytes of static RAM is provided in addition to the main processor RAM. The memory is used for program and/or data storage for the auxiliary processor.
- 16 single option. Allows ROM boot-up capability, system at power-on. RAM storage is 2706 kompatible and may be reprogrammed by the user for custom applications.

#### CRT
- **Display Size:** 12-inch dynamically focused 54 phosphor
- **Display Format:** 25 lines x 80 characters per line.
- **Sweep Rate:** 8 x 8 character matrix on a 8 x 12 character field.
- **Line Drawing Character Set:** Eighteen special alphanumeric symbols used for generation.
- **Display Presentation:** Light characters on a dark background. Reversible through keyboard program selection.
- **Color:** Reverse video (black on white).

#### Communications
- **Screen Data Transfer:** 38 kbytes keyboard transmission of data at rates up to 9600 bps.
- **Parallel Interface:** 5 1/2 inch
- **Transparent Mode:** 80 characters/second.
- **Portability:** Enables display of all images and output control codes.
- **Parallel Access:** Choice of even or odd data format.
- **Transmission Mode:** Serial or Parallel, One or two step list.
- **Addressable Current:** Direct portability by either discrete or addressable addressing.

#### System Utilities
- **Disk Operating System:** 12 M
- **DOE Software:** An 8800 disk assembler/deboubler, trait editor and file handling utilities.
- **FORTRAN:** ANSI standard, double and single precision.
- **COBOL:** ANSI standard, double and single precision.
- **BASIC:** ANSI standard, double and single precision.
- **Application Packages:** System ii, ledger, accounts receivable, payroll, and sales order processing.

#### Keyboard
- **Alphanumeric Character Set:** Generates all 128 upper and lower-case ASCII characters.
- **Special Features:** "Key Lockout" automatic repeat at 15 CPS. "Toggle" Lock Unlocked.
- **Number Pad:** 0-9 decimal point, comma, semi-colon and four basic programmable function keys.
- **Special Functions Keys:** Up to 64 user defined two-key function sequences.
- **Cursor Control:** Up, down, forward, backward and home.
- **Internal Construction:** Structural frame.
- **Component Layout:** Two board modular design. All processor related functions and hardware are on one single printed circuit board. All video and power related circuits on a separate single board. Two single boards are inter-connected via a single 22-pin ribbon cable.
- **Mounting:** CRT and single board mounted to bay CRT in a rigid steel frame. Desk drawer assembly mounted into upper cover for ease of servicing.

#### Environment
- **Space:** 134" W x 21" D x 23" H
- **Environment:** Operating 0 to 50 C Storage 0 to 85 C, 10 to 95% rel. humidity - non condensing.
- **Power Requirements:** 158 VAC, 60 Hz. 1 AMP. (optional 230VAC 50HZ model available.)

---

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**BYTE January 1980**

123
Table 1: Typical information displayed on the computer terminal in an automatic telephone dialing system that can be set up using the dialing device described in this article. The user types a single-character access code on the computer keyboard and the system dials the corresponding telephone number automatically.

<table>
<thead>
<tr>
<th>Access Code</th>
<th>Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>381-9604</td>
<td>Parents</td>
</tr>
<tr>
<td>2</td>
<td>699-1626</td>
<td>Office</td>
</tr>
<tr>
<td>3</td>
<td>1-614-353-7795</td>
<td>Spouse’s Parents</td>
</tr>
<tr>
<td>9</td>
<td>828-3384</td>
<td>Weather</td>
</tr>
<tr>
<td>A</td>
<td>828-0553</td>
<td>Computer Shop</td>
</tr>
<tr>
<td>B</td>
<td>227-8341</td>
<td>Fire Dept</td>
</tr>
<tr>
<td>C</td>
<td>227-7201</td>
<td>Police Dept</td>
</tr>
<tr>
<td>D</td>
<td>824-5222</td>
<td>Dial-A-Prayer</td>
</tr>
<tr>
<td>Z</td>
<td></td>
<td>Last Number Dialed</td>
</tr>
</tbody>
</table>

Figure 1: Block diagram of connections in the system.

Table 2: Row and column input lines on the integrated tone dialer device, associated tone frequencies, and corresponding digits or signaling codes derived from the combination of two tones of different frequency.

<table>
<thead>
<tr>
<th>Low Group</th>
<th>Column 1 (1209 Hz)</th>
<th>Column 2 (1336 Hz)</th>
<th>Column 3 (1477 Hz)</th>
<th>Column 4 (1633 Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Row 1 697 Hz</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>A</td>
</tr>
<tr>
<td>Row 2 770 Hz</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>B</td>
</tr>
<tr>
<td>Row 3 852 Hz</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>C</td>
</tr>
<tr>
<td>Row 4 941 Hz</td>
<td>*</td>
<td>0</td>
<td>#</td>
<td>D</td>
</tr>
</tbody>
</table>

Touch Tone Generating Circuit

Now that the method of interfacing the terminal with the Touch Tone circuit has been described, the actual operation of the Touch Tone device will be discussed. Basically, it consists of two medium-scale integration (MSI) quad S-R latches, a Mostek integrated tone dialer, and a relay for switching the Touch Tone device to the telephone.

The integrated tone dialer requires two inputs (a row input and a column input) to generate a tone. These input signals activate tones as shown in table 2. Activating row 1 and column 1 generates the tones for the digit 1; activating row 3 and column 2 generates the tones for the digit 8, etc.
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Circle 75 on inquiry card.
Figure 2: Schematic diagram of the dual-tone multiple-frequency (Touch Tone) telephone dialing circuit. Connections to the terminal apply to the Southwest Technical Products Corp CT-64 unit. Terminals which do not decode the entire ASCII character set may require additional decoding circuitry for use with the telephone interface. The isolating telephone coupler is required for connection to the telephone line of devices which have not been given approval by the Federal Communications Commission.

The tone combinations for the characters A, B, C, and D (column 4 of table 2) do not have corresponding keys on a normal telephone Touch Tone pad but are reserved for future use. Since you will be generating only the tones 0 thru 9, only inputs for columns 1 thru 3 and rows 1 thru 4 will be needed. Hence, seven ASCII control characters will be needed to activate the three columns and four rows. Use of the other three ASCII control characters (for a total of ten) is discussed later.

The purpose of the latches (IC1 and IC2) is to hold the output state of the logic decoder of the terminal. Since the terminal processes only one character at a time and the tone dialer requires the simultaneous presence of two input signals, the latch holds the first input from the terminal while the second input is being transmitted. There is a latch for each column and row of the integrated tone dialer. The latch IC2 is also used to control a relay for attaching the tone device to the telephone. A schematic of the complete Touch Tone generating circuit is shown in figure 2.

The output of the integrated tone dialer goes into an isolating coupler connected to a telephone. The coupler must be approved by the Federal Communications Commission, and it is required for user con-

<table>
<thead>
<tr>
<th>Number</th>
<th>Type</th>
<th>Type</th>
<th>GND</th>
<th>+12 V</th>
</tr>
</thead>
<tbody>
<tr>
<td>IC1</td>
<td>74279</td>
<td>16</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>IC2</td>
<td>74279</td>
<td>16</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>IC3</td>
<td>5086N</td>
<td>6</td>
<td>1.7</td>
<td></td>
</tr>
<tr>
<td>IC4</td>
<td>LM380</td>
<td>7</td>
<td>14</td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Power supply connections for integrated circuits in figure 2.
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constructed devices which attach to the telephone company’s equipment. Approved couplers can be purchased for approximately $5 from electronic supply houses, or they can be leased from the telephone company for $2 to $4 a month.

As previously mentioned, there are three more ASCII control characters required by the Touch Tone device. These perform the reset, relay on, and relay off functions. The reset control is used to turn a tone off after it has been turned on (the tone combination is turned on by activating a row/column combination). (That is, once a row and column have been turned on, they remain on until a reset is issued.) Reset is also used to clear the latches after powering up the circuit. Note that the control character used for reset (pin 13 of the terminal 74154) is connected to the reset pin of the latch for each row and column control (IC1 and IC2). A single reset operation clears all of the row and column latches. This is more convenient than clearing the row and column latches individually.

The relay on and relay off controls are used to make connection to and disconnect from the telephone. The Touch Tone device is connected to the telephone coupler immediately before dialing and is disconnected from the terminal immediately after dialing. This prevents random signals and noise (such as that generated at power on) from entering the telephone line from the terminal.

In my system, the power supply for the Touch Tone device was taken from the terminal’s power supply. After the Touch Tone generating circuit has been constructed, the volume output from the integrated tone dialer should be adjusted with a VU meter so that it will be in the range of -6 to 0 dB. Output signals less than -6 dB in level will not be recognized by the telephone company equipment. Output levels greater than 0 dB cause cross-modulation into other phone lines. The general operation of the Touch Tone device can be tested offline by entering the various control characters with the terminal in full duplex mode.

Dialing

Once the hardware is functioning correctly, dialing is simple. Basically, it consists of the following steps:

- Turn the line connection relay on (send the control character for relay on to the terminal).
- Turn column on for Nth digit (send the control character for the column of digit N to the terminal).
- Turn row on for Nth digit (send the control character for the row of digit N to the terminal).
- Wait 40 ms.
- Turn tone off (send the control character for reset to the terminal).
- Wait 40 ms.
- Turn relay off (send the control character for relay off to the terminal).

Note that from the perspective of the microprocessor unit, generating Touch Tones is accomplished in the same manner as displaying characters on the terminal screen. The 40 ms delays are minimum times required by the telephone company equipment. A tone must stay on for at least 40 ms, and there must be at least a 40 ms delay between tones.

Summary

This Touch Tone interface, used in conjunction with a microprocessor and an ASCII terminal, is an example of a practical computer application in communications. I advise personal computing enthusiasts who construct their own Touch Tone devices to be most careful when debugging the software. Sending random sequences of digits through a Touch Tone interface can be a painful way to debug your program (although the pain may not be felt until the telephone bill arrives a few weeks later).

Acknowledgements

I am grateful to Dink Stockert, Dr David Crouch, and Carl Zettner for their assistance in the design and construction of the hardware. Lynn Mason, of Cimarron Information Systems Inc, was very generous in providing a computer system for preparation of the text of this manuscript.
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Analysis of Polynomial Functions with the TI-59 Calculator

Part 2

Consider the following polynomial:

\[ P(x) = x^4 - 8x^2 + 7 \]

For \( P(x) = 0 \) it is essential to study the characteristic elements, derived polynomials \( P'(x) \) and \( P''(x) \), and automatically plot the function curve. The procedure is as follows:

1. Read the magnetic card of the main program in groups 1 and 2.
2. Initialize by depressing key A.
3. Enter each of the coefficients with the keys. Start with the coefficient for \( x^4 \) by depressing key B each time. A 0 is entered for any term not having a power of \( x \). Thus, you can perform the sequence 0 B, 0 B, 1 B, 0 B, -8 B, 0 B, 7 B.
4. Depress key C.

Depressing key C causes the processing of \( P(x) \) to its conclusion with no other intervention.

When reading listing 1, the following are seen successively, separated by program spaces:

- the column of the seven given coefficients or the 0s which replace them
- the group of the lower boundary \( a \) and upper boundary \( b \)
- the group of interval \( (b - a) \) and increment \( \Delta x \)
- the indication of the maximum error

After these appear the following results:

- the group of roots followed by the series 9. 999...7 that indicates the end of determination of the roots
- the table of the thirty-nine values of \( x \)
- the table of the thirty-nine values of \( P(x) \)

If it is desired to retain the data for \( P(x) \) to plot the function curve later, this is the time to record it in groups 3 and 4.

The procedure for the first derived polynomial is even simpler:

1. Depress key B' once; this causes all the coefficients of \( P'(x) \) to be printed one after the other.
2. Depress key C.

The second derived polynomial is obtained in the same manner. The same applies for the derivatives of order \( n \), provided the polynomial remains derivable. Notice that it is useless to reinitialize to change from one polynomial to the next.

Plotting the Function Curve

By convention, hereafter designate the data used in plotting the function curve as listing 2. It can be the table of values of \( P(x) \) already recorded or any other that could be substituted for reasons that will be discussed. The plot itself will be designated figure 1.
Figure 1: The six segments of output from the TI-59 that define the function curve.
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<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>DESCRIPTION</th>
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<th>AVAILABILITY</th>
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<tr>
<td>PET C2N</td>
<td>2nd Cassette</td>
<td>$100</td>
<td>IMMEDIATE</td>
</tr>
</tbody>
</table>

*The 16K/32K (large keyboard) units do not include a cassette drive. Order C2N Cassette. 2040 Floppy Drive requires a 16K or 32K unit. 8K RAM Retrofit available July.

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<table>
<thead>
<tr>
<th>SOFTWARE/APPLICATION</th>
<th>REQUIRES</th>
<th>AUTHOR</th>
<th>AVAILABILITY</th>
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</table>

*The CMS Software (G/L, A/R, A/P) are based on Osborne & Associates trial tested business basic software. Software is complete with full documentation and user instructions. All packages require a printer for output. Commodore recommends the NEC Spinwriter (available from NEECO) as the output printer for WORDPRO.

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Listing 1: A listing containing the data and error specification for a six-degree polynomial, \( P(x) \). Thirty-nine values of \( x \) are also printed along with the corresponding values of \( P(x) \) calculated for each value of \( x \).

<table>
<thead>
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<th>( 0 )</th>
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<th>( 0 )</th>
<th>( 0 )</th>
<th>( 0 )</th>
<th>( 0 )</th>
<th>( 0 )</th>
<th>( 0 )</th>
</tr>
</thead>
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<td>( -3 )</td>
<td>( -3 )</td>
<td>( -3 )</td>
<td>( -3 )</td>
<td>( -3 )</td>
<td>( -3 )</td>
<td>( -3 )</td>
<td>( -3 )</td>
<td>( -3 )</td>
<td>( -3 )</td>
<td>( -3 )</td>
<td>( -3 )</td>
</tr>
<tr>
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<td>( 7.565854249 )</td>
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<td>( 0 )</td>
<td>( 0 )</td>
<td>( 0 )</td>
<td>( 0 )</td>
<td>( 0 )</td>
<td>( 0 )</td>
<td>( 0 )</td>
<td>( 0 )</td>
<td>( 0 )</td>
<td></td>
</tr>
<tr>
<td>( 0.000001 )</td>
<td>( 0.000001 )</td>
<td>( 0.000001 )</td>
<td>( 0.000001 )</td>
<td>( 0.000001 )</td>
<td>( 0.000001 )</td>
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<td>( 0.000001 )</td>
<td>( 0.000001 )</td>
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<td></td>
</tr>
<tr>
<td>( -3.651065796 )</td>
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<td>( -2.835709029 )</td>
<td>( -2.671968857 )</td>
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<td>( -0.397624628 )</td>
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<td>[9, 999999999]</td>
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<td>[9, 999999999]</td>
<td>[9, 999999999]</td>
<td>[9, 999999999]</td>
<td></td>
</tr>
</tbody>
</table>

The procedure is as follows in practice:

1. In groups 3 and 4 read listing 2 mentioned above.
2. In groups 1 and 2 read the magnetic card of the program for the function curve.
3. Initialize by depressing key A.
4. With the keys enter the two extremes envisaged for the curve starting with the lower and then each time depressing key B.
5. Depress key C.

Depressing key C initiates the entire process with no other intervention. The six strips obtained are separated by cutting with scissors, and are assembled with glue or adhesive tape. This is the standard automatic procedure, and nothing prevents the operator from applying it in every case using the data collected in listing 1.

However, you may desire to center the reproduction in a smaller field. When examining the table of values of \( P(x) \) obtained, it is obvious that, for registers R21 thru R25 and R3 thru R8, small variations in \( x \) cause considerable variations in \( P(x) \). In other words, the curve ends with parabolic branches. In the same way a photographer takes a close-up of a subject, you can neglect the infinite range and concentrate on useful details.

For this purpose, you must disconnect automatic operation and gain control of the field of the display. The procedure will be as follows:

1. Reread the magnetic card in groups 1 and 2.
2. Initialize by depressing key A.
3. Re-enter the initial coefficients of \( R_{16} \) to \( R_{10} \) by each key to the register or key B as previously indicated.
4. Switch to programming mode LRN, and perform the few modifications required:
   - Replace the neutral NOP instructions provided for this purpose at statements 087, 096 and 119 by R/S instructions.
   - Replace the initial partition of the interval \((a, b)\) at statement 120 thru 122 by as many NOP instructions.
   - Replace all occurrences of \( x \) with a deliberately excessive number, for example 999...

5. Return to the calculating mode, and depress key C. The rest of the program will be executed but will stop whenever useful to permit the entry of a data item of your choice.
   - Boundary a with the first stop: here, it will be 3 in absolute value but the calculator will recognize it as negative 3.
   - Boundary b with the second stop: it will again be 3.
   - Partition of the interval \((a, b)\) at the third stop: keep it at 20 on seeing the value of the interval the machine has just printed out after the boundaries.

Naturally, each data entry with the keys is followed by operation of the R/S key to restart the calculation.

What happens now? Without getting involved in a root calculation that is no longer of interest at this point, the
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Listing 2: Listing of a sample input of data used to plot the function curve.

<table>
<thead>
<tr>
<th>x</th>
<th>y</th>
</tr>
</thead>
<tbody>
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</tr>
<tr>
<td>1</td>
<td>-0.6</td>
</tr>
<tr>
<td>2</td>
<td>-0.45</td>
</tr>
<tr>
<td>3</td>
<td>-0.3</td>
</tr>
<tr>
<td>4</td>
<td>-0.15</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>0.15</td>
</tr>
<tr>
<td>7</td>
<td>0.3</td>
</tr>
<tr>
<td>8</td>
<td>0.45</td>
</tr>
<tr>
<td>9</td>
<td>0.6</td>
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<tr>
<td>10</td>
<td>0.75</td>
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<tr>
<td>11</td>
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</tr>
<tr>
<td>12</td>
<td>1.05</td>
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<td>1.8</td>
</tr>
<tr>
<td>18</td>
<td>1.95</td>
</tr>
</tbody>
</table>

The TI-59 cannot execute its program with great speed. Therefore, most users can tolerate a delay of a few minutes with no hardship. Some will appreciate the option of allowing users to disable automatic operation to follow their own inspiration.

6. In groups 1 and 2 read the card of the program for the function curve.
7. Initialize with key A.
8. With the keys punch in -9 B then 8 B to enter the extremes which are obviously appropriate here.
9. Depress key C which delivers the six ideal strips after this mathematical ‘zooming’ as can be seen from looking at the curve in detail (see figure 1).

Above all, the question is one of knowing if this plot is technically satisfactory.

For verification purposes, see if the coordinates of the minima measured by the calculation (+2, -9) and the coordinates measured on the plot are consistent.

For verification purposes, see if the coordinates of the minima measured by the calculation (+2, -9) and the coordinates measured on the plot are consistent.

More precisely, determine the abscissa of the minimums with an ordinate of -9. From the small median triangular sign marking the 0 abscissa on the base line, you can easily count ±13 intervals each having a value of 0.15, the increment of x. This gives ±13 × 0.15 = ±1.95. This abscissa is very close to the value calculated (+2), and it can be said that the plot is extremely accurate.

As for the points of inflection, their ordinate is found to be -1.888... for P(x) evaluated from the roots of P(x) = 0, in other words abscissas of ±1.154700. The points of inflection whose abscissa is ±1.15 in accordance with the calculation fall slightly before the eighth point on the base line at the abscissa (8 × 0.15 = 1.20). This is also very close to the value calculated (+2), and it can be said that the plot is extremely accurate.

The abscissa of the minimums found by the calculation fall slightly before the eighth point on the base line at the abscissa (8 × 0.15 = 1.20). This is also very close to the value calculated (+2), and it can be said that the plot is extremely accurate.

All that remains is to use these values contained in

<table>
<thead>
<tr>
<th>x</th>
<th>y</th>
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<tbody>
<tr>
<td>0</td>
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<tr>
<td>1</td>
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<tr>
<td>20</td>
<td>3.43</td>
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The zero ordinate can easily be deduced from a simple rule. Given that the difference between minimum and maximum is 9 + 8 = 17 in absolute value and there are 4 × 20 + 17 = 97 elementary intervals between these points, each has a value of 0.175. From this the axis of the curve is at 9/0.175 = 51 intervals from the minimum of the curve.

From the table of P(x) it can be seen that the curve cancels between registers R4, R12, R20, and R28, and that this effectively corresponds to the interval 6-7 of the base line. Without providing the precision of a professional plotter, the reproduction obtained is thus of suitable quality given the means employed.

Conclusion

When a procedure is used for a rather long calculation that requires only three keyboard operations:

- initialization by key A
- data entry by key B or B’
- complete execution by key C

the drawbacks of the relative slowness of calculation are considerably reduced.

The TI-59 cannot execute its program with great speed. However, most users can tolerate a delay of a few minutes with no hardship. Some will appreciate the option of allowing users to disable automatic operation to follow their own inspiration.
The availability of fast, reliable, high capacity hard disk storage for the S-100 computer market has created a wave of excitement. It has also underscored the somber necessity for a reliable means of backup. No serious application is practical without a dependable, economical method for backup and archiving of critical on-line data.

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Circle 82 on Inquiry card.
I had a dream the other night. A wondrous vision: I built an inexpensive, simple plotter and it worked. I remember that just before retiring, I was reading the March 1977 BYTE, specifically the article on building a plotter using model aircraft servomotors ("Give Your Micro Some Muscles," page 9).

The servomotor idea sounded great at first, but is quite complicated to run. For one thing, the plotting routine must constantly send out carefully timed pulses. Either that or you need a set of programmable clocks. Second, you must have a circuit that indicates when the plotter is finished with the current line segment or you would be plotting the next line before the first line is finished (unless you want to wait out the worst case every time). Third, there is that trigonometric routine. I don't even want to think about that. Fourth, there is the problem of wobble. With arms long enough to give a decent sized plotting area, the slightest bump or small snag on the paper and your beautiful plot begins to look like a Los Angeles seismograph record. Arms rigid enough to avoid this problem would be extremely difficult to build. There is also the problem of play. At the end of 10-inch arms, a small amount of play at the servomotors would be greatly magnified, possibly enough to miss the desired point by a fair margin.

I propose the following alternative design approach. The idea isn't perfect, but I think it will work.

Mechanical Description

The basis for the plotter (and the hardest part to build) is the crossbars (figures 1 and 2). These are two sets of perpendicular bars that slide on long rails set at the edge of the plotting bed. The pen mount with its solenoid sits on the intersection of the bars. It slides along in a fashion similar to the crossbars and their rails. By moving the crossbars to the proper X,Y coordinates the pen moves with the intersection to the desired point.

The bars are moved by cables wrapped around a drive shaft. Rotating the shaft in one direction moves the bar up (or down). The other bar is moved by a similar arrangement, right or left. In order to keep track of where the bars are, each drive shaft has a disk mounted on the end with holes evenly spaced around it. As the disk rotates...
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with the shaft, the holes pass through an optical interrupter (a U-shaped device with a light source on one side and a phototransistor on the other). Each time a hole passes through the interrupter, a pulse passes to the control circuit, driving a counter up or down depending on the direction it's turning. By comparing the counter, which contains the current position of the bar, with the desired destination point, the control circuits can move the bar in the proper direction.

One small problem lies in the hardware department. The motors which drive the crossbars must be able to stop fairly fast, at least before the next hole comes up on the disk. If not, the plotter would signal the computer that it is finished even though the motors would have to reverse themselves to return to the original point. If you are using motors that are geared down (i.e.: the motors are spinning fast, but the shaft is turning slowly) then this problem tends to disappear. The disadvantage to geared down motors is time, of course. The more gear reduction that is used, the longer it takes to draw a line segment, and the longer your processor is sitting idle. The ideal motor is one that turns the shaft as fast as the pen and paper can tolerate and which can stop quickly.

Controlling the Plotter

From here there are two ways in which you can control the plotter: software and hardware. My choice is hardware, although both methods have their advantages.

The hardware controller I came up with (figure 3) is simple. Set up three input/
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output (I/O) ports: one for commands and one each for the X and Y coordinates.

The command port accepts four commands: pen up, pen down, signal and move. The two pen commands are self-explanatory; the signal command generates an audible tone. This is an option I included for signalling the end of a plot or calling attention to a particular point in the plotting process.

The move command starts the motor circuits (otherwise they would start moving the plotter before both coordinates were in) and also generates a hold signal for the processor until the line segment is finished. When the move command is received, the motors drive the crossbars until the counters, which hold the current plotting position, match up with the eight-bit latches which contain the position that the plotter is to move to. When the coordinates match, the hold line is dropped, allowing the computer to output the next command.

The comparator circuits are also used to determine whether the pulses coming from the interrupters are used to drive the counters up or down.

The only other circuit needed is an initialization circuit that drives the pen to location (0,0) and clears the counters. This is used to synchronize the counters and pen when the plotter is first turned on.

As to the circuits which actually drive the motors and pen solenoid, these depend on the components themselves. If you wish to drive the plotter directly by software, the two coordinate I/O ports are used to read the current location of the pen. A software routine then decides how to move the crossbars, one step at a time, to get to the desired point. However, this requires more commands for the plotter, such as X up, X down, Y up, Y down.

With this hardware method you run into what I call the 45° syndrome. Since the motors turn at about the same speed, the pen will tend to move at an angle which is a multiple of 45°. For example, if the pen has farther to go in the X direction, the pen will reach the proper Y coordinate first, giving a line with two segments (figure 4). If the line you wish to draw is a multiple of 45°, drawing axes and such, then this presents no problem, but with lines at other
Word Processors are here. Just thumb through the pages of this magazine. There are at least five different companies selling them. So, which one’s for you? How do you judge the difference? And what about cost? Are you willing to pay the $200 plus dollars that some of the companies are asking?

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angles it will become apparent, especially if the lines are very long.

If, as in most plotting, the increments are very small, this problem is no more serious than the usual stepping phenomenon that occurs on most plotters. With the software driven plotter, the routine can smooth a long line out by adjusting the increments in the X and Y directions.

The decision of which method to use lies mostly in the use to which you will put the plotter. If you are drawing long straight lines, then by all means use the software driven method. If you are like me and plan to use it mostly for plotting functions, the hardware method is much simpler to use because the length of the line segments tends to be short.

Design Details

In designing a plotter for your own use, there are three factors to keep in mind. They are the desired resolution, the size of the plotting area and the number of bits used for the coordinates. Determining any two of these factors automatically sets the third.

For instance, in my design I used a resolution of 0.05 inches (0.13 cm) and an 8-bit coordinate system. This gave me a plotting area of 12.8 inches (33 cm) square. That was big enough for me.

The drive shaft is what causes problems. In order to have an exactly evenly spaced set of holes on the disk, you have to have a shaft with a circumference that is a multiple of the resolution, in this case 0.05 inches (0.13 cm). This is not easy. Short of going to a machine shop and having them turn out special drive shafts, I decided to search for a standard diameter that would come close. One half inch works out fairly well.

With 31 holes in the disk, the formula:

\[ \text{RES} = \left( \frac{\pi \times \text{DIAM}}{H} \right) \]

gives the true resolution. Here, \( \pi \) is 3.1415, DIAM is the drive shaft diameter (0.5 inches), \( H \) is the number of holes and RES is the true resolution, in this case 0.05067 inches, which was close enough to 0.05 to suit me.

What this formula means is that the holes divide the circumference of the drive shaft into 31 segments, each one 0.05067 inches long. Thus as the cable comes off the shaft, driving it one hole means that the crossbar will move 0.05067 inches.

