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write a program containing variables whose values are strings. Dr W Douglas Maurer explores two techniques for implementing this task in Variables Whose Values Are Strings. Page 90

Jefferson H Harman describes how IBM Compatible Disk Drives should perform. Not all manufacturers who say that they are IBM compatible mean fully compatible. Page 100

The talking computer is now within the grasp of personal computer users. Tim Cargaglino and Kathryn Fons discuss the Votrax voice synthesizer that is available for the Radio Shack TRS-80 in The TRS-80 Speaks: Using BASIC to Drive a Speech Synthesizer. Page 113

The Intel 8255 programmable peripheral interface is a large scale integration part that makes interface designing easy. David L Condra gives advice on the procedure and includes a design in Interfacing the S-100 Bus With the Intel 8255. Page 124

Using a principle invented years ago, simulated three-dimensional graphics may be produced on a personal computer equipped with a plotter or similar device. William T Powers explains the method in The XYZ Phenomenon. Page 140

In Curve Fitting With Your Computer, Fred R Ruckdeschel describes a simplified method for obtaining a reasonably accurate equation as a “best fit” to a collection of data points. Page 150

When working with time-critical or memory-critical programs, optimization techniques are often employed. James Lewis discusses some of these in his article on Low-level Program Optimization: Some Illustrative Cases. Page 168

What is the “Conservation of Agony?” It is one of the rules of personal computing proposed by Dr T G Lewis in his thought provoking article, Some Laws of Personal Computing. Read it and find out why Dr Lewis suggests that “software should be shared, but hardware should be replicated.” Page 186

Loring C White describes a real-time Space Game which requires you to maneuver a ship within gun sights and then destroy the enemy. Page 196

Hashing is a common method of handling lists, widely used in assemblers and compilers for handling the symbol table. In this issue Don Kinzer discusses an Easy to Use Hashing Function for the 6800 microprocessor. Page 200

Many companies are offering blank S-100 compatible computer boards. Dan S Parker describes the substantial savings that can be achieved by populating these boards and following some simple guidelines in Budget Building on a Bare Board. Page 206
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*CIRCLE 291 on inquiry card.*
This month's editorial is the latest in a series begun last July describing a new homebrew 6809 personal computer system. The general backplane design was presented last month. This month we describe the processor board. Its ideal features would include:

- 6809 processor (40 pins) and buffers for external signals.
- 4 K bytes of 2708 read-only memory for systems software.
- Interrupt flags for lines IO through I7 and peripheral interface adapter (PIA) port with its interrupt request (IRQ) output tied to the fast interrupt request (FIRQ) input of the processor.
- If it fits, logic for a primary serial terminal port and connector.

In order to find out whether this is a reasonable allocation of function for the 4.5 by 9.0 inch area of 1 card in the system, we must systematically estimate the parts required for each of these segments of the logic. The series of photographs 1a through 1d show how integrated circuit sockets are used as markers in the layout of the board space requirements. Each socket has a sticky paper label attached which is marked with its assigned number. Placement of the socket on an unused prototyping board can be done to help plan the layout.

**Processor Logic Requirements**

The processor alone occupies a 40-pin socket, which we will call IC1 since it is the most important part of the whole computer. In addition, the discrete components of the clock crystal's parallel-resonant circuit will conservatively require the space equivalent of 1 24-pin socket. The buffers required for the data bus are a pair of DM8833 tristate, bidirectional bus buffers. These are labeled IC2 and IC3. Three SN74367 tristate drivers provide the buffering for the 16 address lines. Two sections of 1 of the address buffer chips remain unused. These circuits are labeled IC4 through IC6. Another SN74367, which will be labeled IC7, is required so that 3 of its 6 buffer sections can be used for the ENABLE, QENABLE, and RW signals of the backplane. These 7 socket positions plus the 1 24-pin dummy for the clock crystal and related discretes are shown in position for layout purposes in photo 1a.

In order to provide a uniform connection to the backplane bus, every major segment of the system will be isolated by a set of bus buffers, such as the DM8833 parts which are included in the processor section. For the remainder of the logic on the processor board which will interface to the data bus, a pair of DM8833 parts labeled IC8 and IC9 will suffice to define a local bus extension. This local bus extension will service the 2708 read-only memory, the peripheral interface adapter used for interrupt logic, and the asynchronous communications interface adapter (ACIA) used for the primary terminal of the system.
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Photo 1: By using a prototyping board as a matrix, it is easy to mark wire-wrap sockets with logical identification numbers and use them as markers in creating a layout of parts for the board. This series of photographs documents the discussion of the main parts of the central processor card of the new 6809 homebrew system.

(a) The first segment of the layout is the processor itself and its crystal timing standard, data bus extension buffers, and address buffers.
(b) The second segment of the layout adds 4 read-only memory circuits and 2 socket positions needed to decode and select the individual 1024 byte segments (10, 11, 12 and 13).
(c) The third segment of the layout process adds a peripheral port (16) and logic associated with 8 interrupt flags. Miscellaneous logic at this stage includes decoding of the address of the parallel port.
(d) Finally, the logic of the central processor card is completed with the addition of a communications adapter, 25, and associated decoding and buffer circuits.

The next logic item to consider is the read-only memory bank. Four 2708 parts will be used to store up to 4 K (4096) bytes total. This memory bank will contain the resident systems software of the machine, including the fixed handlers for the 3 different classes of interrupts, the power on reset routines, etc. We will thus require 4 24-pin sockets for these integrated circuits, IC10, IC11, IC12 and IC13. In addition to the requirements of the read-only memory parts, we also require logic to decode the high-order 6 bits of an address and the read signal. The read-only memory bank must overlap addresses FFFF to FFFF in order to provide the vector addresses for interrupts. Thus decoding logic should be provided to place this 4 K segment of memory at the upper end of the memory address space of the 6809, locations F000 to FFFF. Decoding the high-order 4 bits of addressing can be done with one half of a 7420 integrated circuit, IC14. The active-low output of this 7420, along with the RW signal and the next 2 address bits (A11 and A10) can then be decoded by a single 7442 integrated circuit, IC15. The 4096 byte address space reserved for 1/0 will be more than adequate. The balance of the 64 K address space is left to the main memory.

The decision to allocate 8 K bytes for read-only memory space is a conservative one which allows for the addition of up to 4 more 2708 sockets on another board. The 4096 byte address space reserved for I/O will be more than adequate. The balance of the 64 K address space is left to the main memory.

Within the I/O address space of D000 to DFFF, let us arbitrarily decide that all parallel I/O will be via peripheral interface adapters, and that these parts will be located at address D000 and continuing through D0FF. Since each 6821 requires 4 address locations for its interface, this gives a maximum of 64 such parallel ports in the
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system. At the same time, thinking ahead, let us allocate 6850 asynchronous communications adapters to address locations D100 through D1FF. This reserves 128 logical slots for potential 6850 parts — again far in excess of what will actually be implemented. The main reason for making these allocations start at even hexadecimal digit boundaries (D0 and D1 in the high-order) is to simplify interpretation of machine code and references to addresses in the hand-assembled systems software to be created later. We could just as easily have compressed the allocations into a contiguous segment of address space without holes.

After this detour into address space allocation, we can return to the problem of estimating the parts needed to decode the 6821 peripheral interface adapter used for the interrupt flag input. First, we note that the decoding of the D0xx and D1xx addresses for the 2 peripherals on this board will share common logic for 7 bits of high-order information. These 7 bits include 3 which must be logical 1 and 4 which must be logical 0. Two 8-input 7430 NAND gates, IC17 and IC18, will be used to form the high-order decoding logic, with 1 7404 hex-inverter package (IC19) used to invert the 4 bits which must be logical 0. An additional 7404 section will be required for the D0 decode to invert bit line A8. The outputs of the 2 7430 parts are active-low selections of high-order addresses D0xx and D1xx.

Returning to the 6821 part, IC16, let us allocate its detail addresses as D000 to D003. The 2 register select inputs of the circuit will get connected to the low-order address lines, A0 and A1. We need to verify that all bits, A7 through A2, are 0 when these addresses are selected: to do this, logic of another 7404 inverter IC20 and a 7430 8-input NAND gate IC21 is required. The final result is the definition of 1 chip select input to the 6821 from the high-order address selection of D0 and a second chip select input from the low-order address selection from IC21.

With its addresses decoded, the 6821 now talks to the bus extension of the system, but we have one more item to consider: the 74279 interrupt flag chips and pull-up resistors. We will assign the numbers IC22 and IC23 to the flag registers, and assign the number IC24 to a 16-pin socket which will be used to hold 8 resistors which tie the 8 interrupt lines (I0-I7) up to +5 V when no input is present. Photo 1c shows a layout of the board after all the sockets connected with the interrupt peripheral interface adapter have been added, IC16 through IC24.

The one remaining device to consider is the addition of a 6850 asynchronous communications interface adapter which we will call IC25. This will be the terminal port through which initialization information will be sent in an American Standard Code for Information Interchange (ASCII) encoded form from the primary computer and mass storage device of the multiple processor system. In separate tests of the 6809 system, this port can be driven by a terminal, since the initialization sequences will use standard ASCII characters as opposed to a more compact binary form.

The address decoding for this port was begun in earlier considerations. We have a line decoding the D1 address of serial ports in the high-order, an output of IC18. With an asynchronous communications interface adapter, we have to decode 7 out of 8 low-order bits in order to assign the necessary 2 addresses. Using addresses D100 and D101 for this port, we need a single 7430 8-input NAND gate IC26 for the low-order selection. The inverted states of address bits A2 through A7 are shared with the decoding of the 6821 part discussed earlier, and inversion of the A1 bit can use a spare section from either the 7420 IC14 or one of the hex-inverter packages.

Also required for the serial interface is some form of a socket header for a D connector attached to a cable and level conversion integrated circuits. Thus IC27 which is an MC1488 and IC28 which is an MC1489 provide our level conversion. IC29 is a socket devoted to attachment of the cable to the D connector. By popping off the plastic cover on a wire-wrap socket, such as IC29, it is possible to insert a small (#20 gauge) stranded wire into the contacts of the socket. This wire can then be carefully soldered so that no bridges to the next pin occur, or every other pin can be assigned to this I/O function where only a subset of the 14 or 16 pins is necessary. Photo 2 illustrates this point of fabrication by way of an example.

There is one minor detail which still remains with respect to the communications interface: we need a clock which can supply a frequency of 16 times the data rate of 19,200 bps, or 307.2 kHz. It turns out that given a 5 MHz central processor clock source, we come very close to the desired data rate by simply dividing by 16 to get 312.5 kHz. The error in this frequency is 1.7 % , with respect to the proper clock of 307.20. Will this work? Yes, for the
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In the next installment of this series on building a homebrew general purpose computer for use as a communications controller, we shall start with a verification of these design considerations as an actual diagram, then proceed to discuss construction and testing of this first card in the system. As emphasized in the earlier comments in this series, the timing of the publication of these notes depends upon the amount of spare time I have available to devote to this activity. The intent of this series is to show our readers how simple it is to assemble homebrew systems out of standard parts, using design information which is available in various publications put out by semiconductor manufacturers.

---

**Articles Policy**

BYTE is continually seeking quality manuscripts written by individuals who are applying personal computer systems, designing such systems, or who have knowledge which will prove useful to our readers. For a more formal description of procedures and requirements, potential authors should send a large (9 by 12 inch, 30.5 by 22.8 cm), self-addressed envelope, with 28 cents US postage affixed, to BYTE Author's Guide, 70 Main St, Peterborough NH 03458.

Articles which are accepted are purchased with a rate of up to $50 per magazine page, based on technical quality and suitability for BYTE's readership. Each month, the authors of the two leading articles in the reader poll (BYTE's Ongoing Monitor Box or "BOMB") are presented with bonus checks of $100 and $50. Unsolicited materials should be accompanied by full name and address, as well as return postage.
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Author Ciarcia Replies:

The particular transducers used in the March article are from MASSA in Hingham, MA, I obtained them through Bullet Electronics, POB 40244E, Garland, TX 75040, (214) 278-3553. I suggest calling them to determine price and availability. Since I usually purchase components in large quantities long before I actually need them for an article, I hesitate to quote a price and a definite source. The MASSA units had an output frequency of 23 kHz.

LONG DISTANCE COMMUNICATION

I saw your article in the May issue of BYTE ("Communicate on a Light Beam," page 32) and became very interested. I have an application which requires sending data up to a kilometer at speeds from 2000 to 9600 characters per second (cps). Your descriptions of the fiber optic cable and the light-emitting diode (LED) transmission circuits seem to be ideal, if they are cost effective. Could you give more details of the distances which the circuits can drive and the addresses of the suppliers of the fiber optic components?

R H Fields
1 Wythegate
Riverside Rd
Staines, Middlesex
United Kingdom

Author Ciarcia Replies:

Realize, of course, that the circuits presented, while possibly usable in commercial applications, are presented more to introduce the reader to the concept of fiber optic communications than solve any particular application problem. Their usability in a 1 kilometer data link depends upon more than just the electronic parameters of the circuit. The laser probably can drive such a length, but cable losses and mechanical/optical connections are going to be an important factor in any success.

When you speak of 9600 cps that is approximately 100 k bits per second (bps) and is a reasonable transmission rate. However, response time of the receiver electronics is going to be much more critical than a 10 k bit rate. Given the length of cable as 1 kilometer, I would caution you that a certain intensity must be maintained at the output to achieve this response.

Rather than try to reinvent the wheel or try to second-guess the technical people who really know the field, I think you would be better off purchasing a commercial system. The following is a list of American companies which deal in fiber optics. I am sure they will have a cost-effective solution for you:

Corning Glass Works
Telecommunications Dept
Corning, NY 14830
(607) 974-8812

Dupont Co
Plastic Products and Resins Dept
Wilmington, DE 19898
(302) 774-7850

Fiberoptic Cable Corp
POB 1492
Framingham, MA 01701
(617) 875-5530

Galileo Electro-Optics Corp
Sturbridge, MA 01618
(617) 347-9191

General Cable Corp
500 W Putnam Ave
Greenwich, CT 06830
(203) 661-0100

ITT
Electro-Optical Products Div
Roanoke, VA 24019
(703) 563-0371

Quartz Products Corp
688 Somerset St
Plainfield, NJ 07061
(201) 757-4545

Times Fiber Communications Inc
358 Hall Ave
Wallingford, CT 06492
(203) 265-2361

Valtec Corp
Electro Fiberoptics Div
West Boylston, MA 01583
(617) 835-6083

For further descriptive information on the use of fiber optics I suggest you refer to the January 5, 1978 issue of EDN magazine and an article titled "Designer's Guide to Fiber Optics."
The North Star Horizon computer can be found everywhere computers are used: business, engineering, home — even the classroom. Low cost, performance, reliability and software availability are the obvious reasons for Horizon's popularity. But, when a college bookstore orders our BASIC manuals, we know we have done the job from A to Z.

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— Melvin Davidson, Western Washington University, Bellingham, Washington

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— Harold Nay, Pleasant Hill HS, Pleasant Hill, California

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— Armando Picciotto, Kennedy HS, Richmond, California

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— Gary Montante, Ygnacio Valley HS, Walnut Creek, Calif.

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New York NY 10022

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- SBC 80/10 - $750.00
- 6800 - $750.00

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CI-6800 — 16KB to 64KB on a single board. Plugs directly into Motorola's EXORcisor and compatible with the evaluation modules. Addressable in 4K increments up to 64K. 16KB $390.00. 64KB $750.00.

CI-8080 — 16KB to 64KB on a single board. Plugs directly into Intel's MDS 800 and SBC 80/10. Addressable in 4K increments up to 64K. 16KB $390.00. 64KB $750.00

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I have a Heath microcomputer that I am using for market research. I am trying to locate a company where I can buy the weekly closing prices of the New York Stock Exchange and the Commodity exchanges on audio cassette. I hope one of your readers can help me. Thank you.

Earl O Williams
280 Henderson St Apt 7J
Jersey City NJ 07302•
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[Image of a printer]

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A large Japanese hardware manufacturer recently introduced a good, low cost print mechanism into the U.S. market. They also announced a fully packaged printer using this mechanism to the OEM market. Then another company started to sell this printer to hobby, home and small business computer users.

We took a long hard look at this printer and liked what we saw. The mechanism was reliable. The case was beautifully designed. What we didn't care for was the 5 x 7 dot matrix format. We also believed some form of condensed character set and a few other alterations in software would be significant improvements.

So we bought the mechanism and the case. But we designed our own logic board and wrote new software. The Microtek Printer. Looks the same as the others but really isn't. It's better. It's one giant step ahead of its competition.

**CHECK THIS CHART...**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
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<td>9x7</td>
<td>9x7</td>
<td>5x7</td>
<td>7x7</td>
<td>5x7</td>
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<td>Characters per line</td>
<td>80/120</td>
<td>80</td>
<td>80/132</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>96 char ASCII (upper + lower case)</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
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<td>84 lpm</td>
<td>21 lpm</td>
<td>21 lpm</td>
<td>63 lpm</td>
</tr>
<tr>
<td>VFU</td>
<td>Standard</td>
<td>Standard</td>
<td>N/A</td>
<td>N/A</td>
<td>Standard</td>
</tr>
<tr>
<td>Bi-directional printing?</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Built-in self test?</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Unit price</td>
<td>$750*</td>
<td>$995</td>
<td>$1,350-1,559</td>
<td>$970-995</td>
<td>$985</td>
</tr>
</tbody>
</table>

*Parallel interface

Comparison data from manufacturer's current (August '79) literature.

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Tracing your own roots satisfies an intangible craving that many people have — a craving to understand your place in a heritage that was developed by people who are perhaps more like yourself (at least genetically) than any other people on Earth. The process involves untangling puzzles that tax the most intelligent imagination. Relationships must be deciphered from other people's memories and from bits and pieces of written records that form a fragile and sometimes inadequate link between you and your ancestors. It is a natural application for a microcomputer.

Doing Genealogy
How does a person go about tracing his or her roots? There are several steps that make the process simpler. Some of these steps are enumerated in the following section.

Step 1. The best place to start searching for your family is, of course, at home. You should jot down on paper or key into the computer all the things that you know (or think you know) about your ancestry, then look for family records, such as Bibles and correspondence. Frequently these will contain useful leads that make it easier to document facts later on. Next, contact family members: parents, siblings, the proverbial great-great-aunt, and anyone else who might possess a piece of family information. It is useful to quiz these relatives about parents, events, dates, and places, beginning with those people who are closest to you in time, and working backward.

If other family members are interested, it may be possible to establish a family organization that will hold occasional family reunions and share the fun and work of searching out ancestors. Such an organization already exists in many families.

Step 2. The memories collected from family members cannot usually provide adequate proof of the events recalled, since the human capacity to remember information accurately is imperfect. Memories merely provide hints for where to look for birth, marriage, and death certificates (known as vital records), or for entries in church and civil record books that will document the information. These documents provide official information about particular ancestors, and also give possible clues about other ancestors in the chain.

Several sources exist for finding these documents. Often ancestors will have resided in a single locality for several generations. A letter to the clerk of the political jurisdiction (county, province, etc) where they lived, or to the parish cleric in countries where churches kept the vital records, will often elicit copies of desirable information. These places can be visited in person as well.

A number of institutions collect and preserve genealogical records on a national or international basis, and make these records available to the public. The institution with what is undoubtedly the most complete collection is:

The Genealogical Society
Church of Jesus Christ of Latter Day Saints
50 E North Temple
Salt Lake City UT 84102

You do not have to belong to the Church of Latter Day Saints in order to use their genealogical data sources. While the main library is in Utah, branch libraries are scattered throughout the United States and much of the world. The telephone number of a unit of the church can be found in most telephone directories, and a phone call will produce information about the location of the nearest branch library.

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If it’s worth remembering, it’s worth Scotch Data Recording Products.
This list is not exhaustive, but writing or visiting one of these places will help anybody get started. It is also useful to talk to a reference librarian at a local library. They will often know of nearby sources of genealogical information.

Step 3. It is fairly easy and pleasant for most people to trace back their ancestry 3 or 4 generations. But when a line migrates across an ocean, or when records become less complete (as they invariably do when going further back in time), ingenuity comes into play. Passenger lists, censuses, and tax lists may provide clues to the identity of ancestors who cannot be located in vital records. A knowledge of history is acquired while searching for clues about mass movements in which ancestors may have participated.

This is where the computer comes in. To know what is missing becomes increasingly difficult as the number of ancestors for whom you have information increases. It scarcely needs to be said that computerizing the records makes it much simpler to keep track of the data.

Still more helpful is the use of the computer to solve puzzles. Suppose, for instance, that you cannot find any more family members in a certain line, but you notice from the output data that a related family line has moved to a new locality at about the same time. You have been given a hint that the first family line may also have migrated there, and you can begin to search for information in the records of that particular place.

Using the Program
You need not be a genealogical expert to utilize the program that is listed here. Item 1 on the program's menu (table 1) automatically prompts the user for the most important information about each ancestor. (See listing 1.) This information includes birth date and place, parentage, marriages, and date and place of death. The program asks for the sources of information too, so that the inevitable need to check entries will be easier.

To list the information for any or all of the names that have been entered into the file, you can use item 2 on the menu. An example of a listing for one individual is shown in listing 2. A person can be located by name or by number. Because it is possible for there to be more than one individual in the file with the same name, you should make certain that the person listed is the correct one.

The program as now written will not search beyond the first occurrence of a name unless the all option is selected. When all is typed in response to the prompt, the subroutine will read sequentially through all of the records in the file.
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*Apple II is a registered trademark of Apple Computers, Inc.
In addition to listing file entries, menu item 2 will revise entries. If a revision is made because new information has been found, simply enter the number (or name) of the person for whom the revisions are to be made, and then select the type of information that is to be updated.

The revision subroutines are document oriented, that is, each asks for all of the information that is commonly found on a particular vital record. For example, the marriage revision subroutine requests the date of marriage, the spouse’s name, the place where the marriage was performed, and the source from which the information was obtained, because all of these items are found on a marriage certificate. The document orientation of the revision routines suits the genealogist’s situation well, for the need to update information about an ancestor will usually arise from the discovery of a new document.

If you wish to revise an error that was made while entering information the first time, you should first finish entering all of the information requested by the program. The computer will then prompt for changes by going back to the original menu.

Item 2 will also generate blank data-collection forms which can be used for gathering information to enter into the computer. This is done by putting a special symbol in the data fields for every relevant name.

---

Table 1: The genealogy program prompts the user for a specific use. The user can enter and modify information, list a person’s pedigree for 4 generations, or finish the program use.

---

Listing 1: When adding information to the file, the program prompts you for every input and describes the form that it should take. If an error is made during input, the rest of the information should be completed and the revise option chosen from the main menu upon completion.
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**Task: Read and Revise File Information**

Do you wish to search by 'name' or by 'number'? 

? Number

Please enter the number: 

? 14

Genealogical Information For: 

Thomas Merrill 

Number: 14

Born: 20 November 1715 

Birthplace: Hartford Connecticut

Father: Abel Merrill (number: 15) 

Mother: Mehitable Easton (number: 16)

Married To: 

Martha Wood 

Date: 5 October 1755 

Place: Hartford Connecticut

Death Date: 16 June 1814 

Place of Death: Hartford Connecticut

Records Source: 

Birth and Parentage: Birth Certificate 13347A 

Marriage #1: Marriage Certificate 3445 B 

Death: Death Certificate 3988 C

Do you wish to change anything? 

? No

Would you care to examine another record? 

? Yes

Listing 2: A file may be found and read by either name or number. When the data has been reviewed, the user may update the file using the revision command.

**Task: List Pedigree**

Whose pedigree would you like printed? 

(Enter his/her number, please) 

? 14

The symbol 'F' stands for 'Father' 

The symbol 'M' stands for 'Mother'

Pedigree for Person #14

Thomas Merrill 

P: Abel Merrill (Number: 15) 

M: Mehitable Easton (Number: 16)

F: Alliel Merrill (Number: 15)

M: Mehitable Easton (Number: 16)

FF: John Merrill (Number: 17)

FM: Sarah Watson (Number: 18)

MF: John Easton (Number: 19)

MM: Elizabeth (Easton) (Number: 20)

FFF: Nathaniel Merrill (Number: 21)

FPM: Susannah Wolterton (Number: 22)

FMF: John Watson (Number: 23)

FMM: Margaret Smith (Number: 24)

MFF: Joseph Easton (Number: 25)

MFM: Hannah (Easton) (Number: 26)

MMF: Unknown (Number: 0)

MFM: Unknown (Number: 0)

Listing 3: When a pedigree is requested, a person's ancestry is traced back 4 generations. If the ancestry is unknown, then this is stated.

Place, date, and source in item 1. (A question mark (?) makes a good symbol for this purpose. The number 0 can be used when the computer prompts for a number for the individual and his parents. The number 1 is a good response when the computer asks how many times the individual was married.) Either the special symbol or the number assigned by the program to the special form is then used in item 2. The number or symbol can be requested repeatedly to obtain as many copies of the form as are desired.

The program assigns a unique number to each ancestor so that it can differentiate between people with the same name. (My own genealogy contains cases where as many as 3 individuals have identical names.) Utilizing these numbers, the program will link up any person in the file with 4 generations of his or her ancestors, thus forming a pedigree chart. An example of such a pedigree is shown in listing 3. It is not necessary that everyone in the file be related. The program can tell who is related to whom on the basis of the number assigned to each person.

**Other Ideas**

The genealogy program in listing 4 prompts you to enter important identifying information about your ancestors. It will print back this information and allow revisions. It will also print a 4 generation pedigree for any person in the file, but its usefulness need not stop there: your own imagination can provide personal additions. You might wish to expand the pedigree section to print out more generations, or write a subroutine which will sort persons of the file into nuclear family groups. You might choose to add a subroutine to calculate age of death for each ancestor and average age of death for subgroups of ancestors. This could provide insight into the impact of historical conditions on longevity in your family, and could even be applied toward figuring out your own life expectancy. Among these same lines, you could add a prompt for cause of death — an item usually found on a death certificate. Inspection of the cause of death for a large number of ancestors might even alert you to special diseases that occur regularly in your family.
TI's new TM990/189 University Module is a stand-alone learning lab. Fully assembled and designed for maximum hands-on experience. To ease and simplify learning and teaching.

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A 570-page tutorial text accompanies the module. It is a detailed guide for self-paced learning. Or the basis for a three-hour university course. Chapters include an overview of microprocessors; programming exercises; assembly language; memory systems; I/O concepts and designs; software engineering; product development; a variety of lab experiments, and much more. Also with the module: a 300-page user's guide.

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Or better yet, see your local dealer.

Listing 4: The genealogical program source listing in BASIC Plus 2. Only the input and output statements will need to be changed to adapt this program to most microcomputers with disk storage.

```
00010 PRINT TAR(19);"GENEALOGICAL PROGRAM"
00020 I
00030 | WRITTEN BY STAN W. MERRILL
00040 | OF COMPUTER RESOURCE ASSOCIATES
00050 | 914 EAST SIXTY-FIRST STREET
00060 | CHICAGO, ILLINOIS 60637
00070 | (312) 363-6183
00080 |
00090 | ALLOCATE FILE AND COUNT NUMBER OF CASES ALREADY IN IT
01000 | SET COUNTERS
01100 |
01200 PRINT\PRINT\PRINT
01300 ON ERROR GO TO 350
01400 MAP GENDATA B,C$(3)=16,D$=25,E$=16,F$=25,G$(3)=25,H$=20,J$=16,K$(3)=20
01500 OPEN 'GF.N' AS FILE 01, SEQUENTIAL VARIABLE, MAP GENDATA, INVALID 130
01600 LET I2=0
01700 LET I3=0 I3 COUNTS NUMBER OF CASES IN FILE
01800 I
01900 PRINT "WOULD YOU LIKE A LIST OF THE NAMES CURRENTLY"'"IN THE FILE?"
02000 PRINT "IN THE FILE?"
02100 INpUT WIS
02200 PRINT
02300 IF WIS='Y' THEN PRINT "THE FILE CONTAINS THE FOLLOWING NAMES:"'"THE FILE CONTAINS THE FOLLOWING NAMES:"'
02400 PRINT
02500 PRINT
02600 GET #1
02700 LET I3=13+1
02800 IF WIS='Y' THEN PRINT Ds,B
02900 IF WIS='YES' THEN PRINT Ds,B
```

This genealogy program was written on a DECsystem 2050 at the University of Chicago, using DEC's BASIC Plus 2. The file I/O (input/output) under BASIC Plus 2 differs from that in many other BASICS and may require some revision when running the program under another interpreter or compiler. For instance, the MAP statement, which BASIC Plus 2 uses to allocate space for variables, is unnecessary in some versions of BASIC.

To make the program smaller, reduce the number of prompts. Another possibility is to break the program into smaller programs, each of which can be loaded into memory independently as needed. The 3 major subroutines (labeled "procedure subroutines" in listing 4) are almost self-sufficient, that is, they can be entered as separate programs with only slight modification. However, procedure subroutine 2 calls several revision subroutines (lines 4170 thru 4850) which should be included with it, if it is made into a separate program.
MetaFloppy™ goes beyond.

The Micropolis MetaFloppy™ gives you more than four times the capacity of anyone else’s 5¼-inch floppy because it uses 77 tracks instead of the usual 35. For maximum capacity, choose our new MetaFloppy:1054 system. Which actually provides you with more than a million bytes of reliable on-line storage, for less money than you’d believe possible.

The MetaFloppy:1054 comes complete with four drives in dual configuration. A controller, power supply, chassis, enclosure, all cabling. A new BASIC software package. And a DOS with assembler and editor. There’s even a built-in Autoload ROM to eliminate tiresome button pushing.

For maximum capacitv, choose our new MetaFloppy:1054 system. Which actually provides you with more than a million bytes of reliable on-line storage. For less money than you’d believe possible.

In other words, if your application keeps growing, we’ve got you covered. With MetaFloppy.

Another use for the information in the file is for studying naming traditions. Do certain names appear over and over in the family? Are surnames commonly used for given or middle names? Perhaps the file contains ideas for naming your own children (pets, etc.). Studying names can help in the understanding of implicit family values and the transfer of power and prestige in the family.

You may wish to add a subroutine for collecting biographical anecdotes about ancestors. This is a real programming challenge, given the limited string handling capabilities of most versions of BASIC.

Conclusion

Genealogy matches you and your computer against exciting and worthwhile puzzles that challenge the best abilities of both man and machine. Its rewards include a closer relationship with your family, increased knowledge of history gleaned from a search for facts that may have affected ancestral migration and marriage patterns, and a self-knowledge derived from examination of people like yourself.

Listing 4 continued:

00300 1
00310 IF B>I2 THEN LET I2=B
00320 IF R>I2 THEN LET I2=R
00330 IF T>I2 THEN LET I2=T
00340 GO TO 260
00350 RESUME 390
00360 1
00370 1 MENU OF PROCEDURES
00380 1
00390 PRINT
00400 PRINT 'PLEASE ENTER THE NUMBER OF THE PROCEDURE'
00410 PRINT 'YOU WANT:'
00420 PRINT
00430 PRINT TAB(10);'(1) ENTER INFORMATION'
00440 PRINT TAB(10);'(2) READ OR REVISE INFORMATION'
00450 PRINT TAB(10);'(3) LIST PEDIGREE'
00460 PRINT TAB(10);'(4) END THE PROGRAM'
00470 INPUT A
00480 IF A=1 THEN GOSUB 570 ENTER INFORMATION
00490 IF A=2 THEN GOSUB 3090 READ THE INFORMATION
00500 IF A=3 THEN GOSUB 3090 LIST PEDIGREE
00510 IF A=4 THEN GO TO 4900 END PROGRAM
00520 GO TO 390 INPUT ERROR—TRY AGAIN
00530 1
00540 1 PROCEDURE SUBROUTINE #1
00550 1 BIRTH CERTIFICATE INFORMATION
00560 1
00570 PRINT
00580 PRINT "TASK: ADD GENEALOGICAL INFORMATION TO THE FILE"
00590 OPEN "GEN" FOR INPUT AS FILE #1, SEQUENTIAL, VARIABLE, ACCESS APPEND, MAP GENDATA, INVALID 130
00600 PRINT
00610 PRINT "WHAT IS THE PERSON'S NAME?"

Listing 4 continued on page 32
Up Your Output.

TEMPOS

MULTI-TASKING!

The TEMPOS Operating System is quickly becoming the standard in Multi-User, Multi-Tasking operating systems for 8080 and 280 microcomputers. Multi-Tasking means that, even with only one user at one terminal, more than one job can be running on the system simultaneously! If you have ever had to go get a cup of coffee while you wait for your computer to print listings, you know the advantages of a system that will handle one job while you are working on another. TEMPOS is a true time sharing system, and the maximum number of jobs is limited only by your memory.

MULTI-USER!

Want to share your computer with another user? With TEMPOS all it takes is another terminal... up to seven interactive terminals are allowed! And with Re-Entrant programs, each user does not need a complete copy in memory. We include three Re-Entrant programs (the OPUS/THREE High-Level Language, the TEXTED Text Editor, and FILES, a disc file directory/manipulator) or write your own! In addition, we include an assembler, a linking loader, over a half-dozen other utility programs and over 60 system subroutines, callable by the programmer!

PROVEN!

With TEMPOS, you get a package that has been tested in our facilities for over two years, and in the field at over 50 different installations. We have used this system ourselves for everything from writing high-level languages to developing applications to text editing to games. TEMPOS is undoubtedly the most flexible software tool on the market... and you can have it for much less than you think!

COMPATIBLE!

TEMPOS is available for many different systems; pre-written drivers may include yours. Or, using our interactive System Generation Routine, you can add your own. Call or write now for our free catalog and the name of a dealer near you. The TEMPOS Operating System is available for $787.00, the manual set (price may be credited toward the purchase of the TEMPOS package) for $21.50 (prices include shipping within the U.S.).

Listing 4 continued:

00620 PRINT "(USE MAIDEN NAME WHERE APPROPRIATE)"
00630 INPUT D$0
00640 PRINT",D$
00650 PRINT "TO PREVENT \";D$0
00660 PRINT "FROM BEING CONFUSED WITH SOMEONE ELSE"
00670 PRINT "WHO MAY HAVE A SIMILAR NAME, HE/SHE"
00680 PRINT "SHOULD HAVE A UNIQUE NUMBER IN THIS FILE."
00690 PRINT
00700 PRINT "HAS A NUMBER ALREADY BEEN ASSIGNED?"
00710 INPUT V$0
00720 IF VS="Y" THEN 820
00730 IF VS="YES" THEN 820
00740 IF VS="N" THEN IF VS="NO" THEN G0 TO 690
00750 LET I2=I2+1
00760 LET B=I2
00770 PRINT
00780 PRINT "HE/SHE HAS BEEN ASSIGNED THE NUMBER:"0
00790 PRINT
00800 PRINT TAB(10);B
00810 G0 TO 850
00820 PRINT
00830 PRINT "PLEASE ENTER THE NUMBER:"
00840 INPUT B
00850 PRINT
00860 PRINT "I WILL ASK YOU FOR SOME DATES."
00870 PRINT "PLEASE ENTER DATES IN THE FOLLOWING"
00880 PRINT "FORMAT: DAY MONTH YEAR"
00890 PRINT "EXAMPLE: 23 APRIL 1949"
00900 PRINT "IF YOU DON'T KNOW A DATE, ENTER 'UNKNOWN'."
00910 PRINT
00920 PRINT "WHEN WAS \";D$0; \" BORN (DA MO YR)?"
00930 INPUT E$0
00940 PRINT
00950 PRINT "WHERE WAS HE/SHE BORN?"
00960 INPUT H$
00970 PRINT
00980 PRINT "WHAT WAS \";D$0; \"S FATHER'S NAME?"
00990 PRINT "(IF YOU DON'T KNOW, ENTER 'UNKNOWN')"
01000 INPUT Q$0
01010 IF Q$="UNKNOWN" THEN G0 TO 1200
01020 PRINT
01030 PRINT "DOES \";Q$0; \" ALREADY HAVE A NUMBER?"
01040 PRINT
01050 INPUT V$0
01060 IF V$="Y" THEN 1160
01070 IF V$="YES" THEN 1160
01080 IF V$="NO" THEN G0 TO 1270
01090 LET I2=I2+1
01100 LET R=I2
01110 PRINT "HE HAS BEEN ASSIGNED THE NUMBER:"0
01120 PRINT
01130 PRINT TAB(10);R
01140 PRINT
01150 G0 TO 1220
01160 PRINT
01170 PRINT "PLEASE ENTER HIS NUMBER:"
01180 INPUT R
01190 G0 TO 1220
01200 LET R=O
01210 PRINT
01220 PRINT "WHAT WAS \";D$0; \"S MOTHER'S NAME?"
01230 PRINT "(USE MAIDEN NAME IF POSSIBLE. IF YOU"
01240 PRINT "DON'T KNOW HER NAME, ENTER 'UNKNOWN')"
01250 INPUT S$0
01260 IF S$="UNKNOWN" THEN G0 TO 1430
01270 PRINT
01280 PRINT "DOES SHE ALREADY HAVE A NUMBER?"
01290 INPUT V$0
01300 IF V$="Y" THEN G0 TO 1400
01310 IF V$="YES" THEN G0 TO 1400
01320 IF V$="NO" THEN G0 TO 1270

Listing 4 continued on page 42
16 COLORS

The C4P and C8P offer a brilliant array of 16 colors including black available in both alphabetics and graphics.

THE FACTS
SPEED

Speed separates the computers from the toys. The faster the processor executes instructions the more elaborate and greater the I/O can be. The C4P and C8P have execution speed that is twice as fast as Apple II, or Commodore PET and over THREE times as fast as TRS-80. They are many times faster than the recently introduced flock of video game type computers.

GT OPTION

As if that weren't fast enough, the C4P and C8P's speed is nearly doubled when equipped with the Ohio Scientific GT option. By utilizing a 6502C microprocessor in conjunction with ultra-fast static memories, a C4P or C8P equipped with the GT option, will yield the following performance:

1.2 million instructions per second. Average.
Memory to accumulator ADD time — 600NS.
JUMP extended — 900NS.

DISPLAY

The C4P and the C8P offer more display than other personal computers — 2048 characters — 32 rows of 64 columns with upper and lower case. Long display width makes user instruction easier to program and to read. The effective graphics resolution of 256 x 512 points allows these computers to match the display limit of even the best color television sets.

CONSTRUCTION

The C4P incorporates a fully RF shielded aluminum case with 2-step baked on enamel finish. It is trimmed with solid oiled walnut and die-cast chromed dress panels. Compare its construction to the plastic cases that are standard on other personal computers.

The quality doesn't stop at the surface. The C4P and C8P are modular BUS orientated computers with 4 and 8 slots respectively. The internal electronics are built to rigorous industrial standards.

Modularity means expandability and obsolescence protection. In fact, the original 1977 vintage C2-4P can be upgraded to a C4P by changing PC cards at substantially less cost than purchasing a new computer.

* Apple II, Commodore PET, TRS-80, and Atari 800 are registered trade names of Apple Computer Inc., Commodore Business Machines Ltd., Radio Shack, Atari, respectively.
The C4P MF is shown with optional accessories (clockwise). Home Color TV set (requires RF modulator), 2 joy sticks, AC-Remote console and 2 modules, wireless smoke detector and window detector, modem, printer and wireless remote security console (on top of TV.)
JUST LOOK AT ALL THE I/O OF THE C4P MF — BUILT IN INTERFACES

I/O capabilities. The most important feature to look for when you purchase your next computer. Compare these standard features of the C4P and C8P disk systems to any other computer system. Regardless of price, you'll find none that even come close.

HOME SECURITY INTERFACES
1-home security interface with fire and intrusion detection

CONTROL INTERFACES
16 parallel I/O lines

CLOCK
1-Real time clock and count down timer

Only an Ohio Scientific C4P MF or C8P DF can offer you all this I/O.
AVAILABLE ON THE BACK AND READY TO RUN.

ACCESSORY BUS
One accessory BUS connector for an external 48 line I/O board, PROM blaster, analog data module or education board.

SOUND
1-programmable tone generator 200 — 20KHz
1-8 bit companding digital to analog converter (DAC) for music and voice output

HUMAN INPUT EXPANSION
2-8 axis joystick interfaces
2-10 keypad interfaces

HOME INTERFACES
1—AC-12 AC remote control interface
SOFTWARE
Ohio Scientific offers a full comprehensive library of both systems and applications software for the C4P and the CSP. And, because our main language is Microsoft BASIC like most other personal computers, much of your old software can be used on the C4P and CSP with little or no modification except for the special I/O functions and the much faster speed of your new computer. This would include software from the TRS-80 Level II, Apple floating point BASIC, Commodore BASIC and many others.

SYSTEMS INTEGRATION
There is a lot of software available for a lot of computers. Unfortunately for the user in almost every case the computer is available from one supplier, software is available from a dozen independent suppliers and accessory devices are available from yet other suppliers. Ohio Scientific has a different approach. We offer a comprehensive library of systems and applications software for the C4P and CSP. In fact, we offer more factory supported software than any other personal computer company. For example, say you have a brand X computer and you buy a real time clock from company Y which supplies software to use the clock. Then you buy an AC controller from company Z who also provides software. The system works fine as long as you want to monitor time or control AC devices but you are out of luck when you want to use the clock in conjunction with controlling AC devices. With Ohio Scientific’s systems you can be monitoring home security, time, controlling AC devices and be playing an exciting video game, all at the same time because the systems software, the applications software, and the accessories form an integrated package which works together without end user modification.

UNION PHONE INTERFACE
Our new universal telephone interface (UTI) can respond to touch tone or rotary dial telephone lines. For a very long time, using touch tone telephone lines meant you had to learn to “talk” to your computer. Now you can “talk” to your computer.

imited Config. Total Memory RAM + Display + ROM
Maximum RAM
TV/Video Monitor
Cassette Recorder
Mini-Floppy Disk
Dual Mini-Floppy Disk
Dual 8” Floppy Disk
Video Display
Color Graphics (up to 16 colors), Upper and Lower Case, Graphics + Gaming Elements
Effective Screen Resolution
Audio Output (200 to 20KHz)
DAC for Voice and Music Generation
Key Pad Interfaces
Joystick Interfaces
AC Remote Control Interface
Audio Cassette Interface
Real Time Clock
Home Security System Interface
Printer Interface
Modem Interface
16 Parallel Lines + Acc’y, BUS GT Option
Winchester Hard Disks Option
Voice I/O
Telephone Interface

FEATURE
Microprocessor type
GT option 6502C
Full 53-key Keyboard
BASIC in ROM
BASIC on Disk
Minimal Config. RAM
Minimal Config. Total Memory RAM + Display + ROM
Maximum RAM
TV/Video Monitor
Cassette Recorder
Mini-Floppy Disk
Dual Mini-Floppy Disk
Dual 8” Floppy Disk
Video Display
Color Graphics (up to 16 colors), Upper and Lower Case, Graphics + Gaming Elements
Effective Screen Resolution
Audio Output (200 to 20KHz)
DAC for Voice and Music Generation
Key Pad Interfaces
Joystick Interfaces
AC Remote Control Interface
Audio Cassette Interface
Real Time Clock
Home Security System Interface
Printer Interface
Modem Interface
16 Parallel Lines + Acc’y, BUS GT Option
Winchester Hard Disks Option
Voice I/O
Telephone Interface

EXPANSION
As you can see, the C4P and CSP are truly exceptional premium computers with just their standard features alone. Above and beyond that they are easily expandable to add exciting advanced features like word processing, additional memory, voice I/O, and our new universal telephone interface (UTI).

C4P VS. CSP
The C4P is a 4-slot portable computer with one open slot for expansion. The CSP is an 8-slot mainframe class computer with five open slots. It features over 3 times the expansion capability of the C4P for advanced home, experimental and small business applications. The CSP’s dual 8” floppy store about 8 times the information of a single mini-floppy and access it many times faster.

ADVANCED FEATURES FOR CSP DF EXPANSION
Voice I/O
The CSP DF can be optionally equipped with a voice I/O system that includes a Votrax module capable of generating English speech phonetically. It also has provisions for a user populated 5-channel feature extractor for voice input experimentation.

Universal Telephone Interface (UTI)
Optionally equipped with a Universal Telephone Interface system, the CSP DF has the ability to dial any telephone number, utilizing rotary dial or touch tone telephone lines. It can respond to touch tone or modem signals and can route voice to tape recorders. It can also answer by touch tone, modem, stored message or Votrax voice output (when equipped with Votrax module or used in conjunction with a CA-14 Voice I/O.)

A CSP DF with UTI, voice output, AC-Remote, home security and its clock yield the home computer of the future with uncannily human-like capabilities to communicate via phone lines and operate and monitor typical home functions.

FINAL FACTS
Buying a new computer is a serious, long-term investment. So we invite you to shop around and compare. The closest thing you’ll find to a C4P or CSP will cost twice as much and offer less than half the performance. We know because there’s nothing like these exceptional premium computers at any price, anywhere. And probably won’t be for a very long time.

*TRS-80 Level II, Apple floating point BASIC and Commodore BASIC are registered trade names of Radio Shack, Apple Computer Inc., Commodore Business Machines Ltd., respectively.
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*Not wired to connector.

Compared with keyboards and floppies where specified. Other equipment shown is optional.
### HARDWARE

#### COMPUTERS

- **C4P**
  - 8K BASIC in ROM, 8K RAM, Demo Cassette: $698
  - 24K RAM, Single Mini-Floppy, OS-65D 3.1 operating system and 2 demo disks: 1,695
- **C4P MF/GT**
  - 8K BASIC in ROM, 8K RAM, Demo Cassette: $895
- **C8P**
  - 32K RAM Dual 8" floppies, OS-65D 3.1 and 2 demo disks: 2,597

#### ACCESSORIES

- **AC-3P**
  - 12" B/W Combination Monitor/TV: $115
- **AC-15P**
  - 12" Color Monitor: 399
- **AC-16P**
  - 2-8 Axis Joy sticks with cables: 39
- **AC-11P**
  - Answer/Originate 300 baud modem with cable: 199
- **AC-12P**
  - AC-Remote starter set, console, 2 lamp modules, 2 appliance modules, OS-65D home control operating system: 175
- **AC-17P**
  - Home security starter set (wireless), console, 1 fire detector, 2-window units, one door unit and Demonstration software: 249
- **AC-15**
  - Universal telephone interface with touch tone encoder/decoder, 300 baud originate/answer modem, analog signal mux/demux: 499
- **CA-15V**
  - As above with Votrax voice module for computer generated voice response: 799

#### PRINTERS

- **AC-18P**
  - Low cost high speed 8½" aluminized paper printer with upper/lower case: $695
- **AC-9TP**
  - Centronics 779 110 cps tractor feed Business printer with interface: 1,250
- **AC-14**
  - NEC Spinwriter—word processing printer with high speed parallel Interface: 2,795

#### GT OPTIONS

- **C4P MF/GT**
  - 24K, 120NS Memory, 6502C processor, 2-speed clock: $950
- **C8P DF/GT**
  - 48K, 120NS Memory, 6502C processor, 2 speed clock: 1,825

### SOFTWARE

- Here is a partial listing of diskettes for the C4P and C8P. For a complete listing of diskettes and cassettes consult the current full line price list.