The only other critical parts are the crossbar slides since the crossbars must glide smoothly.

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A recent note in "BYTE's Bits" (June 1979 BYTE, page 225) brought to the attention of BYTE readers the prospect of direct reception of weather satellite photographs by amateurs using home-built equipment. The purpose of this brief article is to expand on that note, and to direct the interested reader to a number of existing resources.

Applications of the home computer in this field are many and varied. They include such projects as orbital predictions, antenna tracking calculations, signal error analysis, generation of map overlays, and weather system modeling, to name just a few. Most of the mathematical calculations involved are quite simple, requiring the use of nothing more difficult than high school trigonometry. A computer enthusiast can derive a great deal of personal satisfaction from writing software to arrive at the correct solutions. Those who are hardware oriented will want to go a step further and use their computers to drive a tracking antenna in real time.

The 1968 report by Vermillion (NASA SP-5079) mentioned in BYTE's Bits was not the first to appear on the subject. A comprehensive article on building a home receiving station appeared in QST magazine as far back as 1965. Vermillion himself put out a number of other excellent NASA reports since the 1968 document, including SP-5080 and TN D-7994. Scientific American carried a construction article based on a design similar to the 1965 QST equipment.

The great majority of technical literature on the subject, however, has appeared in the various American and British amateur radio magazines over the past five or six years. A review of the annual indices (usually appearing in the December issues) of Ham Radio, QST, Radio Communication, and Wireless World will reveal a wealth of information. These articles are indexed under "Satellites," "Weather Satellites," "OSCAR," and "Facsimile." The subject matter runs the gamut from construction details for homebrew state-of-the-art receivers and recorders, to surplus equipment conversions, to computer software for orbital calculations and antenna tracking.

An excellent book on the subject has been written for amateurs by Ralph Taggart. Mr Taggart is the author of
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BYE January 1980 149
many of the articles that have appeared in the amateur radio magazines, including a very good introductory treatise for beginners.

BYTE has published material which is directly applicable to the subject. This was related to computer generation of map overlays for satellite photos. It is a very handy capability to have on occasions when your received pictures show nothing but cloud cover and you need a system of reference (see my article series "Computer Generated Maps," May 1979 BYTE, page 10; June 1979 BYTE, page 100).

Those who are concerned about the cost and complexity of such a project need not worry. It is entirely possible to assemble a station capable of receiving high-resolution photos (both visible light and infrared images) with an outlay of less than $100. Excellent quality picture recorders, capable of recording images up to 19 inches (48 cm) square, are available on the surplus market for as little as $50. Recorders that produce pictures about 4 by 6 inches (10 by 15 cm) can be found for as little as $30. Advertisements in the amateur radio magazines and visits to ham radio swap meets provide the best leads to equipment buys. Many of the previously mentioned articles even show you how to build a recorder from scratch, flyback switching device with a unique starting and restarting circuitry scheme and a secondary winding mechanism which counteracts typical power supply problems of power dissipation and breakdown.

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Every few weeks or so). Reference orbit information is typical home-computer programs for polar orbiting and National Weather Service offices on the TBUS circuit. The information produced them are based on articles that have appeared in amateur radio magazines, and they require just a few seconds to execute.

As you can see, there are quite a few areas of opportunity for home computer projects in this exciting field. It is intriguing to receive real-time weather satellite photos right in your own home and to try to outguess the

using simple materials (eg: a kitchen rolling pin for a recording drum!), if you cannot find or do not want to buy a surplus recorder.

The necessary radio receiving equipment is also reasonably simple. If you already own a general coverage receiver, a converter can be built for as little as four or five dollars. In fact, many public-service band radios and scanners can receive the satellites directly (on 137.5 MHz), and all you need to add is an outdoor antenna.

Satellite tracking should be a snap for the average computer enthusiast. The published literature includes many articles on satellite tracking software. The only additional data you need is the time and longitude of the equator crossing of an occasional reference orbit (once every few weeks or so). Reference orbit information is transmitted daily via teletypewriter to most National Weather Service (NWS) offices on the TBUS circuit. The National Weather Service also carries the information on their high-frequency radio teletypewriter (RTTY) circuits. The American Radio Relay League station W1AW transmits the same information by both voice and radio teletypewriter. See any recent issue of QST for the W1AW transmission schedule. It is also possible to have your name put on a mailing list maintained by the National Environmental Satellite Service, and receive this information by mail on a monthly basis.

Some weather satellites are in geosynchronous; that is, their periods of revolution are the same as the rotational period of the earth (ie: 24 hours). Consequently, they remain stationary with respect to the earth's surface. This makes life really simple because you do not have to track them. It is only necessary to compute the antenna pointing angles once for each satellite. A recent article about locating geosynchronous satellites in QST gives the procedure for doing this on either a pocket calculator or a home computer.

Listings 1 and 2 show portions of the output from typical home-computer programs for polar orbiting and geosynchronous satellites, respectively. The programs that produced them are based on articles that have appeared in amateur radio magazines, and they require just a few seconds to execute.

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weatherman! You can even use your computer to maintain weather records over long periods of time to aid in your forecasting.

I do not personally have additional advice to offer on construction details or equipment recommendations, other than to refer the reader to the many excellent articles already in print. I can, however, provide some assistance with tracking data. As an extension of a service I provide to amateur radio operators to assist in tracking the OSCAR communications satellites, I also provide perpetual orbital-prediction printouts for the current primary polar orbiting weather satellite, TIROS-N. (I have discontinued the printouts for all of the earlier weather satellites, but the service will be extended to include NOAA-6, which was launched in June 1979.) A printout showing antenna pointing data to all geosynchronous satellite locations, in one-degree increments, is also available.

All printouts are computed based on the exact station location, and can be used directly for tracking or as a check on the accuracy of programs you develop on your own. There is a nominal charge for the printouts ($5.00 for the TIROS-N printout, and $1.00 for the geosynchronous satellite printout) to help defray the cost of postage and materials. If you would like additional information about the printouts, be sure to enclose a self-addressed, stamped envelope with your letter.

REFERENCES

An Improved Maze Program

David Lyons, 77 Elizabeth St S, Brampton Ontario, CANADA L6Y 1R3

I enjoyed "My Computer Runs Mazes," by David E Stanfield in the June 1979 BYTE, page 86. I agree that the form of the listing provided is easy to enter, but it could be difficult to modify the program for other systems. Therefore, I have compiled the following information which might help.

The maze matrix will not print properly on terminals with line lengths other than thirty-two characters or
without screen wraparound, since screen wraparound is relied upon for the carriage return and line feed after each row of alternating X and space characters. These missing characters can be added by a modification to the appropriate printing routine, as in listing 1.

Cursor-right and cursor-up characters do not always seem to be standard. The locations in which they occur are listed in table 1, if you need to alter them. Contrary to what is implied in the listing in the original article, the maze-running program is contained in two sections of memory, one from hexadecimal 0030 to 0060, and the other from hexadecimal 0100 to 0784. Also, the display memory is located between hexadecimal 0800 and 09FF.

Now I shall suggest some possible enhancements. Provisions are made to open up corridors and set the goal, but not to replace a wall or remove the food except by redrawing the entire maze. By adding the patch in listing 2, the command table can be extended to allow the setting of an X at the current cursor location by pressing the X key.

If the goal is not accessible in the maze, the same branches can be searched repeatedly before the search ends. This seems due to the search strategy of eliminating only the end location of a branch each time a dead-end is reached, even though the entire branch back to the nearest node could be eliminated when backtracking is necessary. The strategy can be modified so that dead-end paths are searched only once by changing four conditional branch (BEQ) instructions as shown in table 2.
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There are times when you need to hold the output of your keyboard in the uppercase mode for all alphabetic characters. A great deal of software is designed to accept only uppercase alphabetic American Standard Code for Information Interchange (ASCII) characters. The circuit given here is designed to be placed between the transistor-transistor logic (TTL) parallel output of the keyboard and the parallel input port on the computer (or the output to the parallel-to-serial converter in a serial data arrangement). The programmer will then be able to reduce the beautifully designed 128-character set to a 102-character set.

A quick glance at a table of ASCII characters will show that the alphabetic characters are easy to recognize. (Such a table appeared in "Complete ASCII" by David M Cierniewicz in the February 1978 BYTE, page 19.) They all have a 1 in bit 6 (the most significant data bit not considering the parity bit). Lowercase characters have bit 5 equal to 1, and uppercase characters have bit 5 equal to 0. If the problem was as simple as this, the circuit shown in figure 1 would do the trick. (I was inspired to

<table>
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<tr>
<th>ASCII Character</th>
<th>Binary 6543210</th>
<th>Bits 6,4,3 Octal</th>
<th>Bits 2,1,0 Octal</th>
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<td>^</td>
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<td>7</td>
<td>6</td>
</tr>
<tr>
<td>Delete</td>
<td>1111111</td>
<td>7</td>
<td>7</td>
</tr>
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</table>

Table 1: The 12 ASCII characters with a binary representation having bit 6 (the most significant data bit, not considering the parity bit) equal to 1 that should not be shifted by the uppercase alpha-lock function.

Figure 1: A simple circuit to provide alphabetic uppercase lock. It causes the undesired shift of 6 punctuation and control codes in addition to the alphabetic characters.
You Just Bought a Personal What?

by Thomas Dwyer and Margot Critchfield

Whether you are a novice programmer or an experienced computer user, this book is filled with practical ideas for using a personal computer at home or work. It will take you through the steps necessary to write your own computer programs, and then show you how to use structured design techniques to tackle a variety of larger projects. The book contains over 60 ready-to-use programs written in Radio Shack TRS-80 Level II BASIC in the areas of educational games, financial record keeping, business transactions, disk-based data file and word processing. $11.95 ISBN 0-07-018492-5

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develop this circuit by an idea description "Recognize Uppercase Letters Only with a Simple 2-Gate Circuit," in Electronic Design, July 1977, page 106, written by Chacko Neroth.)

Of course there is a catch. There are 64 binary combinations in which bit 6 is 1, and only 52 of them are letters. The remaining combinations are punctuation marks, with the exception of the delete control code, as shown in table 1. If the keyboard omits these characters, the simple circuit of figure 1 will force bit 5 low when bit 6 is 1 and the circuit is enabled. However, if the keyboard does have these codes (and it probably has delete), remembering to unshift when necessary can be a headache.

To overcome this problem, it is necessary to detect the 12 non-alphabetic characters and inhibit the shift automatically. My first thought was to use a multitude of inverters and 8-input NAND gates (such as the system described by Steve Ciarcia in "Build a Keyboard Function Decoder," July 1978 BYTE, page 98), but there had to be a better way. Use of a programmable read-only memory would be nice, but it seemed like overkill and perhaps more expensive than necessary.

The solution turned out much simpler than I expected. By forming the octal equivalent of the group of bits 6, 4, and 3 and of the group of bits 2, 1, and 0, as shown in the last columns of the table, the user can see that by detecting the coincidence of these combinations, the desired shift enabling line can be obtained. The lucky combination of octal numbers allows the use of a 3-to-8-line decoder (74LS138) to unscramble the 3 most significant bits of interest and an 8-line multiplexer/data selector (74LS151) driven by the 3 least significant bits. By selecting the proper outputs from the decoder and data selector (those corresponding to the codes we wish to recognize), there can be case shifting at the proper times. The new circuit is shown in figure 2.

When the high-order bits are decoded, the corresponding output goes to 0. If the low-order bits select a 0 output from the decoder, the shift enable line will also go to 0. This allows bit 5 to pass through unchanged. If the alpha-lock function is not desired, allowing the active-low strobe input on the data selector to be pulled up to a 1 will force the shift enable line to 0 regardless of the data being sent.

The use of low-power Schottky TTL integrated circuits allows adding the alpha-lock function while typically increasing the load on the power supply by only 14 mA. The cost of the three integrated circuits will be easily under $2.
Most people and businesses share the common problem of being required to perform some actions at definite future dates. These actions may be of a one-time-only nature, or they may be periodic according to some rule.

The penalty for forgetting an event such as a birthday may be minor, but the penalty for neglecting to file an income-tax return may be more severe.

Solutions to the problem are numerous, and include the use of human memory alone, writing notes on a wall or desk calendar, or maintaining an ordered stack of notes and forms. The solution that I suggest here, called the Tickler filing system, involves the use of a computer to help perform this function. The program described here was written for a small maintenance service company which has, in addition to the normal requirements of small businesses, the necessity of keeping track of periodic preventative maintenance calls for its client companies.

The Tickler system enables a clerk to input a series of messages, each of which has a starting date and a code indicating the type of repetition desired for the message. Each time that the program is executed, it can check a file of messages and print and reschedule all messages for which the time limit has expired since the last printing. The clerk can then delete and add additional messages, as required. Since the program contains no features that are specific to the maintenance service company, it
**MORE NEWS FROM THE MEMORY LEADER.**

This month, we spotlight Econoram XIXA — an S-100 bank select board that's completely compatible with Alpha Micro, Cromemco, and similar systems (all 8 bits of the data word are available for bank select). Addressable on 4K boundaries, available in 16K, 256K, or 32K configurations; see list below (which includes our other popular memories) for prices.

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<th>Unkit</th>
<th>Assm</th>
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<td>$729</td>
<td>n/a</td>
</tr>
<tr>
<td>16K x 16 or 32K x 8 Econoram XVI — coming soon!</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(1) Bank select board addressable on 4K boundaries
(2) Extended addressing (4K address lines); Single block addressable on 4K boundaries
(3) Bank select option for implementing memory systems greater than 64K.

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We've been expanding the memory of Model I TRS-80** machines for over a year now with our low power, high speed memory expansion chip set ($370. Cost now you can use the same chip to expand memory in Apple, newer PET, Exidy Sorcerer, and Heath H89 machines — as well as an expanded 32K Model II TRS-80** to 48K or even 64K. And if that isn't enough memory for you, watch this space for news on our high-density, Model II compatible 64K board with bank select! **TRS-80 is a trademark of the Tandy Corporation.

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Unkits have edge connectors and termination resistors pre-installed in place for ease of assembly. These boards exceed the latest S-100 specs and will work with 8 to 10 MHz CPUs. Includes true active termination, grounded Parity shield between all bus signals, and edge connectors for all slots.

---

**ACTIVE TERMINATOR BOARD** $34.50 kit

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**S-100 MEMORY MANAGER BOARD** $59 kit, $85 assm, $100 CSC

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**3P PLUS S "Interfacer II" S-100 I/O Board** $189 unkit, $249 assm, $324 CSC

Incorporates 1 channel of serial I/O (with all the features of a port from the 25 "Interfacer"), along with 3 full duplex parallel ports. The parallel section uses LSTL octal latches for latched input and output data with 24 mA drive current, timing/enable and strobe bits for each parallel port (with selectable polarity). Interrupts for each input port, and separate 25 pin connectors with power for each channel along with a status port for interrupt mask and port status.
should be of general use to other businesses and individuals needing a similar facility.

A sample series of executions of the program appears in this article. The program provides prompts for the user after the file has been established. The user must enter NEW to establish the file. The ability to enter messages, message types, and starting dates should provide sufficient flexibility for virtually any simple application.

Program Details

The program in listing 1 was written using a SwTPC 6800 running the MSI 14K Disk BASIC interpreter level 1.3. The hardware includes 32 K bytes of main memory, one MSI floppy disk drive, and one low-speed (thirty character per second) printing terminal. The interpreter and this program require about 24 K bytes of memory. Since it uses random access techniques, adapting the program to a cassette tape system would be difficult. Implementing it on another disk system or on a timesharing system should not be difficult.

A flowchart of the major portion of the system appears as figure 1.

Initialization

Line 200 of listing 1 sets the string length to 68 bytes. For those with SwTPC 8 K BASIC, this statement may be replaced with POKE (62, 68). Line 300 sets up the output routine to print numeric values with a floating, not fixed, decimal point. Line 400 causes the output routine to ignore right margin considerations on output.

Line 600 allocates an area of 255 variables to point to those records that have been deleted and may be reused. Line 1100 causes the computer to wait until the clerk indicates that the proper disk has been mounted, since the data disk is kept apart from the program disk. Line 1150 checks for the entry of the word NEW, which indicates that the data file does not yet exist and is to be constructed.

Line 1200 opens the data file in update mode; the MSI BASIC interpreter allows opening data files in Input, Output and Update modes. Line 1300 defines the format of the
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Why should you help? Because St. Jude Children’s Research Hospital knows no boundaries. Its impact is everywhere. Because you care.

Danny Thomas, Founder
ST. JUDE CHILDREN’S RESEARCH HOSPITAL
Listing 1 continued:

6460 INPUT "ENTER NEW TO CLEAR DISK",Z#
6470 IF Z#="NEW" RETURN
6500 OPEN #10, "TICKLER" FOR OUTPUT
6520 FIELD #10, M1=2, N1=2, N2=0, N3=1, M$="TICKLER MESSAGE SYSTEM"
6540 INPUT "ENTER NUMBER OF MESSAGES TO BE HELD IN FILE",K
6560 IF RBS(T)=NKH GOTO 6540
6570 K=INT((K+2)/3)*3
6580 N1=0, N2=0, M$=""
6590 FOR I=2 TO K
6600 INPUT "ENTER NUMBER OF MESSAGES TO BE HELD IN FILE" I
6610 IF K(I)<> "TICKLER" RETURN
6620 K(I)=1, K(I)=K(I)/S)*3"
6630 NEXT I
6640 NEXT I
6660 IF K(I)=1.00 GOTO 6550
6670 K=I K(I+2) /$)*3"
6680 PUT #10, "TICKLER MESSAGE SYSTEM"
6690 IF K(I)= "" RETURN
6700 CLOSE #10
6710 REM ASTRONOMICAL DAY (D) FROM YEAR (I), MONTH (J), DAY (K)
7020 TT=INT((14-J)/12)
7040 T2=INT((1461*I+4000*T+1))/4
7060 T3=INT((267*(J-2-T1*12))/12)
7080 T4=INT((3*I+9000*T+1)/1000)/4
7100 DM=32075*T2+T3-T4
7120 RETURN
7200 REM YEAR(I), MONTH(J), DAY(K) FROM ASTRONOMICAL DAY (D)
7220 L=I+680569
7240 I=INT((4*L)/146097)
7260 I=INT((146097*N+3)/4)
7280 T2=L=I
7300 L=INT((4000*I+D))/1461001
7320 J=INT((1461*I+4)/4)
7340 L=2L+J=3
7360 J=INT((300*L)/2447)
7380 K=INT((2447*L)/80)
7400 L=INT(J/11)
7420 M=J+2-L
7440 K=1000*N+49)+I+L
7460 RETURN
7500 PRINT "FILE FULL OF MESSAGES NOW"
7520 RL=A2
7560 SET #10=1
7580 GET #10
7600 NL=0, N3=RL, N4=A2
7620 FWRITE #10
7640 CLOSE #10
7650 INPUT "INSERT PROGRAM DISK AND HIT RETURN",2#
7660 END

Control Options

Lines 1620 through 1680 request print-control for the current execution of the program. Options are explained in table 2. Lines 1700 through 1900 obtain the current date from the clerk and validate it. Line 1940 checks for run option of N (no printing) and, if it is N, skips the checking of the current messages.

Message Display

Lines 2000 through 2300 successively check every message in the file. Line 2020 reads the next record in the data file record, shown in table 1. Since this defines an 85-byte record and each sector on the MSI disk (GSI 110) is 256 bytes in length, there will be three records per sector.

Lines 1400 through 1480 check the first record in the data file. If the message text is not TICKLER, the program assumes that the disk is not valid and asks the clerk if the disk should be cleared. Lines 1500 and 1600 retrieve the current and maximum end-of-file pointers from the first record in the file.
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Figure 1: Flowchart of a portion of the Tickler program that initializes disk files, selects options, prints messages, and computes new time intervals for the next activation of periodic messages.

Table 1: Format of the data file record for opening data.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>External Length</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>N1</td>
<td>Message type</td>
<td>2 bytes</td>
<td>Numeric</td>
</tr>
<tr>
<td>N2</td>
<td>Days</td>
<td>3 bytes</td>
<td>Numeric</td>
</tr>
<tr>
<td>N3</td>
<td>Message date</td>
<td>6 bytes</td>
<td>Numeric</td>
</tr>
<tr>
<td>N4</td>
<td>Date of last update</td>
<td>6 bytes</td>
<td>Numeric</td>
</tr>
<tr>
<td>M$</td>
<td>Message text</td>
<td>68 bytes</td>
<td>Character</td>
</tr>
</tbody>
</table>

Table 2: Options for updating messages.

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>Selectively print and update messages</td>
</tr>
<tr>
<td>A</td>
<td>List all messages without updating dates</td>
</tr>
<tr>
<td>N</td>
<td>Only enter messages</td>
</tr>
<tr>
<td>U</td>
<td>Update message dates without listing</td>
</tr>
</tbody>
</table>
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file. Lines 2060 through 2090 check the print-control option and current date to determine if a given message is to be listed. Lines 2100 and 2120 print a heading before the first message. Lines 2145 through 2156 reduce the number of trailing blanks to be printed.

Line 2160 formats and prints the current message, along with entry number and type, expiration date, and date of last update. Line 2180 checks the print-control option for A (print all), and if it is A, bypasses updating the message date. Lines 2190 through 2220 update the message date and type, as required, on disk. Lines 2240 through 2280 add deleted record numbers to a table for later reuse.

Message Deletion

Lines 2320 through 2580 allow the clerk to delete additional lines from the file and add any deleted record numbers to the table described above. Deleted lines are recognized by having a message type of zero. Figure 2a shows the deletion procedure.

Entering New Messages

The message addition procedure is shown in figure 2b.

Lines 2600 through 4020 allow the clerk to enter new messages into the file. Line 2600 requests that a message type be entered. Line 2620 ensures that an integer value was keyed. Line 2640 checks this value for zero and, if it is zero, prepares to exit the program. Lines 2660 through 2920 print the message types, shown in table 3.

Line 3020 returns to request that a new message type be entered for an invalid type entry. Lines 3040 through 3220 request that a date be entered to be used as an initial message date. Lines 3240 through 3260 request the clerk to enter the message text and ensure that something was entered.

Lines 3280 through 3390 attempt to allocate a record number for the new entry from those just deleted or at the end of the file.

![Figure 2: Flowchart of (2a) the routine that deletes messages and (2b) the routine that adds messages to the file.](image-url)
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end of the current file. Lines 3400 through 3450 read the data at the allocated record number and overlay the record with more current data. Lines 3460 through 3820 continue this process by filling in parameters depending upon message type. Lines 3760 through 3800 request and validate the number of days for message type 9 (repeat every N days). Line 4000 updates the record on disk. Line 4020 returns to request additional message entries.

**Message Repetition**

Lines 6000 through 6400 compute the next message activation date for a message whose current-activation interval has elapsed. It does this using the message type and old expiration date. If the newly computed message date is still earlier in time than the current date, the new message date becomes the old date, and the new message date is recomputed.

**Data File Initialization**

Lines 6460 through 6700 prepare a new-disk data file for use by the program. Lines 6460 and 6480 validate the format request. Lines 6500 and 6520 open the file for output, creating a new file, and provide the format of each record, as described earlier. Lines 6540 through 6570 request and validate the maximum number of records to be placed into the data file. Lines 6580 through 6660 format the records in the file. Line 6680 closes the file to complete the last sector and directory entry.

This disk-clearing subroutine is shown in flowchart form as figure 3.

**Date Conversion**

Lines 7000 through 7460 provide Gregorian date to Julian day number (as used by astronomers, a system that counts consecutive days since January 1, 4713 BC) conversions to help facilitate the process of recomputing the message activation date for message types 1, 2, 3, and 9. To calculate the Gregorian date N days from another, the following steps are performed:

1. Convert Gregorian date to Julian day number.
2. Add N to Julian day number.
3. Convert Julian day number to Gregorian date.

---

**Flowchart**

![Flowchart of the subroutine that initializes a new disk file.](image)

**Flowchart**

![Flowchart of the routine that terminates execution of the Tickler system in an orderly manner.](image)

**Exit Procedures**

A flowchart of the exit operations is shown as figure 4.

Lines 9000 through 9300 update the first record in the file, which contains...
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Of course, our ability to successfully penetrate and maintain our position in this ever-increasingly competitive marketplace is due to the support of our many marketing, technical and service personnel. As our marketshare increases, so does our requirement for qualified personnel. We are presently recruiting marketing representatives to work closely with our dealers in the field. A sales/management background in this industry would qualify you for consideration for one of these positions. Also, we are in search of technical personnel to assist us here in South Carolina in supporting the varied applications our customers have for our products. At present, we are recruiting Basic, Fortran and Assembly language programmers as well as lab and production technicians.

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City, State & Zip______________________________
Telephone {_________}______________________________
Listing 2: A sample series of executions of the Tickler program.

```dots
MSI READY
*RUN
TICKLER MESSAGE SYSTEM
INSERT DATA DISK AND HIT RETURN
ENTER PRINT CONTROL AS FOLLOWS:
S=SELECTIVE, A=ALL, N=NONE, U=UPDATE ONLY ? A
ENTER CURRENT DATE (YYYYMMDD) ? 790301
ENTER ENTRY NUMBERS TO BE DELETED, FOLLOWED BY ZERO? 0
ENTER TYPE FOR NEW MESSAGE (Q=QUIT, 99=HELP)? 99

TYPES ARE AS FOLLOWS:
1=SPECIFIC DATE ONLY
2=EVERY DAY
3=EVERY WEEKLY
5=EVERY MONTHLY
6=EVERY QUARTERLY
7=EVERY SEMI-ANNUALLY
8=EVERY ANNUALLY
9=EVERY N DAYS

ENTER TYPE FOR NEW MESSAGE (Q=QUIT, 99=HELP)? 2
ENTER DATE FOR NEW MESSAGE (YYYYMMDD) ? 79020310
ENTER MESSAGE 1:
enter type for new message (q=quit, 99=help)? 3
enter date for new message (yyyymmdd) ? 790220
enter message 2:
enter type for new message (q=quit, 99=help)? 4
enter date for new message (yyyymmdd) ? 790301
enter message 3:
enter type for new message (q=quit, 99=help)? 5
enter date for new message (yyyymmdd) ? 790215
enter message 4:
enter type for new message (q=quit, 99=help)? 6
enter date for new message (yyyymmdd) ? 790209
enter message 5:
enter type for new message (q=quit, 99=help)? 7
enter date for new message (yyyymmdd) ? 790401
enter message 6:
enter type for new message (q=quit, 99=help)? 8
enter date for new message (yyyymmdd) ? 790401
enter message 7:
enter type for new message (q=quit, 99=help)? 9
enter date for new message (yyyymmdd) ? 790401
enter message 8:
INSERT PROGRAM DISK AND HIT RETURN?

MSI READY
*RUN
TICKLER MESSAGE SYSTEM
INSERT DATA DISK AND HIT RETURN
ENTER PRINT CONTROL AS FOLLOWS:
S=SELECTIVE, A=ALL, N=NONE, U=UPDATE ONLY ? A
ENTER CURRENT DATE (YYYYMMDD) ? 790301

ENTRY TYPE DATE UPDATE MESSAGE
2 2 790210 790209 -MESSAGE 1
3 3 790220 790209 -MESSAGE 2
4 4 790320 790209 -MESSAGE 3
5 5 790320 790209 -MESSAGE 4
6 6 790325 790209 -MESSAGE 5
7 7 790401 790209 -MESSAGE 6
8 8 790401 790209 -MESSAGE 7
9 9 790209 790209 -MESSAGE 8
10 10 790401 790209 -MESSAGE 9

ENTER ENTRY NUMBERS TO BE DELETED, FOLLOWED BY ZERO? 9
ENTER TYPE FOR NEW MESSAGE (Q=QUIT, 99=HELP)? 0
INSERT PROGRAM DISK AND HIT RETURN?

MSI READY
*RUN
TICKLER MESSAGE SYSTEM
INSERT DATA DISK AND HIT RETURN
ENTER PRINT CONTROL AS FOLLOWS:
S=SELECTIVE, A=ALL, N=NONE, U=UPDATE ONLY ? A
ENTER CURRENT DATE (YYYYMMDD) ? 790501

ENTRY TYPE DATE UPDATE MESSAGE
9 9 790210 790209 -MESSAGE 1
10 10 790220 790209 -MESSAGE 2
11 11 790301 790209 -MESSAGE 3
12 12 790401 790209 -MESSAGE 4
13 13 790501 790209 -MESSAGE 5
14 14 790601 790209 -MESSAGE 6
15 15 790701 790209 -MESSAGE 7
16 16 790801 790209 -MESSAGE 8
17 17 790901 790209 -MESSAGE 9

ENTER ENTRY NUMBERS TO BE DELETED, FOLLOWED BY ZERO? 0
ENTER TYPE FOR NEW MESSAGE (Q=QUIT, 99=HELP)? 0
INSERT PROGRAM DISK AND HIT RETURN?

MSI READY
```

current and last record numbers. Line 9400 closes the file to update the first record and directory entry.

Line 9500 restores the input routine so that commas become string delimiters once again. Line 9990 requests the clerk to insert the program disk and acknowledge this action.

If you or your business have the problem of needing one-time or periodic reminders, then this program should be worth the effort it takes to key it in (and convert it, if necessary). There are rewards for using it and penalties for not using it.

---

January 1980 © BYTE Publications Inc
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A Pascal Checkbook Balancing Program

Carl T Helmers, Editorial Director, BYTE Publications

Probably the most hackneyed example of what one can do with a personal computer is the proverbial checkbook balancing program. Well, here I have gone and done it: I sat down and profaned Pascal by writing a simple little interactive checkbook balance figuring program (listing 1).

The interactive sequence at initialization reflects a hardware specific aspect of a system which has UCSD Pascal bootstrapped through the CP/M operating system’s “BIOS” drivers. This is the use of the "<control> P" character from the keyboard to toggle a single bit flag which determines whether or not the printer is on. We assume the program is off upon entry, so that one depression of the <control> P character will turn on the printer through the “BIOS” keyboard driver’s action.

The general outline of the program, found in the last eight non-blank lines of listing 1, is fairly standard and applicable to a host of specific uses. For nearly every use of a computer, we start with a procedure called initialization which sets up the necessary initial conditions of processing. Then, we continue with a repeat until done loop construct which does the main logic of the process over and over again.

When the flag done becomes true during the main logic, the repeat loop discontinues and we fall through to the standard procedure summarize which does any final processing before the program is complete. Of course, in this particular example, summarize is a null operation, since I have no particular need to provide any reporting or file operations other than those encountered in the main loop. I have left the dummy procedure summarize in the listing to document this need for a possible summary procedure in a more elaborate version of the same program.

This program is run in UCSD Pascal, version 1.5. This same program should run identically on any computer with the UCSD Pascal software system. A sample run follows the listing. I have used the program now for several months; the interactive sequence used for all the detailed computations could be much improved, even though the present form has proved quite practical.

Listing 1: A Pascal listing of the checkbook balancing program.

```pascal
PROGRAM checks;
{ A simple little program written March 26 1979 by Carl Helmers }
{ Time from inception to working program approximately 15 minutes }

VAR
done : BOOLEAN;
detail, balance : REAL;
anychar : CHAR;
count : INTEGER;

PROCEDURE initialize;
BEGIN
balance := 0;
count := 0;
{The following sequence turns on my printer if I type <ctrl P> }
PAGE(COLPRT);
WRITELN('Checkbook balance program');
WRITELN('Set printer to top of form, press <ctrl P>, then any key.');
READ(keYBOARD, anychar);
{Premature end of program if I type <esc> now}
IF anychar = CHR(27) THEN done := TRUE
ELSE done := FALSE;
{A sequence to get the initial balance...}
IF NOT done THEN
BEGIN
anychar := 'N';
REPEAT
WRITELN('');
WRITELN('Enter Initial Balance');
READLN(balance);
WRITELN('Balance Starts at ',balance:10:2);
WRITELN('Is this correct?');
READ(keYBOARD, anychar);
WRITELN(anychar);
UNTIL ((anychar='Y') OR (anychar='y'))
END;
END initialize;

PROCEDURE process_one_check;
VAR
s : STRING[50];
```
PROCEDURE get_charge;
BEGIN
  anychar := 'N';
  REPEAT
    WRITE('Enter amount of ', s, ': '); 
    READLN(detail);
    WRITE('Is ', s, ': ', detail: 10:2, the correct value of the ', s, '?');
    READ(KEYBOARD, anychar);
    UNTIL ((anychar = 'Y') OR (anychar = 'N'));
END [get_charge];

PROCEDURE display_balance;
BEGIN
  WRITE('Current Balance = ', balance: 10:2);
END [display_balance];

BEGIN [process_one_check]
  WRITE('Is this correct?
  WRITE('Enter amount of ', s, ': ');
  READLN(detail);
  WRITE('Is ', s, ': ', detail: 10:2, the correct value of the ', s, '?');
  READ(KEYBOARD, anychar);
  IF anychar = 'Y' THEN
    done := TRUE
  ELSE
    CASE anychar OF
      'C', 'c':
        BEGIN
          s := 'check';
          get_charge;
          balance := balance + detail;
          display_balance
        END;
      'D', 'd':
        BEGIN
          s := 'deposit';
          get_charge;
          balance := balance + detail;
          display_balance
        END;
      'I', 'i':
        BEGIN
          s := 'interest';
          get_charge;
          balance := balance + detail;
          display_balance
        END;
    END;
  END [CASE];
END [process_one_check];

PROCEDURE summarize;
BEGIN
  (Remarkable... this procedure doesn't do anything!)
END [summarize];

BEGIN [checks]
  ([Isn't this simple... all we do is ]
  initialize;
  REPEAT
    process_one_check
  UNTIL done);
END.

Listing 2: A sample run.

Checkbook balance program
Set printer to top of form, press <ctrl P>, then any key.

Enter Initial Balance
3.1415927
Balance Starts at
3.14
Is this correct?

Enter amount of check:
15.00
Is 15.00 the correct value of the check?

Enter amount of interest:
2.00
Is 2.00 the correct value of the interest?

Enter amount of deposit:
1000
Is 1000.00 the correct value of the deposit?

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Illustrating BASIC

Donald Alcock
Cambridge University Press, 1977
134 pages, softcover with ring binding $4.95
hardcover $14.95

BASIC by Donald Alcock, is for you. In order to set the general approach used throughout this book, the author presents a line drawing of the famous program "bug." This is but one of the many "biff! bam! pow!" Batman and Robin type inserts used to reinforce specific concepts as they develop. This approach leads the reader through a convenient how-to-do-it explanation of BASIC programming.

The first chapter introduces the reader to what the author calls "Components of the Language." Immediately, the reader gets a taste of the unique presentation offered by this book; illustrations, short programs, and interesting problems abound. The fundamental concepts of most BASICS are introduced via a short note, an illustration, and a few program lines which allow the reader to see how the program should appear. Numeric variables (integer, real, and exponent form) and text variables (strings) are presented in a short but thorough exposition.

Chapter 2, entitled "Input and Output, Expressions and Functions," covers the statements: DATA; READ; RESTORE; INPUT; the functions SGN, ABS, SQR, INT, LOG, EXP, SIN, COS, TAN, and ATN; RND; DEF; PRINT; TAB; and PRINT USING. For each of these statements, a simple illustrative program is given. For example, an engineer may be interested in the short routine that calculates the spring properties of a diving board; the businessman will find the monthly repayment on a loan useful; the game player can use the die throwing routine; the mathematician has a routine that plots the graph of the cosine function; and everyone should enjoy the examples given for the PRINT USING statement.

After these concepts is Chapter 3, "Control." As in every chapter, the pertinent statements such as GOTO, IF, THEN, STOP, ON...GOTO, FOR...NEXT, GOSUB, and RETURN are introduced, illustrated, and programmed into short routines. Chapter

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3 does just that with the GOTO. Some of the programs include: solving a pair of simultaneous equations having any number of right-hand sides; area calculations for triangles, rectangles, and circles; and the game of Moo (quite similar to Bulls and Cows; ie: a number-based Mastermind).

A useful routine in Chapter 3 introduces the reader to stacks and to the way approach of introducing and examining a relatively complex idea is done rather subtly and painlessly.

Arrays are covered quite well in Chapter 4, and matrix operations are presented in Chapter 5. The concepts in Chapter 4 concerning arrays are enhanced when the reader finishes examining the matrices in Chapter 5. The author explains and illustrates matrix functions, although not all BASIC systems have them. He then manipulates matrices without the functions, using nested loops. Some of the more interesting matrix operations include: arithmetic operations upon arrays; transposing a matrix; initializing an array to all zeros or all ones; inverting a matrix; and input and output statements performed on arrays.

The array manipulating routines deal primarily with matrix algebra applications and could prove useful to the engineer or the mathematician.

Chapter 6, entitled "Complete Example Programs," contains only two programs. The first is a routine which converts Roman numerals to Hindu-Arabic (such as VII to 7). The other program is a critical-path analysis routine. Expecting a host of programs in this chapter, I was disappointed to find only two. They are good example programs which bring together most everything the reader has seen so far. Perhaps they could have been included as wrap-up programs in other chapters.

The remaining three chapters ("Commands and Signing On," "Files of Data," and "Syntax") explain how the typical BASIC interpreter handles the RUN, SAVE, UNSAVE, OLD, NEW, and CATALOG commands (the reader is cautioned as to the particulars of his or her personal BASIC); a typical sign-on session (see your owner's manual for this one); a short (unfortunately) discussion pertaining to sequential and direct-access files; and a modified Backus-Naur notation used to summarize the syntax of BASIC.

I ran most of the examples presented in the text on my Level II TRS-80. Since the author does not use any machine- or interpreter-dependent statements in his examples, there should be no problem in running the examples on other microcomputers. Some caution is expressed by the author, however, with regard to the lack of portability of BASIC. The reader should examine his or her BASIC manual for any differences between what the author labels "minimal BASIC" and the BASIC used in the reader's computer.

Overall, Illustrating BASIC is a good first book for the novice computerist. The author's Preface statement does ring true after reading this book: "You don't have to be a computer scientist to read this book: it is for students meeting computers for the first time; for those in industry (parti-
Implementing Software for Non-Numeric Applications

William M Waite
Prentice-Hall, 1973
110 pages hardcover
$21.00

Implementing Software for Non-Numeric Applications is a textbook on list and string processing languages. It covers the basics of lists and strings, and how to implement languages in order to deal with these data types. There are two major reasons why a computer hobbyist might want to read this book: to learn how such languages work and to learn how to implement them.

Most of the book is about lists. It begins with a discussion of what lists are, and then presents an ideal machine for processing them (cf. Pascal p-code), a fairly simple list processing language called HELP, and then LISP. The discussion of LISP focuses fairly heavily on what LISP does internally and why. After more discussion of complex lists, the book proceeds to a discussion of strings: SNOBOL4 is introduced but not discussed in the detail that LISP is treated. The final section is on implementation.

The author of the book favors implementation by abstract machine modeling; this is the way in which Pascal is implemented. It has the advantage that a compiler or interpreter, once written, can be implemented on new machines with much less effort than would otherwise be the case. The discussion of implementation is more than just theoretical; the appendices contain complete FORTRAN listings for an abstract machine model, and for HELP language compiler and interpreter.

HELP is a language similar to LISP. The software may be directly implemented if you have a FORTRAN compiler; otherwise it has to be translated into assembler (or perhaps BASIC, if execution speed is not important). I cannot say how successful this would be; I already have LISP for my Z80 processor and so was not tempted to implement HELP.

In conclusion, this book is fairly heavy going. If you want a thorough introduction to how list languages work, why they do what they do, and how to implement them, this is an excellent book. If you want an introduction to LISP, it would probably be better to first read an introductory text. Then read Implementing Software for Non-Numeric Applications to really understand the way things work.

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January 1980 © BYTE Publications Inc
Relocating 8080 System Software

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Dept of Physics
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Owners of both large and small computer systems often experience software problems when the time comes to upgrade the system. All old applications programs will have to be modified to run under the new system. However, the real problem occurs when you want to use some or all of the old system software. This was recently the situation at the University of North Carolina at Charlotte (UNCC) Physics Department.

The original hardware consisted of an IMSAI mainframe with 20 K bytes of memory interfaced with a Teletype and audio cassette. We added a floppy disk and Tektronix 4006-2 graphics terminal. To operate the disk, we acquired the CP/M operating system written by Digital Research and distributed by IMSAI.

The CP/M system has a disk-based version of BASIC called BASIC-E, which was written by Gordon Eubanks. This is an excellent version that allows up to 31 characters for variable names, nearly form-free entry of statements with line numbers required only for program transfer (eg: GOTO ..., GOSUB ..., etc), and numerous built-in functions, as well as file handling capabilities. However, it is unusual for BASIC because programs are first created using an editor, compiled into an intermediate file (using BASIC-E), and finally run (using RUN-E).

Our system is used primarily for instructional purposes and some of our students have had no previous programming experience. Hence, we felt that it was desirable to have an interactive version of BASIC for their use. We already had an interactive BASIC with our old system. However, there was a catch. To run under the CP/M system, it was necessary to shift the origin of BASIC to the address hexadecimal 0100 from its original starting address of 0000. (The CP/M monitor uses the addresses hexadecimal 0000 thru 00FF.)

In principle, if you have an assembly-language listing and an assembler program, it is always possible to reassemble the assembly-language code to machine code with a new starting address. However, with our old version of BASIC, this listing consisted of 113 typed pages! Ignoring the difficulty of just entering this amount of code, a moment’s reflection will show that the assembler and the code would never fit in 20 K bytes. (The machine code itself occupies about 9 K bytes.) Assembling the code in pieces that fit is a possibility. But, even with a cross-reference table of variable names, this would be an excruciating process. Hence, we were left with the only practicable alternative: relocating the machine code directly.

Thus it was with great interest that I read Leor Zolman’s article in the July 1977 BYTE entitled “A Machine Code Relocator for the 8080.” I have used the program written by Zolman and have found that it works as advertised.

However, I have oversimplified my initial statement of the problems faced in modifying our old BASIC to run under CP/M. There were segments of the old software that had to be removed to be compatible with CP/M. Thus, to avoid a lot of NOPs, various relocations to lower-memory addresses had to be made. (Various additions and replacements also had to be made.) As pointed out by Zolman, his program works by moving blocks of code tail-to-tail. Hence, “relocating backward into lower memory fails if the difference between the source and destination address is not greater than the block length.” Also, his suggested solution to this limitation of performing two relocations was impracticable because of our memory limitations.

I found that by making some modifications I could remove the limitation in Zolman’s original program at the cost of 36 additional bytes of program code. This modified relocator program is presented in listing 1. As written, the program is designed to run with the CP/M system’s Dynamic Debugging Tool (DDT), which is a type of monitor program for machine-code programs. I found this to be a useful procedure, since the Dynamic Debugging Tool allows the machine’s memory to be reviewed and modified via a terminal keyboard. I also found the disassembler routine of this program to be invaluable. (The program can be modified to run without a monitor, or with another monitor, by changing memory location hexadecimal 2DCC.)
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While there are some differences in detail as to the operation of the modified relocator, this program is run in the same manner as Zolman's original program. For ease of reference I have retained Zolman's nomenclature. (nb: Using this nomenclature, you view the memory as though you were looking down into a barrel. Numerically smaller addresses are at the top and numerically larger ones are at the bottom.) The same pieces of information are required for a relocation and reference fix, as in Zolman's program. This required information is outlined in table 1, which, except for memory addresses, is the same as Zolman's.

The LXI Problem

As pointed out by Zolman, the load immediate (LXI) instruction is a potential source of problems in relocating machine-code programs. The main difficulty is that this instruction is frequently used for two different jobs: to load a constant into a register pair, and to load an address into a register pair. The relocator program cannot distinguish between these two uses. Hence, if a program constant happens to be equal to an address within the program block being moved, an erroneous reference fix will be made.

Unfortunately there seem to be no widely accepted conventions for the use of this instruction that produce easily relocatable machine code. Adoption of the following conventions is suggested for all those desiring to write relocatable code:

1. The LXI instruction shall be used only to load addresses into a register pair (eg: LXI H,3101H).

2. All program constants shall be loaded into a register pair using 2 move immediate instructions (eg: MVI H,31H MVI L,01H).

The cost of adopting these conventions is relatively modest in that it will take 4 bytes to load a 2-byte constant into a register pair, instead of the 3 bytes required using the LXI instruction. Furthermore, if you only want to zero out a register pair, the following sequence of instructions achieves the same result at no additional cost, without using the LXI instruction:

```
2D4E 62/sp 8 ORG 2D00H
2D4F 35162E BEGIN ABMB INITIALSE SPACK+8
2D50 7CH redirection SPACK+8 JSET ORIGIN
2D52 2A832E LLDL SBOT SBIT OF SOURCE
2D54 2A8E66 LLDL SSTRT+(A)
2D56 2A812E LLDL SBOT+(A)
2D58 4D MOV C+L
2D5A 44 MOV B+C
2D5C 0CD2D CALL COMPH JSPL MTMENT(A) & ADD I
2D5E 1F DAD D JH E=(B)+(A) BLOCKSIZE
2D60 75 PUSH H JSAVE ON STACK
2D62 21A2 2D55E2 LLDL DTOP JOB OF DESTINATION
2D64 EB XCHG L.C.
2D66 69 MOV H,B JH E=SSTRT
2D68 66 MOV H,B JH E=SSTRT
2D6A 2A072E LHLD SBOT BOTTOM OF SOURCE
2D6C 2A032E LHLD SBOT BOTTOM OF SOURCE
2D6E 68 CALL COMPH JSPL MTMENT(A) & ADD I
2D70 69 CALL COMPH JSPL MTMENT(A) & ADD I
2D72 5F POP PSW JCHECK FOR MOVE
2D74 61 POP F GC DW ON J(C)>(A) IF CARRY SET
2D76 63 POP F GC DW ON J(C)>(A) IF CARRY SET
2D78 F1
2D7A 63 POP F GC DW ON J(C)>(A) IF CARRY SET
2D7C 63 POP A GC DW ON J(C)>(A) IF CARRY SET
2D7E 63 POP A GC DW ON J(C)>(A) IF CARRY SET
2D80 EB XCHG ;D,E=SBOT=CB>
2D82 09 DAD B H,L=CB>-<A>=BLOCKSIZE
2D84 0A XI LDAX B a,c:SSTRT SOURCE PTR.
2D86 0A XI LDAX B a,c:SSTRT SOURCE PTR.
2D88 7A MOV M,A MOVE TO NEW LOC.
2D8A 7A MOV M,A MOVE TO NEW LOC.
2D8C 87 MOV M,A MOVE TO NEW LOC.
2D8E 87 MOV M,A MOVE TO NEW LOC.
2D90 87 MOV M,A MOVE TO NEW LOC.
2D92 87 MOV M,A MOVE TO NEW LOC.
2D94 87 MOV M,A MOVE TO NEW LOC.
2D96 7A MOV M,A MOVE TO NEW LOC.
2D98 7A MOV M,A MOVE TO NEW LOC.
2D9A 7A MOV M,A MOVE TO NEW LOC.
2D9C 69 MOV M,A MOVE TO NEW LOC.
2D9E 69 MOV M,A MOVE TO NEW LOC.
2D00 69 MOV M,A MOVE TO NEW LOC.
2D02 69 MOV M,A MOVE TO NEW LOC.
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2D18 69 MOV M,A MOVE TO NEW LOC.
```

Listing 1: A relocatable program for use on 8080 systems. This is a modified version of the relocatable program written by Leon Zolman in the July 1977 BYTE. This relocatable program will move a source program to any location in memory and fix address references. Relocations of a source-program block to any address outside the source are performed without overwriting. The program is designed to run with the Dynamic Debugging Tool (DDT) of the CP/M software system. If need be, the program can be modified to run without a monitor or with another monitor by changing the contents of hexadecimal memory location 2DCC. While differing in some details with Zolman's relocatable program, it requires the same information and is run in the same manner.
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Meanwhile, back in the real world, the LXI problem will usually be encountered by anyone relocating software. Going through a massive assembly listing and manually fixing references would be a tedious and time-consuming chore. Fortunately, the computer can be used to do the "grit" work.

A program that enables the computer to look through the machine code for LXI operation codes is presented in listing 2. I have called it FIXLXI, though corrections must still be made manually. However, the computer does the tedious job of finding LXI operation codes. Upon finding an LXI operation code, the computer outputs the address where the instruction is located, followed by the operation code (eg: 01 for LXI B), and finally the 2-byte hexadecimal constant that is loaded into the register pair. For compatibility with the terminal, all output is in the form of ASCII code. (The conversion from binary to ASCII is done by a simple table look-up procedure.)

For example, upon finding the machine code equivalent of LXI D,21AEH at hexadecimal address 24AB, the program will cause output of the following:

```
24AB 11 21AE.
```

Afterward, control passes to the monitor and the operator consults the listing to verify that the code is correct. If not, a manual fix must be performed. (Using CP/M’s Dynamic Debugging Tool program as a monitor makes this an easy task. Simply typing in S24AB to the terminal invokes the program, then it waits for a command to quit.) When the program is reentered, the search for LXI operation codes resumes at the next previously found LXI operation code. To operate FIXLXI you need only
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specify the starting address (SSTAR) and the ending address (SSTP) of the code to be examined. In listing 2 this information is entered at hexadecimal addresses 2E42 and 2E44.

Employing the FIXLI program with a terminal operating at a data rate of 1200 bits per second (bps), I found that I could get through our BASIC listing in less than two hours. Similar results were obtained when I relocated another old assembler program.

Data Block Problems

It is not good programming practice to place program constants in the midst of executable code. Unfortunately, this and other kludges are frequently found. However, you will find in most cases that the program constants are at least huddled together in a contiguous block. If this is true, the data block can be moved, but no fixing of references should be performed within the data block. As indicated by Zolman, the procedure in this case is to perform the fixing of references in two stages. First, program references are fixed in the program block up to, but not including, the data block. Then, skipping over the data block, program references after the data block are fixed for the remaining portion of the program block.

In addition to the usual data block problems that have been mentioned, there is another difficulty encountered when systems software is relocated. The data blocks in an applications program will normally contain constants that are independent of the location of the program. In a systems software program like BASIC this is not true for all constants. This is so because of the design logic of an interpreter program. Essentially the interpreter works by comparing an input command or function to a table of legal commands or functions. If a match is found, con-
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trol is passed to that routine within the BASIC code. This procedure is frequently implemented by storing the address of the desired routine immediately adjacent to the command (function). (Actually, since commands (functions) are not all the same length (RESTORE is larger than FOR), it is common practice to place a delimiter, such as 0, immediately after the command (function). The address of the proper routine then follows.)

Thus, after the system software has been relocated and program references fixed, the command and function table addresses must also be fixed. These areas will usually be clearly indicated in the program listing. Also, since the data that must be changed is reasonably small, a manual fix can be readily performed. The success of this process is dependent upon your knowing the new addresses of the command (function) routines. Consequently, if a number of shifts and/or additions must be made, I would strongly suggest that changes and fixes be made one at a time. While this procedure requires more work, it is preferable to making all changes at once, since it is easy to lose track of where everything is located.

Caveat Emptor

After carefully implementing the programs and following the procedures that have been outlined, you may still find that your relocated software has glitches. Excluding pilot error, the source of any problems can logically be only an improper reference fix. While there may be many ways for this to happen, I have found only two species of software bugs that create this problem.

The first, and potentially least troublesome, bug occurs when an isolated byte or two of data is buried in the middle of executable code. With this particular gem I also found that my relocated software has glitches. Excluding pilot error, the source of any problems can logically be only an improper reference fix. While there may be many ways for this to happen, I have found only two species of software bugs that create this problem.

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usual case, the isolated byte will be identical to a 2- or 3-byte operation code. Then the possibility exists not only for an improper reference fix, but also for a mangling of the operation code(s). Fortunately, this mangling process is generally not self-propagating, so the damage is usually localized.

The second, and potentially most troublesome, bug involves the writing of relocatable code. While it may come as a surprise, yes there is such a thing as nonrelocatable code. To see that this is so, recall that the relocator program fixes references by operating only on the 2-byte hexadecimal constant following 3-byte operation codes. Implicit in this procedure is the logical assumption that all references to program addresses will be made via 3-byte operation codes. Certainly this is the easiest and most natural way to handle addresses. However, it is possible to use the 1- and 2-byte operation codes to manipulate addresses.

As a case study of this particular "buggy" (and bugging) practice, I submit the verbatim example from a listing of an assembler program in listing 3.

In this example the programmer needed to load the character following an operation code into the DE register pair without disturbing the HL register pair. Without a detailed knowledge of other program constraints, it is difficult to specify a foolproof fix for this code. Assuming no stack problems, appropriate substitutions are suggested in listing 4.

Those wishing to write relocatable code will avoid use of the programming practice illustrated in listing 3. (This is not an onerous requirement, since code that violates this convention tends to be tortured and unnatural.) Those who, for proprietary or other reasons, wish to write nonrelocatable code will liberally sprinkle their code with such examples.

**What To Do**

At this point it is reasonable to ask what can be done if you encounter one of the exotic bugs I have discussed. Unfortunately, there is no quick fix that is generally applicable. However, the following guidelines and suggestions may be helpful.

First, the source of the bug needs to be isolated to an area less than the size of the whole program. To do this, study the actual operation of the program. For which commands or functions does the program fail? After this bit of detective work, examination of the command or function table of your listing will tell you where to begin looking for the bug(s).

If nothing turns up at this point, the bug may be in a subroutine called by the command (function) routine. Even worse, it may be in a subroutine called by the subroutine, etc.

Finally, if all else fails, it will be necessary to perform a step-by-step trace of the operation of the program. At best this is a tedious process. If, however, you have isolated the bug, it is possible to set up a breakpoint that is activated only upon entry to the program segment that is suspect. (A breakpoint works by causing program control to pass to the monitor when the breakpoint is encountered. Before the breakpoint is activated, program execution is performed at normal machine speed.) With the Dynamic Debugging Tool program of the CP/M system distributed by IMSAI, a single breakpoint can be set by temporarily replacing a byte of the suspect software with the RST 07 instruction (FF in machine code). After the monitor has control, you can use it to generate a detailed trace of the program's operation for the suspect area.

After this recounting of the perils of relocating systems software, I hope that the reader is not totally discouraged. For well-designed software, relocation can be easily managed using the relocator and FIXLXI programs.

---

**Listing 3:** An example of poor programming practice. In this example, the programmer has loaded the DE register pair without disturbing the HL register pair. However, because the reference to the address hexadecimal D4F0 is done via 1 and 2-byte op code, this machine is not machine relocatable.