#### APPLICATIONS SOFTWARE

- **Game Disk 1**
  - Arcade games: $29
- **Game Disk 2**
  - Arcade games: 29
- **Game Disk 3**
  - Popular Conventional Computer games: 29
- **Game Disk 4**
  - Popular Conventional Computer games: 29
- **Game Disk 5**
  - Advanced Arcade games: 29
- **Game Disk 6**
  - Advanced Arcade games: 29
- **Game Disk 7**
  - Joy stick Arcade games: 29
- **Game Disk 8**
  - Animations and Cartoons (2 disk set): 29

#### BUSINESS SOFTWARE

- **Business Disk 1**
  - Depreciation/return on investments etc.: $29
- **Business Disk 2**
  - Mailing list/Address list/etc.: 29
- **OS-WP2**
  - Complete word processing system: 200
- **OS-MDMS**
  - 65D based Data Base Manager and information management system. A must for business use: 49
- **MDMS-A/R**
  - Accounts Receivable System: 29
- **MDMS-A/P**
  - Accounts Payable System: 29
- **MDMS-Inventory**
  - Inventory System: 29
- **MDMS-Aux. 1**
  - Sort/File packer/key File editor for ISAM: 29

#### UTILITIES

- **65D Aux. 1**
  - Sort/packer/memory test/disassembler: $29
- **Graphics 1**
  - Color graphics utilities with high resolution plot package: 29
- **Home Control 2**
  - Advanced home control program using AC-12 and AC-17: 29
- **DAC Routines 1**
  - Music composition system with chord generation capability: 39

**Purchase your C4P or C8P and accessories direct from your local Ohio Scientific dealer. Over 300 dealers nationwide.**

### OHIO SCIENTIFIC

1333 S. Chillicothe Road • Aurora, Ohio 44202 • (216) 562-3101
The September '77 and March '79 covers of BYTE are now each available as a limited edition art print, personally signed and numbered by the artist, Robert Tinney.

These prints are strictly limited to a quantity of 750 for each cover, and no other editions, of any size, will ever be published. Each print is 18" x 22", printed on quality, coated stock, and signed and numbered in pencil at bottom.

The price of each print is $25. This includes 1) a signed and numbered print; 2) a Certificate of Authenticity, also signed personally by the artist and witnessed, attesting to the number of the edition (750), and the destruction of the printing plates; and 3) first class shipment in a heavy-duty mailing tube.

To order your limited edition art print, fill out and mail the order form below.

Send me ________ "Breaking the Sound Barrier" prints at $25 each, and ________ "Trap Door" prints at $25 each. I understand this price includes Certificate of Authenticity and first class shipment.

☐ I have enclosed check or money order to Robert Tinney Graphics.
☐ Charge this to my Master Charge or Visa
   Card #__________ Expires:______

Ship my print(s) to:
Name__________________________
Address________________________
City_________________ State______ Zip________

Send order to:
robert tinney graphics
P.O. Box 45047 • Baton Rouge, LA 70895

Circle 380 on inquiry card.
Listing 4 continued:

```
01330 PRINT
01340 LET I2=I2+1
01350 LET T=T+1
01360 PRINT "SHE HAS BEEN ASSIGNED THE NUMBER:" 
01370 PRINT
01380 PRINT TAB(10);T
01390 GO TO 1450 ! GO BACK FOR NUMBER
01400 PRINT
01410 PRINT "PLEASE ENTER HER NUMBER:" 
01420 INPUT T
01430 PRINT\PRINT
01440 LET T=0
01450 PRINT\PRINT
01460 PRINT "WHERE DID YOU GET THE INFORMATION ABOUT" 
01470 PRINT D$;"'S BIRTH AND PARENTAGE?"
01480 PRINT "BE SPECIFIC)"
01490 INPUT D$ 
01500 ! MARRIAGE CERTIFICATE INFORMATION 
01520 !
01530 PRINT\PRINT
01540 PRINT "HOW MANY TIMES WAS ";D$;" MARRIED?"
01550 PRINT '(ENTER A DIGIT FROM 0 TO 99)'
01560 INPUT F
01570 IF F=0 THEN GO TO 1730
01580 FOR I=1 TO F
01590 PRINT\PRINT
01600 PRINT "WHERE DID YOU GET THE INFORMATION ABOUT MARRIAGE #";F;"?"
01610 INPUT D$ 
01620 PRINT
01630 PRINT "WHAT WAS THE SPOUSE'S FULL NAME?"
01640 PRINT ' (USE MAIDEN NAME WHERE applicable)'
01650 INPUT C$ 
01660 PRINT
01670 PRINT "WHERE WERE THEY MARRIED?"
01680 INPUT K$ 
01690 PRINT\PRINT
01700 PRINT "WHERE DID YOU GET THE INFORMATION ABOUT MARRIAGE #";F;"?"
01710 INPUT D$ 
01720 NEXT I
01730 IF F=0 THEN C$="NOT APPLICABLE"
01740 IF F=0 THEN K$="NOT APPLICABLE"
01750 ! DEATH CERTIFICATE INFORMATION 
01760 !
01770 !
01780 PRINT\PRINT
01790 PRINT "WHEN DID ";D$;" DIE (DA MO YR)?"
01800 PRINT "(IF YOU DON'T KNOW, ENTER 'UNKNOWN'."
01810 PRINT "IF HE OR SHE IS STILL LIVING, ENTER 'ALIVE'.)"
01820 INPUT J$ 
01830 IF JS="ALIVE" THEN GO TO 1900
01840 PRINT\PRINT
01850 PRINT "WHERE DID HE/SHE DIE?"
01860 INPUT L$ 
01870 PRINT\PRINT
01880 PRINT "WHERE DID YOU GET THE INFORMATION ABOUT HIS/HER DEATH?"
01890 INPUT D$ 
01900 IF JS="ALIVE" THEN L$="NOT APPLICABLE"
01910 PRINT\PRINT
01920 !
01930 PUT #1
01940 CLOSE #1
01950 RETURN
01960 ! PROCEDURE SUBROUTINE #2
01970 !
01980 ! READ AND REVISE FILE 
01990 !
02000 PRINT\PRINT
02010 PRINT "TASK: READ AND REVISE FILE INFORMATION"
02020 PRINT\PRINT
02030 OPEN "GEN" AS FILE #1, SEQUENTIAL VARIABLE, ACCESS MODIFY, MAP GEN
```

Listing 4 continued on page 44
What it means to you.

digi-kit-izer/dij-e-kit-izer/ n: (1): a high-value low-cost computer graphic input device designed to be assembled by the user (2): the most advanced graphics tablet in kit form (3): An instrument that, when assembled, allows the user innumerable methods of design and analysis functions (4): The latest addition to the most extensive, accurate and reliable line of digitizers, by Talos

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Circle 361 on inquiry card.
Listing 4 continued:

```
DATA, INVALID 130
02040 PRINT "DO YOU WISH TO SEARCH BY 'NAME' OR BY 'NUMBER'?
02050 INPUT W2S
02060 PRINT
02070 IF W2S='NAME' THEN GO TO 2200
02080 IF W2S<>'NUMBER' THEN GO TO 2040
02090 PRINT "PLEASE ENTER THE NUMBER:"
02100 INPUT A1
02110 PRINT
02120 RESTORE #1
02130 LET Z5=0
02140 LET Z5=Z5+1
02150 IF Z5>13 THEN PRINT "PERSON #";A1;"IS NOT IN THE FILE."
02160 IF Z5>13 THEN GO TO 2940
02170 GET #1
02180 IF A1<>B THEN GO TO 2140
02190 PRINT
02200 PRINT "IF YOU ARE LOOKING FOR SOMEONE IN PARTICULAR"
02210 PRINT "PLEASE ENTER HIS OR HER NAME. IF YOU WANT"
02220 PRINT "TO READ THROUGH THE ENTIRE FILE, ENTER 'ALL'."
02230 INPUT P1$
02240 PRINT
02250 LET P2S=P1$
02260 RESTORE #1
02270 LET Z5=0
02280 LET Z5=Z5+1
02290 IF Z5>13 THEN PRINT P1$;"IS NOT IN THE FILE."
02300 IF Z5>13 THEN GO TO 2940
02310 GET #1
02320 IF P1$='ALL' THEN LET P2S=D$
02330 IF P2S<>D$ THEN GO TO 2280
02340 PRINT
02350 PRINT "GENEALOGICAL INFORMATION FOR:"
02360 PRINT D$
02370 PRINT "NUMBER:";B
02380 PRINT
02390 PRINT 'BORN: ';F.$
02400 PRINT 'BIRTHPLACE: ';H$
02410 PRINT
02420 PRINT 'FATHER:";D$I$;"(NUMBER:";B;")"
02430 PRINT 'MOTHER:";D$;"(NUMBER:";T;")"
02440 PRINT
02450 IF F=0 THEN GO TO 2530
02460 PRINT 'MARRIED TO:"
02470 FOR I=1 TO F
02480 PRINT 'PLACE: ';K$ (I)
02490 PRINT
02500 PRINT "DEATH:";JS
02510 PRINT 'PLACF.OFDF.ATH: ';LS
02520 PRINT
02530 IF JS='ALIVE' THEN GO TO 2560
02540 PRINT "DEATH DATE:";JS
02550 PRINT 'PLACE OF DEATH: ';L$
02560 PRINT
02570 PRINT "RECORDS SOURCE:";
02580 PRINT "BIRTH AND PARENTAGE:";D1$
02590 FOR I=1 TO F
02600 PRINT 'MARRIAGE #:";F;";";D2$ (I)
02610 NEXT I
02620 IF JS='ALIVE' THEN GO TO 2640
02630 PRINT "DEATH:";D3$
02640 PRINT
02650 IF P3$='N' THEN GO TO 2930
02660 PRINT "DO YOU WISH TO CHANGE ANYTHING?"
02670 INPUT P3$
02680 IF P3$='N' THEN GO TO 2930
02690 IF P3$='NO' THEN GO TO 2930
02700 I
02710 I
02720 I
02730 PRINT
```

Listing 4 continued on next page
Listing 4 continued:

02740 PRINT 'PLEASE ENTER THE NUMBER OF THE ITEM'  
02750 PRINT 'YOU WISH TO CHANGE:'  
02760 PRINT  
02770 PRINT ' 1) NAME AND NUMBER'  
02780 PRINT ' 2) BIRTH AND PARENTAGE'  
02790 PRINT ' 3) MARRIAGE INFORMATION'  
02800 PRINT ' 4) DEATH INFORMATION'  
02810 PRINT ' 5) NOTHING'  
02820 PRINT  
02830 INPUT P4  
02840 IF P4=1 THEN GOSUB 4190  
02850 IF P4=2 THEN GOSUB 4300  
02860 IF P4=3 THEN GOSUB 4460  
02870 IF P4=4 THEN GOSUB 4670  
02880 IF P4=5 THEN GO TO 2940  
02890 PRINT  
02900  
02910 IF P$='Y' THEN IF P$='ALL' THEN GO TO 2030  
02920 IF P$='YES' THEN IF P$='ALI.' THEN GO TO 2030  
02930 IF P$='Y' THEN GO TO 2310  
02940 IF P$='YES' THEN GO TO 2310  
02950 CLOSE 171  
02960 RETURN  
02970 PROCEDURE SUBROUTINE 173  
02980 LINK PEDGREE BY NUMBER  
02990  
03000 TASK: LIST PEDIGREE  
03010 OPEN 'GEN' AS FILE 171, SEQUENTIAL, VARIABLE, MAP GEN_DATA, INVALID  
03020 LET X1=0  
03030 PRINT 'WHOSE PEDIGREE WOULD YOU LIKE PRINTED?'  
03040 PRINT '(ENTER HIS/HER NUMBER, PLEASE)'  
03050 INPUT XI  
03060 PRINT  
03070 PRINT 'WE SYMBOL 'F' STANDS FOR 'FATHER''  
03080 PRINT 'THE SYMBOL 'M' STANDS FOR 'MOTHER''  
03090 PRINT  
03100 PRINT 'F:';O$;'(NUMBER:';R;')'  
03110 PRINT 'M:';S$;'(NUMBER:';T;')'  
03120 PRINT  
03130 FIND GRANDPARENTS AND LIST  
03140 LET X2=R  
03150 LET X3=T  
03160 LET X12=X1  
03170 LET X12=X1  
03180 LET X12=X1  
03190 LET X12=X1  
03200 LET X12=X1  
03210 IF X2<>0 THEN PRINT 'PERSON #';X2;'IS NOT LISTED IN THE FILE'  
03220 IF X3<>0 THEN PRINT 'PERSON #';X3;'IS NOT LISTED IN THE FILE'  
03230 IF X12<>0 THEN PRINT 'PERSON #';X12;'IS NOT LISTED IN THE FILE'  
03240 GET #1  
03250 IF B<>X1 THEN GO TO 3240  
03260 IF B<>X1 THEN GO TO 4150  
03270 LET #1=I4+1  
03280 IF I4<>XI THEN PRINT 'PERSON #';XI;'IS NOT LISTED IN THE FILE'  
03290 IF I4<>XI THEN GO TO 4150  
03300 PRINT  
03310 PRINT D$  
03320 PRINT  
03330 PRINT TAB(5);F:;'O$;'(NUMBER:';R;')'  
03340 PRINT TAB(5);M:;'S$;'(NUMBER:';T;')'  
03350 PRINT  
03360 PRINT  
03370 PRINT 'FIND GRANDPARENTS AND LIST'  
03380 PRINT  
03390 LET X2=R  
03400 LET X3=T  
03410 LET I5=0  
03420 LET I12=0  
03430 IF X2<>0 THEN I12=I12+1

Listing 4 continued on page 46
Listing 4 continued:

04170 I REVISION SUBROUTINE #1
04180 I
04190 I CHANGE NAME AND NUMBER
04200 I
04200 !
04210 PRINT;PRINT
04220 INPUT 'NAME: ';D$       
04230 PRINT
04240 INPUT 'NUMBER: ';B
04250 RETURN
04260 I
04260 I
04270 ! REVISION SUBROUTINE #2
04280 I CHANGE BIRTH INFORMATION
04290 I
04300 I CHANGE BIRTH INFORMATION
04310 PRINT;PRINT
04320 INPUT 'BIRTHDATE: ';E$  
04330 PRINT
04340 INPUT 'BIRTHPLACE: ';H$  
04350 PRINT
04360 INPUT 'FATHER'S NAME';Q$      
04370 INPUT 'FATHER'S NUMBER';R
04380 PRINT
04390 INPUT 'MOTHER'S NAME';S$      
04400 INPUT 'MOTHER'S NUMBER';T
04410 PRINT
04420 INPUT "SOURCE OF INFORMATION";D1S
04430 RETURN
04440 I
04450 I REVISION SUBROUTINE #3
04460 I CHANGE MARRIAGE INFORMATION
04470 I
04480 PRINT;PRINT
04490 INPUT "WHICH MARRIAGE (ENTER NUMBER)";I
04500 PRINT
04510 PRINT "DATE OF MARRIAGE #";I;
04520 INPUT CS(I)
04530 PRINT
04540 INPUT "SPOUSE'S NAME";GS(I)
04550 PRINT
04560 INPUT "PLACE OF MARRIAGE";KS(I)
04570 PRINT
04580 PRINT "SOURCE OF INFORMATION?"  
04590 INPUT D2S(I)
04600 PRINT
04610 PRINT "FOR HOW MANY OF THIS PERSON'S MARRIAGES DOES"  
04620 PRINT "THE FILE NOW CONTAIN INFORMATION?"
04630 INPUT F
04640 RETURN
04650 I
04660 I REVISION SUBROUTINE #4
04670 I CHANGE DEATH INFORMATION
04680 I
04690 PRINT;PRINT
04700 PRINT "DEATH DATE"
04710 PRINT "(IF YOU DON'T KNOW, ENTER 'UNKNOWN'. IF "  
04720 PRINT "HE OR SHE IS STILL ALIVE, ENTER 'ALIVE'.)"
04730 INPUT JS
04740 IF JS='ALIVE' THEN GO TO 4800
04750 PRINT
04760 INPUT "PLACE OF DEATH";L$  
04770 PRINT
04780 PRINT "SOURCE OF INFORMATION?"
04790 INPUT D3S
04800 RETURN
04810 I
04820 I RESTORATION OF FILE POINTER
04830 I
04840 RESTORE I
04850 RETURN
04860 I
04870 I PROCEDURE SUBROUTINE #4
04880 I END THE PROGRAM
04890 I
04900 PRINT
04910 END

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Circle 176 on Inquiry card

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We all know there are many reasons for increasing utility costs, from higher oil prices to billion dollar Environmental Protection Agency regulations, but that doesn’t make the paying any easier.

There has been much rhetoric about personal conservation and elimination of waste. In order to formulate an effective and efficient plan for conservation of electricity in your home or business, you need to know the cost of operation for individual appliances and other electrical devices.

The Power program (see listing 1) calculates from your electric bill your cost per kilowatt-hour of power used. The program then generates the cost per month and per hour to operate specific appliances, given their electrical specifications.

You will also need the listed voltage, which will usually appear as 120 V or 120 V AC. If voltage is given in a range of, say, 110 V to 130 V, it means that the appliance will operate at any voltage within the range. In the program, use the voltage which is running through the circuit that the appliance is plugged into.

A table of household appliances is provided for your convenience in gathering and recording needed inputs and monthly costs. A word of warning about the estimation of hours an appliance is operated in a month: I repeatedly underestimate this time, perhaps because it seems that months fly by and hours are inconsequential. But there are 720 hours in a 30-day month and in order to make this analysis useful one must realistically estimate hours of use.

Another problem can exist in obtaining an estimated wattage for some of the high power consumption devices such as electric furnaces, or air conditioning units. New models, today, will have many of their technical specifications listed in information sheets available to the public. Among these specifications will be an estimate of total system power requirement in kilowatts. For the sample run in listing 2, I used the total system kilowatts that were listed for a heat pump during its cooling cycle, given various other criteria such as outdoor temperature.

The listed power requirement was 6.3 kilowatts; however, the program requires that watts, not kilowatts, be entered. If the data on your equipment is in kilowatts, multiply by 1,000 to obtain watts.

Home electric furnaces are usually rated at 5 kW and up depending on how much heat is required. A very rough estimate for an average home with an electric furnace is 15 to 25 kW, or 15,000 to 25,000 W. If you cannot obtain your particular system’s wattage, you might try using this average, but it could be significantly different from your actual system’s draw.

Sample Run

The Power program, listing 1, is written in North Star BASIC. There are no instructions for providing hardcopy, but if you desire one you could place a statement for selecting your printer at, perhaps, line 415. You could then select the video monitor again at line 495.

The program presents two options. If you already know the cost per kilowatt-hour the utility company uses to calculate your bill, you can select option 2. This allows you to input the cost per kilowatt-hour by jumping to the main portion of the program.

If you do not know the kilowatt-hour rate, select option 1, as in the example. Actually, your cost per kilowatt-hour will probably vary from one month to the next because of the rating structure systems used by power companies, especially if time of day rates are being used. So, you just might
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CP-170

Circle 163 on inquiry card.
Listing 1: North Star BASIC program to calculate the cost of running electrical appliances. The program helps you determine the operating cost of an appliance based on the average wattage or the voltage and amperage ratings of the product.

```basic
10 DIM D$(1)
20 PRINT ' THIS PROGRAM CALCulates POWER USAGE AND COSTS'
30 PRINT ' PROGRAM OPTIONS:'
40 PRINT ' 1. CALCULATE COST PER KILOWATT HOUR'
50 PRINT ' 2. CALCULATE APPLIANCE POWER USAGE AND COST'
60 PRINT ' 10 INPUT '
70 PRINT ' 20 PRINT
80 PRINT ' 100 INPUT '
90 ON A GOTO 120, 200
100 INPUT ' ENTER ENDING KWH READING FROM ELECTRIC BILL ', E
110 PRINT
120 INPUT ' ENTER BEGINNING KWH READING FROM BILL ', B
130 PRINT
140 INPUT ' ENTER AMOUNT OF ELECTRIC BILL ', T
150 PRINT
160 LET C = T/(E-B)
170 GOTO 200
180 INPUT ' ENTER COST PER KWH ', C
190 PRINT ' OPTIONS'
200 PRINT ' 1. CALCULATE WATTS'
210 PRINT ' 2. INPUT WATTS'
220 PRINT '
230 PRINT ' 170 ON A GOTO 300, 350
240 INPUT ' ENTER APPLIANCE VOLTAGE ', V
250 PRINT ' 2. INPUT WATTS'
260 PRINT '
270 INPUT '
280 PRINT ' 260 PRINT '
290 ON A GOTO 300, 350
300 INPUT ' ENTER APPLIANCE AMP DRAW ', Z
310 PRINT
320 INPUT ' ENTER APPLIANCE WATTAGE ', W
330 PRINT ' 340 GOTO 360
340 LET W = Z * V
350 INPUT ' ENTER NUMBER OF HOURS USED IN TIME PERIOD ', H
360 PRINT
370 PRINT ' 360 LET K = (W*H)/1000
380 PRINT ' 390 LET D = K * C
390 PRINT
400 PRINT ' 410 PRINT ' 420 PRINT ' COST PER KILOWATT HOUR OF USAGE = ', C
430 PRINT ' 440 PRINT ' KILOWATT HOURS OF POWER USAGE = ', K
440 PRINT ' 450 PRINT ' 460 PRINT ' MONTHLY COST OF THAT POWER USAGE = ', D
470 PRINT
480 PRINT ' 470 PRINT ' COST PER EST. HOUR'S USE = ', D/H
490 PRINT
500 INPUT ' DO YOU WISH TO CALCULATE ANOTHER APPLIANCE (Y/N)? ', D$
510 IF D$ = 'Y' THEN 210
520 END
```

out of curiosity calculate your cost per kilowatt-hour each month as you get your bill and see if it is changing. Sometimes there are different rate block structures between summer and winter.

After entering option 1, you are prompted to input the ending kilowatt-hour reading from a recent electric bill (66,239, for example). Next, input the previous reading, which should also appear on the bill (62,213, for example).