<table>
<thead>
<tr>
<th>Address</th>
<th>Hexadecimal Code</th>
<th>Instruction Mnemonic</th>
<th>Operand</th>
<th>Commentary</th>
</tr>
</thead>
<tbody>
<tr>
<td>BDC4</td>
<td>3E F0</td>
<td>MVI</td>
<td>A,ABUFF and 0FH</td>
<td>;LOAD LOW BUFFER ADDRESS</td>
</tr>
<tr>
<td>BDC6</td>
<td>80</td>
<td>ADD</td>
<td>B</td>
<td>;ADD LENGTH OF OP CODE</td>
</tr>
<tr>
<td>BDC7</td>
<td>5F</td>
<td>MOV</td>
<td>E,A</td>
<td></td>
</tr>
<tr>
<td>BDC8</td>
<td>3E D4</td>
<td>MVI</td>
<td>A,(ABUFF and 0FF00H)256</td>
<td>;GET HIGH ORDER ADDRESS</td>
</tr>
<tr>
<td>BDA5</td>
<td>CE 00</td>
<td>ACI</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>BDC7</td>
<td>57</td>
<td>MOV</td>
<td>D,A</td>
<td></td>
</tr>
<tr>
<td>BDC8</td>
<td>1A</td>
<td>LDAX</td>
<td>D</td>
<td>;FETCH CHARACTER AFTER OP CODE</td>
</tr>
</tbody>
</table>

**Listing 4:** Another method of performing the operation shown in listing 3. Here the reference to the address hexadecimal D4F0 is done using the LXI op code. This code is machine relocatable.

<table>
<thead>
<tr>
<th>Address</th>
<th>Hexadecimal Code</th>
<th>Instruction Mnemonic</th>
<th>Operand</th>
<th>Commentary</th>
</tr>
</thead>
<tbody>
<tr>
<td>BDC4</td>
<td>11 F0 D4</td>
<td>LXI</td>
<td>D,D4F0</td>
<td>;LOAD BUFFER ADDRESS</td>
</tr>
<tr>
<td>BDC7</td>
<td>E5</td>
<td>PUSH</td>
<td>H</td>
<td>;SAVE H,L PAIR</td>
</tr>
<tr>
<td>BDC8</td>
<td>68</td>
<td>MOV</td>
<td>L,B</td>
<td>;GET LENGTH OP CODE</td>
</tr>
<tr>
<td>BDC9</td>
<td>28 00</td>
<td>MVI</td>
<td>H,00</td>
<td>;PAD WITH ZEROS</td>
</tr>
<tr>
<td>BDCB</td>
<td>19</td>
<td>DAD</td>
<td>D</td>
<td>;ADD LENGTH TO BUFFER</td>
</tr>
<tr>
<td>BDD8</td>
<td>98</td>
<td>XCHG</td>
<td>D,E</td>
<td>;PUT RESULTS IN D,E</td>
</tr>
<tr>
<td>BDCD</td>
<td>E1</td>
<td>POP</td>
<td>H</td>
<td>;GET H,L BACK</td>
</tr>
<tr>
<td>BDC8</td>
<td>1A</td>
<td>LDAX</td>
<td>D</td>
<td>;FETCH CHARACTER AFTER OP CODE</td>
</tr>
</tbody>
</table>
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Clubs and Newsletters

Hobby Computer Club of Holland (HCC)
The HCC now has over 3000 members in 12 local groups which meet on a monthly basis. They welcome information on all aspects of microcomputing and currently are in need of information on hardware and software for the Apple II. Contact the HCC, Christinalaan 171, Eindhoven, NETHERLANDS.

Home Software Exchange's Program of the Month Club
This club offers an opportunity for persons who own small computers to buy and sell cassette computer programs. Upon joining, each member receives a yearly catalog of all programs listed on the exchange and monthly newsletter updates. A $2 royalty fee is given each time a member's program is purchased. Membership dues are $6 per year. To join send the membership dues and the programs you wish to list on cassettes with a listing of the program and a short description. Contact the Home Software Exchange, 1716 Dixie Dr, Jackson MS 39209.

Computerized Investments Club
The purpose of this club is to trade ideas, data, and programs related to the stock, option, and commodity markets. Club projects include the development of computerized trading and investment systems, and the development of a shared data base. Write to Computerized Investments Club, R D 1 Box 138, Sicklerville NJ 08081.

Videodisc News
This monthly newsletter is designed for readers in communications, education, television, audio and visual production, information storage and retrieval, microcomputers, and home video entertainment. Articles will cover new developments in software and hardware, competitive comparisons, conferences and services, and more. A special subscription rate of $95 per year is available to BYTE readers. Contact Subscriber Services, Videodisc News, P.O. Box 5340, W Bloomfield MI 48033.

Medical Computer Journal
MCJ is a newsletter that is devoted to information about computers and their uses in the daily practice of private physicians. Issues will cover the most common illnesses and the use of computers in dealing with them, computer systems, laboratory test interpretation and analysis using computers, and ideas for the uses of computers in offices. Subscriptions are $15 per year. For information, contact Dr. Aziz Ghaussy, editor of the MCJ, 42 E High St, E Hampton CT 06424.

Computer Newsletter for Engineers
Engineering Computer Applications Newsletter (ECAN) is being published monthly to inform and advise engineers on how to use advanced computer technology and increase productivity and profits. ECAN will contain articles on small
computers, peripheral equipment, engineering programs, combining large and small computers, graphics in engineering design, and many other topics. Subscriptions are $36 per year. Contact ECA N, 5 Denver Tech Ctr, POB 3109, Englewood CO 80111.

Crescent City Computer Club

This club meets once a month in a general meeting and they also have monthly meetings for their specialized groups. Their meetings are held at 8 PM in room 2120 of the University of New Orleans Science Bldg, on the main campus. The club also publishes a newsletter that covers the events of the meetings.

Contact the Crescent City Computer Club, POB 1097, University of New Orleans LA 70122.

Arcadian Newsletter

This newsletter has articles concerning various aspects of computing. Programs, schedules of events, corrections of programs, and general information items appear. Ads are welcome, and the latest issue included an item from the editor looking for reviews of software programs.

Contact Arcadian, 3626 Morrie Dr, San Jose CA 95127.

Apple Canada Users Group

This new group has been meeting on the first Wednesday of every month at the Computerland/Toronto store, 2180 Yonge St, Toronto, Ontario Canada. The meetings begin at 7:30 PM.

Contact Apple-Can, 2180 Yonge St, Toronto, Ontario M4S 2B9 CANADA.

Heath Users Group (HUG) Newsletter

REMark is a HUG membership magazine published quarterly for members only. The newsletter contains articles on programming, expanding the capabilities of Heath computers and items of general interest. Subscriptions are $14 a year and should be sent to the Heath Users' Group, Hilltop Rd, St Joseph MI 49085.

Sphere Newsletter

The Sphere Microcomputer Newsletter contains hardware and software features of interest to M6800 microcomputer owners and more specifically to Sphere owners. The newsletter is mailed 6 times a year. The subscription rate is $12 and should be addressed to Jeffrey Brownstein, 2 Tor Rd, Wappingers NY 12590. Material for publication should be sent to coeditor Roger J Spott, 13975 Connecticut Ave, Wheaton MD 20906.

BYTE's Bugs

Like All Modern Vehicles — The Cost Goes Up

George, the programmable toy van from Beneficial Marketing, was listed in the November issue as costing $24.95. This should read $39.95.

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CIRCLE 140 ON INQUIRY CARD.
Larry Atkin of Northwestern University, regained written by David Slate and however, Belle suffered a setback in the third round of during the convention of the Association for Computing Machinery (ACM) in Detroit, Michigan from October 28 to October 31, 1979. Slate and Atkin's program (then called Chess 4.7) was upset in the 1978 championship by the program Belle, written by Ken Thompson of Bell Laboratories. Belle won the 1978 competition with a perfect score of four wins in the 4-round Swiss System tournament. (See "Computer Chess Report," May 1979 BYTE, page 174.) In the 1979 Tenth Annual North American Computer Chess Championship, however, Belle suffered a setback in the third round of competition when the Chaos program (written by Mike Alexander, Fred Swartz, John O'Keefe, and Victor Berman of the University of Michigan) fought Belle to a draw. The hopes of Belle's backers were further dashed when Chess 4.9 also achieved a draw with Belle in the fourth and final round. With this final half-point, Chess 4.9 wrested a clear-cut victory in the tournament with a score of 3½ out of 4 possible points.

Three programs of the twelve competing in the event were run on microcomputer systems. The program Mychess, written in Z80 assembler language by David Kittinger of Anchorage, Alaska, ran on a Cromemco Z-2D system with 64 K bytes of memory and gained a score of 2⅗ points. Dan and Kathe Spracklen entered version 2.5 of Sargon, which ran on a 6502-based electronic chessboard processor; the program obtained a score of 1⅛ points. The program Rufus, written by Charles Sullivan in 6502 assembler, did not fare so well. It lost all games and ended with a score of zero. Rufus ran on an Apple II computer in 48 K bytes of memory.

Besides these three programs that used microprocessors to calculate what moves to make, two programs that ran on large computers employed microprocessors to control electronic chessboards that indicate moves with light-emitting diodes and transmit opponent's moves automatically. Both Chess 4.9 and Blitz 6.9 (written by Robert Hyatt and Albert Gower of the University of Southern Mississippi) used these devices.

The tournament was organized by a committee comprising Monroe Newborn, Ben Mittman, Ira Purchis, and David Dahm. The tournament director was International Master David Levy (who was featured in "Chess 4.7 versus David Levy," by J R Douglas, December 1978 BYTE, page 84). In attendance as observers were one-time World Champion Max Euwe (ny - vuh), president of the Federation Internationale des Echecs (FIDE), and George Koltanowski, former presi-
dent of the United States Chess Federation (USCF) and noted player of blindfold chess.

Stanford University professor John McCarthy presented the tournament awards and spoke at a ceremonial luncheon held on the final day of the ACM convention.

A cross-table of game results achieved by the twelve programs is reproduced here in Table 1. According to Dr Newborn, the strength of play of all the programs in the 1979 competition was greater than in the previous tournaments.

An interesting experiment took place on the Saturday preceding the tournament. David Levy, with an ability rating of about 2390, played a single game against a team consisting of David Slate (USCF rating of about 2050) and his program, Chess 4.9 (also rated at about 2050). The purpose was to find out if cooperation between man and machine could produce better play than either man or machine playing alone.

According to rating statistics, a player rated 2050 should, in a 20-game match, win perhaps two games and draw perhaps five. It was expected that the Slate-Chess 4.9 team would have an effective rating of about 2150, with Levy favored to win.

True to expectation, Levy used his knowledge of the strong and weak areas of the opposing team and won the game. Nevertheless, development of the symbiotic relationship between the human player and a computer may yet extend the capabilities of both men and machines.

Microcomputers in Education

A nonthreatening first experience with microcomputers for kindergarten to 12th grade teachers has been developed by Dan Isaacson at the University of Oregon. He designed a self-instructional, laboratory-type course to help teachers use computers without having to be programmers.

The course consists of programs and text that show how to turn on the computer, load programs, explore materials at various levels in fine arts, business, English, foreign languages, consumer economics, and more. The program will be released in the summer of 1980 for use by public schools and colleges of Education. For more information, contact Dan Isaacson, Computer Center, University of Oregon, Eugene OR 97403.

Reformatting Dollars and Cents

Mr J R Borden of Laguna Hills CA, has pointed out an error in my recent letter on formatting dollars and cents ("Good Cents," September 1979 BYTE, page 150). In trying to compact the procedure to one line, I erred in the roundoff, the results not being correct for \$1,995 and similar cases. A correct version is given in line 30 of the adjacent listing.

In short, you can have a full-fledged data terminal for about the price of a high-quality electric typewriter.

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Reformatting Dollars and Cents

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20 IF X < 0 THEN X = ABS (X): PRINT "-":
30 X = X + 0.005: PRINT "$": INT (X):...:RIGHT$ (STR$ (INT (100 * (X + 1))),2)

Mr Borden also considered the case of negative quantities. To handle these requires an additional line, line 20 in the listing.

I apologize for any inconvenience this error may have caused.

James D Childress
5108 Springlake Way
Baltimore MD 21212
JANUARY 1980

Education Coordinators' Workshops 1980. Held throughout 1980, these workshops will cover costing, justifying costs, course design strategies, scheduling, record keeping and reporting to management. For information on when and where the workshops will be held, write to Deltak Inc, 1220 Kensington Rd, Oak Brook IL 60521, or call (312) 920-0700.

January 3-4
Hawaii International Conference on System Sciences, Honolulu HI. The conference will cover developments in theory and practice in software and hardware, and advanced computer systems applications in selected areas, with emphasis on medical information processing and computer-based decision support-systems for upper level managers in organizations. For more information, contact Perry G Patteson, Office of Management Programs, University of Hawaii, 2404 Maile Way, Honolulu HI 96822.

January 5-8
International Winter Consumer Electronics Show, Las Vegas Convention Center, Grand Ballroom of the Las Vegas Hilton and the Jockey Club Hotel, Las Vegas NV. The show will have over 850 exhibitors covering markets including audio systems, software, television and video tape and disk systems, home computers, calculators, and many more. Contact Consumer Electronics Shows, 2 Illinois Center, Suite 1607, 233 N Michigan, Chicago IL 60601.

January 5 and 12
Introduction to Computing and Personal Computers, Human Computing Resources, 10 St Mary St, Toronto Ontario M4Y 1P9 CANADA. This course will cover introductions to computers, programming, software and hardware, using computers in homes and offices, and buying and owning a personal computer.

January 8-24
Tuesdays and Thursdays, Introductory Programming in BASIC, Human Computing Resources, 10 St Mary St, Toronto Ontario M4Y 1P9 CANADA. Direct execution of commands, the writing of simple BASIC programs, system dialects, error handling and debugging, and programming methods and style will be covered in this course.

January 15
Invitational Computer Conference, Orange County CA. New developments in computer and peripheral technology such as Pascal systems, printers, and streaming tape drives will be featured in this conference directed to the quantity buyer. For more information, contact B J Johnson and Associates, 2503 Eastbluff Dr, Suite 203, Newport Beach CA 92660.

January 15-18
TV-Microelectronics and Microprocessing Exhibition, National Exhibition Centre, Birmingham, England. Manufacturers and suppliers of microprocessors, electronic and microcomputer games, video display units, video cameras and projection systems and digital consumer electronics are invited to participate. Over 9000 retailers, wholesalers, distributors and government buying authorities are expected to attend this show. For more information, contact TMAC, 680 Beach, Suite 428, San Francisco CA 94109.

January 17
Electronic Road Shows, Proud Bird Restaurant, Los Angeles Airport, Los Angeles CA. This traveling exhibition of components, materials and instruments is being produced by the Electronic Representatives Association (ERA). Over 80 ERA member firms will participate, and products from over 700 electronic companies will be displayed. For more information, contact the Southern California ERA office, 20969 Ventura Blvd, Suite 9, Woodland Hills CA 91364.

January 21-24
American Association of Physics Teachers and the American Physical Society, Chicago Marriott Hotel, Chicago IL. An introduction to microprocessors, a Pascal programming workshop, and a course on the use of personal computers in learning physics, plus more sessions on microprocessors will be presented. Contact the American Association of Physics Teachers, Graduate Physics...
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Electric Pencil $150

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January 22-24
Designing, Installing and Managing An International Telecommunications Private User Network, Dallas TX. This course is intended for communication professionals interested in understanding and developing communication systems, services, and techniques. For more information, contact Telecom Systems Group, 579 Pompton Ave, Cedar Grove NJ 07009.

January 30-February 1
MIMI '80 Asilomar, Asilomar Conference Grounds, Pacific Grove CA. This symposium covers all aspects of mini and microcomputers including technology, hardware, software engineering, languages, education and more. Contact The Secretary, MIMI '80 Asilomar, POB 2481, Anaheim CA 92804.

FEBRUARY 1980

February 6
Invitational Computer Conference, Ft Lauderdale FL. This conference is directed to the quantity buyer and will feature the newest developments in computer and peripheral technology. Contact B J Johnson and Associates, 2503 Eastbluff Dr, Suite 203, Newport Beach CA 92660.

February 12-14
Data Communications Conference and Exhibition, Harbour Castle Hilton, Toronto Ontario, Canada. Panel sessions, presentations, workshops, and technical sessions related to the field of data communications will be featured. Network control, management, performance and architecture; communications hardware and software; fiber optics; distributed data processing; and international communications policies are some of the subject areas that will be discussed. The exhibition at the convention center will feature over 100 exhibitors.

For more information, contact Whitsett Publishing.
conference and exposition will cover business communications. For program information, contact the Director of Program Development, The Conference, 60 Austin St, Newton MA 02160. For exhibit information, contact the national sales manager, Communications Networks '80, POB 96, Haddon Heights NJ 08035.

February 25-28
Compcon 80, Jack Tar Hotel, San Francisco CA. The conference theme is "VLSI: New Architecture Horizons." It will be devoted to developing advanced technologies for computers. Contact Compcon Spring '80, POB 639, Silver Spring MD 20901.

February 26-28
Nepon West '80, Anaheim Convention Center, Anaheim CA. The conference and exhibit will deal with the latest advances in electronics by covering such topics as wave soldering, etching, automated assembly, die attaching, hybrid circuit packaging, photo lithography, precious metal recovery, laser annealing, and much more. For further information, contact ISCM Inc, 222 W Adams St, Chicago IL 60606.

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Congress Center, Atlanta GA. A combination conference and exhibition of office computer systems has been developed to help management understand the growing technology of business computer systems. For more information, contact H A Bruno and Associates Inc, 78 E 56th St, New York NY 10022.

March 10-12
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March 17-20
Interface ‘80, Miami Beach Convention Center, Miami Beach FL. This conference and exposition is devoted to data communications, distributed data processing, and networking. Approximately 1000 exhibitors are expected and attendance is expected to exceed 12,000. For information, contact Interface ‘80, 160 Speen St, Framingham MA 01701.

March 17-21
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March 20
Electronic Road Shows, Castaways Restaurant, Burbank CA. See January 17 for details.

March 24-28
Fourth European Conference on Electrotechnics, Stuttgart. This conference will review recent development trends and applications in the field of microelectronics. Microprocessors, computer communication, industrial electronics applications of microelectronics in the automobile and in medicine, and other topics will be covered. The conference language will be English. Contact Professor Dr W E Proebster, IBM Deutschland GmbH, Postsach 80 08 80, D-7000 Stuttgart 80 GERMANY (BRD).

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A French-English/English-French Dictionary

Dr Fred Levit, 251 E Chicago Ave, Chicago IL 60611

The program FRENGLSH turns a microcomputer into a foreign language dictionary. As written here, it will look up the French or English word entered and then print the translation. It does not translate phrases or sentences, but serves as a replacement for a paper dictionary.

FRENGLSH is written in CBASIC and uses two files which are stored on a disk. The first file, called DICTION, is a random access file each record of which contains pairs of words with the pairs separated by slashes. Each pair of words consists of a French word followed by a dollar sign and then the corresponding English word, or an English word followed by a colon and then the corresponding French word. As you can see in table 1, the word pairs are arranged in the record alphabetically by the left-hand word of each pair.

The second file used by FRENGLSH is called FRINDEX and is an index to the diction file. It contains a list of the first words in each record of the DICTION file, arranged alphabetically, with the corresponding line number in the DICTION file where that word is found. This file is read into an array in memory so that it can be searched rapidly when the program is running.

When a word is entered, FRENGLSH first searches the index to find the line number in DICTION where the wanted word pair will be found (lines 70 to 97 of listing 1). It then goes to that line in the file and searches the record for the wanted word plus the correct separator. Searching for the word with the separator appended avoids problems caused by similarly spelled words with different meanings which may be shared by French and English. When the correct left-hand member of the word pair has been found then the right-hand member of the pair is extracted (lines 99 thru 108, listing 1) and the entered word and its translation are printed. (See listing 2.)

The DICTION file contains about 1100 French words, which includes those most commonly used and needed by someone studying the language. Naturally not every word one might seek can be found, but, before giving up, FRENGLSH does one more thing. The infinitive form of most French verbs ends in -er or -oir, and that is the way the verbs are listed in a dictionary. But many verbs are most frequently encountered in the second person form,
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Table 1: A portion of the file DICTION. Each record of 240
characters or less occupies about two and a half lines. Note tlzat
th e words are in pairs, either French$Englis h or English: French.
The list is alplzabetized by th e left-hand word in each pair.
''/ A$TO / ABORD$APPROACH/ABOVE :AU· DESSUS(V)/ ABOVE
A LL :SURTOU T/ ABSENCE :ABSENCE(LA)/ABSENCE$ABSENCE/
ABSENT:ABSENT/ABSENT$ABSENT/ABSOLUMENT$ABSOLUTELYI
ABSOLUTEL Y:ABSOLU MENTIACCEPT:ACCEPTER/''
''/ACCE PTER$ACCEPT(TO)IACCIDENT$ACCIDENTI ACCI DENT:
ACC IDENT(LE)/ ACCORD$AGREEMENTIACCOUNT:COMPTE(LE)I
ACE :AS( LE)IACHAT$PURCHASEIACHETER$BU Y(TO)/ACHEVER$
FINISH(TO)/AC IE R$STEEUACOUAINTANCE:CONNAISSANCE(LA)/''
'' /ACQU E RI R$ACOU IREIACOU IRE : ACO U ERi A/ACROSS :
TRAVERS/AC T:AGI RI AC T I F$ACT IVE/ ACTI ON$ACTION OR
STOCK/ACTION :ACT ION I ACT IVE :ACT I F/ACTU EL$PRES ENT
TIMEIADD :AJOUTER/ADDITION$CHECK(RESTAU RANT)/''
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ADMIT(TO)/ADMIT:ADMETTREIAD RESS:ADRESSE(LA)IAD RESSE$
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Listing 1: A listing of FRENGLSH . The program is written in
CBAS/C so that the line numbers at th e left are not referenced
by GOTO statements . Instead statemen t numbers are added by
the programmer for statements which must be returned to. For
example, lin e 61: GOTO 75 sends the program to line 48, which
is statement 75.
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Listing 1 continued on page 208

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Listing 1 continued:

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142 IF WORDS[4] = "HELLO"  THEN
143 DO TO 500
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145 IF WORDS[4] = "HELLO"  THEN
146 DO TO 500
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148 IF WORDS[4] = "HELLO"  THEN
149 DO TO 500
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305 DO TO 500
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307 IF WORDS[4] = "HELLO"  THEN
308 DO TO 500
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310 END
311
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Listing 2: In this run of FRENGLSH the first prompt FR= ? was answered by typing "bonjour," and FRENGLSH found the corresponding English word "hello." In the third example, the word "voulez" is not the dictionary form of the verb. The -ez ending signifies it is second-person present tense. FRENGLSH did not therefore find "voulez," so it looked for the stem of the word with common infinitive endings, -er or -oir. "Vouloir," the correct infinitive form of the verb, was found and the corresponding English was printed.

**Program FRENGLSH**

A FRENCH-ENGLISH DICTIONARY

ENTRY MODE IS FRENCH-ENGLISH. TO REVERSE MODE ENTER # 1 INSTEAD OF A WORD

TO END THE PROGRAM ENTER A 9 INSTEAD OF A WORD

PLEASE WAIT 40 SECONDS WHILE WE LOAD

ENTER FRENCH WORD AFTER FR= OR ENGLISH AFTER EN=

```
FR= ? ECHOL LCH, "HELLO"

EN= ? VOLEZ

FR= ?

EN= ?
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ending in -ez. For example, *vouloir* means "to want" while *voulez* means "you want." *Parler* means "to talk" and *parlez* means "you talk." If the word you give to FRENGLSH ends in -ez and is not found in the DICTION file, FRENGLSH will search for the root of the word with an -er ending, and, if that fails, for an -oir ending (lines 116 thru 128 in listing 1). Only if those additional two searches are unsuccessful does FRENGLSH report failure.

As can be seen, at 130 lines, including comments and blank lines, FRENGLSH is not a very long program. Of course, the real problem is in creating the DICTION file with its thousands of words. This was done by using several other programs. One program permitted the entry of word pairs, assigning the correct separator, and writing the list to a file which was then corrected using the system editor. These lists were concatenated as they were created, and the completed list was split into twenty-six separate lists, each beginning with a different letter of the alphabet. These individual lists were then proofread, corrected, concatenated, and alphabetized to make a single long file. The final file was then read by a program which created the DICTION file by inserting slashes between the word pairs and assembling the pairs into records of 204 or less characters. Finally a small program was used to read the first word in each record in the DICTION file, together with its record number, to create FRINDEX, the index file.

FRENGLSH is quite fast. Most of the time it is considerably faster than thumbing the pages of a paper dictionary, especially for people like me who have never really learned which letters follow which in the alphabet. ■

Z80 User Stack Emulation

**Allen Gelder, Box 11721 Main Post Office, San Francisco CA 94101**

Passing arguments to subroutines via the Z80 hardware stack is complicated by the presence of the subroutine return address at the top of the stack. This artifact of the CALL instruction makes a cork-in-the-bottle effect that precludes just PUSHing the arguments onto the stack and later POPing them into the subroutine after the CALL. The problem is solved on the new Motorola 6809 by the addition of a user stack which does
not participate in the CALL housekeeping. Such a structure is easily emulated and can be integrated very naturally into the Z80 instruction set by the use of the restart instruction group.

Recall that the restart (RST) instructions are 1-byte calls to selected page 0 locations. For example, hexadecimal op code D7 is RST 10. When program flow encounters this instruction, the program counter (register PC) will be pushed onto the stack and control will be transferred to location 0010. Often this location contains a vector to the actual routine, which will typically be concluded by a return (RET). This is the arrangement here (see listing 2, page 210). It is easy to link this emulation; just initialize UPSTO R with a 2-byte user pointer to the desired top of the user stack, and then vector the restarts as indicated. (See listing 1, page 210.)

When program flow encounters a D7 op code (RST 10), the result will be a POPU DE, that is, the top of the user stack will be popped into DE, and the user pointer (UP) will be updated. Similarly, a DF op code (RST 18) will result in a PSHU DE onto the top of the user stack, etc (see table 1). This action is perfectly consistent with current hardware stack usage, right down to the near congruence of the POPU and PSHU instruction bytes.

The difference is that this stack is totally controlled by the user, at very little programming expense. In the configuration of table 1, the user stack access covers the primary register pairs BC, DE, HL and AF. An alternative assignment (see listing 3, page 210, and table 2) of restarts can include registers IX and IY. This is at the expense of register pairs DE and AF, but saves one byte over the corresponding PUSH or POP IX (or IY) instruction.

Interpretation of the restart group of instructions is varied. In the literature, the restart instructions are described as saving space, useful for interrupts, or as left over 8080 instructions. In practice they are often usurped by the input/output (I/O) software, or perhaps page 0 is submerged in read-only memory. If this is the case in your Z80-based system, it is worth looking for a vector table in programmable memory or in some other way gaining access to the restart instructions. Because they are an embedded group of 1-byte, user-programmable instructions, they bestow a kind of microprogrammability on the Z80.

<table>
<thead>
<tr>
<th>User Stack Instruction</th>
<th>Hardware Stack Instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>POPU BC</td>
<td>C7 (RSTD0)</td>
</tr>
<tr>
<td>PSHU BC</td>
<td>CF (RST08)</td>
</tr>
<tr>
<td>POPU DE</td>
<td>D7 (RST10)</td>
</tr>
<tr>
<td>PSHU DE</td>
<td>DF (RST18)</td>
</tr>
<tr>
<td>POPU HL</td>
<td>E7 (RST20)</td>
</tr>
<tr>
<td>PSHU HL</td>
<td>EF (RST28)</td>
</tr>
<tr>
<td>POPU AF</td>
<td>F7 (RST30)</td>
</tr>
<tr>
<td>PSHU AF</td>
<td>FF (RST38)</td>
</tr>
</tbody>
</table>

Table 1: Restart (RST) instructions assigned to user stack in listing 1.

<table>
<thead>
<tr>
<th>User Stack Instruction</th>
<th>Hardware Stack Instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>POPU IX</td>
<td>D7 (RST10)</td>
</tr>
<tr>
<td>PSHU IX</td>
<td>DF (RST18)</td>
</tr>
<tr>
<td>POPU IY</td>
<td>F7 (RST30)</td>
</tr>
<tr>
<td>PSHU IY</td>
<td>FF (RST38)</td>
</tr>
</tbody>
</table>

Table 2: Restart (RST) instruction assignments made by modified user-stack emulation in listing 2.

In this user stack setup, the restart instructions are exploited as 1-byte PSHU and POPU instructions in service of an emulated processor architectural feature. They could as easily call an emulated addressing mode not available on the Z80. The point is that an appropriate use of the restart group is in calling instruction-like subroutines that represent the primitives serving the user's own fanciful structure. Thus you can design your own corner of the Z80. Let your curiosity PSHU into trying it.
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Listing 1: Vectoring RST10.