The program prompts you to enter the amount of the bill. If your utility company sells both electricity and gas to you, be certain that only the electric portion of the bill is entered. There may also be a fuel adjustment cost figured into the total cost, and sales tax will probably appear on the bill. It's up to you if you want to include these figures in the total cost you enter into the program. If you do include them, you can apportion their cost to individual appliances. The cost per kilowatt-hour will probably not be affected significantly whether you do or
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Software Authors—see separate ad on page 120.
Table 1: This table can be used to collect data from your appliances for the Power program.

<table>
<thead>
<tr>
<th>Appliance</th>
<th>Watts oramps and volts</th>
<th>Hours usedper month</th>
<th>Monthly cost</th>
<th>Cost per hour of use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coffee maker</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Microwave oven</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oven</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dishwasher</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refrigerator</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freezer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clothes dryer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clothes washer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electric blanket</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stereo</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Television</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lawn mower</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electric saw</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Lighting</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sewing machine</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air conditioner</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dehumidifier</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electronic air filter</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fan</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electric furnace</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electric hot water heater</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waterbed heater</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Swimming pool filter</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Listing 2: A sample run using the Power program.

**THIS PROGRAM CALCULATES POWER USAGE AND COSTS**

**PROGRAM OPTIONS:**
1. **CALCULATE COST PER KILOWATT HOUR**
2. **CALCULATE APPLIANCE POWER USAGE AND COST**

SELECT 1 OR 2

ENTER ENDING KWH READING FROM ELECTRIC BILL 66239
ENTER BEGINNING KWH READING FROM BILL 62213
ENTER AMOUNT OF ELECTRIC BILL 170.71

OPTIONS
1. **CALCULATE WATTS**
2. **INPUT WATTS**

SELECT 1 OR 2

ENTER APPLIANCE VOLTAGE 120
ENTER APPLIANCE AMP DRAW 3
ENTER NUMBER OF HOURS USED IN TIME PERIOD 100

Listing 2 continued on page 54

do not include these additional costs. In the sample run, we will enter $170.71 for the total cost of electricity.

The program now presents two more options: to **calculate** watts from amps and volts, or to **input** watts. In the example we wish to calculate watts, so we enter 1. We are prompted to enter the appliance voltage, in this case 120. Then we enter the amps, in this case 3. The number of hours used a month is estimated at 100.

The calculations are quickly done and four results are presented. The inputs in this example were for a sewing machine and now I know what it's costing me to keep repairing my 5 year old's torn clothes. The first result shown is the cost per kilowatt-hour, which was calculated from the utility bill. Notice the E-02 at the end of the number. This floating point notation means that you move the decimal point two places to the left for a dollars and cents answer. Therefore, the utility company rate on my last bill averaged out to be $0.04 per kilowatt-hour of use.

The next result is the number of kilowatt-hours of power used for the sewing machine. This is the product of the kilowatt draw times the estimated hours of use. Your electric meter records the total number of kilowatt-hours of usage; this is what appears on your bill. In this case, 36 kWh of my total usage were due to the sewing machine.

The monthly cost of using the machine is shown next. In this example, it cost me $1.53 to operate my sewing machine for 100 hours during the month. That doesn't seem too bad. In fact, the next result presented shows me that one hour's usage of the machine costs me about 1½ cents. That's a bargain!

The program now asks if we wish to calculate costs for another appliance. To do so we enter Y.

The program already has calculated the cost per kilowatt-hour, so we loop back to the options for entering or calculating wattage. The next appliance I want to check is a portable color television for which I know the wattage. So, we enter option 2 for this prompt.

The wattage for the television is 240, so this figure is entered as prompted. The estimated hours of usage in a month are 200. The results show me that running that television for 200 hours cost me $2.04 and the cost for each hour's use was $0.01.

I want to enter a third appliance, a heat pump air conditioner. The watts are 6,300 and the estimated hours of use were 300. The results are significant, revealing a total cost of $80.14 and a cost per hour of $0.27. You can see the implications for conservation.
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Listing 2 continued:

COST PER KILOWATT HOUR OF USAGE = 4.240188E-02
KILOWATT HOURS OF POWER USAGE = 36
MONTHLY COST OF THAT POWER USAGE= 1.52646E1
COST PER EST. HOUR’S USE = 0.01526468
DO YOU WISH TO CALCULATE ANOTHER APPLIANCE (Y/N)? Y
OPTIONS
1. CALCULATE WATTS
2. INPUT WATTS
SELECT 1 OR 2

ENTER APPLIANCE WATTAGE 240

ENTER NUMBER OF HOURS USED IN TIME PERIOD 200

COST PER KILOWATT HOUR OF USAGE = 4.240188E-02
KILOWATT HOURS OF POWER USAGE = 48
MONTHLY COST OF THAT POWER USAGE= 2.0352906
COST PER EST. HOUR’S USE = 0.0176453E-02
DO YOU WISH TO CALCULATE ANOTHER APPLIANCE (Y/N)? Y
OPTIONS
1. CALCULATE WATTS
2. INPUT WATTS
SELECT 1 OR 2

ENTER APPLIANCE WATTAGE 6300

ENTER NUMBER OF HOURS USED IN TIME PERIOD 300

COST PER KILOWATT HOUR OF USAGE = 4.240188E-02
KILOWATT HOURS OF POWER USAGE = 1890
MONTHLY COST OF THAT POWER USAGE= 80.139568
COST PER EST. HOUR’S USE = 0.26713189
DO YOU WISH TO CALCULATE ANOTHER APPLIANCE (Y/N)? N

Pay As You Turn On

After you have calculated individual power costs for appliances, the next step is to use the information to conserve energy and lower your bill. The first thing that should strike you is how little most appliances really cost to operate per month. The second impact will be how expensive certain other items are to use.

Look at the appliance table and decide if you can decrease the hours used for these most costly items. Set a lower hour goal and then recalculate the monthly cost. When you think you have a workable goal that will help your budget, try to realize those desired hours of usage. Achieving the goals will demand your own personal determination and discipline. The Power program can show you problem areas and help establish targets and priorities, but that’s where your battle really begins.

Perhaps, on/off timers would be helpful in regulating certain devices. Another approach that has been attempted is a “pay as you turn on” method. With the cost per hour of use figure from the program, you can charge yourself accordingly for the privilege of turning on specific appliances, such as televisions, washing and drying machines, ovens, ranges, electric lawn mowers or stereos (even your personal computer, heaven help us!).

Putting pennies into a bank on top of the television may sound a bit primitive but perhaps it would make one check the television listings in the paper more carefully before switching on the set and turning the selector to see if there’s anything on worth watching.

I hope the Power program will aid in energy conservation. But its informational possibilities, alone, make it useful. At least you can know more clearly which devices are most power hungry and by how much. This is certainly better than receiving your electric bill and simply groaning in the dark.

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BYTE October 1979 55
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Self-Refreshing LED Graphics Display

Steve Ciarcia
POB 582
Glastonbury CT 06033

Light emitting diodes (LEDs) have been in use for a number of years. When first introduced they, like transistors, were very expensive, and were used only for special applications. Fortunately, manufacturing techniques have advanced to a point where a single red LED costs less than $0.10. A further achievement is the availability of yellow, orange, and green LEDs.

When we think of graphics displays, we usually think of television-type video displays. All of the more popular personal computing systems have video displays, with the majority of them supporting graphics. It is not inconceivable that we will eventually see economical, flat, high-resolution LED displays which have the same capabilities as the current cathode ray tube displays. A manufacturing breakthrough will be required before this is a reality.

There have been some military programs requiring the construction of such displays. A few years ago, while still a member of the military-industrial complex, I worked on a bid to build a 10 by 10 foot LED display comprised of 792,000 discrete LEDs. My calculations at the time predicted that it would take about 3 kW of power to run.

This article is not going to describe how to replace your television screen with a flat panel LED display, but will attempt something a bit more modest. The concept of LED graphics is not that far in the future. While we’re waiting for technology to catch up with interest, we can experiment with the concept on a limited scale and analyze the various logic alternatives. A side benefit is the construction of an 8 by 16 LED display as your newest peripheral device.

Light Emitting Diode Displays

We all know about LEDs, correct? They are the little red things that glow when a current is passed through them. Most of us even remember to use a resistor to limit the average current to around 20 mA. What many people don’t realize is that an LED can also be driven by much higher currents if pulsed on and off, rather than run continuously. This is a significant fact to keep in mind when building a large LED display.

Figure 1 shows standard methods for using transistor-transistor logic (TTL) to drive LEDs. The TTL gate can be used to either sink or source current to the LED without external transistors. In general, TTL devices will sink 16 thru 20 mA, while some go as high as 50 mA. (It’s best to check manufacturer specification sheets if you are unsure.) Open collector gates, shown in figures 1a and 1b, can be wired in either series or shunt configuration.

In figure 1a the circuit is completed and the LED is lit when a logic 1 is applied to the inverter input. The low-level output of the gate also provides a path to ground for the LED. Figure 1b, on the other hand, is a shunt circuit and exhibits an opposite logic. Normally current flow is through the LED, and it is lit. When a logic 1 is applied to the inverter, the resultant low output shunts the current to ground, shutting off the LED. There are advantages to both methods which I will discuss later.

Logic parts such as the 7400 NAND gate or 74LS04 inverter have active pull-up totem pole outputs. Rather than just a single NPN transistor like the open collector types, these have 2 transistors connected in series between the supply voltage VCC and ground. Depending upon the logic state, only 1 of the 2 transistors will be conducting. Generally speaking, series and shunt LED drivers are more easily built with open collector devices. Figure 1d, however, cannot be accomplished with open collector logic, because this circuit depends upon the internal active pull-up resistance to source current to the LED. The exact amount of available current depends upon the logic type.
LOGIC TYPES & LOW

<table>
<thead>
<tr>
<th>Logic Type</th>
<th>IOUT LOW</th>
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<tbody>
<tr>
<td>74S</td>
<td>20mA</td>
</tr>
<tr>
<td>74H</td>
<td>20mA</td>
</tr>
<tr>
<td>74L</td>
<td>16mA</td>
</tr>
<tr>
<td>74 LS</td>
<td>8 mA</td>
</tr>
<tr>
<td>74 LS</td>
<td>3.6mA</td>
</tr>
<tr>
<td>CMOS 4049</td>
<td>3 mA</td>
</tr>
<tr>
<td>CMOS 4009</td>
<td>8 mA</td>
</tr>
</tbody>
</table>

**OPEN COLLECTOR GATES**

\[ V_{CC} \]
\[ R \]
\[ V_{CC} \]

---

**ACTIVE PULLUP - TOTEM POLE GATES**

\[ V_{CC} \]
\[ R \]
\[ V_{CC} \]

---

**SERIES - LED POWER SUPPLIED THROUGH GATE**

\[ V_{CC} \]
\[ R \]
\[ V_{CC} \]

---

**SERIES SHUNT**

\[ V_{CC} \]
\[ R \]
\[ V_{CC} \]

---

Figure 1: There are several ways of driving LED displays. A method employing a series circuit with an open collector gate turns on the LED when a logic 1 is applied to the inverter input. The shunt version of the open collector circuit turns on the LED when a logic 0 is applied to the inverter input.

If active pull-up totem-pole gates are used (the kind found in nearly all TTL gates), the circuits may be wired only in series. In figure 1c the voltage needed to power the LED comes from the supply voltage \( V_{CC} \). In figure 1d the LED is wired in series, and the power to light the LED is supplied through the logic gate. Typical output currents are given for various types of logic in the accompanying table.

Returning to the discussion of displays using LEDs, it is quite simple to take the logic concepts of figure 1 and put them to use. Figure 2 outlines a simple 8-bit LED driver with latched output. It is suitable as a bar-graph display, 8-level indicator, or 8-item annunciator. We always think first of using the video display to display the results of a logic decision, but if the result is simply yes or no, the binary answer can be signified on an LED. In my own case, such an 8-bit display is used to keep track of enabled peripherals and I/O (input/output) channels.

**Larger LED Displays Have to Be Multiplexed**

Using 8 LEDs probably doesn’t excite too many people, especially when I started out with a number like 792,000. The 8 LEDs can, of course, be expanded to 64 by multiplying this same circuit 8-fold. With an average current of 15 mA for each LED and 100 mA for each 74100 dual 4-bit latch, the grand total to run it is slightly under 2 A at 5 V. This fact, and the necessity of having 64 resistors as well, leads us to consider some other means of driving the LEDs.

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<tr>
<td>Word-Star T.M.</td>
<td>$495/40</td>
<td>Super-Sort T.M.</td>
<td>$250/25</td>
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<tr>
<td>Word-Master T.M.</td>
<td>$150/25</td>
<td>Super-Sort II T.M.</td>
<td>$200/25</td>
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<tr>
<td>Tex-Writer T.M.</td>
<td>$75/15</td>
<td>Super-Sort III T.M.</td>
<td>$150/25</td>
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</table>

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For pulsed applications, a curve of maximum peak current, pulse width, and repetition rate can be used to determine the maximum recommended operating conditions. Figure 3 illustrates a typical curve for a T-1 ¾ LED such as that used in this article. It is determined by comparing peak and average junction temperatures during strobed operations, and maintaining a limit equivalent to the maximum allowable DC conditions. At any specified repetition rate, the relationship between maximum current and pulse width is shown. If, for example, 5 LEDs were to be multiplexed, and brightness maintained equivalent to a 10 mA continuous current, each would have to be pulsed for 1 ms 100 times a second, with a peak current of 100 mA.

Figure 4 shows a simple 4 by 4 LED matrix which demonstrates this concept. It also serves to point out some of the limitations of this bare-bones approach. A latched 8-bit parallel output port is all that is necessary to run this display. Four bits define the column and 4 bits define the row. Multiplexing is done in software.

To turn on the LED at location A22, bits B2 and B6 would be set to a logic 1, while lighting A43 would require a combination of bits B1 and B4. The logical process is essentially an extension of the shunt circuit described in figure 1.

A microprocessor can be used to control an X,Y addressable array of LEDs. The external circuitry required is minimal, and relatively little processor time is used to refresh the array. The technique used is to periodically strobe a row and column address into an output latch. At a predetermined later time, new information concerning the next display point is sent out to the latch. If this addressing can proceed faster than 100 times per second, then the entire display will appear to be DC driven. Usually, refresh timing is handled through interrupts.

There are important considerations to keep in mind when building this type of circuit. 7406 and 7407 inverting and noninverting drivers are not high current drivers, but they can sink 40 mA. They were chosen because they are cheap and available. If brightness is a problem and peak current has to be increased, these drivers can be replaced with transistors which have a higher current rating, or more gates of the same type can be added in parallel. The fact

Figure 3: A typical curve for a T-1 ¾ LED showing the relationship between maximum current and pulse width for specified pulse rates.

Figure 4: A simple 4 by 4 LED matrix which is software driven.
Graphics for small systems were too expensive...

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that they are open collector devices readily allows this.

The second concern is lamp brightness. LEDs operated at low currents can have widely varying brightness. It is a good idea to pretest and select LEDs which appear to have the same intensity at a specific current.

Build a Self-Refreshing LED Display

So far I’ve discussed arrays which, because of their size, have limited appeal and application. A 4 by 4 display is still in the realm of indicator, rather than information display panel. To be really effective it should at least be able to display an alphanumeric character. Such a requirement dictates a minimum matrix size of 5 by 7. This adequately displays all upper-case letters and numbers. But if you are going to have 5 by 7, why not 10 by 7 for 2 letters and so on?

At some point we have to be rational. If it were that easy to make 200 by 200 LED arrays, someone would be making them now. In my case I needed a multipurpose flat panel display that could flash a message (even if only 1 letter at a time) and serve as a sophisticated annunciator for my alarm system. The latter was the true reason for the use of LEDs.

A transparent sheet with an outline of my security system is placed over the LED array. Significant information is indicated by flashing the LED at the point within the array that corresponds to appropriate sensor activation. It is quite interesting to watch the approach of a car down the driveway as a series of LED indicators track it.

A 4 by 4 display was too low in resolution, and while a 5 by 7 display allowed ASCII alphanumeric displays, it was also a bit limited. Considering the hardware techniques employed and relative indifference to refresh considerations, I settled on an 8 by 16 display.

Photos 1 and 2 show the completed display prototype. The prototype consists of 128 red LEDs arranged in 16 columns of 8. Photo 1 illustrates them all lit. A red plastic filter is used to enhance the display. Photo 2 shows it without the filter.

The schematic diagram for this interface is outlined in figure 5. As with the majority of my designs, I’ve made this to be processor, and program execution-speed independent. It works equally well with assembly language or BASIC systems, provided that a program can directly address output ports. The interface is a stand-alone peripheral. Once loaded with display data, refresh operation is locally controlled, and the computer can even be shut off without disturbing the display.

Self-Refreshing—How Does It Work?

There are 3 major hardware sub-systems in the 10-chip circuit: input decoding, data storage, and refresh scanning. To the computer, this interface appears as 16 output port addresses numbered 112 thru 127 decimal (remember BASIC uses decimal

<table>
<thead>
<tr>
<th>Table 1: Power-wiring table for figure 5.</th>
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<tbody>
<tr>
<td>IC1</td>
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<td>IC10</td>
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<tr>
<td>IC11</td>
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Photo 1: The prototype board for the light emitting diode (LED) display showing all of the LEDs turned on. A piece of red plastic is held in front of the display to increase visibility.

Photo 2: The prototype board displaying GO—without a red filter in front of the LEDs.
Apple lets you get personal with Pascal.

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If you'd like to let the world know who speaks Pascal, here's how:

Preheat iron (dry-wool setting) for 3 minutes. Slip garment on ironing board over scrap material. Remove wrinkles. Position transfer face down and pin edges to ironing board cover. Iron transfer slowly for one minute. If paper browns, iron is too hot. Let transfer cool for one minute, then unpin and slowly pull transfer straight up. Results are best when t-shirt is at least 50% polyester.
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Our high-level, full feature Language System consists of a plug-in 16K RAM language card, five diskettes containing Pascal as well as Integer BASIC and Applesoft extended BASIC, plus seven manuals documenting the three languages.

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Apple's Pascal language takes full advantage of Apple high resolution and color graphics, analog input and sound generation capabilities. It turns the Apple into the lowest priced, highest powered Pascal system on the market. With Pascal, programs can be written, debugged and executed in just one-third the time required for equivalent BASIC programs. With just one-third the memory.

On top of that, Pascal is easy to understand, elegant and able to handle advanced applications. It allows one programmer to pick up where another left off with minimal chance of foul up.

And, because Apple uses the UCSD Pascal standard, you're guaranteed to get the most comprehensive version available — and one that can be used on any computer that runs Pascal, no matter what the size. Which is really something an enthusiast can get enthused about.

To be more specific.

The Apple II's specs are tempting enough without the Language System and Pascal. With them, they're downright irresistible.

The text, normally displayed as 24 lines of 40 characters each, expands to 80 characters thanks to the use of horizontal scrolling.

Characters are normal, inverse or flashing, 5 x 7, upper case. Full cursor control is standard.

Since Pascal runs on an Apple computer with 48K bytes of on-board RAM, the additional 16K bytes on the language card bring the total to a full 64K bytes.

And, Pascal runs on the new Apple II Plus. It features an Auto-Start ROM that boots the Disk II at power-on for turn-key operation. Applesoft extended BASIC is resident in ROM.

Standard color graphics offer 40h x 48v resolution, or 40h x 40v with 4 lines text, in fifteen colors.

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Figure 5: Schematic diagram for the self-refreshing 8 by 16 LED array display. The display is fully static and appears as 16 output ports to the computer. Note that the schematic diagram shows the use of 10 integrated circuits, while the prototype board only has 9 integrated circuits on it. The I/O decoding logic on the prototype system was not constructed on the board, but on the other end of the ribbon cable shown in the photographs.
### Figure 6: The 128 light emitting diodes (LEDs) are laid out in groups of 8. Each group of 8 is assigned to a consecutive output port. The port numbers are given here in decimal notation. Each column represents the 8 bits of that port.

The most significant bit (MSB) is at the top and the least significant bit (LSB) is at the bottom. The leftmost column is decoded as port number 112 and the rightmost is port number 127. This is depicted in detail in figure 6. These selections are arbitrary and can be any 16 successive port addresses you have available. These ports can also be memory mapped to use PEEK and POKE instructions rather than input/output instructions, if you wish. (For further information on memory mapped I/O I refer you to the book Ciarcia's Circuit Cellar from BYTE Books.) ICs 1 and 2 decode these 16 addresses.

Integrated circuits IC3, IC4, IC5 and IC8 perform the data storage function. IC4 and IC5 are each 4-bit by 16-word programmable memory devices which together form an 8-bit by 16-word storage. When data is ready for display, the computer performs an output procedure to the selected port. The entry-enable line goes low, selecting address bus lines A0 thru A3 to be applied as the address inputs to the 2 memory devices.

If port decimal 115 were selected in BASIC, the binary address would be 0011. Sections c and d of IC2 are included to forestall a potential race condition and serve to delay the firing of the one-shot monostable multivibrator IC3 until the propagation delay of ICs 4, 5, and 8 is satisfied. Once this port address is set through the 74157, the one-shot fires and writes the data present on the data bus into the memory. This is essentially the same sequence as any latched output port with the exception that 16 data bytes can be stored.

The schematic diagram as shown uses transistor-transistor logic (TTL) devices. If you have an S-100 system, or otherwise have limited bus driving capabilities, you may want to substitute low power TTL devices where necessary, or buffer all incoming lines.

The final area of significance is the LED refresh scanner. Figure 7 provides an expanded illustration. Rather than successively addressing 128 LEDs, resulting in a very low-

---

<table>
<thead>
<tr>
<th>Port Number (Decimal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127</td>
</tr>
</tbody>
</table>

---

**Figure 7:** Expanded illustration of column scanning techniques used in self-refreshing LED graphics unit shown in figure 5. Each LED is not addressed sequentially; the LEDs are addressed by column. This results in a higher refresh rate and lower peak current to maintain a uniform brightness. For any particular LED to be turned on, the equivalent of 2 switches has to be closed (SW1 and SW2 in 7b). For this to happen in the circuit of figure 7a, the column must be addressed by the 74154, and then the coinciding byte of memory (7489) provides the other switch. The LED is lit when the correct row is addressed and the corresponding bit is set to 1.
duty cycle, this design incorporates column scanning. Each light emitting diode (LED) is refreshed once every 16 clock pulses, rather than once every 128. The result is that lower peak current is required to maintain sufficient illumination.

When no data is being written into the memory (ICs 4 and 5), the address multiplexer is in the display mode. In this case it continually channels the output of a 4-bit free-running counter (IC9) to the memory address input. IC10 also receives this address and enables the particular column to which the data pertains.

In a normal sequence, the first address is 0000 binary. Since the memory is in a read condition, the output will reflect the data contents which had been stored previously as an output to port 112. IC10, a 4 to 16 demultiplexer, enables the first line by bringing it to a logic 0. The shunt drivers now enabled will allow any LED in that column to turn on in response to a stored logic 1 on that bit position. The only LEDs that can light at this time are in the first column.

The circuit will stay on this address until the next clock pulse from IC's 2a and 2b. The next address would enable the next column with similar results. The scan oscillator should be fast enough that the display does not flicker.

Various LEDs can be used. Probably the most popular size is the T-1 ⅝ (such as the Texas Instruments TIL-220) made by most LED manufacturers and priced at about $0.11. If space is a problem, a smaller T-1 can be used with cost at about $0.09. Their relative sizes are shown in photo 3.