```
0010 C310 50 00099 RST10 JP FROM10 ; Now D7 calls FROM 10
```

Listing 2: Assembled program for Z80 user-stack emulation using restart (RST) instructions.

```
5000 00100 ORC 5000H ; CF saved here.
5001 00101 SPMOP NOP
5002 00103 UPSTOR NOP
5003 00104 NOP
5004 00105 FRO M0 PUSH HL
5005 00106 LC HL, 00C1H
5006 00107 JR USRSTK
5007 00108 FROMR0 PUSH HL
5008 00109 LD HL, 00C5H
5009 00110 JR USRSTK
5010 00111 FROM1H PUSH HL
5011 00112 LD HL, 00D1H
5012 00113 JR USRSTK
5013 00114 FROM1H PUSH HL
5014 00115 LD HL, 00D5H
5015 00116 JR USRSTK
5016 00117 E5 ASM 00118 LD HL, 00E1H
5017 00119 JR USRSTK
5018 00120 MOVEX H PUSH HL
5019 00121 LD HL, 00E5H
5020 00122 JR USRSTK
5021 00123 FROM40 PUSH HL
5022 00124 LD HL, 00F1H
5023 00125 JR USRSTK
5024 00126 FROM60 PUSH HL
5025 00127 LD HL, 00F5H
5026 00128 USRSTK LD (USRSTK), HL; Place in USRSTK.
5027 00129 POP HL
5028 00130 LD (FRO M8), SP; Save the SP.
5029 00131 LD (SP, USRSTK); Initialize user stack.
5030 00132 POP HL; Event happens here.
5031 00133 OPSTOR NOP
5032 00134 OPSTOR NOP
5033 00135 FD TION NOP
5034 00136 TION NOP
5035 00137 POP HL
5036 00138 PUSH HL
5037 00139 PUSH HL
5038 00140 PUSH HL
5039 00141 PUSH HL
5040 00142 PUSH HL
5041 00143 PUSH HL
5042 00144 PUSH HL
5043 00145 PUSH HL
5044 00146 PUSH HL
```

Listing 3: Alternate assembled listing to include index registers IX and IY. These two sections of code are directly substituted for the code in listing 2.

```
5050 00100 ORC 5050H ; CF saved here.
5051 00101 SPMOP NOP
5052 00103 UPSTOR NOP
5053 00104 NOP
5054 00105 FROM0 PUSH HL
5055 00106 LC HL, 00C1H
5056 00107 JR USRSTK
5057 00108 FROMR0 PUSH HL
5058 00109 LD HL, 00C5H
5059 00110 JR USRSTK
5060 00111 FROM1H PUSH HL
5061 00112 LD HL, 00D1H
5062 00113 JR USRSTK
5063 00114 FROM1H PUSH HL
5064 00115 LD HL, 00D5H
5065 00116 JR USRSTK
5066 00117 E5 ASM 00118 LD HL, 00E1H
5067 00119 JR USRSTK
5068 00120 MOVEX H PUSH HL
5069 00121 LD HL, 00E5H
5070 00122 JR USRSTK
5071 00123 FROM40 PUSH HL
5072 00124 LD HL, 00F1H
5073 00125 JR USRSTK
5074 00126 FROM60 PUSH HL
5075 00127 LD HL, 00F5H
5076 00128 USRSTK LD (USRSTK), HL; Place in USRSTK.
5077 00129 POP HL
5078 00130 LD (FRO M8), SP; Save the SP.
5079 00131 LD (SP, USRSTK); Initialize user stack.
5080 00132 POP HL; Event happens here.
5081 00133 OPSTOR NOP
5082 00134 OPSTOR NOP
5083 00135 FD TION NOP
5084 00136 TION NOP
5085 00137 POP HL
5086 00138 PUSH HL
5087 00139 PUSH HL
5088 00140 PUSH HL
5089 00141 PUSH HL
5090 00142 PUSH HL
5091 00143 PUSH HL
5092 00144 PUSH HL
5093 00145 PUSH HL
5094 00146 PUSH HL
```

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Eighteen with a Die

A Learning Game Player

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The simulation of human intellect by a machine of human invention has fascinated mankind for centuries. Unfortunately, the attainment of such a goal still seems to be distant. The advances in machines that might achieve such a goal seem to be continually offset by additions to our knowledge of the complexity of the human intellectual process. Simple game-playing machines, however, are feasible, and their popularity probably stems from the above mentioned human yearning, even though these games represent only a narrow slice of human intellect.

Game-playing programs are of great value to the personal computer owner, since results of great interest to spouse and neighbors can be produced with only a small investment in memory and software. Rarely do such programs involve more than logic plus simple integer arithmetic, and they are so short that hand assembly of machine-language programs is entirely feasible.

Many games are well adapted to interaction with the human player through the same I/O (input/output) channel used for programming. I am sure that the first program tried by most buyers of the Southwest Technical Products Corp 6800 computer system (after some memory check programs) is the Tic-Tac-Toe program whose listing is supplied with the computer kit.

Although such beginner games soon become boring, game-playing programs of real and continuing challenge are now becoming feasible for all amateur computer owners. Meanwhile, simple game players such as the one described here continue to intrigue computer enthusiasts.

Game Categories

Thus far I have been using the term "game player" loosely, and indeed the term is loosely used in many articles. Three distinct categories are easy to define: puzzles, gambling machines, and man versus machine game players.

It seems to me that a game like Shooting Stars (by Willard I Nico, May 1976 BYTE, page 42) is really a puzzle that the human tries to solve in as few moves as possible. Star Trek-type games might be considered examples of a gambling program. Through the use of random number generators, the human's moves produce random results following prescribed odds; luck is involved in the result.

Tic-Tac-Toe is an example of a man versus machine game. The machine plays the role of an adversary, playing by the same rules that apply to the human.

This last category comes the closest to the simulation of human intellect, which is why I feel it is of great interest to the computer owner. However, all three types of games are interesting to players, and many games combine elements of all three in their architecture.

Game Learning Program

A natural extension of the third category is the game learning and playing program. In this type, the machine is given the rules of the game, but initially does not possess any strategy for selecting its moves. Through playing a series of games with the human, it learns a strategy for increasing its chances of winning. This type comes even closer to the simulation of human intellect.

The design of such machines has been one of my hobbies for over thirty-five years. I recently purchased a computer because my ambitions outgrew what could be built using relays and stepping switches, or even

About the Author

Russell Yost studied physics at the California Institute of Technology before World War II diverted him into working on defense electronic systems. Since 1952 he has worked for Motorola; he is now the chief engineer for radar systems in the Government Electronics Division. When he saw the rising tide of microprocessor electronics, he bought a Southwest Technical Products 6800 computer system to gain experience in the new field. He uses the 6800 system to design logic circuits at home; at work he writes FORTRAN programs for simulation on a Sigma 5 computer. He is active in amateur radio and photography.
small-scale integration logic elements. Software generation for such machines is now my current hobby.

The learning process can be implemented in various ways. One way is the “reward or punishment” approach exemplified by the game Hexapawn, which was described by Martin Gardner and based on a learning machine developed by Donald Michie. (See “Mathematical Games,” Scientific American, volume 205, number 3, March 1962, page 138.)

The computer’s response to each game situation is selected at random from a set of legal moves whose individual selection probabilities are the result of a previous experience. After each game in which the computer wins, the moves that it used are enhanced in probability. After each game it loses, the moves that it used are reduced in probability.

Gardner presented a simple model of such a game in which each response was the label of a box containing a certain number of beads. Losing moves were penalized by the removal of beads; winning moves had beads added to their boxes. The probability of selecting a given move in future games was related to the number of beads contained by its box. Robert Weir described a simpler process in which the various response probabilities were either 0 or 1 (“Hexapawn: A Beginning Project in Artificial Intelligence,” November 1975 BYTE, page 36).

**Win Table**

Another learning process is the construction of a table of winning moves for each position or situation of the game. Many games are characterized by the existence of such a table. Each player tries to move to prevent the other player from getting to a winning situation in the table. Such a table is sometimes referred to as a game tree because of the multiple branches that lead to a single final winning position represented by the trunk of the tree.

For learning, the machine can initially be given the table of all possible moves for each game situation, with winning moves unidentified. For each situation the machine plays from, it fills in the winning moves by determining which of its permitted moves prevent the player from reaching a winning situation. Furthermore, after making its move, the machine may again analyze the new situation, before allowing the player to take his or her turn.

For the early games in a sequence of games, when most of the winning moves are unidentified, this process produces many errors. However, when the end of the game can be reached from the situation being analyzed, this process correctly identifies winning moves.

In subsequent games of a series, the correct entries appearing close to the end of the game permit the correction of earlier errors. To do this, the computer designates as losing moves those resulting in a situation from which the player can, with a legal move, attain a winning situation.

The net result is that during a series of games, the win table, which originally identified none of the winning moves, is gradually improved until it contains no significant errors and a sufficient number of winning moves to enable the machine to play faultlessly. Thereafter, one of the two players has no chance to win unless the other errs. Naturally, the game must be arranged so that the losing player is the human player; otherwise the learning process would not be apparent.

The above process of computer learning is quite similar to the way a human would learn to play such a game. At the start of the early games, play would be more or less random. Near the end of each game the beginning player would consider the opponent’s legal responses to each of the permitted moves, and would try to select one that prevented a win by the opponent. In subsequent games the player would remember the situations from which he or she was able to win,
and would attempt to attain those positions earlier in the game.

There is another interesting parallel to human behavior in a machine that learns by this scheme. The machine’s rate of learning (ie: the rate at which it corrects errors in the win table) is dependent on the skill of the human opponent. Since the human cannot win when the win table is error-free, the only way the new player can win early in a series of games is to take advantage of the errors, by playing to reach those situations for which the win table is erroneous. If this is done, the machine has an opportunity to analyze the results of moves from, and correct the errors for, that situation. On the other hand, if the human plays poorly and does not take advantage of the machine’s errors, the machine does not correct the errors for early game situations, but wins in the end game.

A final, and most provocative parallel to the learning process of living systems is the need for random trials to discover winning moves that have been erroneously erased or never discovered. In analyzing a given situation, the machine sometimes cannot find a winning move because of an error in a situation closer to the end of the game. I found that no fixed preprogrammed move strategy would guarantee that the machine would correct such an error.

It was absolutely essential for the machine to try moves at random each time it analyzed that situation until it “accidently” made the correct move, played to the erroneous situation, and then corrected the error residing there. This is a striking analogy to the random attempts of the smallest insect (or for that matter, a human baby) to manipulate its environment.

A Suitable Game

As implied above, it is essential to find a simple game to demonstrate learning by filling in the win table. At the same time, the game must be challenging enough to maintain the interest of its human player. Eighteen with a Die is such a game.

I discovered a variant of the game in a book by Geoffrey Mott-Smith a number of years ago (Geoffrey Mott-Smith, Mathematical Puzzles for Beginners and Enthusiasts, The Blakiston Co, Philadelphia PA, 1946). As described, the game was
played with a die (half of a pair of dice). One player makes a random roll for his first play. Thereafter each player, in turn, turns one of the four vertical faces of the die upward by rotating it 90 degrees in a direction of the player’s choice. A running total of all the plays is kept, and the object is to make the total hit a given target value on the move. Mott-Smith used the goal number of thirty-one.

I have shortened the game to the goal number of eighteen, and have allowed the first player a free choice for the first move, rather than making it random. Mott-Smith described an algorithm by which, given the current total and the last player’s move, a winning play could be derived. However, it was not infallible, particularly near the end of the game. Thus the idea of the win table evolved as the approach to a learning machine.

Since the opposite faces of a die sum to seven, the rules for Eighteen with a Die become the following:

The machine’s rate of learning is dependent on the skill of the human opponent.

after the first play, each player may play a number from one to six inclusive, but it may not be the number just played by his opponent nor its complement with respect to seven. Thus, if the total is seventeen, one is a winning play if the opponent has not just played one or six. Sixteen is always a winning situation for the player whose turn it is. The player can win by playing two, or if that is not legal, by playing one, which prevents the opponent from hitting eighteen exactly on his turn.

Electromechanical Game Player

In 1959 I designed and constructed a relay and stepping-switch machine that demonstrated this learning game.

I called it GLIM, for Game Learning Intelligent Machine. Photo 1 shows GLIM and the author (quite a bit younger then). Each memory bit was implemented as a pair of neon lamps sharing a common dropping resistor. One of the lamps of each pair was used internally as part of the memory readout system. The other was included in a random display on the front panel which was shaped somewhat like a human brain. Though randomly arranged (to prevent utilization by the human player), the lamps that would be lit when the win table was error-free were located in the upper part of the brain display. Thus the degree to which the machine had become “highly” educated could be estimated.

The memory was read out by a motor-driven scanner containing six photocells, one for each of the six plays that the machine might make. A servo-mechanism positioned the scanner over a 6 by 18 array of neon lamps so that the photocells could
scan ahead in the memory, looking for lighted memory cells through a "legal play" mask mounted on the scanner. Plexiglas light collectors formed an optical OR function, while the mask formed an AND with each neon cell.

For example, the photocell that looked at the row of memory corresponding to the current total plus a move of one was masked so that it could see only the neon lamps in columns 2, 3, 4, and 5 of the memory array. These are the human's legal responses to a play of one. The next photocell could see only columns 1, 3, 4 and 6. Similar logic is embodied in the program described in this article.

As described above, the machine would play faultlessly after its win table was error-free. With the goal number of eighteen, the first player (the human) has no winning play and is doomed to lose every game after the machine has learned the game. To make the game more interesting, the logic was designed to cause the machine to "goof" occasionally. It skipped the procedure of picking out a winning move and merely selected a random legal play. In the program given here this is available as a software option. If selected, the goofs occur at random (controlled by a pseudo-random number generator) about once every eight machine plays.

Software Game Player

Figure 1 shows the flowchart of the main program for Eighteen with a Die. As can be seen, it is quite general. Most of the details that characterize it for this particular learning game are contained in the subroutines which are described below. The storing of human play (HPLAY) and machine play (MPLAY) in lastplay (LSTPLA) is an exception. Another exception is the setting of scan flag (SCNFLG) to allow the win table (WINTBL) to be updated both before and after the machine's play is added to the total.

The initialization subroutine (INITLZ) is flowcharted in figure 2. Mask table (MSKTBL) is initialized with a pattern of ones that correspond to legal responses to plays represented by the row indices. The least significant bit (LSB) represents a response of one.

Next, win table (WINTBL) is ini-
Figure 2: Flowchart of the initialization subroutine (INITLZ). The bit pattern set into mask table (MSKTB L) signifies legal responses to plays denoted by the row numbers. Win table (WINTBL) is loaded with blanks until the six rows after the game end. These rows are loaded to cause correct winning plays to be found during game playing.

must be initialized to zero. SCOREH and SCOREM are used to accumulate the human’s and machine’s scores, and must start from zero for each series of games.

After initialization, the main program prints the game instructions, ending with the question, “READY TO PLAY?” All such messages and formats are stored as strings of ASCII characters, terminated by hexadecimal 04 (Control-D, or EOT).

After loading the microprocessor's X register with the starting address of the string, the string is output by a subroutine starting at hexadecimal E07E in the MIKBUG monitor. It tests for hexadecimal 04, outputs the character to the terminal, increments the X register, and recycles. Detection of a hexadecimal 04 causes a return to the user program. If you do not have MIKBUG or a similar monitor, you can easily write this subroutine.

Next, a human response to the question at the end of the instructions is sought, a Y, or N, signifying yes or no. Again, a MIKBUG subroutine INTEE (location ElAC) is used for this process. The ASCII character representing the human's response ends up in the A accumulator. After the human's response to this question, one of two messages is printed.

Figure 2: Flowchart of the initialization subroutine (INITLZ). The bit pattern set into mask table (MSKTB L) signifies legal responses to plays denoted by the row numbers. Win table (WINTBL) is loaded with blanks until the six rows after the game end. These rows are loaded to cause correct winning plays to be found during game playing.

initialized. Rows 1 through 18 are cleared, signifying no winning moves. However, rows 19 through 24 (those reachable by attempted plays from 18) are loaded with ones in both the 1 and 2 columns. One or both will represent a legal, winning human response, and will cause correct win or lose move information to be recorded in one or more of the columns of win table rows 13 through 18, when individual games have progressed that far. RANUM must be initialized to any nonzero value for the pseudorandom number generator.

LTSTIN is a 2-byte variable that is the operand for the legal test subroutine. The low-order byte could be loaded and utilized before a double-precision load and test is made, so the high-order byte

Table 1: Use of cursor and cassette tape control characters assumed in this program, compared with uses recommended by Southwest Technical Products Corp.
Both begin by erasing the instructions.

For a Y response, the message then comprises the new game header, while the “thanks for playing” message occurs for any other response. Instruction erasure is performed by ASCII control characters at the start of each of these two messages that activate cursor-home and erase-to-end-of-page (EOF). The ASCII codes I have used for such terminal controls are shown in table 1. The codes are compatible with those recommended by SwTPC.

The “goof” feature causes the computer to make an occasional mistake.

Figure 3 shows the flowchart for the subroutine get valid legal human play (GTVLHP). This begins by looking for an ASCII character from the keyboard to be loaded into accumulator A, which is accomplished by using the MIKBUG INEEE subroutine. Subtracting hexadecimal 30 converts the ASCII code to a binary number, which is tested to determine if it is in the range 0 through 6. If the number is not in this range, an “invalid” message is printed. It is then subjected to the legal test (LGLTST) subroutine, figure 4, where it is compared with last play (LSTPLA) according to the rules governing legal plays. Legal plays are then loaded into HPLAY. Illegal plays are denoted by setting the zero flag bit in the M6800’s condition register to one.

Figure 5 shows the flowchart for the subroutine advance and analyze total (AVAZTO). Two totals are actually calculated. One is TOTBCD, a binary-coded-decimal version of the total that is output to the terminal. Each time it is augmented by adding LSTPLA to it, the 6800 decimal adjust instruction (DAA) is employed to restore the number to binary-coded-decimal form. TOTAL is the total in hexadecimal notation and is used in the program for determining the end of the game, advancing the win table index, etc. If the total equals or exceeds hexadecimal 12 (decimal 18), the flag, ENDGAM, is set, and the win or lose logic decides who won and increments the scores accordingly. The scores are used only for display, and are stored in binary-coded-decimal form.

The next subroutine used is revise win table (RVSTBW), shown in figure 6. This process is accomplished in two steps. First, the rows of the win table corresponding to trial machine plays of 1 through 6 are ANDed with corresponding rows of mask table, which contain the legal responses to those plays. The results are stored in a 6-byte table of winning human response flags (WHRF).

Next, machine trial play pattern (MPTPAT) is initialized to hexadecimal 20, which sets bit 5 to 1. The index register, X, is initialized to a corresponding value of six. Starting with six and decrements facilitates subsequent use of the 6800’s stack pointer.

In the second phase of this subroutine, each row of the WHRF table is tested to see if any winning human responses were found in the first phase for the play held in the X register. If no winning human response was found, MPTPAT is ORed into the win table row cor-

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Figure 3: Flowchart of subroutine to get a valid, legal human’s play (GTVLHP). A MIKBUG subroutine (INEEE) is used to input a move. After verifying that the play is in the valid range 1 through 6, LGLTST is called to see if the move is legal.

Figure 4: Flowchart of the legality testing subroutine (LGLTST). The legal-move flag is first cleared to indicate an acceptable move. The computer-generated random plays of 0 and 7 are rejected. A trial play is then compared with the last play (LSTPLA) and with a value of 7+LSTPLA to implement the rules. If the flag returns from this routine with a value of 1, the move is not legal.
Figure 5: Flowchart of the subroutine for game analysis (AVAZTO). LSTPLA is added to two totals, a binary-coded-decimal version for display and a hexadecimal version for internal program use. If the game is over, the binary-coded-decimal score of the winning player is incremented.

 responding to the current total, to add an apparent winning move to the row. If any winning human response was found, the Xth column of the win table row corresponding to the current total is zeroed, by being ANDed with the one's complement of MPTPAT, thus deleting any erroneous winning play indication.

In the first case, X represents an apparent winning play for the machine, so it is tested to determine if it is a legal play. If so, it is stored in machine play, winning (MPLAW). X is then decremented and MPTPAT is shifted right by one place, to correspond to a play of five, and the second phase is repeated. At the conclusion, MPLAW holds the smallest winning play discovered, and the win table
Making the Machine Fallible

The subroutine select machine play (SELMPL) shown in figure 7 is needed because sometimes no machine winning plays are found, in which case the machine must choose a legal play at random. If the "goof" feature is desired, the program's current winning move (MPLAW) will be ignored, and a random play will be selected.

The generate random play (GNRNPL) subroutine actually generates numbers from 0 thru 7. The occurrence of a zero causes the computer to make a random move if the "goof" option is active. Next, MPLAW is tested to determine if it has changed from its initial value of zero. If it is no longer zero, its value is loaded into MPLAY as the machine's play. If MPLAW is zero, another random number from 0 thru 7 is generated and tested for legality. Numbers are generated again and again until a legal one is found for use as MPLAY, the machine's move.

The GNRNPL subroutine (figure 8, page 229) uses logic feedback around a shift register to generate a pseudo-random sequence. Two bytes plus the carry bit comprise a 17-stage register. Since seventeen is a prime number, coding theory assures us that every unique feedback arrangement will generate a sequence that will not repeat until after $2^{17} - 1$ (or 131,071) shifts. The three least significant bits are masked off to generate numbers from 0 thru 7.

Three shifts are used to generate each play, to assure that all three bits are randomly changed. I could have used a shorter shift register, but I found that with a shorter register, a given play was followed by only a few of the theoretically possible values. A few additional instructions are required to implement the 17-stage register, in which any given play will be followed with nearly equal probability by all of the values 0 thru 7.

The feedback comprises the Exclusive-OR of the zero and third order bits. This is accomplished by ANDing the low-order byte with hexadecimal 09. The carry bit is set to one if the result is one or eight and to zero if the result is zero or nine. The carry bit is

Figure 6: Flowchart of the subroutine that revises the win table (RVSTBW). The win table row corresponding to the total before and after the computer's play is revised by trying all possible computer plays, and by selecting those plays that block the human from a legal winning response. The smallest apparent winning computer play is saved in MPLAW. The following logical notation is used: "·" is logical AND, "+" is logical OR.
then shifted into the most significant bit of the high-order byte. The least significant bit is shifted into the carry and then into the most significant bit of the low-order byte. The latter’s least significant bit is discarded.

During initialization, at least one of the shift register bits must be set to one, otherwise only zeros would circulate endlessly. The full 17-bit word cannot take the value zero, but the three least significant bits can take this value.

Other Random Methods

The above scheme has the disadvantage that the sequence is fixed by the initialization constant, so that each new series of games set up by loading the program start out with the same sequence of random plays. If the human should play the identical sequence of moves for a whole series of games, the machine’s responses to those moves would not vary.

I have employed a way around this in other machines using the player’s response time, measured in sufficiently small units, to generate random numbers. For example, three asynchronous free-running flip-flops at frequencies of 100, 141, and 173 Hz can be allowed to run during the time the computer is waiting for the human to respond. When stopped by the response, they will represent a random binary number from 0 thru 7 that depends on the human’s response time measured in hundredths of seconds, modulo 7. Using frequencies related by ratios close to $\sqrt{2}$ and $\sqrt{3}$ assures that the flip-flops will generate a relatively long sequence (of order 100) before repeating.

This approach was not feasible, however, when using a MIKBUG subroutine to get the human’s response.

Listing 1 is the program listing in assembler format for the SwTPC 6800. MIKBUG subroutines were freely used for input and output. All constants and variables are stored on page one of memory, starting at hexadecimal address 0020. The initialization subroutine is also stored here. The main program begins at hexadecimal 0100. Messages start at hexadecimal 0200 and extend to hexadecimal 057F. About 1380 (decimal) bytes are needed. Addresses from 0000 to 001F were not used, in compliance with SwTPC’s suggestion that these be reserved for a disk operating system.

You may wish to revise message formats. Revisions of starting addresses will require revisions of the load index register (LDX #) instructions in the main programs and subroutines wherever the messages are printed.

How to Play Against the Machine

The human player has several options for competing with the machine. With the goof feature disabled, try to see how many games you can win, starting with the win table empty, before the machine is winning every game. Your strategy should be to induce the machine to load as many errors as possible into the win table, then play to inhibit the machine from correcting those errors.

When you have memorized all of the winning plays for each total, you will do better. This knowledge can be acquired through experience, or by examining the win table after the machine has thoroughly learned the game. Unless the goof feature is used, some winning moves may not be found by the machine, but it will find enough that one or more will be legal.

Figure 7: Flowchart of the subroutine that determines the machine’s play (SELMPL). If the goof option is selected, the odds are one in eight that the computer will make a random legal play, instead of playing the apparent winning play discovered while revising the win table. If no winning play is found, a random play is made.
How to Use the Program Listing

The program in listing 1 was assembled using Jack Emmerich's Tiny Assembler for the 6800 processor. Since this assembler operates using only one pass through the source code, it must handle forward references in a special way.

A forward reference occurs during assembly when some instruction in the program references a symbol that appears after it in the source code. (A symbol is a label for an instruction or for data.) Since the assembler has not yet come to the referenced symbol and does not know what its address is, the assembler cannot initially generate the proper object code.

If you have your own assembler, you will face no difficulty in using Eighteen with a Die (since you will probably wish to reassemble it on your own system). If you do not have an assembler in your 6800 system and want to enter the object code directly from listing 1, you must be aware of the behavior of the Tiny Assembler in its treatment of forward references.

As the Tiny Assembler scans the source code, it maintains a forward-reference table in memory. When it comes to a forward reference, such as:

    JSR TXTOUT

(which appears at hexadecimal location 0109 in listing 1) that has not been encountered and is therefore not yet defined in the symbol table, the Tiny Assembler generates "dummy" code (consisting of zeros) in the locations where the address of TXTOUT should be. Data identifying TXTOUT and keeping track of where the dummy code was generated is placed in the forward-reference table.

When the Tiny Assembler gets to the definition of TXTOUT in the source listing, it resolves all previous forward references to TXTOUT at once. At the place in listing 1 where the symbol TXTOUT appears, we see the source code:

```
TXTOUT JMP PDATA1
```

At this point the following object code is generated:

```
018E 7E E0 7E
010A 01 8E
0117 76
0126 67
0137 56
018B 02
015D 30
017F 0E
```

The resolution of hexadecimal location 010A uses the extended addressing mode; other resolutions shown use the relative addressing mode. After the address of the symbol TXTOUT is found, the reference to TXTOUT is deleted from the forward-reference table.

When the output of the assembler is loaded into memory by the loader program, the forward-reference resolution data is written over the dummy values (zeros) that were originally generated. If loading the object code by hand, they should be written over the dummy values in the same way.

You can, if you wish, look at the symbol table shown at the end of the listing at any time to find out what values were obtained for all symbols during the assembly. The Tiny Assembler uses only four characters (the first three and the last one) of a symbol, and the symbol table uses these condensed symbols, not the full spellings found in the program.


Reprints of these magazine articles plus PAPERBYTE bar codes for optical scanning are available in book form under the title Tiny Assembler 6800, Version 3.1, by Jack Emmerichs. You may obtain this book for $9.60 (including postage) from BYTE Books, 70 Main St, Peterborough NH 03458.
Listing 1: Complete assembler listing Eighteen with a Die as coded for the 6800 microprocessor in a system equipped with a MIKBUG (or MIKBUG-compatible) monitor.