There is nothing which requires that the display be monochromatic. Considering that color television screens are actually discrete dots which seem to blend together when viewed from a distance, this same possibility is open for use with LEDs to a limited extent. The 3 LEDs can be mounted quite closely as demonstrated in photo 4. Experimenting with the tricolor system produced some interesting results. You must realize, of course, that a 3-color display would require 3 sets of digital logic equivalent to the circuit of figure 5.

Using a Flat Panel Display

The first thing to do after powering up and checking out the circuitry is to try to write data to it. Listing 1 is a BASIC program which sequentially exercises all 128 LEDs. Erroneous data entry can usually be traced to a too long pulse width on the one-shot (IC3).

Once the arrays have been built, you are ready for the big time—displaying a 5 by 7 dot-matrix character. Photo 5 illustrates this final achievement, and listing 2 shows the simple BASIC program required to accomplish this.
Listing 1: BASIC program to turn each light emitting diode (LED) on and off in order.

100 REM THIS PROGRAM CHECKS EVERY LED INDIVIDUALLY
110 REM BY OUTPUTING A SERIES OF COMPUTED VALUES TO THE
120 REM APPROPRIATE OUTPUT PORT
130 REM
140 REM 8X16 DISPLAY IS ADDRESSED AS 16 PORTS - NO.S 112 TO 127 DECIMAL
150 REM WITH LSD ON THE LEFT AND MSD ON THE RIGHT
160 REM
170 REM FIRST THE DISPLAY IS BLANKED BY OUTPUTING ALL ZEROS
180 FOR S=112 TO 127
190 OUT S,0
200 NEXT S
210 REM
220 REM STARTING FROM THE LOWER LEFT CORNER LEDS ARE PROGRESSIVELY LIT
230 REM UP AND DOWN THE COLUMNS MOVING TOWARD THE RIGHT
240 FOR I=112 TO 127
250 FOR B=0 TO 7
260 A=2^B
270 OUT I,A
280 GOSUB 1000
290 NEXT B
300 OUT I,0
310 NEXT I
320 GOTO 240
330 FOR T=0 TO 50
340 NEXT T
350 FOR S=1 TO 16
360 READ X(S)
370 NEXT S
380 FOR C=112 TO 127
390 OUT C,X(C-111)
400 NEXT C
410 STOP :GOTO 190

Listing 2: BASIC program to write GO-> on the LED display.

100 REM THIS PROGRAM WRITES GO -> ON THE DISPLAY
110 REM USING DATA STATEMENTS TO ENTER MATRIX DATA
120 DIM X(100):DIM S(100)
130 DATA 124,130,130,138,142,0
140 DATA 124,130,130,130,124,0
150 DATA 16,84,56,16
160 FOR S=1 TO 16
170 READ X(S)
180 NEXT S
190 FOR C=112 TO 127
200 OUT C,X(C-111)
210 NEXT C
220 STOP :GOTO 190

Static displays are interesting, but if you really want to do a little crowd-pleasing, then I suggest simulating a moving marquee. Because this display interface is column-oriented, it is relatively simple to accomplish this feat. Listing 3 is a program for shifting the letter A across the display.

The character is left-justified when first displayed with the 5 by 7 data written in ports 112 thru 116. On the next programmed update, the same data is written to ports 113 thru 117.

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Circle 48 on inquiry card.
Listing 3: BASIC program to move the letter A across the display from left to right.

100 REM THIS PROGRAM DEMONSTRATES USING THE DISPLAY PANEL AS A MOVING MARQUEE
110 REM A 5X7 DOT MATRIX LETTER A IS DISPLAYED ON THE LEFT SIDE
120 REM AND THE SHIFTED ACROSS THE DISPLAY TO THE RIGHT. USING THIS CONCEPT
130 REM VIRTUALLY ANY MESSAGE CAN BE WRITTEN.
140 DIM A(100) :DIM S(20) :DIM X(100)
150 REM FIRST THE LETTER A IS LEFT JUSTIFIED ON THE DISPLAY
160 A(1)=254 :A(2)=144 :A(3)=144 :A(4)=144 :A(5)=254 :REM A(1)-A(5) EQUAL THE LETTER A
170 FOR O=6 TO 20 :A(O)=0 :NEXT O
180 REM
190 REM
200 REM CLEAR THE DISPLAY
210 FOR L=112 TO 127 :OUT L,0 :NEXT L
220 REM
230 REM
240 REM DEFINE TRANSPOSED MATRIX X(1) TO X(16) AND SHIFT RIGHT ONE COLUMN
250 S=1
260 FOR D=1 TO 16
270 X(D)=A(S)
280 S=S+1
290 IF S>20 THEN S=1
300 NEXT D
310 S=S+3
320 GOSUB 370
330 GOTO 260
340 REM
350 REM
360 REM WRITE TRANSPOSED MATRIX TO DISPLAY
370 FOR L=112 TO 127
380 OUT L,X(L-111)
390 NEXT L
400 FOR T=0 TO 300 :NEXT T :RETURN
410 RETURN

effectively shifting it to the right by 1 column. For long messages, the most effective method is to utilize a software pointer. Even a 2½ character moving marquee is very impressive and can easily convey intelligent information.

This 8 by 16 matrix can be expanded by adding more memory and column decoders. It can be further enhanced by the addition of other colors within the same array.

The video screen need not be the only output display on a personal computer. It is only a matter of time before large arrays are commercially available, but in the meantime we can experiment with the concept. I hope that by presenting a self-refreshing interface design which eliminates the necessity of interrupts or dedicated program refresh, I may spark the interest of many experimenters.

If you have any questions on this or any previous article, don't hesitate to write to me. Please include a self-addressed stamped envelope.

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I was pleased to see a good introductory article on the use of finite state machines appear in BYTE (see "Designing a Command Language" by G A Van den Bout, BYTE, June 1979, page 176). I have found the finite state machine described and analyzed in any textbook on compiler design! Unfortunately the finite state machine is an aid to organizing one's thoughts while designing, a good way of producing a really unambiguous specification document, and as an implemented program it can yield very efficient and reliable code.

The finite state machine has long been a plaything of the theoreticians of computer science; you can find it described and analyzed in any textbook on compiler design (it is a good textbook if you can understand the description!). We hit on the idea of using finite state machines frequently moves out of the textbook and into practical programs. I would like to extend Van den Bout's article with examples from my own experience as a professional programmer that show how the finite state machine solved difficult programming problems in the real world.

The first case arose during the design of a timesharing system that was to have a large number of commands. The syntax of the command language was laid down early in the project, but the specification of the commands themselves kept changing. If I and my colleagues had tried to write detailed code to parse each of the many commands and operands, especially in the face of changing specifications, we would have been swamped. We had to do something to systematize the command-parsing code.

We hit on the idea of using finite state machines represented as directed graphs (like the figures in the previous BYTE article). Since we were using a macroassembler, we created NODE and ARC macroinstructions so that we could "draw" the graph of a command by writing a series of macro calls. Listing 1 shows how some of the chess game commands in the prior article might look in such a macrolanguage.

Each macroinstruction assembled to a small group of constants. We thought of these groups as the machine language of an imaginary finite state computer. We then wrote a finite state interpreter which could process these machine instructions. This interpreter program took as its input: (1) the top node of a graph; (2) the tokenized command line from the user; and (3) a small working storage area where semantic routines could leave their results.
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output. It returned either a verb number (from an ANODE macroinstruction) or an error message (from a ZNODE macroinstruction). The only other code needed was a set of small, easily coded semantic routines, one to convert and store away each kind of token.

With this mechanism in place we had only to "draw" each command's graph in macroinstructions, and add any semantic routines unique to that command. The job was much smaller than writing code for all commands, and far easier to update as the specifications fluctuated. The same interpreter was used again in a later project with a similar command language.

This method of writing a command language turned out to have an advantage we had not expected. Every time we wrote a ZNODE macroinstruction, we were faced with the fact that someday a user would enter a bad command that would drop through to that ZNODE. Each time we were forced to decide what the system should do when that occurred. Every possible user error was made evident to us and we had to think about error responses in more detail than usual, but the very specific circumstances under which each error was trapped made it easy to give explicit, helpful messages.

The second example comes from the construction of an interpreter for a programming language. An interpreter has to do a lot of converting between the character form of numbers and their internal form (binary, in this case). The language being implemented supported every form of numeric constant, including things like

1. (for a real 1.0)
   3E25 (decimal not required)
   +00319645.26E-0005 (leading zeroes, signs)

When I was presented with this problem I had just completed a course in compiler writing, where I had seen finite state machines applied to exactly this problem. It took but a day to work out an array like that in table 1. This is a finite state machine, but one represented as an array instead of a graph. The 2 representations are equivalent; a finite state machine drawn as a graph can be drawn as an array or vice versa. The nodes of the graph become the rows of the array; the lines become columns.

The array is processed like this: the finite state machine is always active on some row, initially row 1. Get the next input token. Find the column with that token at its head (of course a clever designer will have arranged that a token is just an integer that is a valid column-index). At the intersection of that column and the active row, find 2 items, such as 2/A1. The first item, like 2, becomes the new active row. The second item, like A1, is the label of a semantic action to be performed. Repeat until the active row number is 0, then stop.

Look at row 1 of table 1. Reading across, if the first token of a numeric constant is:

+ do nothing and go to row 2
- remember to negate the result and go to row 2
0 do nothing and go to row 3
1...9 collect a digit and go to row 4
. note the number will be rational ("real") and go to row 5
E error — number starts with E, stop
<end> error, stop

If you read the other rows the same way, you will see how this finite state machine can parse any legitimate numeric constant. It also finds every possible syntax error in a very explicit way.

So far I had not gone beyond what any textbook could tell me, but I had the additional objective of making the fastest assembler language constant converter that I could. I wanted to use every hardware advantage allowed by my machine, yet keep reliable, readable code — and the finite state machine helped me!

I eventually ended up with an array several rows higher than the one in table 1. Each additional row was designed to pick up a particular set of input characteristics that I could take advantage of. One optimization was row 3 of table 1, which does not appear in most textbooks. The finite state machine stays on row 3 as long as it is seeing leading zeroes on the integer part of the number. Action A2, "collect integer digit," will typically involve performing arithmetic operations on the token. A leading zero contributes nothing to the final binary value, so why "collect" it? The finite state machine stays on row 3, spinning through the leading zeroes and doing almost no work, until a significant digit is found. If the finite state machine takes exit action Z1, it has recognized a constant of zero (fairly common in programs) without doing any arithmetic.

We expected single-digit constants to be quite common in typical programs. It happened that the binary value of a single digit could be obtained from the input token with a logical AND operation. I put in another row between rows 3 and 4 of table 1, so that a special exit action would be taken for the case of <digit> <end>. Now the finite state machine would process any single-digit constant without doing arithmetic. These and other hardware-level optimizations were achieved during design; they added almost nothing to the complexity of the final code.

The array form of a finite state machine is easily coded using a pair of integer matrices, one for the next-state numbers and one for the action-numbers (action-labels, if your language allows label variables; action-addresses in assembler language). The resulting program almost has to be smaller and more readable than the brute force code needed to do the same job. Since the act of designing the array forces you to consider every possible input sequence, the program will usually be much more reliable.

I have drawn these examples from professional software projects, but those are certainly not the only places where finite state machines can be used. I hope I have shown that the finite state machine can be a valuable tool for anyone faced with programming for a complicated input string. Designing it clarifies the problem and reveals all error situations, and coding it yields elegant, efficient programs.
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BYTE October 1979 75
Picking Up the Pieces

Alfred S Baker
2327 S Westminster
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Everything had been going so smoothly. I had just saved several important programs on a disk and had planned to spend the rest of the afternoon doing fun things with them. Now the computer was telling me that my full disk was completely empty.

I had been using my floppy disk system for over 6 months before the output error mentioned above occurred. I discovered, to my sorrow, that while input and output errors on a floppy disk are very rare, they can still happen. I survived my catastrophe. I hope that my experience can help you survive yours.

Disk Files

Generally, 2 different methods are used to place files on a floppy disk: sequential file storage, and track or sector allocation.

In the sequential file storage method, a new file is placed on the disk in the unused sectors following the last file added to the disk. This is demonstrated in figure 1. Any files that are deleted, such as file B, will generate unused space on the disk that is not used for storing new files. New files go at the end of all previously used space. But what about all of the unused space taken up by the deleted files? Simple. These systems provide a utility program which eliminates this unused space by shifting the files on the disk. This process, which is called compressing or packing the disk, is shown in figure 2.

If this is the way your system works, then the data block that got wiped out on my system exists on your system. However, as you will see, its contents and use are totally different.

The track, or sector allocation method is also known as the bit map method or chained, sequential-storage method. It is used by the more impressive, and efficient, large-system support packages. It is also used by my Peripheral Vision floppy disk operating system (FDOS).

Figure 1: In the sequential storage method, files are placed on the disk starting at the first empty sector after the last stored file.

About the Author

Al Baker is 30 years old and lives with his wife, Janet, and 2 children in Wheaton IL. He is currently the programming director for The Image Producers Inc, Northbrook IL. He is a member of the American Association for the Advancement of Science, the National Space Institute, and the Chicago Area Computer Hobbyist Exchange. He says, "My favorite sports are volleyball and handball, and my hobbies are playing with computers, photography, and playing with computers."
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In this method all of the space on the disk is represented by a single bit map. Each bit in the area called the bit map represents 1 physical area on the disk. In my system this area is a sector. (Refer to figure 3.) On each floppy disk there are 74 tracks represented in the bit map for that disk. (There are actually 77 tracks on the floppy disk, but the first 2 tracks contain the operating system, and the third functions as the directory, containing the bit map itself and the names and addresses of all the files on the disk. Since each track has 16 sectors when using FDOS, the bit map contains 74 times 16, or 1184 bits. This represents 1 bit for each sector on the disk. Dividing by 8 gives a bit map size of 148 bytes. This fits easily into a single 256-byte sector on the disk.

Now we can use the bit map to determine which sectors on the disk are in use. A file program will read the bit map into memory and will find a 0 bit in the map. The sector represented by this bit is unused. If a new file is being created and it needs another sector, FDOS turns the bit on (makes it a logic 1) and writes the bit map back onto the disk. When a file is deleted, the bits representing each sector in the file are turned off. The space is immediately available for use by another file. Now we have a way of using space on the disk which eliminates the problem of wasted space caused by the old way of doing things.

Unfortunately this method creates its own set of problems. The first problem is not very obvious. If a file is longer than 1 sector, it won’t fit. The wrong solution is to try to find an area with enough empty sectors located adjacently. We might as well consider all of those areas with just a few free sectors as useless space. Also, we never know how big a file is going to be until it is too late to look for a bigger space.

The correct solution is to let each sector in the file point to the location of the next sector in the file. Look at figure 4. Here we have a 1000-byte file of data contained on four 256-byte sectors. When a program tries to read the 257th byte from the

![Figure 2: In a system which uses the sequential storage method, unusable space is turned into usable space by compressing the data. Starting with the data stored on the disk (2a), the usable data is shifted toward the beginning of the storage space until the files are behind each other (2b). This process is continued until all of the unusable space has been pushed to the end of the disk and is usable.](image-url)
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In the Peripheral Vision FDOS system, each sector is represented by 1 bit in the map (3a). If the bit is on (logical 1), then that sector is being used; if the bit is off, that sector is free space (3b).

When a file is too long for one sector, it must be broken into several sections. Often, there are not enough contiguous sectors to contain a file. One method of solving this problem is to have bytes in the sector point to the location of the next sector. The FDOS system also has a backward pointer so 2 bytes are used.

One becomes accustomed to the way that machines sound in operation. I had just saved a file on disk, and it didn’t sound right. Since the disk was nearly full, most of the empty sectors were far from the bit map. I had become accustomed to hearing the disk drive data transfer head make a particular sound as it moved from the bit map to the next empty sector and back to the bit map as new files were written out. The sound was missing!

I knew that something was wrong. I quickly checked the number of free sectors on the disk. The correct number should have been around 300. The answer that I got from my inquiry was 1100. Except for the file I had just written, the bit map said that I had an empty disk!

It was time for careful thought. I listed the directory: it still thought I had over 50 files on the disk. But I knew that some of those files had been destroyed, completely or partially, by the file I had just written on the disk.

I was left with 2 problems. First, I had to correct the bit map. The best way to do this was to read every sector for every file listed in the directory. As each sector was read, I could turn on its bit in the bit map. This would correct the first problem.

The second problem was more serious. I had to determine which files were destroyed. The file I had just written had almost certainly used sectors which had been part of good files. Fortunately, FDOS keeps 2-way pointers. The solution was simple. While solving the first problem, I had to read every file on the directory and check to see if each sector in a file pointed back to the previous sector. If it did not, then this sector no longer file, FDOS automatically follows the pointer (contained in the first sector of the file) to the second sector, retrieves the first byte of that sector, and returns it to the user program. FDOS also keeps backward pointers, so you can read the file backwards, too!

The second problem is that the bit map is the most important block of data on the disk. If something happens to it, every other file space on the disk is up for grabs.
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Listing 1: Program ANALIZ is used to rebuild a bit map of the used sectors on a disk. This program is written using the TDL Z80 Relocating Assembler version 1.2. The workings of the program are explained in the comments.

```
Listing 1 continued on page 84
```

Conclusion
If you have Peripheral Vision FDOS, you can use the program as it is. If you have another bit-mapped disk system, then it should be a fairly straightforward matter to tailor it to your needs. If you have the sequential file storage method, then you have your own set of problems.