```assembly
**esiac**
**seiac** MIKBUG SR; GET ASCII CHAR. IN 'A' REG.
**eicb** MIKBUG MON. RET. POINT
**eibal** PRINT RIGHT WYBLE OF 'A' REG.
**eiaa** MIKBUG SR; STRING PRINTER. TERM'D BY $8A.

**esiac** VARIABLES AND TABLES

**esiac** ORG $2000
**esiac** MIKTLRMB 7 LEGAL RESPONSES MASKS
**esiac** WPRINT INTABLE OF WINNING PLAY BIT PATERNS
**esiac** RMB 7 SPACE FOR END GAME MARKERS
**esiac** MPATM RMB 1 M. TRIAL PLAY PATERN
**esiac** III REM RMB 1 K. AND M. BCD SCORES
**esiac** RMB 1 TOTAL RMB 1 BINARY TOTAL OF ALL PLAYS
**esiac** TOBCD RMB 1 DITTO, RML.
**esiac** PLAYRMB 1 VALID, LEGAL, N. PLAY.
**esiac** SPTBL RMB 1 OPPONENT'S PREV. PLAY.
**esiac** SPPPL RMB 1 N. TURN FLAG.
**esiac** HMLRMB 1 SCAN WIN TABLE FLAG. 1 MEANS
**esiac** PRIOR M'S PLAY; 0 MEANS AFTER M'S PLAY.
**esiac** PSYM RMB 1 END GAME FLAG. SET IF TOTAL > 17.
**esiac** LSTTS RMB 2 DUMMY INPUT VARIABLE FOR LEGAL TEST
**esiac** LSTTS RMB 2 2 BYTES ACCOMODATE X REG.
**esiac** WHRF RMB 6 TABLE STORES WINNING HUMAN RESPONSES TO TRIAL M PLAYS.
**esiac** HMLRMB 1 TRIAL M PLAY.
**esiac** HMLRMB 1 WINNING M PLAY DETECTED IN REVISIING WIN TABLE.
**esiac** HMLRMB 1 TEMP. STRK. PNTR STORAGE.
**esiac** HMLRMB 1 WINTABLE ROW POINTER.
**esiac** RANUM RMB 2 RANDOM NUMBER SHIFT REGISTERS.

**esiac** SUBROUTINE INITIALIZE - INITLZ

**esiac** 00744 04 A7 04 STAA 4X CLEAR WIN TABLE BEFORE
**esiac** 00764 0F CE 00 01 LDX #1 FIRST GAME.
**esiac** 00774 17 A7 26 JMP WNTBL-1,X
**esiac** 007C4 08 TC 00 CPX $13
**esiac** 007D4 8D 0C 13 BEQ $11
**esiac** 00804 2E 06 BD #00 STORE DUMMY WIN PLAY.
**esiac** 00824 8D 0B 12 LDAA #3 SO MACHINE CAN SEE END OF
**esiac** 00844 08 BEQ $12 GAME COMMING.
**esiac** 00864 8B 00 DEX NME.
**esiac** 00874 7C 00 STORE RAM P INITIALIZ RANDOM NUMBER GENERATOR.
**esiac** 00884 0E 5A 00 CLRA CLEAR SCORE.
**esiac** 00894 F9 7F 4A LDX #SEED.
**esiac** 008A4 91 97 41 STAA 1, X.
**esiac** 008B4 93 97 42 STAA 2, X.
**esiac** 008C4 95 59 JMP CLEAR HIGH BYTE OF L. TEST; ALSO
**esiac** 008D4 00 09 JSR CLR.

**esiac** MAIN PROGRAM

**esiac** ORG $1800
**esiac** 008F4 00 0D B5 47 JSR PRST.
**esiac** 00904 08 00 BF 05 JSR GET PRINT INSTRUCTIONS AND
**esiac** 00914 00 0D BF 05 JSR TXTOUT ASK "READY TO PLAY?".
**esiac** 00924 00 05 B5 47 JSR INEEE GET RESPONSE;
**esiac** 00934 F0 43 59 COPA "Y" IF NOT 'Y' THEN
**esiac** 00944 11 7F 03 JSR SET END GAME.
**esiac** 00954 11 13 CE 00 00 M1 LDX #MES2 PRINT "THANKS, GOODBYE",
**esiac** 00964 11 0C BF 01 JSR TXTOUT
**esiac** 00974 11 1B 5F 05 BSR CONTRL
**esiac** 00984 11 12 CE 00 00 M2 JSR EXIT TO MIKBUG.
**esiac** 00994 11 1B 4F JSR TOTALS.
**esiac** 009A4 11 1C BF 00 JSR TOTM.
**esiac** 009B4 11 12 CE 00 00 M2 JSR LCP.
**esiac** 009C4 11 12 CE 00 00 M3 JSR LCP.
**esiac** 009D4 11 12 CE 00 00 M2 JSR LCP.
**esiac** 009E4 11 12 CE 00 00 M3 JSR LCP.
**esiac** 009F4 11 12 CE 00 00 M2 JSR LCP.
**esiac** 00A04 11 12 CE 00 00 M3 JSR LCP.
**esiac** 00A14 11 12 CE 00 00 M2 JSR LCP.
**esiac** 00A24 11 12 CE 00 00 M3 JSR LCP.
**esiac** 00A34 11 12 CE 00 00 M2 JSR LCP.
**esiac** 00A44 11 12 CE 00 00 M3 JSR LCP.
**esiac** 00A54 11 12 CE 00 00 M2 JSR LCP.
**esiac** 00A64 11 12 CE 00 00 M3 JSR LCP.
**esiac** 00A74 11 12 CE 00 00 M2 JSR LCP.
**esiac** 00A84 11 12 CE 00 00 M3 JSR LCP.
**esiac** 00A94 11 12 CE 00 00 M2 JSR LCP.
**esiac** 00AA4 11 12 CE 00 00 M3 JSR LCP.
**esiac** 00AB4 11 12 CE 00 00 M2 JSR LCP.
**esiac** 00AC4 11 12 CE 00 00 M3 JSR LCP.
**esiac** 00AD4 11 12 CE 00 00 M2 JSR LCP.
**esiac** 00AE4 11 12 CE 00 00 M3 JSR LCP.
**esiac** 00AF4 11 12 CE 00 00 M2 JSR LCP.
**esiac** 00B04 11 12 CE 00 00 M3 JSR LCP.

**esiac** LISTING 1 CONTINUED ON PAGE 224

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Listing 1 continued:

0163 27 AE > BEQ M1 ELSE, SET UP NEW GAME.
0165 28 B4 > BRA M2
0167 B0 00 00 > M5 JSR RUSTTW IF GAME NOT OVER, LOOK AHEAD FOR
016A 8E > M RESPONSES TO M TRIAL PLAYS
016B 8E > AND REVISE WIN TABLE.
016C 8E >
016D 8E > M铨 SFNLG
016E 8E > IF SCAN FLAG CLEAR, THEN
016F 8E > BEQ M6 GET NEXT H. PLAY.
0170 8E 00 00 > M7 SELPM ELSE, SELECT M. PLAY.
0172 96 52 > LDAA MPLAY
0174 97 46 > STA LSTPLA
0176 4F > CLR CLEAR SCAN FLAG TO REVISE WIN TABLE BY
0177 4F > LOOKING AHEAD AFTER M'S PLAY.
0179 97 48 > STA SCNFLG
017A 97 4F > STA HURN CLEAR H. TURN FLAG.
017B CE 00 00 > LDX #M57 ANNOUNCE M'S PLAY,
017E 9D 00 > BSR TXOUT
0180 8D 00 > LDAA MPLAY
0182 8D 00 00 > JSR OUTHR
0185 20 8E > BRA M4 AND PROCESS IT.
0187 >
0188 CE 00 00 66 > LDX #MES7 IF SCAN FLAG WAS RESET, REQUEST
0189 18 >
018A 8D 00 > BSR TXOUT NEXT H. PLAY,
018B 59 00 > BRA M3 AND GET IT.
018E 7E EM 7E > TXOUT JMP PDATAI BSR TARGET FOR MIKBUG STRING PRINT
019A 01 8E
019B 7E
019C 67
019D 86
019E 00
019F 04
019F 04 >
01A0 > SURROUTINE GTVLHP - GET VALID LEGAL H. PLAY.
01A1 >
01A2 >
01A3 > ORG $1A3
01A4 > BD E1 AC > GTVLPJ JSR I NEEE GET H. KEYBOARD INPUT;
01A5 01 AD
01A6 09 30 > SUBA #130 CONVERT TO HEX,
01A7 5F 00 > BLE GI IF LESS THAN 1,
01A8 81 06 > CMPA #6
01A9 2F 00 > BLE 06 OR GREATER THAN 6.
01AB >
01AB CE 00 00 > G1 LDX #MES8 PRINT "INVALID"
01AC 05 00 > BD E1 0E > BSR TXOUT
01B0 20 EE > BRA GTVLP AND TRY AGAIN.
01B2 >
01B3 97 4E > STA LST THINK CHECK H. PLAY FOR LEGALITY.
01B4 07 00 > JSR LGTST ZERO (2) BIT OF C REG. IF
01B5 0E 00 > BNE G3 PLAY IS LEGAL.
01B9 EB 00 00 > LDX #MES9 IF NOT, PRINT "ILLEGAL"
01BC 8D 00 > BSR TXOUT
01BE 8a 00 > BRA GTVLP AND TRY AGAIN.
01C0 >
01C1 96 4B > LDAA LST THX STORE VALID LEGAL H. PLAY.
01C8 07 > STA HPLAY
01CA 39 > RTS
01CC 8E > LEGAL TEST S.R., LGTST
01CC >
01CE 06 4E > ORG $1CE
01C0 01 8E > BEQ L1 FROM RAND. NO. GEN. ARE TREATED AS
01CA 01 8E > CREG if L1
01CC 8E > CMPA #7 ILLEGAL.
01CE 0E 00 > BEQ L1
01DF 01 8E > CMPA LSTPLA IF TEST PLAY = LAST PLAY,
01DE 0E 00 > ADDA LSTPLA OR IF SUM < 7, THEN
01DF 0E 00 > CMPA #7 TEST PLAY IS ILLEGAL.
01E0 39 > L1 RTS "Z" BIT OF COND"N (C) REG. RETURNS
01E0 0C
01EC 08
01EE 04
01ED > RESULT OF TEST.
01E9 >
01E9 >}
01E9 >
01F1 CE 00 44 > LDX #TOTCD SET 'K' AS PTR FOR MIKBUG S.R.
01F2 CE 00 44 > JSR OUTHS PRINT TOTAL.
01F3 80 30 > LDAA LSTPLA NOW, ADD LAST PLAY TO
01F4 80 30 > LDAH HURN AND M TURN FLAG
01F7 80 12 > STAA TOTAL
01F8 80 00 > SUBA #18 IF TOTAL < 18, THEN RETURN.
01FA 80 00 > LDAA LSTPLA ELSE, SET END GAME FLAG.
01FB 80 00 > BEQ A4
01FC 80 00 > BSTB AND IF M'S TURN, THEN
01FD 80 00 > BEQ A3
01FE 0E 00 > BEQ A1
01FF 80 00 > STA TOTCD ADD LAST PLAY TO BCD TOTAL.
01F0 80 00 > STA TOTCD
01F1 80 00 > STA TOTCD SET 'K' AS PTR FOR MIKBUG S.R.
01F2 80 00 > JSR OUTHS PRINT TOTAL.
01F3 80 00 > LDAA LSTPLA NOW, ADD LAST PLAY TO
01F4 80 00 > LDAH HURN AND M TURN FLAG
01F7 80 12 > STAA TOTAL
01F8 80 00 > SUBA #18 IF TOTAL < 18, THEN RETURN.
01FA 80 00 > LDAA LSTPLA ELSE, SET END GAME FLAG.
01FB 80 00 > BEQ A4
01FC 80 00 > BSTB AND IF M'S TURN, THEN
01FD 80 00 > BEQ A3
01FE 0E 00 > BEQ A1
01FF 80 00 > STA TOTCD ADD LAST PLAY TO BCD TOTAL.
01F0 80 00 > STA TOTCD SET 'K' AS PTR FOR MIKBUG S.R.
01F2 80 00 > JSR OUTHS PRINT TOTAL.
01F3 80 00 > LDAA LSTPLA NOW, ADD LAST PLAY TO
01F4 80 00 > LDAH HURN AND M TURN FLAG
01F7 80 12 > STAA TOTAL
01F8 80 00 > SUBA #18 IF TOTAL < 18, THEN RETURN.
01FA 80 00 > LDAA LSTPLA ELSE, SET END GAME FLAG.
0226 > A4 TST "ELSE, IF TOTAL = 18,"
0226 > 0266 I F
0227 > " AND IF M'S TURN, THEN"
0227 > 0277 A1 "AWARD VIB TO MACHINE."
0229 > 0299 EDT "ELSE, IF M'S TURN, AWARD"
0229 > "TO HUMAN."
022B > ORG 0250
022B > 4F"RSTB CLRA"
0168 00 30
0231 97 53 > STAA MPLAW "RESET WINNING PLAY REG. TO 'NONE' STATE."
0233 97 55 > STAA WDLRP "CLEAR V, TABLE PTR, HIGH"
0235 97 56 > "BYTE FOR PAGE 0 USE."
0235 9F 54 > STS SSTO "SAVE STACK POINTER."
0257 CE 00 01 > LOD #1 "LOAD TABLE POINTER WITH TRIAL"
025A > 027A 9F 4B "PLAY IF ON TOP"
025A > 028A 8E 25 > ADDA WINTBL-1 1WZ W TABLE PTRN LOW BYTE TO
025C 98 43 > ADDA TOTAL "CORRESPOND TO CURRENT TOTAL."
025E 97 57 > STAA WDLRP+1 ""\n025E 9E 56 > LDA WDLRP SET STK PTR TO NEXT ROW OF W. TABLE.
0260 32 > R1 "PULA GET W. TABLE ROW (BYTE) IN 'A'."
0260 43 > " (THIS IS THE ROW CORRESPONDING TO"
0260 45 > "THE CURRENT TOTAL PLUS THE TRIAL"
0260 47 > "MACHINE PLAY)."
0262 4A 20 > ANDA MSXBL "X MASK WITH LEGAL RESPONSES"
0264 > 0284 A7 4B "TO M'S TRIAL PLAY."
0264 > 028C 4D "H RESPONSES TO M TRIAL PLAYS."
0267 08 > INX "GET NEXT TRIAL M PLAY;"
026F 00 > 028F 00 07 "CPX #7 "IF < 7, REPEAT SCAN FOR LEGAL WINNING"
026F 2F 75 > BNE R1 "H RESPONSES."
024D > "NOW, ADD WINNING M PLAYS FOUND ABOVE TO THE WIN TABLE"
024D > "IN THE ROW CORRESPONDING TO THE CURRENT TOTAL. LIKE-
024D > "WISE, DELETE ANY PREVIOUSLY INCORRECTLY DEFINED WIN-
024D > "ING PLAYS FROM THE SAME ROW."
024D > ORG 028B
024F 00 26 > LDA #500 "SET 6TH BIT OF M TRIAL PLAY PATTERN."
0251 00 06 > STAA MPLAT "STT MPTPAT"
0254 > 0274 9E 55 > LOD6 "SELECT M TRIAL PLAY OF 6,"
0254 > 0276 9E 56 > (BY COUNTING DOWN, GET SMALLEST"
0254 > 0278 9E 57 > "WINNING PLAY IN M.PLAY."
0256 9E 58 > R2 "TOTAL ROW (BYTE) OF W. TABLE."
0257 9E 6B > TST "WINNF-1, X BID PREVIOUS SCAN DETECT ANY WINNING"
0259 9E 6C > "M LEGAL RESPONSES TO M TRIAL PLAY?"
025B 26 00 > BNE R3 "IF NOT, M TRIAL PLAY IS A WINNING PLAY."
025B 32 > PULA "SO 'OR' THE TRIAL BIT PATTERN INTO THE"
025B 9A 40 > CHPA "MPTPAT CURRENT TOTAL ROW OF THE W. TABLE."
025E 9B > 027E 9F 54 "COMPARE MPLAT IF LEGAL WINNING H RESPONSES TO TRIAL"
025E 75 80 40 > R3 "PLAY WERE DETECTED IN PREVIOUS SCAN,
Listing 1 continued:

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0544 41 54 45
0557 52 21
055A 04
055A => MY PLAY IS - MES6
055A
055A OR SG5A
055A CA => MES6 PCD L9FD
07C 05 5A
0558 00 0A => FDB CRLF
055D 16 => FDB EOF
055E 00 00 => FDB 0
0568 00 00 => FDB 0
0562 40 59 20 => FDC 11, MY PLAY IS
0563 50 4C 41
0568 59 20 49
0569 53 20
056D 04 => FDB ENDST
056E
056E => YOUR PLAY? - MES7
056E
056E OR SG5E
056E 2E => MES7 PCD 1,*
0188 05 6E
056F 00 0A => FDR L9FD8
0571 20 20 59 => FDC 13, YOUR PLAY?
0574 4F 55 52
0577 20 50 40
057A 41 59 3F
027D 28
057E 04 => FDB ENDST
057F
057F
057F => END

<<< UNRESOLVED ITEMS >>>
Symbols for the Eighteen with a Die learning program (written for the Motorola M6800 processor) shown in listing 1.

Table 2: Symbols for the Eighteen with a Die learning program (written for the Motorola M6800 processor) shown in listing 1.

Text continued from page 221:
for every total having winning moves. (Some totals, including zero, have none.)

Using the goof feature, and if the human does not err and seizes every opportunity to win, the game becomes a game of luck. The random plays made by the machine may be winning plays, and a sequence of winning plays found at random is not impossible. With the goof feature activated, the machine will sometimes surprise you by playing the very first game of a series faultlessly.

The game can readily be extended to a goal total greater than eighteen. Multiples of nine assure that no winning play is available to the first player. Longer games will slow the learning process; not only will each game be longer, but the propagation of “good” information from the end of the win table to its beginning will require many more games. Another elaboration could be a “brain” display similar to the one that I implemented in my mechanical machine, GLIM.

References
Apple Writer — A Low-Cost Text Editor for Apple II Users

Using the Apple Writer, a document needs to be typed into the computer only once; corrections, text additions and the rearrangement of text can be accomplished easily and quickly. Automatic search and replacement for specified words or phrases, justification of text, and uppercase and lowercase type are some of the other features of Apple Writer. The 48 K byte storage capacity of the Apple II permits storage of at least 12 pages of text on each online file.

The package consists of two master 5-inch floppy disks and an operating manual. The floppy disks include an interactive tutorial which the user can call to the screen for quick learning or review of the Apple Writer system. The cost for the system is $75. Contact Apple Computer Inc., 10280 Bandley Dr., Cupertino CA 95014.

Circle 562 on Inquiry card.

Program Simulates Solar Home

The Sunsim-1 program calculates the sun’s energy in hourly intervals at any specific location on earth, and demonstrates its use for domestic space heating, cooling, and hot water heating.

Cumulative energy and temperature values are displayed, including solar energy collected and used, backup energy used, thermal and hot water storage temperatures, and more. Users can input their requirements for size of home, volume of thermal storage, and area and angle of solar collector. Written in Level II BASIC for TRS-80 this program requires 16 K bytes of storage. Sunsim 1 is available on cassette for $49 from Solartek, POB 298, Guilderland NY 12084.

Circle 563 on Inquiry card.

Pascal Compiler for the 8800

Dynasoft Pascal is a subset of standard Pascal intended for cassette-based microcomputers that cannot support full-scale implementations such as UCSD Pascal. It includes the control structures of standard Pascal and supports most of the data types. Language extensions include EXTERN, PROCEDUREs and FUNCTIONS, LINK to other Pascal programs, an optional OTHERWISE clause on the CASE statement and absolute memory addressing.

The one-pass compiler produces pseudo-code which requires only a 1.3 K byte interpreter to execute, making it possible to run programs in as little as 2 K bytes. The system, including the compiler, interpreter, a line-oriented editor, and system supervisor, occupies little more than 7 K bytes of memory and compiles a 2000-character source program in 12 K bytes of memory.

Price for the basic cassette version, with manual, is $35, from Dynasoft Systems, POB 81, Windsor Junction, North Saskatchewan BON 2V0 CANADA.

Circle 564 on Inquiry card.

LISP Interpreter for Apple II

This new LISP system features a built-in prettyprinter and LISP editor, both written in LISP, along with prompts that make it clear that LISP is taking in an expression and returning its value. Errors are trapped by the interpreter, and a full trace-back can be printed.

Owl LISP has eliminated the PROG pseudofunction, yet defines local variables by using an extended syntax which allows for optional and local variables with default values. Owl LISP also provides a LOOP, WHILE, and UNTIL construction to allow for iterative programming. PEEK, POKE and CALL are provided to access Apple graphics and other functions. String processing can be carried out using IMPOSE and EXPLODE which convert between character strings and lists.

The system consists of about 6 K bytes of code, 300 bytes of garbage collector work space and 4 K bytes of predefined LISP work space. LISP costs £40 from Owl Computers, 41 Stortford Hall Park, Bishops Stortford, Hertfordshire, CM23 5AJ ENGLAND.

Circle 565 on Inquiry card.

C Compiler for 8080 and Z80 Microprocessors

The BDS C Compiler is the implementation of a subset of the C Programming Language. It is designed for 8080 and Z80 microcomputer systems running under the CP/M 1 operating system. The practical minimum memory size necessary to run BDS C is 32 K bytes, although many modestly sized programs may compile in as little as a 24 K byte system. A larger memory size allows for larger sized source files, since BDS C loads the entire source file into memory at one time. Separately compiled functions can always be linked together, so a source file which is too lengthy for compilation in one group may be broken up into pieces, compiled separately, and then linked together for execution.

The C Compiler and a copy of The C Programming Language, by Ritchie and Kernighan, are available from Lifeboat Associates, 2240 Broadway, New York NY 10024, for $110. The manual is $15.

Circle 566 on Inquiry card.

Dental Office Management Package

Dental System I performs patient registration and inquiry, manages accounts receivable, including aging, and provides delinquency reports. Itemized statements and insurance forms can be printed, finance charges on past due amounts can be included for any patient, or the entire practice. The system produces a daily journal of charges, receipts and adjustments, a payment journal summarized by payment method, a report summarizing charges generated by each doctor or hygienist, recall and reminder lists, and more.

Minimum hardware requirements are a 64 K byte computer, two double-density 8-inch floppy disk drives, a video terminal and a 132-column printer. This system can support a practice with up to 4000 patients and the addition of a hard disk would make it possible to handle a larger number of patients.

The price for the Dental System I is $1995. For further information, contact STR Corp, 5455 Buford Hwy, Suite B-123, Atlanta GA 30340.

Circle 567 on Inquiry card.

Where Do New Products Items Come From?

The information printed in the new products pages of BYTE is obtained from "new product" or "press release" copy sent by the promoters of new products. If in our judgement the information might be of interest to the personal computing experimenters and homebrewers who read BYTE, we print it in some form. We openly solicit releases and photos from manufacturers and suppliers to this marketplace. The information is printed more or less as a first in first out queue, subject to occasional priority modifications. While we would not knowingly print untrue or inaccurate data, or data from unreliable companies, our capacity to evaluate the products and companies appearing in the "What's New?" feature is necessarily limited. We therefore cannot be responsible for product quality or company performance.
**Software**

**Music System for Apple II**

Micro Music Inc, University Plaza, Suite 8, 309 W Beaufort, Normal, IL 61761, has released Micro Composer, an Apple II compatible music-system that allows the user to enter, display, edit, and play music with up to four voices in a 4-octave range. The program allows the user to see all four voices as music is played; enter music by a coding system which keeps track of rhythmic durations, program pitch, rhythm and timbre; choose from seven tone colors for each voice or create tone colors; and has seven preset timbres. Micro Composer comes with a manual, software, and a music card for the Apple II extension slot and is connected to an 8 ohm speaker. Memory requirements are 32 K bytes for the cassette-based system and 48 K bytes for the disk-based system. The price for the package is $220.  
Circle 566 on Inquiry card.

**MMSForth for the TRS-80**

Forth is a structured language similar to Pascal except that, in Forth, the programmer defines additional commands as they are needed. The MMSForth System Diskette supplies reliable disk I/O, virtual memory, double precision integer math, in-line editing, string handling and arrays, and user called disk and tape I/O. MMSForth includes full source code for the majority of MMSForth which is written in Forth. Speed is approximately half that of assembler code, while development is usually much less than half. This system costs $64.95 from Miller Microcomputer Services, 61 Lake Shore Rd, Natick MA 01760.  
Circle 569 on Inquiry card.

**Radio Shack Has Variety of Software for TRS-80 Systems**

Radio Shack's programs come on cassette and 5-inch floppy disks for the TRS-80 systems. Among the new programs available are a General Ledger I, an Inventory Control System, Statistical Analysis, Real Estate, a Level-I BASIC course that teaches the user how to program, and several advanced programming aids. Radio Shack also has a number of computer games and novelty programs for the TRS-80. For further information on Radio Shack TRS-80 software or products, contact the Radio Shack Computer Customer Service, 205 NW 7th St, Ft Worth TX 76106.  
Circle 570 on Inquiry card.

**Hard Copy Graphics Program for the PET, Apple II, and TRS-80**

West Coast Consultants software provides users with full graphics capability for Houston instrument's Hiplotter. Programs that drive the plotter through an RS-232 interface are currently available on tape cassette for the PET, Apple II, and TRS-80. The programs are written in BASIC and require a minimum of 16 K bytes of memory. For further information, contact West Coast Consultants, 1775 Lincoln Blvd, Tracy CA 95376. The prices are $50 and $75 for the programs.  
Circle 571 on Inquiry card.

**Pascal Software Compiler for the 1802 Microprocessor**

The new GR-Pascal compiler runs with a minimum of 20 K bytes of programmable memory plus a floppy disk system and utilities. Minimum target systems can be from 2 K bytes upwards of program code, including full 16-bit arithmetic package for signed integer variables. The compiler is written in Pascal and features a provision for assembler code, hexadecimal numbers, byte variables, interrupt procedures and disk input/output (I/O) facilities. A typical 200-line Pascal program will compile into 3 K bytes of programmable memory, and processing speed is increased by a factor of 3 to 4 by restricting variables to signed integers with 16-bit accuracy. The compiler comes on an 1802 circuit board with 64 K bytes of programmable memory and sells for $40. For more information, contact The Golden River Co Ltd, Telford Rd, Bicester, Oxfordshire, OX6 6UL ENGLAND.  
Circle 572 on Inquiry card.