One final comment. Six files were destroyed on my disk. All of these files existed on the backup copy of the disk 1 had taken 2 weeks earlier. It is a very good idea to make periodic backup copies of your active disks. My only loss was a little time. I gained a better understanding of the way my disk system works, and a very interesting program.

```
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I decided to use it to read the blocks on each file. For this reason, each time a valid file name is found, the directory buffer (which contains a directory block) is saved in the area "DIRBLK." After "EXIT" is called to process the current file, this buffer is moved back into the FDOS buffer "RFPLNF" before getting the next directory block.

DEF: A grand loop which reads directory blocks. First, the directory is opened with a call to FDOS at "DIRP." Then each directory entry is processed in the loop. When "DIRBLK" is called to get the next directory entry, it sets the condition code to zero if there are no more processed ends on this condition. We are through "DIRBLK" and places the first byte of the name of the file in the accumulator. If it is 255 decimal (all ones binary), this is an unused entry and is not to be processed if it is to be processed. "NAME" is called to save the name of the current file. "NAME" is called to print out this name on the console so the user will know which file is being processed. The current directory disk block is saved, "EXIT" is called to process the file, and the directory block is moved back.

DEF: SET: 0083' CD 05 DF CALL DIRPON 0086' CD 05 DF CALL DIRBLK 0089 ' RZ 008E' FEFF CPI 255 008F ' 2088 JZ 1 ... 11 0090' CD 01 DF CALL NAME 0093 ' CD 02 DF CALL NAME BUFFER 0096 ' CD 03 DF CALL TXTYP 0099 ' CD 0A DF CALL XDR 009C ' CD 01 DF CALL BUFFER 009F ' CD 01 DF CALL LITBNS 00A2' CD 0B DF CALL ED00 00A5' CD 0A DF CALL XDRW 00A8' CD 02 DF CALL FIXIT 00AA' CD 02 DF CALL FIXIT 00AB' CD 02 DF CALL FIXIT 00AC' CD 02 DF CALL FIXIT 00AD' CD 02 DF CALL FIXIT 00AE' CD 02 DF CALL FIXIT 00AF' CD 02 DF CALL FIXIT 00BF' CD 02 DF CALL FIXIT 00C0' CD 02 DF CALL FIXIT 00C1' CD 02 DF CALL FIXIT 00C2' CD 02 DF CALL FIXIT 00C3' CD 02 DF CALL FIXIT 00C4' CD 02 DF CALL FIXIT 00C5' CD 02 DF CALL FIXIT 00C6' CD 02 DF CALL FIXIT 00C7' CD 02 DF CALL FIXIT 00C8' CD 02 DF CALL FIXIT 00C9' CD 02 DF CALL FIXIT 00CA' CD 02 DF CALL FIXIT 00CB' CD 02 DF CALL FIXIT 00CC' CD 02 DF CALL FIXIT 00CD' CD 02 DF CALL FIXIT 00CE' CD 02 DF CALL FIXIT 00CF' CD 02 DF CALL FIXIT 00D0' CD 02 DF CALL FIXIT 00D1' CD 02 DF CALL FIXIT 00D2' CD 02 DF CALL FIXIT 00D3' CD 02 DF CALL FIXIT 00D4' CD 02 DF CALL FIXIT 00D5' CD 02 DF CALL FIXIT 00D6' CD 02 DF CALL FIXIT 00D7' CD 02 DF CALL FIXIT 00D8' CD 02 DF CALL FIXIT 00D9' CD 02 DF CALL FIXIT 00DA' CD 02 DF CALL FIXIT 00DB' CD 02 DF CALL FIXIT 00DC' CD 02 DF CALL FIXIT 00DD' CD 02 DF CALL FIXIT 00DE' CD 02 DF CALL FIXIT 00DF' CD 02 DF CALL FIXIT 00E0' CD 02 DF CALL FIXIT 00E1' CD 02 DF CALL FIXIT 00E2' CD 02 DF CALL FIXIT 00E3' CD 02 DF CALL FIXIT 00E4' CD 02 DF CALL FIXIT 00E5' CD 02 DF CALL FIXIT 00E6' CD 02 DF CALL FIXIT 00E7' CD 02 DF CALL FIXIT 00E8' CD 02 DF CALL FIXIT 00E9' CD 02 DF CALL FIXIT 00EA' CD 02 DF CALL FIXIT 00EB' CD 02 DF CALL FIXIT 00EC' CD 02 DF CALL FIXIT 00ED' CD 02 DF CALL FIXIT 00EE' CD 02 DF CALL FIXIT 00EF' CD 02 DF CALL FIXIT 00F0' CD 02 DF CALL FIXIT 00F1' CD 02 DF CALL FIXIT 00F2' CD 02 DF CALL FIXIT

Listing 1 continued...
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Listing 1 continued:

0175 CALL NAME
0176 LL DISK BUFFER
0177 CALL TXTYP
0178 RET
0179 ML
0180 84841532h ASCII ' / ' IS AN INVALID
0181 D ADDRESS.
0182 8D BYTE 13+128

; THIS ROUTINE COPIES THE CURRENT FILE
; NAME OUT OF THE DIRECT ENTRY WHICH
; IS POINTED TO BY 'DE'. INTO THE HOLDING
; ARRAY 'NAME'.
0184 NAME:
0185 1:1 D5
0186 E5 PUSH H
0187 D5 PUSH D
0188 C5 PUSH B
0189 65 XCHG
018a 1c ll1:00
018b 01 0009 LXI B,9
018c 018b ED80 LDIR
018d 00 A1 CALL TXWP
018e 0000 PC
018f 000H ML
0190 019E BUFFER . BLKB 300H

; THESE ARE THE IMPORTANT ROUTINES DEFINED
; WITHIN FDOS. THEY ARE NOT DEFINED FOR
; THE USER TO USE. HOWEVER, I AM USING
; THEM ANYWAY.

0194 FDOSYSMK
0195 D585 BITYN = 0055H
0196 ; C INPUT A CHARACTER FROM THE DISK
0197 ; I HL-DISK BUFFER
0198 ; O CY=EOF=H+BYTE
0199 ; K INPUT DISK BYTE 10
019a D586 BYT0 = 0056H
019b ; C OUTPUT A CHARACTER TO THE DISK
019c ; I HL-DISK BUFFER,C=BYTE
019d ; O M FLAGS
019e ; K OUTPUT DISK BYTE 10
019f D58b BLKIN = 005bH
0200 ; C READ A BLOCK FROM DISK.
0201 ; I HL-DISK BUFFER,BUFFER++4 CONTAINS
0202 ; I TRACK AND SECTOR TO BE READ IN.
0203 ; O CY=FAIL,BUFFER++4=NEXT BLOCK IN
0204 ; O CHAIN
0205 ; K INPUT DISK BLOCK 10
0206 D58e BLKOF = 005eH
0207 ; C WRITE A BLOCK TO DISK.
0208 ; I HL-BLOCK IN BUFFER++10
0209 ; O CONTAINS ITS DESTINATION DISK ADD.
020a ; O CY=FAIL,BUFFER++10=NEXT DESTINATION OF
020b ; NEXT BLOCK
020c ; O OUTPUT DISK BLOCK 10
020d D594 OPENIN = 0064H
020e ; C OPEN INPUT DISK FILE
020f ; I HL-DISK BUFFER CONTAINING NAME
0210 ; O CY=FAIL
0211 ; K INPUT OPEN DISK
0212 D595 OPENOUT = 0067H
0213 ; C OPEN OUTPUT DISK FILE
0214 ; I HL-DISK BUFFER CONTAINING NAME
0215 ; O CY=FAIL
0216 ; K OUTPUT OPEN DISK
0217 D598 CLSOUT = 0068H
0218 ; C CLOSE AN OUTPUT DISK FILE
0219 ; I HL-DISK BUFFER
021a ; O
021b ; K CLOSE OUTPUT DISK
021c D59d FILEIN = 006dH
021d ; C INPUT, CHECK AND PLACE A DISK
021e ; C FILE NAME
021f ; I HL-DISK BUFFER
0220 ; O CY=INVALID FILENAME
0221 ; K INPUT CONSOLE DISK 10
0222 D5a6 TXTYP = 0067H
0223 ; C OUTPUT A MESSAGE TO THE CONSOLE
0224 ; I HL-MESSAGE ENDING IN '80' BIT ON
0225 ; OR '80' BYTE
0226 ; O HL-STOP CHAR
0227 ; C 0
0228 ; K INPUT CONSOLE DISK 10
0229 D5a6 TI = 0067H
022a ; C INPUT FROM CONSOLE AND SET FLAGS
022b ; I O CY=EOF='13' '29' 0;
022c ; K INPUT CONSOLE DISK 10
022d D5a9 TXTIN = 0067H
022e ; C NO-OP
022f ; I O
0230 ; K
0231 ;
0232 ; THESE ARE THE GENERAL ROUTINES DEFINED
0233 ; FOR THE USER TO USE WITHIN FDOS.
0234 ; FDOSYSMK
0235 D5aa MAPIN = 0066H
0236 ; C READ IN ALLOCATION TABLE OFF DISK
0237 ; I O
0238 ; K INPUT DISK LOOKUP BITMAP
0239 ; O
023a D5ab MAPOFF = 0067H
023b ; C PUT BITMAP BACK ON DISK
023c ; I O
023d ; K OUTPUT DISK LOOKUP BITMAP
023e D5be RED256 = 0075H
023f ; C READ IN RECORD TO SYSTEM INPUT BUFFER
0240 ; I O
0241 ; K EVERYTHING
0242 ; O K INPUT DISK
0243 ; I D666 TSIGN = 0066H
0244 ; C CONVERTS A DISK ADDRESS TO A BITMAP
0245 ; ADDRESS AND BIT
0246 ; I HL-TRACK AND SECTOR
0247 ; O HL-BYTE IN BIT MAP, H-BIT IN BIT MAP
0248 ; K CONVERSION DISK LOOKUP BITMAP
0249 ; I O
024a ; K THESE ROUTINES CONTROL I/O TO THE
024b ; DISK DIRECTORY,
024c ; FDOSYSMK
024d D5df DIRECL = 005FH
024e ; C GET THE NEXT DIRECTORY ENTRY
024f ; I O DE-> BLOCK
0250 ; A-FIRST CHAR IN NAME
0251 ; CY=EOF OF DISK=FIRST USED
0252 ; O CY=INVALID NAME
0253 ; K INPUT DISK DIRECTORY
0254 D5f0 DIRINN = 0060H
0255 ; C OPEN DISK DIRECTORY FILE
0256 ; I O
0257 ; K INPUT OPEN DIRECTORY DISK
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D600 END ANALIZ
D601 ANALIZ 0060g BITMAP 004c BL
D602 KIN 0058 BLKGT 005E
D603 BUFFER 0121h BITYN 0055 BY
D604 TOT 0058 CLSOUT 0064
D605 DIRBLK 05EF DIRPN 060F EN
D606 TRK 0076 FILEIN 0060
D607 FIXT 0054 HEAD 0107' IN
D608 IT 0064 LINK 0133' IN
D609 LN256 0121h MAPIN 0066 MA
D60a PNT 0068 NAME 014E NE
D60b NAME 0195h NAMEN 019E' NE
D60c XT 0116h OPNOUT 0064
D60d OPNOUT 006f RDLMN 019C RE
D60e D256 057E RDLMN 019C RE
D60f KRYLKN D5f0 SET 0663' SE
D610 TRPN 0129 TESTR 016b' SI
D611 TESTR 0134h TESTR 0168' TI
D612 0176 TRACK 018F SE
D613 TRKRED D5fa TRKRED 0164 TS
D614 ZET 0065 TXTIN 0067a
D615 TXTYP 0173
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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Almost every programmer has wanted to write a program in which there were one or more variables with strings as their values. Many programmers, however, are discouraged by the programming difficulties that arise in this connection, in all but the simplest cases. This is particularly true when space is at a premium and assembly language is used as it is in many microcomputer applications. We would like to describe here two alternative ways of solving these problems. These are quite different from each other stylistically; each is fascinating in its own way, and each has certain difficulties which have to be surmounted, but either one of them will solve the basic problem with which we are concerned.

Many versions of FORTRAN allow variables to have strings as their values, but these strings cannot have lengths which are greater than some maximum, and this maximum is usually much too small for practical purposes. The maximum is, in fact, the number of characters in a word, which is usually two, four or six; sometimes it is five (as on the PDP-10) and sometimes eight (as on the IBM 370, using double words), but in practice the strings we are concerned with are often 20, 40 or even 60 characters long. In many COBOL programs, this problem is taken care of by assigning some large number of characters to every such variable. This is particularly common when the value of the variable is someone's name and address, to be printed on an envelope by the computer. Often 25 characters are reserved for the name, 25 for the address, and 25 for the city, state and zip code. This gives rise to two kinds of problems. In the first place, 25 characters is not enough for an address like 1527 San Jose-Los Gatos Rd., even if we leave the period off the end. More important, however, is the fact that, if we reserve that many characters for every name and address, there are going to be quite a lot of wasted characters. That doesn't matter too much in a COBOL program, where space, particularly on a disk, is usually quite abundant; but on a microcomputer we would like to make optimum use of all the space we have.

The first solution to this problem that we will consider involves the use of a large array, called SPACE, for the storage of strings. Let us consider each element of this array to be one character long. Then the first string (whose length is L1) is stored in the characters SPACE(1), SPACE(2) and so on through SPACE(L1). The next character, SPACE(L1+1), contains an illegal character code (zero, for example) to denote the fact that this is the end of the first string. The second string starts at SPACE(L1+2) and continues from there. Every string ends with a zero character code, and all the strings are stored in the array called SPACE, in sequential order.

Suppose now that these strings are supposed to be the values of variables K1, K2 and so on in the program. The actual value of each of these variables will be an integer that indicates where the corresponding string starts. Thus, for example, if 17 is the value of K2, then SPACE(17) is the first character of the given string; SPACE(18) is the next character, and so on. This is the basic concept of a pointer: a quantity which indicates where another quantity is in memory. The pointers we have set up have been index pointers, but it would have been just as easy to set up address pointers. That is, instead of the integer 17, we could have used the address, in memory, of the character SPACE(17).

The basic problem that arises when this method is used can be seen if we consider the process of setting a variable to a new value. Suppose that the value of K1 is 'SMITH' and we want to change it to 'JOHNSON'. Unfortunately, 'JOHNSON' has more letters in it than 'SMITH', so we cannot simply store the new characters in the same places as we stored the old ones. We can, however, take advantage of the fact that not all of our array SPACE has been used. Suppose that we have used the characters from SPACE(1) up through SPACE(LSPACE); then 'JOHNSON' can start at SPACE(LSPACE+1), and we can set the pointer in K1 to be LSPACE+1. Of course, we also have to update LSPACE at this point, by adding to it the length...
of JOHNSON, or 7 (plus 1, for the zero character).

The trouble with this method is that now SMITH is still in memory, together with its zero character. We are not really using all the space from SPACE(1) up through SPACE(LSPACE); there are five characters, plus a zero character, that we are not using. By itself this causes no problems; but now consider what happens as our program continues to run. Every time we have a variable with a string as its value, and this variable gets a new string as its value, we are going to “abandon” some of our string storage area, just as we did with SMITH in this case. Eventually, we are going to run out of space; the whole SPACE array will be used up, except for “abandoned” areas as above. What do we do next?

Let us agree that, whenever we abandon a string, we write a zero character over the first character of that string. This character will immediately follow the zero character at the end of the preceding string, so that two zero characters in a row will denote the start of an abandoned area. We can now consider the possibility of moving all the strings backwards by just enough so that the abandoned areas disappear, as shown in figure 1. This is known as collapsing (or sometimes compactifying). If we think of the left side of figure 1 as a row of bricks, with spaces between them to represent the abandoned areas, then putting our hands on the two ends of the row and collapsing it would produce the situation shown in the right side of the figure.

An algorithm to do this involves two pointers, I and J. As we move each character in SPACE, we set $SPACE(J) = SPACE(I)$, and then add 1 to both I and J. When we have to skip over an abandoned area, we increase I, but not J. Thus I always indicates the current character we are moving, and J always indicates the place we are moving it. At the start of the algorithm, both I and J are initialized to 1.

There is still one difficulty. All our variables with string values involve pointers, and after the collapsing process has taken place, the pointers will be wrong. We have to have some way of adjusting these pointer values. There are at least two reasonable ways of doing this. One of these involves what may be called back pointers. The first character (or possibly the first two characters) of each string, as given in the array SPACE, is now some indication of which variable has this particular string as its value (such as, for example, the address of that variable). Whenever a back pointer is moved, by the operation $SPACE(J) = SPACE(I)$, we look in that position (which should contain I) and change it to J.

The other method involves a sorting operation. All the pointers that are contained in all the variables with string values are placed in an array and sorted in ascending order, together with back pointers to the given variables. As we are going through the SPACE array and setting $SPACE(J) = SPACE(I)$, we are also going through this new array, from the beginning to the end. At each stage, the pointer in this array that we are currently considering points to the place in the SPACE array that we will have to treat next, as the start of a string to be moved. When we get to this point in SPACE, we reference the associated back pointer and proceed as before; then we continue through the SPACE array, but also move forward by one position in the new array, so that we will be ready to treat that pointer when we come to it.

Let us now pass to the second method of handling string values of variables. Again we use a large array, which we will call FREE this time, rather than SPACE. FREE is organized into groups of characters; to make our example concrete, we will assume that each group is eight characters long. The first six of these characters are actually characters of the given string; the remaining two character positions, taken together, contain a pointer to another group of eight characters.

Any string which is less than six characters long is stored in a single group. If a string is four characters long, for example, the last two characters are zero characters; this tells us that these are not actually to be counted as part of the string. A string which is more than six characters long is stored as a chain. Thus, for example, if a string is 15 characters long, the first six of these characters appear in one group, which contains a pointer to another group. The next six characters appear in this second group,
which contains a pointer to a third group. The last three characters appear in the third group, followed by three zero characters.

If a string is exactly six characters long, it appears in a single group, but the pointer itself contains zero. If a string is 12, 18, 24, etc., characters long, it appears in more than one group, but the pointer in the last group will contain zero. In general, the pointer in the last group always contains zero, and it is this, rather than the presence of zero characters, that determines the fact that it is the last group.

We thus have one or more chains (sometimes called simple lists) which involve various 8 character groups in FREE. We are now in a position to make use of a basic idea in advanced programming techniques: the list of available space. In this case, the list of available space is a chain which contains all those 8 character groups, and only those groups, which are not on any other chain. That is, we think of all these groups as being in some order (it does not matter what the order is). Then the first group, in this order, contains a pointer to the second group; the second group contains a pointer to the third, and so on, up to the last group, which contains a zero pointer.

The point of using a list of available space is that it is now no longer necessary to use a collapsing process, as described in connection with the previous string storage method. In particular, we are no longer “abandoning” anything, as we were before. All we have to do is to make sure that, at all times, every group into which FREE is divided is on some chain, either the list of available space, or a chain which represents the string value of some variable. (There are also programs which use a list of available space, but in which some groups are abandoned, and a process somewhat like collapsing, known as garbage collection, is used to collect all these abandoned groups into a new list of available space. This, however, is necessary only when the various chains contain pointers to each other, which is not the case in the present application.)

By a pointer to a group, we mean a pointer to the first character in the group. Thus if K is such a pointer, then the group consists of FREE(K), FREE(K+1), and so on up through FREE(K+7). We will assume that FREE(K) through FREE(K+5) are the six characters in the group, and that FREE(K+6) and FREE(K+7), taken together, are the pointer to the next group. A variable called LAVS (for “list of available space”) contains, at all times, a pointer to the first group in the list of available space. The basic operations on the list of available space are taking one group off
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value, which is kept in \( n \) 8 bit groups. First we apply the second algorithm above to the first group in the chain that represents the old value of \( J \). This process puts this group on the list of available space. If \( m \neq 1 \), that is, if the pointer in this first group was not originally zero, we apply the same process to the second group in the chain representing the old value of \( J \), and so on through the rest of these groups. (It is not necessary to know \( m \), of course; we merely test for the pointer being zero, which indicates the last group.) Now we take \( n \) groups, or, in general, as many groups as we need, off the front of the list of available space by using the first algorithm above, and use these groups to store the new string value of \( J \).

This system is quite workable as it stands; the only real problems with it come when we try to extend it. Suppose, for example, that we want to set the string value of \( J \) equal to the current string value of \( I \). In that case we might want to save quite a bit of time by setting the pointer in \( J \) to be the same as the pointer in \( I \). Thus we would have two pointers to the same group, or to the first group of the same chain, in the FREE area. This scheme, however, will not work unless we change our setup a bit. The problem comes when the value of \( I \) is later changed to something else. In this case the old value of \( I \) is put back on the list of available space, and this is improper because it is still the current value of \( J \).

Let us look at this case in more detail. Suppose that the value of \( I \) is 'SMITH', and we set \( J \) equal to 'SMITH' by setting \( J \) to point to the same place that \( I \) does. Now suppose that we later set \( I \) equal to 'JOHNSON'. In this case, according to the algorithms we have discussed, the group \( \{ \text{is only one in this case; let us call it } \text{FREE}(K) \text{ through FREE}(K+7) \} \) which contains 'SMITH' is put back on the list of available space, even though \( K \) is still the integer value of \( J \). Now we need two groups to represent 'JOHNSON'. One of these will be this same group, that is, \( \text{FREE}(K) \) through \( \text{FREE}(K+7) \), because it was just put back on the beginning of the list of available space. This group will therefore contain \( \text{JOHNSON} \) (with the final \( N \) in the next group). This means that if at some still later time we want to print out the value of \( J \), we will print out \( \text{JOHNSON} \) rather than 'SMITH'.

One solution to this problem which is sometimes adopted is to reserve the first character of any string for a special integer telling us how many variables have this particular string as their value. This integer is known as a reference count. It is usually 1, but in the case above (where \( J \) and \( I \) point to the same string) it would be 2. Every time a variable is set to a new value, the reference count in the old value is decreased by 1. Only if its value is then zero do we return the space it uses back to the list of available space, because otherwise there are still variables which have that string as their value. The trouble with this scheme is that it may very easily not be worth the effort. Do we really want to add an extra character to every string, not to mention the extra testing that goes on whenever we set a string to a new value, just to be able to save a little time and space in an operation (setting one string to be the same as another) that might not be that commonly used in our program? It is certainly a debatable point.

It should also be clear that there is nothing special about the number of characters in a group (eight, in this case). The fewer characters we have in a group, the more pointers we will have, and the more space these will take up. The more characters we have in a group, the more wasted or zero characters we will have in strings, because the length of a string is not always evenly divisible by the number of characters in a group. This is a space trade-off which should be tuned by the user to fit the requirements of a particular program.
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A-Natural — Narrative assembler with linking loader, librarian, extensive $1120 language library in A-Natural relocatable object form. All manuals from A-Natural source to Microsoft MACRO-80 source and from A-Natural relocatable object form. ...................................... $330/$18

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List No. 6

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IBM Compatible Disk Drives

Jefferson H Harman
Director of Research and Development
PerSci Inc
12210 Nebraska Av
Los Angeles CA 90025

In today's expanding market of double-sided, multiheaded, expanded capacity, autoloading, write-protected, floppy disk drives, one requirement remains constant. Virtually all 8 inch floppy disk drives on the market are described as "IBM compatible." (Some of the smaller 5 inch drives are described as IBM compatible even though IBM doesn't manufacture equipment with the smaller drives!) Manufacturers point to it; buyers insist on it; and yet seldom does anyone define what IBM compatibility really means. That is probably because IBM compatibility is not just a single consideration. Three drives described as IBM compatible may, in fact, be compatible in 3 different ways. One drive may be IBM identical with read/write/erase head carriage and all major operating characteristics reverse engineered from an IBM 33FD drive; another drive may accept IBM type 1- or 2-sided single or double density media, but may or may not choose to employ any of the IBM data formats; and finally, a drive may be designed and manufactured with the positioning system drive motor, erase head, and other characteristics different from the IBM drives, but still be able to read and write in the IBM single or double density formats and interchange diskettes with IBM equipment.

Head

One factor does remain constant, however, among the IBM compatible drives. Virtually all of these drives, with one notable exception, bear read/write heads comparable or identical to the IBM drive (figure 1). The advantages to this design decision are clear. Whether or not the IBM design is the most efficient for the purpose does not matter. When the IBM design is employed in an independent manufacturer's drive, it assures that the drive will read back a signal comparable to that of the de facto standard (ie: IBM), thus assuring maximum interchangeability.

Because a majority of floppy disk manufacturers have chosen to remain with the standard, many systems designers must be prepared to deal with the design parameters of the IBM head, a head intended to read and write the IBM soft-sectored formats. The possibilities, limitations, and requirements imposed by this head when formatting data in floppy disk drives are the concern of this article.

Formats

The IBM 33FD head was designed to read and write the IBM soft-sectored formats. Both the drive and the concept of "soft" electronic sectoring were introduced into the marketplace by IBM in the early 1970s on the popular 3740 system. Prior to this introduction, all floppy disk drives (notably IBM's FD23) and virtually all hard disks had been hard sectored (ie: sectors were delineated by physical openings in the media or on an external sectoring device). The new electronic sectoring idea involved prewriting a certain track with track and sector identification data, then later inserting (usually on another machine) the blocks of data to be processed.

As more IBM compatible drives were offered, most users copied the IBM format. That format involves substantial housekeeping, and long leader and tail gap lengths; thus the available space for data on a diskette is greatly reduced. The gaps (which in fact are pulses) are used by IBM for 2 reasons: to synchronize the phase-lock loop for the data separator, and to put sufficient time between blocks of data to avoid interference of one block with another. Users were torn; on one hand they wanted more data, while on the other hand they respected the data reliability which was assured by the data bytes used to specify gaps, address marks, cyclic redundancy checks (CRCs), track and sector identification, etc, in the IBM formats. Some users struck out on their own to develop expanded formats.

The IBM formats are examples of the type which must be used with IBM heads in order to assure reliable, high-performance operation. The system engineer may choose to design his own format but, that being the case, will do well to observe the rules outlined below. At PerSci, as manufacturers of IBM compatible floppy disk equipment, we had to develop and use this set of rules. These guidelines are based upon the operating requirements and restrictions of drives with 33FD-type heads. They permit the designer to get the most available data space into the format for any given sector length or number of sectors.

About the Author

Jefferson H Harman is the director of research and development for PerSci Inc, a manufacturer of floppy disk drives.
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What is IBM compatibility?

while at the same time permitting sufficient gap length to maintain data integrity.

Model Format

Table 1 is a model format for data blocks. The maximum number of sectors for any block length, N, can be easily determined by dividing the unformatted data by the total number of bytes per sector.

Using housekeeping techniques different from those shown in the model format, slight variations in the length of a sector can be achieved. For example, the user may choose not to write the cyclic redundancy check on the address field, or may increase or reduce the address marks. The minimum length of leader and tail (trail), however, are critical, as they are determined from mechanical drive requirements.

The drive characteristics which determine the required leader and tail lengths are:

- Distance from the active part of the read/write head (read/write gap) to the active part of the tunnel erase head (erase gap).
- Variation in linear speed with track locations.
- Timing of erase turn on and off delays.
- Tolerances on these parameters.

As an example, the PerSci drives, which use a head with similar electrical and mechanical characteristics to those used in IBM 33FD disk drives (figure 1), have a distance of 0.036 inch ± 0.003 inch (0.0914 cm, ± 0.007 cm) from read/write gap to erase gap. The radius of track 76 is 2.029 inches (5.1536 cm), and the radius of track 00 is 3.612 inches (9.1745 cm). The drive speed is 6 revolutions per second (± 2 %), and the instantaneous speed variation is ± 1.5 %. PerSci requires a write clock stability of ± 0.3 %.

Unformatted Data Capacity

Unformatted data capacity is determined by dividing the shortest time for a revolution by the longest time for a byte. Average speed is used for this calculation since, by definition, average speed is speed averaged over 1 revolution:

\[
T = \frac{1}{6 \times 1.02} = 163.399 \text{ ms}
\]

\[
C = \frac{1}{16 \mu s/\text{byte} \times 1.003} = 10,208 \text{ bytes}
\]

\[
C = 5,104 \text{ bytes (frequency modulation)}
\]

Erase Delays

The read/write head has a gap that is 0.014 inches (0.036 cm) long and thus writes a track greater than 0.014 inches (0.036 cm). After passing under the read/write gap the media next passes under the tunnel erase gaps which clean the area between tracks of any transitions. The tunnel erase also trims 0.001 inches (0.003 cm) from each side of the just written data, reducing the track width to 0.012 inches (0.030 cm). Since a 0.012 inch (0.030 cm) track is read with a 0.014 inch (0.036 cm) head, a misalignment of ± 0.001 inches (0.003 cm) will cause no degradation of the data. In fact, experimentally, frequency modulated data has been recovered free of errors with deliberate 0.005 inch (0.013 cm) displacement between track center and read head.