**Data Base Management System for Microcomputers**

This data base management system (DBMS) runs on 8 to 16 K bytes of read-only memory for Z80, 8080, and 6802 systems. This system provides a full network capability and generalizes some features of the CODASYL approach. The Data Definition Language Analyzer/Editor and Data Manipulation Language permit many-to-many-set relationships. Full data base security is maintained by providing read and write access levels for all record types, items, and set relationships. A common data base is maintained in order that no data need be duplicated in different files, and different applications can be supported in the one data base. Routines are callable from host languages and have input/output (I/O) and host language interface routines isolated for adaption to North Star, CP/M, and TRS-80 operating systems. The user's manual and sample application programs are included in the package which costs about $800. For more information, contact Micro Data Base Systems Inc, POB 248, Lafayette IN 47902.  
Circle 574 on Inquiry card.

**Adaptable Operating System for 6809 Microprocessor**

Percom Data Company has developed a 6809 operating system for the company's new SS-50 bus-compatible 6809 control computer and other 6809 microprocessing systems. The 1 K byte operating system, called PSYMON, includes eight monitor-type commands and fifteen callable utilities. Hardware adaptability is easy because interfacing is accomplished with simple, specific device driver routines that reference a table of parameters called a Device Control Block (DCB) which is independent of the operating system. Command expansion or modification is facilitated by a feature that allows user-written routines in read-only memory to alter PSYMON pointers and enhance or modify the basic PSYMON command repertoire. The erasable-programmable read-only memory version for the Percom SBC/9 sells for $39.95 and the versions for the other systems sell for $69.95 including a users manual. For information, contact Percom Data Company, 211 N Kirby, Garland TX 75042.  
Circle 573 on Inquiry card.
**EPROM PROGRAMMERS**

**EP-2A SERIES**
- Programs 2708 and 2716 EPROMs
- Price $59.95 Assembled and Tested
- Kit price $49.95
- Includes Connector

**EP-2A-78 SERIES**
- Programs 2708, 2716, 2758, TMS 2716 and TMS 2532 EPROMs
- Test tool ZERO FOR CE
- Price $79.95 Assembled and Tested
- Includes Connector

Software available for the Rockwell AIM-65, MOS Technology KIM-1, Synertek SYM-1, Motorola D2, RCA VIP and many other single board computers that use the 6502, 6800, 8060/65, Z-80, 1802, F-8 and 2650 CPU's. Specify one set of software.

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Blue Wood 127
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Phone (804) 973-5482

**C Compiler for CP/M**
New, and available now! An easily affordable compiler incorporating most of the features of the full C language.

**BD SOFTWARE**
System requirements: CP/M and at least 24K of RAM
Variable Types: char, int, unsigned
Composite Types: arrays, structures, unions
Pointers: to variables, structures, unions and functions
Features: is a structured language, all functions (Programs) recursive; more powerful expression operators than any other von Neumann type language; allows free-formatted source code; close enough to UNIX**C to make conversions feasible.

**Speed**:
On 2 MHz 8080, the statement for (i = 1; i < 30000; i++) x = 5;
takes about 4 seconds to execute.

**Package contains**:
- Compiler, linker, library manager; standard function library; sample source files include games, a terminal emulator with disk I/O plus the source for
- many standard library functions;
- BCS C User’s Guide;
- Book—The C Programming Language by Dennis Ritchie and Brian Kernighan of Bell Labs.

**Price**: $110

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Earlysville, VA 22936 U.S.A.
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AIM 65
AIM 65 is fully assembled, tested and warranted. With the addition of a low cost, readily available power supply, it's ready to start working for you. It has an addressing capability up to 65K bytes, and comes with a user-dedicated 1K or 4K RAM.

- Thermal Printer
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- Proven R6500 Microcomputer System Devices
- Built-In Expansion Capability
- TTY and Audio Cassette Interfaces
- ROM Resident Advanced Interactive Monitor
- Advanced Interactive Monitor Commands

**PRICE**: $375.00 (1K RAM)

**VAK-4 16K STATIC RAM BOARD**
- Designed specifically for use with the AIM-65, SYM-1, and KIM-1 microcomputers
- Two separately addressable 8K-blocks with write protect.
- Designed for use with the VAK-1 or KIM-4* motherboards
- Has provisions for mounting regulators for use with an unregulated power supply
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We manufacture a complete line of high quality expansion boards. Use reader service card to be added to our mailing list, or U.S. residents send $1.00 (International send $3.00 U.S.) for airmail delivery of our complete catalog.

**VAK-4 DUAL 8K-RAM** $379.00
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Circle 204 on inquiry card.
Inexpensive Word Processor Capable of Powerful Formatting and Text Editing

The SOS 420 consists of a video display, keyboard, floppy disk storage that will store 1.2 M bytes of memory, a computer, and a printer. In addition to standard formatting, the SDS 420 word processor has instructions for right justification, underline, bold text, include a file, indent, exdent, columns, decimal alignment, headings, footings, subscript and superscripts. The 12-inch screen will display 25 lines of 80 characters per line with variable speed scrolling. The printer will print up to 96 standard characters per second.

The system retails for under $12,000 from Scientific Data Systems, 12640 Beatrix St, Los Angeles CA 90066.

Circle 590 on Inquiry card.

Separate BASIC Computer for S-100 Systems

The DLX-10 is a single-board computer that executes BASIC directly in high-speed hardware from 5 to 10 times faster than 8080 systems or 2 to 5 times faster than Z80 systems. It does not replace the microprocessor but functions as a separate BASIC computer. It can boost an S-100 bus microcomputer system into the performance range of a minicomputer.

The DLX-10 runs independently of the main processor and accesses memory as a direct memory access (DMA) device. It runs in parallel to the existing processor, has a stack architecture, and utilizes on-board programmable memory to hold intermediate computations. BASIC source language programs are translated by software to relocatable BASIC stack-machine object code and are then executed by the DLX-10.

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The DLX-10 comes with software to run Northstar BASIC or CBASIC for $1250 from Alasda Computer Systems, 12759 Poway Rd, Poway CA 92064.

Circle 593 on Inquiry card.
Microcomputer Kit with 8086 Processor

The Intel SDK-86 is a complete 8086 microcomputer system on a board with memory and I/O (input/output) systems in kit form. This stand-alone 16-bit microcomputer allows designers to obtain hands-on experience with Intel's 8086 16-bit HMOS microprocessor, which offers ten times the processing power of the 8080 processor.

Included in the kit is an 8086 processor; 8 K bytes of 2316 or 2716-type read-only memory; 2 K bytes (expandable to 4 K bytes) of 2142-type programmable memory; 48 parallel I/O lines (implemented through two 8255A programmable peripheral interface devices); an RS-232 or current loop serial I/O structure (implemented via an 8251A universal synchronous/asynchronous receiver-transmitter); selectable data rate from 110 to 4800 bits per second (bps); TTL-compatible bus signals and parallel I/O signals; 24-key hexadecimal data and control keyboard; 8-digit hexadecimal display and control (using an 8279 programmable keyboard and display controller); and 256 vectored interrupts.

The 2 K bytes of 2142-type programmable memory can be doubled by implementing additional devices in the positions provided. There is room for 8 K bytes of program instructions using either or both of the keyboard and terminal software monitors included in the kit. There is a fully buffered system bus. Programs and data may be entered three ways: from the built-in keyboard; through a built-in serial communications interface; or via cable (SDK-C86) from any Intellic Microcomputer Development System.

A complete design library is provided with the kit. This library includes both the assembly and user manual, plus an MCS-86 user manual and 8086 assembly language reference manual. The SDK-86 microcomputer kit is priced at $570. For further information, contact Intel Corp., 3065 Bowers Ave., Santa Clara CA 95051.

Personal Computer Introduced by Texas Instruments

Texas Instruments has introduced a personal computer featuring easy-to-use computing power for personal finance, home management, family entertainment and education. Designated the Model TI-99/4, the system consists of a console with 16 K bytes of programmable memory, a wide range of sound effects, sixteen colors for graphic display, a powerful extended BASIC programming language, and a 13-digit color video monitor.


Among peripheral accessories offered is a Solid State Speech synthesizer with a price of $150. By building a basic vocabulary into the language system, home programmers can place audible messages in their programs. The speech synthesizer module has 200-word vocabulary and plugs into the console. Speech can be written into programs using BASIC programming language. Future command modules will call up spoken words automatically.

TI BASIC is a full floating point, 13-digit expanded version of BASIC that is fully compatible with ASCII and the BASIC specification of the American National Standards Institute. TI BASIC includes a full complement of 24 BASIC statements, 14 commands, color graphics, and sound and music over four full octaves. A Beginner's BASIC Guide for self-teaching comes with the TI-99/4. For users knowledgeable about programming, McGraw-Hill has published Programming BASIC With the TI Home Computer, a book by Herbert Peckham.

Remote controls are offered as accessories to the TI-99/4. Two of these controls may be connected to the computer at the same time. Each includes a multiposition (360°) rotary lever with a side-mounted pushbutton. Other accessories offered by Texas Instruments include: a printer, disk storage, and an RS-232 interface device for connecting the computer to other electronic devices.

The price for the TI-99/4 system is $1130. Solid State Software command modules carry prices ranging from $19.95 to $69.95 each. For further information, contact Texas Instruments Inc, Consumer Relations, Attn: TI-99/4, POB 53, Lubbock TX 79408.
8-Inch Fixed Disk Drive Series Offers Low Cost Per Megabyte

An 8-inch Winchester fixed disk drive series that offers 5 and 10 M bytes at a low cost has been introduced by Shugart, 435 Oakmead Pky., Sunnyvale CA 94086. Specifications include a capacity of 5.33 M bytes per drive for the SA1002 and 10.67 M bytes for the SA1004; formatted capacity is 4.2 and 8.4 bytes, respectively. Transfer rate for each type is 4.34 M bits per second. Average access time is 70 ms. The Winchester drives offer the same environmental specifications as the standard 8-inch floppy disk drive. Mean time between failure (MTBF) is 8000 power-on hours of typical usage.

Optional data separator and controller printed circuit boards are available. Price for the SA1002 in single quantities is $1600 and $1980 for the SA1004.

Circle 599 on Inquiry card.

MCD Consulting Introduces the Bionic Voice

Designed around a Computalker Consultants CT-1 Speech Synthesizer, the Bionic Voice uses English language design. Knowledge of phonemes or phonetic alphabet is not required. Predefined dictionaries are provided, and custom dictionary entries may be added. Rapid conversations are possible, because of the English language design.

The Bionic Voice can be operated like a conventional language or spelling board. All numerals, letters of the alphabet, and any words or phrases defined on the keyboard may be vocalized instantly as the keys are depressed. There are no commands or codes to memorize nor is knowledge of computers necessary. To upgrade to a version of the Bionic Voice that has more capability, a simple change of keyboard and computer program can be made.

The Bionic Voice may be used as a voice response for nonvocal or nonverbal individuals; for educational and instructional applications in speech pathology and linguistics; and as a foreign language translator. The Bionic Voice is not limited to voice synthesis. It may be applied to other computer functions. The price ranges between $2700 and $3500 depending on necessary modifications.

For further information about the Bionic Voice, contact MCD Consulting, 8306 Selleck, 600 N 15th St, Lincoln NE 68508.

Circle 600 on Inquiry card.

High-Capacity Hard Disk Drive for S-100 Systems

MicroAge has introduced the Fujitsu M2201 Drive with S-100 bus controller for North Star Horizon systems. This system allows accessing up to 40 M bytes of disk storage per drive with the capability of adding up to 4 drives per system. The M2201 was developed with the advent of a new type of direct memory access (DMA) disk controller board capable of very high-speed data transfer. A 2400 RPM rotation combined with a quick seek time and relatively low latency time give the M2201 an average access time of 30 ms.

The system is available for $999S. For more information, contact MicroAge Wholesale, 1425 W 12th Pl, Tempe AZ 85281.

Circle 597 on inquiry card.

Low-Cost Peripheral Accepts Hand-Printed Characters

With the PrestoDigitizer tablet, users can communicate with their computers through ordinary hand-printed characters. Stroke direction and sequence are the parameters which are transmitted to the computer that allow it to recognize the user’s style of hand-printed characters. The learning and recognition algorithms fit in approximately 2 K bytes of memory. Versions of the tablet are available for several popular computers. The tablets can recognize the entire uppercase alphabet, numerals, and many punctuation marks. The PrestoDigitizer retails for $48.50, including software, from InnoVision, POB 1317, Los Altos CA 94022.

Circle 598 on inquiry card.
Video Digitizer Allows Display and Storage of Computer Generated Images

This fast-scan video digitizer can be utilized in consumer environments and in medical, security and other special-purpose applications requiring image storage and analysis.

The device, for S-100 bus computers, converts output from the video camera (or other source of composite video) into 8-bit gray scale digital information. Maximum horizontal resolution is approximately 700 points per line and vertical resolution is 480 lines per image. Data can be transferred via software to either a memory mapped high-resolution video board or to main memory. A driver program, implementing sixteen shades of gray, is included for controlling the board, displaying images on a high-resolution video board, storing images on disk and printing images on a matrix printer.

The price for the video digitizer is $175, and it is available from Vector Graphic Inc, 31364 Via Collinas, Westlake Village CA 91361.

Circle 601 on Inquiry card.

Digital Controller for Touch Screen Digitizer

The TSD Touch Screen Digitizer enables untrained personnel to gain access to a data base by simply touching the screen with a finger. The controller provides an interface between the touch screen and other computer equipment. The controller provides all timing signals required by the screen; measures the time delay between the transmitted signal and the reflected signal from an object touching the glass, which allows the resulting data to be adjusted to overlay the display behind the touch screen; processes and filters the echo times to produce clean X,Y position data; and formats the X,Y data into either parallel or serial form.

It is available from TSD Display Products Inc, 35 Orville Dr, Bohemia NY 11716, for $2000.

Circle 602 on Inquiry card.

The Microtek MT-80 Printer

The MT-80 series printer supports the full uppercase and lowercase 96-character ASCII set in three software selectable fonts on original plus three copies. The printer contains a 240-character buffer, with optional data buffers to 4 K available in 1 K increments. A self-diagnostic program is automatically run on power up. Life expectancy of the print head is 100 million characters and mean time between failures (MTBF) is 1 million lines.

The pin feed system can accept fanfold forms from 4.5 inches (11.5 cm) to 9.5 inches (24 cm) wide. The unit features top of form control and up to 30 vertical tab settings. Form length is software programmable in one-line increments.

The unit weighs 22 pounds and measures 7.3 by 17.7 by 14.8 inches (18 by 45 by 37 cm). The Centronics-compatible parallel interface version is priced at $790 and the serial (RS-232) version is priced at $835. The MT-80G, with an IEEE-488 interface, is also available. Contact Microtek Inc, 7844 Convoy Ct, San Diego CA 92111.

Circle 603 on Inquiry card.

Pocket Computer for General-Purpose Use

Using easily loaded electronic applications modules, the Nixdorf LX-3000 personal computer can be freely programmed to be used as a personal date book or telephone directory, or it can function as a data collection system capable of communicating with other data processing systems. The unit also functions as a hand-held language dictionary to translate German, English, French, Greek, Italian, Spanish, Polish and Swedish words and idioms. The unit is produced by Nixdorf Computer Corp, 168 Middlesex Tpke, Burlington MA 01803, and is priced at $140.

Circle 604 on Inquiry card.

Versatile Printer from Malibu Design Group

The Model 165 printer can be operated as a high-speed dot matrix printer at 165 characters per second (cps); a reduced speed, letter-quality dot matrix printer at 90 cps; or a full graphics matrix printer. The 165 printer can do computer portraits, custom character sets such as Japanese, music symbols, high-density characters for word processing, and more.

Underlining, expanded characters, programmable horizontal and vertical tabs, selectable left margin, user adjustable platen and a feature that shuts off the fan when the printer is idle (which reduces noise and power consumption) are some of the features of this printer.

Price for the basic Model 165 is $2395 from Malibu Design Group Inc, 8900 Eton Ave, Suite G, Canoga Park CA 91304.

Circle 605 on Inquiry card.
Inexpensive and Compact Printer

The low-profile DIP-80 features 7 by 7 or 14 by 14 dot matrix printing, upper and lowercase character set, 100 character per second (cps) bidirectional printout, roll or fanfold paper, a full 96-character ASCII set, upper and lowercase printing at either 80 or 96 characters per line on 8.5 inch wide paper, and a 2-line buffer. Paper feed, at the rate of 1 line per second, is accomplished through a friction roller. Interface options include Centronics-compatible parallel, RS-232C serial or 20 mA current loop. The printer measures 15.75 by 9 by 3.5 inches (40 by 23 by 8.8 cm) and is available from DIP Inc, 210 Lincoln St, Boston MA 02111, for $625.

Circle 606 on Inquiry card.

Telecommunications Facility for Transmitting and Receiving CP/M

The Byrom Software Telecommunications Access Method (BSTAM) allows transmission of program or data files between any two computers and is compatible with all 8080/8085 systems using CP/M operating systems or a derivative, including Heath and TRS-80 adaptations. Transmissions are made over a normal voice-grade telephone line at 300 bits per second (bps) and over direct wire interconnections at 9600 bps. Error checking, cyclic redundancy check (CRC) error checking, protocol information, and group file transmission are featured but no data expansion is performed, resulting in fast transfers. BSTAM can precisely transfer data over poor circuits, with retry provisions and perfect reporting in the event of hard errors. The user interface allows a long sequence of files to be sent, with the file names automatically announced to the receiving computer. Sample drivers for 8250, 8251, 6850 and other Universal Asynchronous Receiver Transmitters (UARTs) are provided.


Circle 607 on Inquiry card.

Single Chip Real-Time Signal Processor

Intel Corp has developed a single chip real-time analog input/output (I/O) microcomputer, the 2920 Signal Processor, and the SP20 hardware and software support package. The 2920 converts analog input signals to digital information, processes this information in its computer, and produces analog outputs in a real-time mode. The SP20 support package, a 2920 software simulator assembler and 2920 erasable-programmable read-only memory (EPROM) board, run on the Intellic Microcomputer Development System. The 2920 interfaces directly with analog signals using the on-chip circuitry and can handle multiple signals using I/O multiplexers, enabling thousands of complex analog systems to be formulated from one standard integrated circuit. The device can implement functions such as filters, limiters, oscillators, modulators and demodulators, nonlinear conversions, and perform logical operations all under program control.

The 2920 can be used in phase lock loops, complex filters, test and instrumentation circuits, speech processing, medical electronics, and many other applications. The 2920 device costs about $300 and the support package costs $3400. Contact Intel Corp, 3065 Bowers Ave, Santa Clara CA 95051.

Circle 609 on Inquiry card.

Apple Serial and Parallel Interface

The A10 interface allows maximum flexibility for interfacing an Apple II with peripherals such as printers, plotters, terminals, modems and other computers. The software-programmable serial interface uses the RS-232 standard and includes three handshaking lines. A switch selects nine standard data transmission rates. On-board firmware provides a powerful driver routine that eliminates the need to write any software to utilize the interface. The A10's parallel interface features software programmable I/O ports with enough lines to handle two printers simultaneously with handshaking control.

The A10 comes with serial interface firmware, two cable assemblies and a manual with easy to follow application notes. It is priced at $175 assembled, and $135 in the kit form, from SSM (Solid State Music), 2116 Walsh Ave, Santa Clara CA 95050.

Circle 608 on Inquiry card.
What's New?

PUBLICATIONS

**Bubble Memory Design Handbook**

A 64-page catalog presenting the features, descriptions and functional characteristics of the 7110 1 M bit bubble memory and its support device family is now available from Intel Magnetics Inc. Included in the handbook are specifications, diagrams, and tables for the 7110 magnetic bubble memory, the 7220 controller, 7230 current pulse generator, 7242 dual formatter/sense amplifier, 7250 coll predriver, 7254 quad VMOS drive transistors, and IMB-100 development board.

Contact Intel Literature Dept, 3065 Bowers Ave, Santa Clara CA 95051, for free copies of the guide.

Circle 610 on inquiry card.

**Quarterly Review of Software for TRS-80**

80 Software Critique is a collection of reviews of TRS-80 cassette software. Program reviews are included only if they have been run several times; weak points and bugs in programs are documented. Program reviews include games, simulations, educational programs, music programs, and others. Business software is not included. Names and addresses of software vendors are provided and software prices are included. A one year (4 issues) subscription is $24 and the price of a single issue is $7. Write to 80 Software Critique, POB 134 Waukegan IL 60085.

Circle 611 on inquiry card.

**New Heathkit Catalog Available Free**

A new 96-page catalog describing nearly 400 electronic kits designed for the hobbyist is available from Heath Co, Dept 350-880, Benton Harbor MI 49022. New products in this catalog include the H89 computer, a 3.5 digit auto ranging multimeter, a low-priced DC to 5 MHz single-trace oscilloscope, and more.

Circle 612 on inquiry card.

**Wall Chart and Book on the Z80**

The Working Programmer Press, 5080 Shady Ave, San Jose CA 95129, has the Z80 processor pins and elements on a wall-chart poster and work-sheet that measures 18 by 24 inches (46 by 60 cm). It sells for $12.95 by mail.

The drawings are from the book *The Z80, How It Works, A Programmers Perspective*, published by Microware Associates Inc, Scottsdale AZ. The book describes the working and programmable elements for the Z80. Sections on instruction cycles with detailed register interactions are included.

Circle 613 on inquiry card.

**New Language for the 6502 User**

XPLO is a simplified Pascal-type language available for 6502 systems with less than 32 K bytes of memory. It is a fast, structured compiler, so users can talk to their computers in their own language. Versions for 20 K Apple II, KIM, TIM, and SYM systems are available for under $70. For further information on XPLO and other languages, assemblers, and games, plus a free catalog, write to The 6502 Program Exchange, 2920 Moana, Reno NV 89509.

Circle 614 on inquiry card.

**Educational Software Catalog for Personal Computers**

A new mail order catalog devoted exclusively to educational software is being published by Queue, 3 Chapel Hill Dr, Fairfield CT 06432. The catalog will contain listings from numerous publishers. Software listings will be separated by educational level and field, and by computer. Listings for all popular personal computers will be included, and all software can be ordered directly from Queue.

Circle 615 on inquiry card.

**Analog Dialogue**

This publication includes application articles on very high-speed data acquisition, statistics methods using RMS to DC, checking converter linearity, a 300 kHz continuous 12-bit conversion system, and more. Product descriptions include voltage to current (V/I) converters for process control, a 14-bit sample/hold amplifier, CMOS switches, three power supplies, and several data converters. The booklet is available for free from Analog Devices, Rt 1 Industrial Park, POB 280, Norwood MA 02062.

Circle 617 on inquiry card.

**Bugbook IV, Microcomputer Interfacing with the 8255 PPI Chip**

This new book details microcomputer input/output (I/O) techniques and their implementation with the 8255 Programmable Peripheral Interface (PPI) integrated circuit. Techniques and experiments are presented in such a way that the principles can be applied to other PPI chips by students, scientists and engineers. All of the modes of operation are detailed, and a clear explanation of data transfer processes, flag sensing, bit testing, and similar topics are included. The price is $8.50. For more information, contact E and L Instruments Inc, 61 First St, Derby CT 06418.

Circle 616 on inquiry card.

**Connecticut microComputer Catalog**

This catalog presents the Data Acquisition Modules Systems (DAM), including the AIM 16 analog to digital (A/D) converter. The publication also includes program reviews and a list of dealers for the company's products.

Contact Connecticut microComputer Inc, 150 Pocono Rd, Brookfield CT 06804.

Circle 618 on inquiry card.
Parallel Input/Output and Timer Board
A parallel input and output (I/O) board has been developed by Tecmar Inc., 23414 Greenlawn Ave, Cleveland OH 44122, for interprocessor communications. It has two 16-bit parallel input ports and two 16-bit parallel output ports, status word for polled operation, interrupts for vectored interrupt operation, and is individually maskable from software.

Tecmar also has a 16-bit timer with 8-bit prescaler, intervals up to 8.4 seconds with resolution of 128 microseconds, status byte for polled operation, interrupt for vectored interrupt operation, and is compatible with conventional S-100 8080 and Z80 systems.

The cost for the entire board is $350.

Smoke Signal’s New 6809 Chieftain Computer
Smoke Signal Broadcasting has developed a new integrated computer system utilizing the Motorola 6809 processor, and configured around the new Chieftain microcomputer with programmable read-only memory (PROM) or erasable-programmable read-only memory (EPROM) storage, and a minimum of 32 K bytes of programmable memory.

The system also includes expansion capability to at least 256 K bytes — and perhaps up to 1 megabyte — requiring larger memory cards than the current 16 K byte board. In addition, the new motherboard will handle as many as sixteen serial or parallel ports in its 30-pin input/output (I/O) section. Nearly unlimited I/O capability is possible if the user wishes to use any of the 50-pin positions.

Smoke Signal has also developed a new disk controller allowing either single- or double-density recording techniques to be employed. Along with the ability to handle double-sided disks, users can store up to 1 megabyte on each 8-inch floppy disk (320 K bytes on a 5-inch floppy disk). Current users of any SS-50 bus disk system compatible with the Smoke Signal system can purchase the controller board separately or as part of the new Chieftain.

The new controller allows instant access and immediate response to an interruption request at any time during disk operation or other multiuser applications. The unit can be expanded for multiuser operation.

The Smoke Signal disk operating system has been converted to run on the 6809, as well as the text editor and text word processor. All higher-level languages are available for the 6809 including UCSD Pascal.

A hard disk capability on the order of 15 megabytes of fixed storage and 15 megabytes of removable storage is available, expandable to 80 megabytes of fixed storage.

For more information, contact Smoke Signal Broadcasting, 31336 Via Colinas, Westlake Village CA 91361, or call (213) 889-9340.

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Circle 248 on inquiry card.
Fiber Optic Evaluation Kit for Systems Engineers

Motorola has introduced a fiber optic evaluation kit, developed to give designers experience with the latest fiber optic components. The kit is called The Link, and refers to the optical link between the transmitter and receiver of any system with all of the optical portions needed. The kit includes an MFOE103FB fiber optic infrared light-emitting diode (LED) source, an MFOD402FB integrated detector/preamplifier, a 1 meter length of fiber optic glass cable with matching AMP connectors, design considerations, applications and circuit ideas.

Price for the kit is $99. Additional ferrule semiconductors and components are available. Contact Motorola, POB 20912, Phoenix AZ 85036.

The BASIC Programmer's Toolkit

The Toolkit is a collection of machine language firmware aids designed to enhance the writing, debugging and polishing of BASIC programs for the PET. This 2 K byte read-only memory chip offers additional read-only memory storage. The Toolkit contains 10 powerful commands to help programmers with their PET. The board attaches to the memory expansion port of any 8 K byte PET. The Toolkit costs $79.95 and the version for the 16 K or 32 K byte PET retails for $49.95. For more information, contact Palo Alto CS, 430 Sherman Ave, Palo Alto CA 94306.

Low-Cost Transmitter/Receiver Integrated Circuit Pair for Radio Control

National Semiconductor Corp has developed a low-cost transmitter/receiver pair of integrated circuits that allow for the design of lightweight and compact remote control systems. The LM1871 and 1872 make use of an unusual pulse code modulation technique that allows the chip set to handle analog and digital control signal information. The chip set is adaptable for use in toys, such as model cars, airplanes and trucks with simple on/off digital control to sophisticated units with several channels of proportional analog control.

The LM1871 and 1872 feature two digital and two analog channels for control, operation in the 27 MHz and 49 MHz unlicensed bands or in the 72 MHz licensed band, 50 meter outdoor control range, and an internal voltage regulator which keeps radiated power constant even if the supply voltage changes. The chips have built-in flip-flops which eliminate the need for bulky timing components.

The devices come in 18-pin dual inline packages and operate on 9 V or less. They are priced at approximately $12 for the set. For more information, contact National Semiconductor Corp, 2900 Semiconductor Dr, Santa Clara CA 95051.

Floppy Disk Mailer

Inmac, 2465 Augustine Dr, POB 4780, Santa Clara CA 95054, has designed a floppy disk mailer that protects up to five standard floppy disks or five 5-inch floppy disks against bending, curling or cupping in transit. The disks are placed in the center of the new Inmac mailer, then the mailer is folded according to the instructions printed on the mailer itself, assuring safety in mailing. Consisting of 10 mailers, a package costs $10. When purchased simultaneously, three or more packages cost $8.50 per package.

Joystick for Apple II

ISC Inc, 2224-C Old Middlefield Way, Mountain View CA 94043, has introduced the Model VS20/APT Videostick X/Y controller for the Apple II. The unit features a large push (firing) button and a linear joystick designed specifically for applications such as plotting graphics or playing games. The controller plugs directly into the Apple II and can be hand-held or table positioned.

The Videostick is priced at $39.95, and is available from Computer Plus Inc, 1324 S Mary, Sunnyvale CA 94087.
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- Expanded version of APPLE-DOS
- Single Density Disk Controller
- Full Cabling, Connectors + Documentation
- Assembled and Tested
- Plug In and GO!!! $1695.00

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

PET

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

TRS-80

Prices and specifications same as for SORCERER with following exceptions:
- Expansion Interface necessary
- Space for up to 48K plug-in dynamic memory on Controller Card
- Software package as above $ 995.00

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- Full Cabling, Connectors + Documentation
- Assembled and Tested
- One S-100 Slot available for Memory Expansion
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OPTIONS:
- 2 8" Double Sided Drives (In place of Single Sided) $2845.00
- 32K Dynamic RAM Memory Board, Assembled and Tested $ 299.00
- 16K Dynamic RAM Internal Memory Expansion Kit $ 69.00
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Circle 207 on inquiry card.
Scotchflex Brand Breadboard System from 3M

3M has developed a breadboard system that eliminates stripping, soldering, and crimping of wires. Connections are made with continuous, 30 AWG solid insulated wire which is easily inserted into the "U"-contact with a hand-tool supplied by 3M, saving time and labor. Multiple busing is simplified by putting 2 wires into each contact which provides 4 connections. The contacts are only about one-third the height of wrap posts so prototype circuit boards can be mounted in the same space occupied by production boards. Wires can be removed without unwrapping or cutting, and dual sockets and plug strips can be removed with an inexpensive hand-tool, simplifying reuse of the board and components.

Kits with 8 contact solder strips, plug strips, 16 position dual sockets and Scotchflex "U"-contacts cost $97.50. Separate components are also available. Contact 3M Co, POB 33600, St Paul MN 55133, Dept EP9-9.

Circle 638 on Inquiry card.

Microcomputer Users Provided Access to Commodity Futures Data Base

A commodity futures data base, used by professionals in the field, is being made available to personal computer owners. The MJK data base provides daily information on 38 major commodities including interest rate futures and foreign currencies, as well as agricultural commodities with cash and price information on many. The data becomes available at 2:15 PM (PST) each trading day. In addition to providing daily price, volume and open interest data, MJK makes available a series of programs for calculating moving averages, spread charts, bar graphs, etc. POISE is a special program for testing trading systems in the history of the data base.

A minimum of $25 per month is charged after a subscriber set-up fee of $25. Additional charges for the service are $16 per hour for connect time and 14¢ a second for processor usage. Included is the cost of TYMNET, providing telephone connection at local message-unit rates from most US population centers. For further information, contact Krause and Co, Central Tower Building, San Francisco CA 94103.

Circle 639 on Inquiry card.

Talking Language Translator Is Introduced by Texas Instruments

A talking Language Translator, utilizing speech synthesis and offering solid state electronic modules for English, French, German and Spanish, has been introduced by Texas Instruments Inc, POB 53, Lubbock TX 79408. Designed for world travelers as an aid in communicating in a foreign country and for language students in learning to pronounce a foreign language, the handheld device is programmed with a vocabulary of words and phrases selected for everyday use, and can be used as a basic vocabulary for learning a language.

The Language Translator has the ability to form thousands of spoken phrases by linking together its spoken vocabulary words. Each module contains about 1000 words of which half will be spoken and displayed, while half will be displayed only. Components include a speech synthesizer integrated circuit, a controller, and four read-only memories. An earplug is provided for quiet use.

There are five basic functions for users:

- Common phrases - allows user to key-

in a numerical code to access one of 25 preprogrammed phrases.
- Partial phrases - users may form thousands of their own phrases by linking preprogrammed partial phrases with words from the word memory.
- Translate mode - translates 1000 words from input language to output language.
- Memory learn mode - drills user on pronunciation and translation of user-selected words.
- In the learn mode - a programmed drill assists the user to learn.

The Language Translator is priced at approximately $250.

English, Spanish, French and German modules are available, Japanese and Chinese will be ready in the first quarter of 1980. The approximate price of each is $50.

Circle 641 on Inquiry card.

Heathkit H8 Extender Board Kit

The H8 Extender Board allows Heathkit owners to troubleshoot their machine easily because the board is up above the computer for access to all circuits and components. Jumper links in power lines make power measurement simple. The links can be replaced with fine copper wire, which protects the traces or the motherboard from damage due to excessive current during testing.

The kit features a double-sided printed circuit board, with plated through holes, and a Molex, 25-pin edge connector, with formed leads.

The kit is available from Mullen Computer Products Inc, POB 6214, Hayward CA 94545, for $39.

Circle 640 on Inquiry card.
SAVE THE WHALE

The Fin Whale is the world’s greatest long-distance communicator.

Scientists believe that loud, deep-tone, low-frequency sounds made by Fin Whales (frequencies around 20 hertz, or cycles per second) actually travel underwater for distances of at least 500 miles, and under optimum conditions might carry for a radius of over 4,000 miles, potentially reaching an area greater than the entire Atlantic Ocean.

Fin Whales, the second largest creatures ever to have lived on planet earth, grow up to 24 meters in length (exceeded only by the 30-meter Blue Whale), and inhabit all the oceans of the world. Tens of thousands of Fin Whales have been “harvested” in recent years, by agreement of the International Whaling Commission, for the sale of products for which substitutes are readily available.

The CONNECTICUT CETACEAN SOCIETY is a small, totally volunteer, non-profit education and conservation organization dedicated to seeking the abolition of all whale killing. Any concerned citizen can help our efforts by sending name and address and a $15 or more contribution to: CCS, P.O. Box 145, Wethersfield CT 06109.

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1 TRS-80 Complete System
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<th>OUR PRICE</th>
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<tr>
<td>Level II—4k</td>
<td>$619.00</td>
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- to 30,000 plugs into any peripheral
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- Parity, either odd or even. Jumper selectable
- Address and output or serial printer. Program for using an
- Apple II for a stapler or an intelligent terminal.
- Also output in correspondence code to

8K EPROM
Saves programs on PROM permanently. Usually
erased using UV light. Up to 8K bytes. Programs
may be directly run from the program saver
such as fixed routines or assemblers. TTL
- 100 bus compatible. Room for 8K bytes
- EPROM non- volatile memory (2708). TTL
- Board supplies a regulated +5
- volts AC at 3 amps. and 24 volts

RS-232/ TTL INTERFACE
- Converts TTL to RS-
- 232 and converts RS-
- 232 TTL to serial. TTL requires $5.00
- BOX at 1.5D amperes
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- go to 10 pin gold plated edge connector,
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9K EPROM MII
- Price on

HEX ENCODED KEYBOARD
- This HEX keyboard has 19 keys, encoded
- with 3 user defined function keys. The encoded
- outputs 8-4-2-1 and STROBE are debounced
- and available in true complement form.
- Four onboard LEDs indicate the HEX code
- generated for each key depression. The board
- requires a single 5 volt supply. Board
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- Converts serial to parallel and parallel to
- serial. Low cost on board baud rate
- generator. Baud rates: 110, 150, 300, 600,
- 1200, and 2400. Low power drain +5
- volts and +12 volts required. TTL compa-
- tible. All characters contain a start bit, 5
- data bits, 1 or 2 stop bits, and parity or
- odd or even parity. All connections go to a 44
- pin gold plated edge connector. Board only
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- Board supplies a regulated +5
- volts at 3 amps +12. -12, and -5
- volts at 1 amp. Power required is
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250 January 1980

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**SD'S VERSAFLOPPY II**
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- The Versafloppy II incorporates all the possible features of a complete drive controller on one board. Capable of handling four drives simultaneously. Combinations of any density are possible, such as 5", dual density, 8" dual density.
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**EXPANDORAM 64K Kit (16K RAM)**

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**SBC-100 KIT** $290.00

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**SD'S MPB-100 280 CPU BOARD KIT**

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- Controls up to 4 drives (single or double sided).
- Directly controls the following drives: Sugar SA400/450 Mini Floppy, Stugart SA800/850 Standard Floppy, PERSCI 70 and 277, MF 700/750, CDC 9404/9406

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**SD'S VERSAFLOPPY II**

**IBM 3740 Compatible SoftSector Format for Single Density Drives**
- Operates with Single and Dual Sided Drives, Single or Double Density Drives and 5 & 8 Drives — in any combination of four simultaneously.
- Drive Select and Select Circuity
- S-100 Bus Suitable
- Vectors Interrupt Operation
- Phase Locked Loop Data Recovery Circuit
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The Computer Terminal Kit comes w/o I/O mapping and includes 1k of memory, character generator, 2 key rollover, processor controlled cursor control, parallel ASCII/BAUDOT to serial conversion and serial to video processing—fully controlled for superb accuracy. PC boards are the highest quality available for the ultimate in reliability and long life.

VIDEO DISPLAY SPECIFICATIONS

The monitor of the Netronics Computer Terminal is the microprocessor-controlled Netronics Video Display Board (VID) which allows the terminal to utilize either a standard ASCII or Baudot signal source. The VID converts the parallel data to serial data which is then formatted to either RS-232C or RS-20 ma. current loop. The VID sends the serial data to the serial I/O port of your computer or other interface, i.e., Modem.

When connected to a computer, the computer echo the character received. This data is processed by the VID which then formats the data, converts the data to video suitable to be displayed on a TV set (using an RF modulator) or on a video monitor. The VID generates the cursor, horizontal and vertical synchronization signals. The VID has the ability to generate a 288 character by 192 line display which is to be displayed on the screen.

Output: 1.5 Vp-p into 75 ohm (EIA RS-170) or Balanced RS-110 and 100 ASCII + Outputs: RS-232C or 20 ma. current loop + ASCII Character Set: 128 printable characters—

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Level "B" adds sockets for EPROM to allow the use of slower memories, two separate buses, provisions for 25-pin monitor/terminal, and support up to six S-100 bus boards. A complete set of memory, character generator, 2 key rollover, processor controlled cursor control.

Level "B" at $2,599.95 includes the advanced Intel 8085 MPU, an 855 ROM with 2k deluxe monitor/operating system, single shot with recording display at each break point, with room for RAM/ROM/PROM/EPROM and S-100 expansion, plus generous processing capacity.

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Level "C" at $299.95 adds sockets for EPROM to allow the use of slower memories, two separate buses, provisions for 25-pin monitor/terminal, and support up to six S-100 bus boards. A complete set of memory, character generator, 2 key rollover, processor controlled cursor control.

Level "C" at $299.95 adds sockets for EPROM to allow the use of slower memories, two separate buses, provisions for 25-pin monitor/terminal, and support up to six S-100 bus boards. A complete set of memory, character generator, 2 key rollover, processor controlled cursor control.

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Level "D" at $999.95 adds sockets for EPROM to allow the use of slower memories, two separate buses, provisions for 25-pin monitor/terminal, and support up to six S-100 bus boards. A complete set of memory, character generator, 2 key rollover, processor controlled cursor control.

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Level "F" at $5,099.95 adds sockets for EPROM to allow the use of slower memories, two separate buses, provisions for 25-pin monitor/terminal, and support up to six S-100 bus boards. A complete set of memory, character generator, 2 key rollover, processor controlled cursor control.

Explorer/85

Explorer/85 is a complete system, perfectly suitable for business, industrial, or industrial control use. It includes: tape recorder input... cassette tape control output... character generator... built-in keyboard... ASCII/Baudot... 2 key rollover... cassette tape recorder... cassette tape control output... character generator.

Explorer/85 is a complete system, perfectly suitable for business, industrial, or industrial control use. It includes: tape recorder input... cassette tape control output... character generator... built-in keyboard... ASCII/Baudot... 2 key rollover... cassette tape recorder... cassette tape control output... character generator.

Explorer/85 is a complete system, perfectly suitable for business, industrial, or industrial control use. It includes: tape recorder input... cassette tape control output... character generator... built-in keyboard... ASCII/Baudot... 2 key rollover... cassette tape recorder... cassette tape control output... character generator.

Explorer/85 is a complete system, perfectly suitable for business, industrial, or industrial control use. It includes: tape recorder input... cassette tape control output... character generator... built-in keyboard... ASCII/Baudot... 2 key rollover... cassette tape recorder... cassette tape control output... character generator.

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Explorer/85 is a complete system, perfectly suitable for business, industrial, or industrial control use. It includes: tape recorder input... cassette tape control output... character generator... built-in keyboard... ASCII/Baudot... 2 key rollover... cassette tape recorder... cassette tape control output... character generator.

Explorer/85 is a complete system, perfectly suitable for business, industrial, or industrial control use. It includes: tape recorder input... cassette tape control output... character generator... built-in keyboard... ASCII/Baudot... 2 key rollover... cassette tape recorder... cassette tape control output... character generator.

Explorer/85 is a complete system, perfectly suitable for business, industrial, or industrial control use. It includes: tape recorder input... cassette tape control output... character generator... built-in keyboard... ASCII/Baudot... 2 key rollover... cassette tape recorder... cassette tape control output... character generator.

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<td>6</td>
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<td>4.72</td>
<td>8.59</td>
<td>10</td>
<td>1.99</td>
<td>7.26</td>
<td>13.57</td>
</tr>
</tbody>
</table>

### Wire Wrap Tool

**Battery Hobby Tool**

- Auto Indexing
- Anti-Overwrapping
- Modified Wrap

**January Sales!**

**Solderless Breadboarding**

**SK10 $95.00**

The SK10’s unique matrix configuration is embedded in a high-temperature plastic molding. It gives you 84 pairs of 5 common spring contacts for principle circuit construction and a series of common bus strips of (5) of 25 connections each.

Dimensions: .33” h x 2.2” w x 6.5”

**RN IC Sockets**

RN High Reliability eliminates trouble. "Side-wire" contacts make 100% greater surface contact with the wire. Flat sides of your IC leads for positive electrical connections.

**TI Edge Card Connectors**

44 pin ST (1156” centers) 1.95
100 pin ST (1125” centers) 2.50
100 pin WW (1125” centers) 2.85

All connectors gold plated.

**Wire Wrap Size**

<table>
<thead>
<tr>
<th>Size</th>
<th>Quant./Tube</th>
<th>Price/Tube</th>
</tr>
</thead>
<tbody>
<tr>
<td>08 pin WW</td>
<td>52</td>
<td>$16.12</td>
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<tr>
<td>14 pin</td>
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<td>10</td>
<td>$9.50</td>
</tr>
<tr>
<td>40 pin</td>
<td>7</td>
<td>$8.40</td>
</tr>
</tbody>
</table>

**Ordering Information**

- Orders under 50c, add 20% handling
- Blue Label or First Class. add 21 (up to 3 lbs.)
- COs, VISA & MC orders will be charged shipping
- Most orders shipped next day

**NEW LOW PRICE**

$5 CREDIT TO CARD PURCHASE OF ANY WIRE KIT

**Available at selected local distributors**

**Order 216 on inquiry card.**
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Your Choice, $200 Value
1) Graphics Option Pack
2) Interface for APPLE II
3) TRS-80 Printer Interface
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Quiet Bus.$295
BB03-18
16IN1

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your choice
$388

Lobo or Vista
Includes Interface Cable

SYSTEM X-10

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Verbain mini-diskettes, 15 value.

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KEYTRONIC KEYBOARD
ASCII & EBCDIC $85

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BYTE January 1980 257

Circle 216 on inquiry card.
Custom Cables & Jumpers

DB 25 Series Cables
Part No. Cable Length Connectors Price
DB25-5 5 ft 1DP58P/1-155 $15.95
DB25-4 4 ft 2DP53S $17.95 ea.

Low-Profile 25-PIN SUB-D CONNECTORS
(Made RS232)
Part No. Measurement Price
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BS252 25 PIN 0.2 in. 3.64
BS25M-251 Plus - Right Angle - PC Mount 4.99
BS25M-315 SOCKET - Right Angle - PC Mount 3.95

Printed Circuit Connectors

156 Spacing Tin-Dipped Road-Out Buff 30 AWG Double Ended Male & Female
Fits 954 & 379 P.C. Board Panels
Part No. Description Price
1V/36 30 AWG Double Ended Male $1.09
1V/36-6E 156 Spacing Tin-Dipped Road-Out Buff 30 AWG Double Ended Male 3.46
2V/36-2E 156 Spacing Tin-Dipped Road-Out Buff 30 AWG Double Ended Male 2.99
2V/36-2W 156 Spacing Tin-Dipped Road-Out Buff 30 AWG Double Ended Female 3.23
5W/16-2W 50 AWG Double Ended Female 3.95
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- Uses 215611 chip, chip
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JE747 ... $29.95

JE701
6-Digit Clock Kit $19.95
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Uses LMD8P90. Heat sink provided. PC board component construction. Provides a solid 1 amp @ 5 volts. Can supply up to .5 amp @ 9 volts. And 1 amp @ 14 volts.

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ADAPTER BOARD
- Adapts to JE205
- +3V, +9V and +12V

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JE205 ...... $14.95

Circle 218 on Inquiry card.

BYTE January 1980 259
Circle 219 on inquiry card.

**FDC-1** FLOPPY CONTROLLER BOARD will drive shugart peritek, remic 5" & 8" drives up to 8 drives, on board PROM with power boot up will operate with CP/M (not included)

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PCBD $47.50

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PCBD $38.75

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**EPM-2** 2709A 2716 16K/32K

**EPROM CARD PCBD**

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** KIT 450 NSEC ........... $141.95

* MEM-2 16K BYTE 2114 RAM BOARD PCBD ............ $31.95

** KIT 450 NSEC ........... $299.95

* CPU-1 8080A CPU BOARD with Vector Interrupt. PCBD ............ $31.95

** KIT ........... $124.95

* EPM-1 4K BYTE 1720A Eeprom PCBD ............ $29.95

** KIT LESS PROMS ........... $59.95

* EPM-2 16K or 32K BYTE Eeprom 2708 or 2176 Interchangeable. PCBD ............ $30.00

** KIT LESS PROMS ........... $74.95

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** KIT ........... $89.95

* GMB-12 12 SLOT MOTHER BOARD Terminated. PCBD ........... $45.00

** KIT ........... $115.95

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** KIT ........... $79.95

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**FIRST TIME OFFERED:**
- Blank PC Board - $28
- Uses 2708's!

Thousands of personal and business systems around the world use this board with complete satisfaction. Puts 16K of software on line at ALL TIMES! Kit features a top quality soldermasked and silk-screened PC board and first run parts and sockets. Any number of EPROM locations may be disabled to avoid any memory conflicts. Fully buffered and has WAIT STATE capabilities.

**OUR 450 NS 2708'S**
- Are $8.95 ea. With PURCHASE OF KIT

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### 8K LOW POWER RAM KIT - S 100 BUSS

**PRICE CUT!**

**$119.50 KIT**

**21L02**
- (450 NS RAMS!)

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**ASSEMBLED AND FULLY BURNED IN ADD $30**

**ALL ASSEMBLED BOARDS ARE TESTED AT 4 MHZ.**

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### 16K STATIC RAM KIT - S 100 BUSS

**PRICE CUT!**

**$259 KIT**

**FOR 4 MHZ ADD $25**

**KIT FEATURES:**
1. Addressable as four separate 4K Blocks
2. On Board Bank Select circuitry (Grommeno Standard) Allows up to 512K on line!
3. Uses 2114 (450NS) 4K Static Rams
4. On Board Selectable WAIT STATES.
5. Double sided PC Board, with solder mask and silk screened layout. Gold plated contact fingers.
6. All address and data lines fully buffered.
7. Kit includes ALL parts and sockets.
8. PHANTOM is jumpered to pin 67.
9. Low Power under 1.5 Amps TYPICAL from the 450NS RAM.
10. Blank PC Board can be populated as any multiple of 4K.

**BLANK PC BOARD W/DATA-$33**

**LOW PROFILE SOCKET SET-$12**

**SUPPORT IC'S & CAPS-$19.95**

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**OUR #1 SELLING RAM BOARD!**

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### 16K STATIC RAM SS-50 BUSS

**PRICE CUT!**

**$249 KIT**

**FULLY STATIC AT DYNAMIC PRICES**

**FOR SWTPC 6800 BUSS!**

**BLANK PC BOARD—$26 COMPLET SOCKET SET—$12**

**SUPPORT IC'S AND CAPS—$19.95**

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**Z-80 PROGRAMMING MANUAL**
- By MOSTEK, or ZILIG. The most detailed explanation ever on the working of the Z-80 CPU chips. At least one full page on each of the 158 Z-80 instructions. A must reference manual for any user of the Z-80. 300 pages.

**$12.95**

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**$159.95**

**WIRED! NOT A KIT!**

**4 MHZ**

**FEATURES:**
- 2 or 4 MHZ Operation.
- Generates MWRITE, so no front panel required.
- Jump on reset capability.
- Two 8080 Signals emulated for S-100 compatibility.
- Dual Quky PCB, Sil screen Script. Masked. Gold Plated Connectors.

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**SPECIAL OFFER:**
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**Circle 221 on inquiry card.**

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**BYTE January 1980 261**
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105/1 16 sectors 4.00 ea

For each 2 boxes of 8 or 4 boxes of 5 you get one plastic storage case, but hurry — supply is limited.

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APPLE II personal computer.

16K Regular or Plus
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$259.

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PAS Cl Language Card
$359.

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16K RAM BOARD

FULLY S-100 COMPATIBLE
USES LOW-PWR 4Kx1
2MHZ OR 4MHZ
4K BANK ADDRESSABLE
EXTENDED MEMORY MANAGEMENT
NO DMA RESTRICTIONS
ASSEMBLED & TESTED
2MHZ $250.00
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FULLY S-100 COMPATIBLE
USES LOW-PWR 4Kx1
MM5257 STATIC RAM
2MHZ OR 4MHZ
4K BANK ADDRESSABLE
EXTENDED MEMORY MANAGEMENT
8-BIT OUTPUT PORT
NO DMA RESTRICTIONS
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SA800 DISK DRIVE
INSTALLED IN DUAL CABINET W/POWER SUPPLY
ASSEMBLED & TESTED
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(2) DRIVES INSTALLED $1125.00

SA800 DISK DRIVE
INSTALLED IN DUAL CABINET W/POWER SUPPLY
ASSEMBLED & TESTED
(1) DRIVE INSTALLED $695.00
(2) DRIVES INSTALLED $1125.00

MCM 6574 CHARACTER GENERATOR
$7.00 ea.

2716's
5 VOLT ONLY
450NS.
$35.00 ea.

8/250.00

2716's
5 VOLT ONLY
450NS.
$35.00 ea.

8/250.00

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2732's
(4K) E-PRoM
5VOLTS
$95.00 ea.
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David C. Lourie, President

ComputerCity Sampler

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* Tandy Corporation Trademark + Requires Radio Shack TRSDOS*
### EDGE CARD CONNECTORS: GOLD PLATED

|--------------------|---------|-------|-----------|--------|--------|

**CONTACT CENTER CONNECTORS:**

|--------------------|---------|-------|-----------|--------|--------|

**CONNECTORS FOR CENTRADIC JOO SERIES:**

<table>
<thead>
<tr>
<th>ITEM USED IN PRI. WINDING</th>
<th>SECONDARY WINDING OUTPUTS</th>
<th>SIZE</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRANSFORMER, CAPACITORS, RESIS., BRIDGE RECTIFIERS, FUSE &amp; HOLDER, TERMINAL BLOCK, BASE PLATE, MOUNTING PARTS AND INSTRUCTIONS.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**BUILD YOUR OWN LOW COST MICRO-COMPUTER POWER SUPPLIES FOR S-100 BUS, FLOPPY DISCS, ETC.**

### POWER TRANSFORMERS (WITH MOUNTING BRACKETS)

<table>
<thead>
<tr>
<th>ITEM</th>
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<th>PRILI. WINDING</th>
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<td>TAPS</td>
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<tr>
<td>T1</td>
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<td>0V, 110V, 120V</td>
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<tr>
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<td>2</td>
<td>0V, 110V, 120V</td>
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<td>T3</td>
<td>3</td>
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<tr>
<td>T4</td>
<td>4</td>
<td>0V, 110V, 120V</td>
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**POWER SUPPLY KITS**

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<tr>
<th>ITEM</th>
<th>USED FOR</th>
<th>@+8 Vdc</th>
<th>@-8 Vdc</th>
<th>@+16 Vdc</th>
<th>@-16 Vdc</th>
<th>@+28 Vdc</th>
<th>SIZE</th>
<th>UNIT PRICE</th>
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<tbody>
<tr>
<td>KIT 1</td>
<td>15 CARDS</td>
<td>2.5A</td>
<td>2.5A</td>
<td>2.5A</td>
<td>2.5A</td>
<td>2.5A</td>
<td>12&quot;x6&quot;x4/8</td>
<td>21.95</td>
</tr>
<tr>
<td>KIT 2</td>
<td>SYSTEM SOURCE</td>
<td>3A</td>
<td>3A</td>
<td>3A</td>
<td>3A</td>
<td>3A</td>
<td>12&quot;x6&quot;x4/8</td>
<td>27.95</td>
</tr>
<tr>
<td>KIT 3</td>
<td>DISC SYSTEM</td>
<td>1A</td>
<td>2A</td>
<td>2A</td>
<td>2A</td>
<td>2A</td>
<td>12&quot;x6&quot;x4/8</td>
<td>27.95</td>
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<tr>
<td>KIT 4</td>
<td>DISC SOURCE</td>
<td>8A</td>
<td>1A</td>
<td>1A</td>
<td>1A</td>
<td>1A</td>
<td>10&quot;x6&quot;x4/8</td>
<td>27.95</td>
</tr>
</tbody>
</table>

**DISC DRIVE POWER SUPPLY "R3"**

**TERMS: MINIMUM ORDER: $15.00 ADD 11.35 For Handling & Shipping. Orders over $100.00 in the USA. We Pay the Shipping. CALIF. RESIDENTS: Please Add 8% Sales Tax.**

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**October BOMB**

"Picking Up the Pieces" (page 76) by Alfred S. Baker won first place in the October 1979 BOMB. Second place was taken by Fred R. Ruckdeschel’s “Curve Fitting With Your Computer” (page 150). “Self-Refreshing LED Graphics Display” (page 58), by Steve Ciarcia, placed third.
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