The turn-on of the tunnel erase current is delayed from the turn-on of write current to give the disk time to travel from the read/write to the erase gap before tunnel erase begins. To insure that the data is tunnel erased, the

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Bytes Modified (MFM)</th>
<th>Bytes Frequency Modulation (FM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address leader (gap)</td>
<td>0.07 (N + 16) + 27</td>
<td>0.07 (N + 10) + 13</td>
</tr>
<tr>
<td>Address address mark</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Track identification</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Sector identification</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Address CRC (cyclic redundancy check)</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Address tail (gap)</td>
<td>21</td>
<td>1</td>
</tr>
<tr>
<td>Data leader (gap)</td>
<td>22</td>
<td>1</td>
</tr>
<tr>
<td>Data address mark</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Data address mark</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>User data</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Data cyclic redundancy check</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Data tail (gap)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Unformatted data</td>
<td>10,208</td>
<td>5,104</td>
</tr>
</tbody>
</table>

Table 1: Model format for data block N bytes long. Two columns are shown giving requirements for the 2 different physical modulation formats used. The frequency modulation (FM) format is commonly referred to as "single density." The modified frequency modulation (MFM) format is commonly referred to as "double density."
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SP09-6 6809 Extended BASIC $100

BASIC Precompiler

This program allows the creation of BASIC programs without the use of line numbers or restrictive two-character variable names. Alphanumeric line and subroutine labels may be used, as well as variable names of any length. Comment lines are marked with non-alphanumeric for easy readability. The output of the precompiler is in the standard BASIC compiled form. This allows applications programs to be written, precompiled, and then distributed in a non-source form. The precompiler can only be used with one of Technical Systems Consultants' BASICS. Specify 8" or 5" (5" 6800 is FLEX™ 2.0) when ordering.

AP68-13 Single Precision 6800 Precompiler $40
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SP09-7 Single Precision 6809 Precompiler $40
SP09-8 Double Precision 6809 Precompiler $50

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Circle 363 on inquiry card.
longest turn-on delay must be shorter than the shortest
time to travel from read/write to erase gap. This may be
calculated in the following manner:

Maximum Linear Speed = MLS
MLS = 6 revolutions/second × 1.035 × 2 π radians
     radian
     × 3.612 inches

MLS = 140.9 inches/second
MLS = 357.9 cm/second

The minimum time is then given by:

Te Min = Minimum Spacing
MLS
Te Min = 0.036 inches - 0.003 inches
        140.9 inches / second
Te Min = 234.1 µs

Erase Delay Short = 234.1 µs

Nominal = 234.1 µs

ED = 213 µs
ED Min = 213 × .9
ED Min = 191.6 µs

Similarly, the erase turn-off delay must be longer than

the longest time for the disk segment to travel from the
read/write to the erase gap:

Slowest Linear Speed = SLS
SLS = Minimum Angular Speed × Minimum Radius
- 6 revolutions/second × (.965) 2 π radians
     radian
     × 2.029 inches

SLS = 73.82 inches/second
SLS = 187.50 cm/second

Maximum time to travel from read/write to erase gap is
given by:

Te Max = Maximum Spacing
SLS
= 0.036 inches + 0.003 inches
73.82
Te Max = 5.28 µs
Minimum TurnOff Delay = 528.3 µs
Nominal TurnOff Delay = 587 µs
Maximum TurnOff Delay = 646 µs

Address Block Tail

The address block is written when the disk is formatted,
and is rewritten only if the disk is reformatted. The
format operation generally writes an entire track at one
pass, completely filling the unused areas with an arbitra­
ry pattern. User data blocks are then inserted between
address blocks. The turn-on of write current when
writing a user data block is timed from the address block
clock; therefore, the address block will not be over­
written by the start of a data block. However, sufficient
tail must be provided to prevent the erase current from
being turned on during the meaningful data in the address
block. If it was turned on, each successive write (as­
suming track alignment between writes shifts slightly)
would trim away some of the address block, thus
degrading data reliability until errors occurred. The tail
required to prevent this occurrence is found by subtrac­
ting the quickest erase turn-on from the maximum time to
travel from the read/write to erase gap:

Address Field Tail = TAB
TAB = Te Max - ED min
= 528.3 µs - 191.6 µs = 336 µs

This 336 µs will occur at slowest drive speed; but the
write clock could be maximum. Therefore the address tail
is given by:

336 µs
20.35 bytes
= µs × 0.997 × 1.035

Use 21 bytes, since partial bytes are not conveniently
written.

Data Block Tail

An address block is never inserted after a data block.
Therefore, the only requirement for a tail on the data
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block is for a bit to guard the cyclic redundancy check from being at a boundary between old and new data. Use 1 byte.

Data Block Leader

The data block is always written later than the address block. Therefore, enough leader to synchronize the data separator is all that is necessary. The PerSci data separator will lock to frequency in 100 µs on any pattern and then requires 4 successive 0s to determine that the input data is clock pulses. This would require 4 bytes in frequency modulation forms. The IBM formats require 6 bytes of 0s for frequency modulation or 12 bytes of 0s for modified frequency modulation.

Address Block Leader

The address block leader must be long enough to guard against the possibility of the inserted data block of the earlier sector overwriting meaningful data; as well as being additionally long enough to prevent the erase turn off of that inserted data block from degrading meaningful address data. Since even degraded data should be good enough to synchronize the data separator, the sum of the bytes required for the first 2 effects is all that is required. Longest erase delay minus shortest time to travel from read/write to erase gap:

\[
646 \mu s - 234.1 \mu s = 412 \mu s
\]

\[
\frac{412 \mu s}{16 \mu s/\text{byte} \times 0.965 \times 0.997} = 26.8 \text{ bytes}
\]

27 bytes double density
14 bytes single density

To absorb the effect of speed variation between format and writing, a gap of the maximum difference in time for a data block must be allowed. A data-block double density will consist of 12 bytes of leader, 1 byte address mark, N bytes of user data, 2 bytes of cyclic redundancy check, and 1 byte of tail. This is N + 16 bytes.

Longest block time, with ±3.5% speed variation:

\[
1.035 \times (N + 16) \text{ bytes}
\]

Shortest Block:

\[
0.965 (N + 16) \text{ bytes}
\]

Difference = \((1.035 - 0.965) (N + 16)\)

= \(0.07 (N + 16) \text{ bytes}\)

The address field leader must then become the sum of these:

\[
\text{AFL} = 27 + 0.07 (N + 16) \text{ modified frequency modulation}
\]

= \(13 + 0.07 (N + 10) \text{ frequency modulation}\)

This leader must be terminated with enough successive 0s to synchronize the data separator.

Conclusions

The formatting rules outlined above allow for the mechanical variations of the floppy disk drive; the user can design a format to give maximum data capacity with maximum reliability. If these rules are not followed, however, the format will cause a slow degradation of the address each time a new block of user data is inserted, until the address is not readable. It is a simple matter then (with a little planning) to maintain compatibility with your IBM head, thus assuring the success of your non-IBM format.

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Circle 231 on inquiry card.
THE S-100 BUS - WHAT IS ITS FUTURE?: Some industry pundits have speculated that the S-100 bus was doomed when integrated machines like the TRS-80, PET, Apple, et al, were introduced. I do not agree with this view.

There are now an estimated 200,000 S-100 systems in operation, and S-100 system sales should continue strong for a number of reasons.

The S-100 bus is not processor dependent. In fact there are presently 8080, Z80, 8085, 6502, 6800, 6809, 9900, 8086, Z8000 and MCP1600 processor boards that plug into the S-100 bus. The 68000, when it becomes available, will surely be adapted for the S-100 bus also.

It allows for extended addressing beyond 64 K bytes of memory. In fact the 16-bit microprocessors on the S-100 bus employ up to 23-bit address words and can access directly up to 2 M bytes of memory. The 8-bit microprocessors can accomplish a similar feat by a bank-switching arrangement. The Institute of Electronic and Electrical Engineers (IEEE) is adopting an S-100 standard, which should eliminate signal and timing problems and encourage sophisticated 16-bit systems.

The S-100 bus has a lot of other goodies such as vectored interrupt, direct memory access (DMA), and master/slave capabilities, which are not possible on the limited bus structures of machines such as the TRS-80, PET, APPLE, etc.

At least 3 new S-100 mainframes have been introduced so far this year. These newer boxes are capable of operating at speeds up to 10 MHz, have larger power supplies and other features.

Those who wish to have a machine capable of getting the maximum benefits of microprocessors must go the S-100 route. The S-100 bus will thus continue to dominate the serious personal computing area for many years to come.

NEW IMAGE SENSOR USES PHOTODIODE ARRAY: An integrated circuit consisting of a 64 by 64 array of 4096 photodiodes with associated registers and accessing circuitry has been developed for video camera use. The manufacturer, Integrated Photomatrix Inc, Mountainside NJ, claims that it can produce video-quality gray scale images with illumination as low as 60 foot candles. This is 5 to 8 times more sensitive than previous devices. However, the most important feature is that it lends itself to computer processing.

RANDOM NEWS: Atari has received FCC approval for their model 400 and 800 personal computers. This will probably make the FCC less willing to grant the Texas Instruments request for changes in the rules, as the FCC finds that other companies are able to pass current requirements . . . . Radio Shack will open 100 Computer Sales Departments in 100 existing stores, in addition to the 50 Radio Shack Computer Centers already in operation . . . Two pioneer personal computer companies have shut their doors and are out of business. They are Processor Technology Company and Xitan Inc (formerly TDL). Their closings are attributed to poor business management, not lack of business.

RANDOM RUMORS: Shugart is about to announce an 8 inch Winchester disk drive for under $1000. Rumor is that it will be called the Model SA-1000 and will store 5 M bytes. In original equipment manufacturer (OEM) quantities it may sell for as little as $750 . . . 5¼ inch Winchester-type drives are being investigated by several manufacturers . . . Digital Equipment Corporation's Computer Stores are proving to be a real success. Four stores are already in operation and 6 more are planned to be opened by the year's end. The stores will sell computers in the $12,000 to $18,000 range with supplies and accessories aimed at small business users . . . A record 78,843 people attended the National Computer Conference (NCC) held in New York City this past June. This was 22,000 more than last year, which also set a record . . . Sinclair Radionics Ltd, London, England, has demonstrated a flat screen (3 inch) black and white television receiver, the size of a paperback book. They are now looking for financing for the production of the unit. This may be the forerunner of the pocket computer terminal.

PERSONAL COMPUTER TIMESHARE NETWORK INAUGURATED: Telecomputing Corporation of America, McLean Va, has started a Personal Computer Network which may be accessed by home users with terminals or personal computer systems. They have about 2000 programs and data bases on-line for immediate access. Included is the United Press International (UPI) daily news file, airline schedules and real estate listings. Called "The Source", the service will be available in 200 US cities at $2.75 per hour from 6 PM to 7 AM, weekends and holidays. The rate during normal working hours will be higher.
DYNAMIC MEMORY AND THE "SOFT ERROR": As programmable memory size increases and memory cell size decreases, users are discovering that programmable memory can have soft errors as well as hard errors. A hard error is when a bit or bits in a given memory location is stuck high or low. This kind of error is easily found with a memory test and always has the same effect on the processor.

The introduction of very large-scale integration (VLSI) dynamic-memories with very small cell size has introduced soft errors which cause varying symptoms in the running of a program. A soft error is defined as a random, nonrecurring, bit change. The occurrence of soft errors appears to be on the increase and standard memory tests do not appear to help in diagnosing the problem.

The integrated circuit (IC) industry is becoming very concerned with the growing problem. Several integrated circuit makers have intensive research going on to discover the sources of the problem. The chief cause appears to be alpha particle radiation produced by the radioactive trace elements in the metal lids which hermetically seal the integrated circuit cavity. Several measures are being adopted by integrated circuit makers including package redesign, processing changes, and recommending that users employ error correction schemes in their memory boards to cope with the problem.

LEAVE THE DRIVING TO THE MICROCOMPUTER: Several automobile makers have research and development programs aimed at developing computer controlled cars. An example is the LISA system now under development by Volkswagen. A small console will be located on the car's dashboard. It will have a small keyboard, graphics and alphanumeric display controlled by a microprocessor. The driver will key in the code for the town he or she wishes to go to. Then as the car passes over sensor cables imbedded in the road, LISA's microcomputer transmits the car's destination to a master computer and receives instructions on the fastest and least congested route. LISA then displays a map showing the driver where to turn. LISA can be extended to control the car's speed from the information received from the master computer and an on-board radar system. Pretty soon, you will get into your car, buckle your seat belt, turn on the ignition and "leave the driving to LISA."

16-BIT MICROPROCESSORS TO DOMINATE THE 1980s: Most industry experts feel that the dominant microprocessor in personal computing and small business applications will be the 16-bit processor. They feel that prices will drop sharply, substantially reducing the price difference between 8-bit and 16-bit microcomputer systems. 8-bit microprocessors are expected to remain strong into the early 1980s because of the strong software base and significantly lower cost. However, the situation is expected to change by the mid-1980s with the 16-bit processor becoming dominant.

1980 should see at least a dozen 8086 and Z8000 processor and memory cards for the S-100 bus. The Motorola 68000 16-bit entry should make its appearance in personal computing systems by late 1980. It is interesting to note that Motorola in designing their new microcomputer development system are introducing a new Polybus which is upgradable to 32-bit service.

NONIMPACT PRINTERS IMPROVING: Considerable research is being devoted to the improvement of nonimpact printers. These efforts should bear fruit within the next 5 years, and will probably result in higher print quality, increased printing speed and greater capabilities. It is expected that quality will improve to produce type quality equal to Selectric and Diablo type printers. Speed will increase dramatically: 12,000 lines per minute will be common. Further, the printers will have multifont and graphics capabilities. Hence, they will simultaneously print the forms and the data, and put in signatures as well. Also, they will be capable of producing half-tone graphics and some even capable of multicolor printing.

LASER DISK MEMORY SYSTEMS IN DEVELOPMENT: At least 3 companies, Sperry Univac, Nippon Electric Co Ltd and Phillips Research Laboratories, are known to be working on laser disk-type data storage systems. Referred to as optical disks, they employ diode-laser recording systems which can record alphanumeric and image data on tellurium coated disks. They will be capable of substantially greater bit density than present magnetic disks.

PASCAL BEING PUSHED: More and more computer manufacturers are jumping on the Pascal bandwagon. Recently, Digital Equipment Corporation, Data General and Texas Instruments introduced packages for their mini and microcomputer systems. Pascal packages have also been introduced for CPM, North Star, Radio Shack TRS-80 and Apple computers.

Sol Libes
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112 BYTE October 1979
The TRS-80 Speaks
Using BASIC to Drive a Speech Synthesizer

Tim Gargagliano
Kathryn Fons
24121 Mound Rd
Warren MI 48091

The rapidly increasing family of Radio Shack TRS-80 computer peripherals has recently acquired a voice synthesizer module. Any application of this computer system which involves human interaction can be improved with the addition of computer voice response. Voice can be used as a supplement to the video display or printer (by repeating what has been printed) or used alone when it is undesirable to print (such as for intermittent feedback while printing a long task). A few of the applications of the verbal peripheral are games, clocks, verbal prompting, alarm systems, doorbells, computer-aided instruction, and a blind user's terminal. The intent of this article is to present an overview of the voice synthesizer as a TRS-80 peripheral and to demonstrate the ease with which TRS-80 applications software can be modified to include the voice unit.

Based on electronic phoneme synthesis, the voice response system synthesizer is capable of producing virtually any English language word and subsets of many foreign languages. Word production is achieved by sequencing the units of sound produced by the synthesizer, referred to as phonemes. The synthesizer, developed and manufactured by the Votrax Division of Federal Screw Works, produces 62 electronic phonemes. Procedures for sequencing phonemes are discussed in the phonetic programming section.

The advantage of phoneme synthesis over other forms of speech production is its low data storage requirement. The average data transfer rate is 100 bps. Another advantage resulting from this low data rate is the negligible processor overhead associated with control of the synthesizer. This allows the computer to execute other tasks while it is generating speech. From a memory requirement standpoint, there are not any cumbersome software drivers or data tables.

Users of the TRS-80 Level I BASIC will be happy to learn that the voice synthesizer will interface with it, without any hardware modifications. This is possible by use of a special PRINT statement as an output command. (Level I BASIC does not have output commands to any device except the video display and cassette tape drive.) Level II and Disk BASIC users may also use POKE commands to drive the synthesizer.

Device Description

The TRS-80 voice synthesizer is packaged in a silver-gray cabinet with a black front grill, slightly resembling a speaker enclosure. There is a volume control and device select indicator on the front panel next to a speaker. A ribbon cable emerges from the back of the cabinet, and connects directly to the TRS-80 microcomputer keyboard module, or to the screen printer port on the expansion interface. Its length is sufficient to allow the cabinet to be placed on top of the TRS-80 video display unit.

Phonetic Programming

Phonetic programming is the operation performed to construct

About the Authors
Tim Gargagliano and Kathryn Fons are employees of the Federal Screw Works, and work in the research and development laboratory.
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<td>#116 Disk Drive</td>
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words and phrases from the constituent sounds of a particular human language. These constituent sounds are called phonemes. The machine need produce only a subset of possible human sounds to be intelligible.

Comparison of the phoneme subsets of various languages shows that there is a large intersection of phonemes between them. This means that given the phoneme subset of a particular language, several other languages can be produced from the same subset with a high degree of accuracy.

The TRS-80 voice synthesizer is an English language phoneme synthesizer. Table 1 lists all of the phonemes produced by the Votrax phoneme symbols, with the associated ASCII character and decimal code. The ASCII character, hereafter referred to as the phoneme character, is used in BASIC statements to select phonemes. The Votrax phoneme symbol is a mnemonic descriptor, for it spells the sound associated with that phoneme.

There are 62 phonemes from which several vowel phonemes have multiple listings, such as Uh1, Uh2, Uh3. These are different durations of the “uh” sound. The larger the digit, the shorter the duration of the sound. The range of phoneme duration is 50 to 200 ms. The long duration version of a vowel phoneme (eg: Eh1) is used in a word with only 1 vowel, or in the syllable of a word that is accented or stressed (eg: yes, better). Shorter duration versions of the vowel (eg: Eh2, Eh3) are used in unstressed syllables (eg: seven).

The phonemes listed in table 1 have been broken down into general groupings which are shown in table 2. In a physical sense, voiced phonemes can be thought of as those having pitch and amplitude resulting from vocal cord vibrations (such as are produced by humming). Unvoiced

<table>
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<td>63</td>
<td>NULL</td>
<td>-</td>
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Table 1: Relationship between Votrax phoneme symbols and ASCII characters used by the TRS-80. The decimal value of the ASCII character is also shown. The ASCII character is placed in the output window, and the synthesizer produces the corresponding sound. The synthesizer must use special phoneme characters to represent its sounds because standard alphabet characters often have several different pronunciations assigned to them.

Note: Table 1 also includes the Votrax phoneme symbols, with the associated ASCII character and decimal code. The ASCII character, hereafter referred to as the phoneme character, is used in BASIC statements to select phonemes. The Votrax phoneme symbol is a mnemonic descriptor, for it spells the sound associated with that phoneme.

There are 62 phonemes from which several vowel phonemes have multiple listings, such as Uh1, Uh2, Uh3. These are different durations of the “uh” sound. The larger the digit, the shorter the duration of the sound. The range of phoneme duration is 50 to 200 ms. The long duration version of a vowel phoneme (eg: Eh1) is used in a word with only 1 vowel, or in the syllable of a word that is accented or stressed (eg: yes, better). Shorter duration versions of the vowel (eg: Eh2, Eh3) are used in unstressed syllables (eg: seven).

The phonemes listed in table 1 have been broken down into general groupings which are shown in table 2. In a physical sense, voiced phonemes can be thought of as those having pitch and amplitude resulting from vocal cord vibrations (such as are produced by humming). Unvoiced
(or voiceless) phonemes are those without vocal cord vibrations, where pitch might not be detected. These phonemes are perceived as hissing.

All phonemes except the stop plosives produce their sound shortly after being selected. Vocal parameters at phoneme boundaries do not change abruptly, but smoothly from one set of values to the next. The exception to this is the stop plosives, which do not make any sound until the phoneme following it begins. When a stop plosive is selected, vocal parameters are adjusted for silence until the beginning of the next phoneme. At this time, the stop plosive phoneme explodes into the following phoneme. An example of this is the word _kick_. The phoneme sequence for this word is PAI, K, 12, K, PAI. The timing of these sounds is graphically depicted in figure 1.

Phoneme symbols, with typical examples of English words in which they might be used, are provided in table 3. The English letter combination that the phoneme replaces has been underlined. In addition, table 4 shows phoneme sequences to produce

**Table 2: Votrax phoneme groupings. The allophones (phoneme variations) marked with asterisks are phoneme variations which must be combined with another phoneme to complete the production of an English sound unit.**

**Figure 1: Progression of stop plosive sequence. The top line shows the phonemes selected during a given instant, and the bottom line shows the sound produced during that instant.**

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multisound units, referred to as diphthongs. Again, the letters in the example word showing where the diphthong goes have been underlined. To give examples of phonetic programming, some commonly used computer words have been listed in table 5.

Basic Operation

Output to the voice synthesizer is accomplished by executing a PRINT AT statement (or PRINT@ for Level II), coupled with the device select/deselect character. Referring to figure 2, an imaginary box enclosing the last 32 positions of the video display is shown. This box defines a window through which printed characters are sent to the voice synthesizer. The sending of a character to the synthesizer happens when the window is open.

If the window is closed, any character printed within cannot affect the synthesizer. Opening and closing the window is controlled by printing a "?" within the window. The "?" printed inside the window is considered a device select/deselect character.

As phoneme characters are printed into the open window, they are also shifted into a 32-stage first-in first-out (FIFO) buffer. This buffer is in the synthesizer interface and is address mapped into the last 32 locations of the video-display refresh memory. Phoneme characters in this buffer determine which sounds the synthesizer produces. Each phoneme duration is timed by the synthesizer. The next phoneme character is removed from the buffer at the end of each cycle. This continues until the buffer is emptied. The synthesizer will continue to process the last character entered in the buffer. This last character should be a pause (or silent) phoneme. This will prevent any sound phoneme from being produced while the synthesizer is in an unused state.

It is a good practice to set up the synthesizer output command in a subroutine. This subroutine should contain the following sequence of operations:

- Open the window (print a "?" in the window).
- Print a " " (use space bar) in the window to synchronize the synthesizer when it has been in an idle state (" " is a pause phoneme).
- Print phoneme characters in the window in the sequence they will be voiced.

Table 3: List of Votrax phoneme symbols with examples of the occurrence of the corresponding sound in English words. The English letter combination the phoneme replaces is indicated. The allophones (see table 2) are marked with asterisks.
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Table 5: Votrax phoneme and ASCII representations of common words in computer applications. The ASCII coding may be entered directly into programs for vocal output.

<table>
<thead>
<tr>
<th>Symbol Combination</th>
<th>Key Words</th>
<th>(VOTRAX)</th>
<th>(ASCII)</th>
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<td>(ASCII)</td>
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<tr>
<td>FULL F</td>
<td>O01 O01 L</td>
<td>(VOTRAX)</td>
<td>(ASCII)</td>
</tr>
<tr>
<td>RUN R</td>
<td>U01 H01 N</td>
<td>(VOTRAX)</td>
<td>(ASCII)</td>
</tr>
<tr>
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<td>T</td>
<td>(VOTRAX)</td>
<td>(ASCII)</td>
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<td>E01 E01 D</td>
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<td>(ASCII)</td>
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<tr>
<td>SAVE S</td>
<td>S</td>
<td>(VOTRAX)</td>
<td>(ASCII)</td>
</tr>
<tr>
<td>HELLO H</td>
<td>E01 H01 L</td>
<td>(VOTRAX)</td>
<td>(ASCII)</td>
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<tr>
<td>TALK T</td>
<td>A02 L</td>
<td>(VOTRAX)</td>
<td>(ASCII)</td>
</tr>
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<td>YES Y1</td>
<td>E02 E01 S</td>
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<td>(ASCII)</td>
</tr>
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<td>NO N</td>
<td>U01 O1 O1 U1</td>
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<td>(ASCII)</td>
</tr>
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<td>CANCEL K</td>
<td>E01 E01 N</td>
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<td></td>
</tr>
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<td>U02 B</td>
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<td>U02 L</td>
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<td>V12 A</td>
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<td>E1 Y K W</td>
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<td>N T ER</td>
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<td></td>
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<td>ZERO Z</td>
<td>AY 13 R U03 O2 U1</td>
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<td>ONE W</td>
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<td>TWO T</td>
<td>13 IU IU IU</td>
<td>(VOTRAX)</td>
<td>(ASCII)</td>
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</tbody>
</table>

Table 4: Phoneme sequences to produce diphthongs, wherein 2 vowel sounds occur adjacenty, without any intervening consonant. The English letters replaced by the phoneme sequence are indicated.

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Table 5 continued from page 120:

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Listing 1: Subroutines for synthesizer output in Radio Shack Level I (listing 1) and Level II (listing 1b) BASIC. Line 1000 opens the output window in the video display, sends a pause, sends the phoneme characters stored in A$, sends another pause, and closes the window. Line 1010 fills the window with 31 spaces to blank out the display. Line 1020 returns to the calling routine.

```
1000 PRINT AT 992,"?",A$;"?";
1010 PRINT AT 992,"
1020 RETURN
```

Listing 2: Modified subroutine for synthesizer output for Level II BASIC only. Phoneme characters are taken out of A$ one at a time, and are POKEed into decimal location 16383, the last location in the output window. This method of output does not disturb the cursor position, thereby saving overhead of restoring the cursor.

```
1000 POKE 16383,63 : POKE 16383,32
1010 FOR Y = 1 TO LEN (A$)
1020 POKE 16383, ASC(MID$(A$,Y,1))
1030 NEXT Y
1040 POKE 16383,32 : POKE 16383,63 : POKE 16383,32
1050 RETURN
```

An example of this sequence is shown in listing 1. A variation on this subroutine which Level II users might consider is shown in listing 2. The phoneme character strings which form words when sent to the synthesizer may be stored in several ways. The simplest way is to store the phoneme strings in a BASIC string variable and then call the voice driver subroutine. An example is A$="TUD@Y": GOSUB 1000. This transmits the phoneme characters for the word “today.” DATA statements may be used to create a lookup table where the English spelling of a word is stored adjacent to the phoneme character string for that word. This would be useful, for example, in creating a name storage table for a game. A user could enter his or her name from the keyboard, and the computer could search the table for a name match and the associated phoneme characters needed to pronounce the name. It is a funny sensation to be verbally addressed, by name, by a computer.

Summary

Merely reading about how to string phonemes together on a TRS-80 voice synthesizer cannot begin to convey the excitement your friends will experience when your computer talks to them. Applications of a voice response system are exciting and plentiful. Any TRS-80 computer can add this voice synthesizer unit without any hardware modification. Changing existing application software to include voice response requires inserting only a few lines of code. Applications of computers in the home will surely come to rely on voice response as one of the most important output devices.

Text continued from page 118:

- Repeat last step if multiple messages are desired.
- Print a " " in the window (a pause for silence at the end of the message).
- Close the window (print a "?" in the window).
- Print spaces in the window to blank out the characters in the video display that were sent to the synthesizer.

An example of this sequence is shown in listing 1. A variation on this subroutine which Level II users might consider is shown in listing 2. The phoneme character strings which form words when sent to the synthesizer may be stored in several ways. The simplest way is to store the phoneme strings in a BASIC string variable and then call the voice driver subroutine. An example is A$="TUD@Y": GOSUB 1000. This transmits the phoneme characters for the word “today.” DATA statements may be used to create a lookup table where the English spelling of a word is stored adjacent to the phoneme character string for that word. This would be useful, for example, in creating a name storage table for a game. A user could enter his or her name from the keyboard, and the computer could search the table for a name match and the associated phoneme characters needed to pronounce the name. It is a funny sensation to be verbally addressed, by name, by a computer.

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David L Condra
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When faced with the job of designing an interface for a Diablo printer, I began looking at the available interface parts. I was amazed at how simple these devices can make an interface design project. In this article I will discuss the Intel 8255 programmable peripheral interface, and its use for interfacing to the S-100 bus. My objective, both in designing the interface and writing this article, is to reduce the problem to its simplest and most essential elements.

I learn easily and enjoy the learning more when I am working on a specific application, rather than merely reading technical material or doing routine experiments. Therefore, this discussion is offered as a simple I/O (input/output) interface design that will allow the nonhardware-type person to build a working interface and gain some basic understanding of the functions of hardware in a microcomputer. This is not intended to be a straight hardware tutorial; additional study in some areas may be required to fully understand what is happening.

Intel 8255 Description
The 8255 is one of a later group of interface integrated circuits which Intel Corp introduced to support the 8080 and related processors. It is a general purpose program-

Use of large-scale integration parts forces a modular approach to a hardware design problem.

mable device with 24 pins that may be programmed in a variety of configurations. A programmable device can have its operating characteristics modified by a processor command. For example, in a programmable serial interface, a single output command can set data rate, number of stop bits, and parity status.

In a parallel interface part like the 8255, a single output command can define how the 24 programmable I/O pins are to be used. Such uses include input, output, handshaking, and interrupts. The 8255 is normally set up so that its control register looks like an I/O port to the processor. The processor sends a specific data byte to that port to determine the mode of operation.

The 8255 modes are as follows:

Mode 0: (Basic I/O) Each group of 12 I/O pins may be programmed in sets of 4 and 8 to be input or output.

Mode 1: (Strobed I/O) Each group of 12 I/O pins may be programmed to have 8 lines of input or output with the remaining 4 pins in each group being used for handshaking and interrupt control signals.

Mode 2: (Strobed Bidirectional Bus I/O) This is a bidirectional bus mode which uses 8 lines for a bidirectional I/O bus and 5 lines for handshaking.

In addition, there is a bit set and reset feature that allows the setting and resetting of any 1 of 8 output bits.
Figure 1: Configuration and names of pins of the Intel 8255 programmable peripheral interface and block diagram of its functional parts.
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using a single output instruction. Figure 1 is a diagram showing pinouts and a block diagram of the Intel 8255. As can be seen, the 8255 combines many logic functions which would have previously required substantial design effort themselves. Since the 8255 is available in a single package form, however, it becomes essentially a 1-piece parallel interface requiring very little external logic.

S-100 Bus Description

At first glance, the S-100 bus with its 100 lines is quite overpowering. However, if one looks only at the signals needed for a specific application, it becomes much more understandable. For example, in the application of interfacing the 8255, we need only:

- Lower 8 address lines (A0 thru A7).
- 8 data-in lines (D10 thru D17).
- 8 data-out lines (DOO thru DO7).
- 2 status lines:
  1. SINP (input).
  2. SOUT (output).
- 3 control lines:
  1. PWR (processor write).
  2. PDBIN (processor data bus input).
  3. POC (power on clear).

Note: The bar above some signal names indicates that these signals are logically active when low; other signals are active high (+5 V).

The reason that you see more bus lines used on most I/O boards is that S-100 boards are usually designed to be very flexible and to serve multiple functions; therefore you find I/O boards using clocks, interrupts, and other functions. Since, however, our objective is to keep things simple, we will confine this application to the bus lines listed above.

S-100 to 8255 Interface Design

We begin our design at the 8255. After examining the various modes in which it can operate and determining that its output and input capabilities are sufficient, it becomes a straightforward matter of determining what signals the 8255 needs to function and how we can obtain them from the S-100 bus. The signals which we need to generate for the 8255 are as follows:

- A CS (chip select) signal to turn the 8255 on.
- A0 and A1 signals to select 1 of 4 ports (A,B,C, or control).
- Data control on pins D0 thru D7.
- A WR (write) signal to tell the 8255 to take the output data from the processor bus and send it out to the appropriate port(s).
- A RD (read) to take input data from the appropriate port and put it on the processor bus.
- A reset signal which clears the 8255 internal registers.

Our problem becomes how to generate these signals using the S-100 bus lines defined above.
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An understanding of timing diagrams is essential in designing any hardware interface.

**Chip Select Signal**

The CS (chip select) signal is basically an on/off signal for the 8255. To avoid stray data being output or input when not desired, the 8255 device is kept disabled until the processor commands that the data be input or output through one of the 8255's ports. To do this, we must understand the definition of the S-100 bus signals which we need to use. This is best explained through the use of a timing diagram as shown in figure 2.

In most respects the S-100 bus timing is based on the 8080 processor signals. These diagrams indicate the state of the bus lines with respect to time and their interaction with each other. Most confusing, at first glance, are the data and address signals which appear to be high and low at the same time. This, of course, merely represents the idea that some of the bits may be high and some may be low when valid and active.

Starting at the bottom of the timing diagram, we see that the S-100 status signals SINP and SOUT are inactive in a low-logic state anytime except during the third machine cycle of an input or output instruction, respectively. By using a simple OR gate (such as the one shown as IC2a in the circuit diagram of figure 3), we can turn on the 8255 programmable peripheral interface whenever the SINP or SOUT signal is high. The inverters IC1a and IC1b are used for convenience and to minimize the number of integrated circuit packages used. They also serve as bus receivers, allowing these signals to drive other circuitry on the same board.

The SINP and SOUT signals could be used to turn on the 8255 every time the processor executes an input or output instruction; however, we want the 8255 to pass data only when it is specifically addressed. To be more exact, we want the 8255 to take action only when a specific port on it is addressed by the processor. Therefore, we need to know when the processor is addressing one of these ports.

The upper and lower bytes of the address bus lines will contain the address of the I/O port during the third

**Table 1: Power supply connections for integrated circuits in figure 3.**

<table>
<thead>
<tr>
<th>Number</th>
<th>Type</th>
<th>+5 V</th>
<th>GND</th>
</tr>
</thead>
<tbody>
<tr>
<td>IC1</td>
<td>74LS04</td>
<td>14</td>
<td>7</td>
</tr>
<tr>
<td>IC2</td>
<td>74LS00</td>
<td>14</td>
<td>7</td>
</tr>
<tr>
<td>IC3</td>
<td>DM8131</td>
<td>16</td>
<td>8</td>
</tr>
<tr>
<td>IC4</td>
<td>DS8833</td>
<td>16</td>
<td>8</td>
</tr>
<tr>
<td>IC5</td>
<td>DS8933</td>
<td>16</td>
<td>8</td>
</tr>
<tr>
<td>IC6</td>
<td>µPD8255</td>
<td>26</td>
<td>7</td>
</tr>
</tbody>
</table>

Figure 2: Timing diagram showing signals on the S-100 bus during a data transfer instruction.
Figure 3: Schematic diagram of an interface circuit using the 8255 device. All numbered connections refer to pins on the S-100 bus. A suitable power supply is assumed, with connections for integrated circuits given in Table 1.
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machine cycle of an I/O instruction. Therefore, what we want to do is decode the lower 8 address lines continuously. When one of the ports on the 8255 is selected, we want an enable signal which we can combine, using a logical AND, with the status signal to turn on the 8255.

A simple method of decoding the address bus is to use a comparator (such as the 6-bit comparator 8131) which will take the enable pin (pin 9) low when the input signals from the bus match the pattern set as the port address. In this case, we are using only the upper (most significant) 6 bits of the port address, since the lower 2 bits will be used to select 1 of 4 ports on the 8255 itself.

We can set up the port address by tying the appropriate lines on the 8131 comparator to either high or low-logic levels as required to match the address. We now have circuitry which will provide a CS (chip select) signal whenever the processor is in an input or output instruction cycle, and whenever any of the port numbers assigned to the 8255 have been addressed by the processor.

Address Lines A1 and A0

As can be seen, pins 9 and 8, carrying low-order address signals A0 and A1, can now be tied directly to the lines A1 and A0 on the S-100 bus. This will allow the processor to select port A, B, C, or control function.

Data Transfer

We have now enabled the 8255 at the appropriate time. The remaining task is to supply the data to the data pins on the 8255 or retrieve the data from the appropriate data pins on the 8255 when the processor is doing an output or input instruction with this port.

The data pins on the 8255 are bidirectional (ie: they will take data from the bus and output it to the appropriate port when the WR signal is active, or will take data from the port and put it on the bus data lines when the RD signal is active). Since the S-100 bus is divided into 8 unidirectional lines of data in (D10 thru D17) and 8 unidirectional lines of data out (DO0 thru DO7), we need a means of tying both of these sets of lines to the 8 data pins on the 8255 and selectively enabling either the S-100 data input or data output bus lines.

An easy way to accomplish this is with the 8833 bus transceiver integrated circuit which can be connected as shown in the circuit diagram of figure 3. When pin 9 on the 8833 is active, the data will be passed from the data output bus to the 8255, and when pin 7 is active, the data will pass from the 8255 to the data input bus of the processor. The S-100 bus provides 2 simple signals with which to achieve this result.

The W Signal

The PWR signal, as shown on the timing diagram (figure 2), will go low when valid data is presented on the data output lines. We can use this signal to enable the 8833 bus transceivers and to strobe (send a pulse to) the 8255 pin WR to pass the data to the appropriate output port.

The RD Signal

Conversely, we see from the timing diagram that the S-100 signal PDBIN is active in a high-logic state when valid data can be accepted on the data input line. We can use this signal to generate the RD signal for the 8255 to pass the data from the appropriate 8255 input ports to the data pins, and to enable the 8833 bus transceivers so that the data is passed directly to the data-in bus in the processor.

One other provision which we want to include in our design is that the RD and WR signals should not be allowed to go active unless the CS (chip select) signal is also active. This provision is primarily for the purpose of keeping extraneous data which might be on the 8255 data lines from being transferred to the data-in (DI) bus at any time that the PDBIN signal is active. We can achieve this by using the AND gates IC2c and IC2d to generate the RD and WR signals only when the 8255 has been selected and the appropriate PWR or PDBIN signal is simultaneously active.

Reset Signal

This leaves us with one simple signal which is needed by the 8255. Since the 8255 can start in an undefined state when power is first supplied to it, a reset signal is necessary to bring it to a known state for further use. Fortunately the S-100 bus provides us with a very convenient POC (processor on clear) signal that can be tied through an inverter to the reset pin. This arrangement will apply a reset signal to the 8255 whenever power is applied to the processor.

We have now designed a simple but powerful interface circuit. As you can see, the parts count of 6 integrated circuits is quite low. The circuit could conceivably be put on a simple piece of perforated circuit board and hung onto an existing S-100 board. The total cost should not exceed...
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$20. This mounting would not be advisable, due to space and maintenance problems. I would recommend using an S-100 prototype board such as one provided by Vector Electronics, which has provisions for a voltage regulator plus power and ground distribution buses on board.

The wiring can then be done point-to-point with wire wrap. There will also be plenty of available room and power for additional circuitry on board. Circuits for other functions would be very easy and economical to add, since we have already provided for data bus transceiving, and we can use many of the same bus interface integrated circuits to add additional circuitry to the board.

One caution — be aware that the S-100 bus expects to see only 1 TTL (transistor-transistor logic) “fan-out” load per board, which means that any given bus line must be tied to the input of only 1 TTL device on the board. The bus line should not be driving 2 or more TTL devices simultaneously. Therefore, if additional circuitry uses the same bus signals, a bus receiver (7404 hex inverter) or driver (8T97 3-state buffer) must be used between the bus lines and the board circuitry.

Check-Out and Troubleshooting

One problem in trying to build other people’s designs is that usually you are not given any troubleshooting information. Therefore, when it is built and does not run, you have to learn it inside out to make it run. You do learn a lot in the process, but a few guidelines, such as the following, can speed up the process considerably:

- Buy a computer with front panel lights and switches. Although manufacturers seem to be drifting away from making true front-panel controls, they are invaluable if you are going to do any hardware design or debugging. A single-step capability alone can help a great deal, but for my money give me as many switches and lights as possible.
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- Get an extender board so that you can place your circuit board where you can get at it. For tracing circuits, checking power supplies, and other general debugging, it is indispensable.
- Test power supply connections to the circuit board before plugging integrated circuits into their sockets. (Use sockets!) Plug in the integrated circuits and recheck power and ground on each one. Then single-step through an output instruction using one of the I/O port numbers you have assigned to the 8255.

When the output status light on the front panel (or on a logic probe you are holding on pin 45 of the S-100 bus) comes on, the processor is in the output phase of its instruction cycle and you have static conditions to check out the circuitry. By looking at the circuitry you can see that CS should be low, WR should be low, and there should be some data on the data pins of the 8255 (ie: either highs or lows, but not open circuits). If these conditions do not exist, trace back through the circuit to the bus and find the problem.

- Once you are able to output data to the 8255, you can proceed to check it out according to specifications given in the application data. For a start, you can output the hexadecimal value 94 to the control register port, which will set port A for input and port B for output. Then you can try input and output commands as you would a normal port.

You will probably experience some frustrations in trying to make the interface work. However, when you finish you will probably know more about how your computer works than you ever thought possible.

Applications

Typical applications for such an interface include peripheral devices where up to 24 I/O bits are required. This might be as simple as an 8-bit parallel interface needing only a strobe and acknowledge signal (which is a clearly defined mode 1 for the 8255), or as complex as the Diablo printer interface which requires 12 data lines, 6 status lines and 6 strobes. In fact, it is difficult to conceive a parallel device which could not be interfaced with this circuit.

In conclusion, for any interface application you have in mind, check first to see what special large-scale integration devices are available. You might find that the entire design can be accomplished through the use of one of these special parts. For more data I recommend the 8080 series applications manuals from Intel Corp, National Semiconductor, and Texas Instruments, and also Don Lancaster’s TTI Cookbook and manufacturers data sheets on the 8833 and 8131. Good luck!

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Stereoscopic Plotting by Computer

When I was small, I visited my grandmother’s house on a hill in Salem, Oregon. The house was just below a peak of the steep hill, and on the peak was a large fir tree. From high in that tree, using my uncle’s binoculars (not authorized for use in trees!), I could look out over Salem on a summer day and see Mt Hood floating above the horizon. Its white cone was hazy and immense. Between me and the mountain lay 60 miles of town and country, looking like artificial scenery painted on layers of glass, one stacked close behind another. The binoculars compressed perspective, just as they magnified lateral dimensions, squeezing those 60 miles of hills, ridges, and forest into what looked like about a thousand yards.

Inside my grandmother’s house was another marvel, also a binocular device: a stereopticon and a huge collection of pictures to look at. The effect was just the opposite of the scene from the tree with the binoculars. A card holding 2 flat and apparently identical pictures was slipped into the frame. Holding the device by its wooden handle and slipping the cupped eyeshield over my eyes, I saw the flat pictures turn into startling solid objects in a world that lay beyond the translucent frame of the pictures, extending from arm’s reach to at least the distance of Mt Hood. Some were frightening views down cliffs in the mountains of Switzerland, where my grandmother was born.

I was about 6 or 7 when I discovered the stereopticon, and was soon told that using it so much was bad for my eyes. When that pronouncement was made, the viewer was put away. However, I knew where the pictures were, and quickly developed a skill that was probably worse for my eyes. I learned to look at them walleyed, and to fuse the pictures without the viewer. You can learn to see the stereo pairs described in this article that way if you like; you can also do it by crossing your eyes. It takes patience and practice, since you have to uncouple the focus of your eyes from their convergence (normally, when we converge our eyes to see something close, the lenses automatically focus for near distance). In a stereo pair of pictures, all the objects are at the same distance, and you have to learn to keep them in focus independently of the convergence of your eyes. I learned to do that when I was 7, so you can probably learn to do it, too. In case it is too much of a strain, we will have a look at a simple viewer that is easy to put together. I use the viewer because it gives better depth.

Illinois in the winter of 1978 was a long way from the clear, warm summer days in Oregon in the early 1930s. However, when I bent over the drawings my computer had produced (using the objective lenses from an inexpensive pair of binoculars balanced on a pair of rulers as a viewer), and saw the tangled lines sink below the paper and stand in space above it, I felt a pang of joy that connected me instantly with that small boy in Oregon long ago. We get bigger and change shape, but the important things stay the same. That is the real reason for writing this article. It is for phenomenon fans.

Calculating Stereo Plots

To make a stereo picture, construct 2 views of the same 3-dimensional object as seen from each of a viewer’s eyes. Placing a picture in front of each eye, you see the 2 images fused. In order to fuse near objects, your eyes have to converge just as for the real object, since near objects are displaced more (to the side opposite the viewing eye) in the 2 pictures, than are the actual far objects. The most natural viewing requires using 2 identical lenses, one in front of each eye, and a cardboard shield to keep each eye from noticing the wrong picture.

Stereo effects arise from image displacements left and right; in the vertical dimension, stereo pictures are essentially identical. The size of the vertical dimension shrinks as the distance to the object increases, but by the same amount for both eyes.

Figure 1 shows the situation from the top of the viewer’s head. The actual pictures will be at some fixed distance, Z0, from the person’s eyes or the lenses of the viewer. Letting the horizontal direction in the plane of the person’s eyes be the X axis (with the origin lined up with the nose), and the Z axis be the direction away from the nose (up, in figure 1), it can be determined where the image of any point in space will be in the picture.

The coordinates of a point (X,Z) are shown in figure 1. This point forms the farthest corner of a right triangle, the other far corner being directly ahead of the person’s left eye, and a distance E left of the Z axis (for this eye, E will be a negative number, being to the left). The length of the far side of the right triangle is thus (X-E).

The corresponding point on the paper is (X1, Z0). X1 is the X position.
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Figure 1: Geometry of generating stereo pictures. Each point of the object to be pictured is projected along the line of sight to the plane in which the picture will be drawn.

where the line of sight to (X,Z) pierces the picture. A smaller right triangle is formed, with (X1,Z0) as the farthest corner and (E,Z0) as the other far corner. The far side of this triangle has a length of (X1 - E).

By similar triangles, we thus have:

\[
\frac{X1 - E}{X - E} = \frac{Z0}{Z}
\]

or

\[
X1 = \frac{(X - E) \times Z0}{Z} + E
\]

That transfers any point at a distance X to the right of center (or -X to the left) and any distance Z from the person's nose into the plane of the picture. For the picture seen by the left eye, E is a negative number (half the distance from eye to eye), and for the other picture E is positive.

The Y dimension (up and down from the person's point of view) is handled exactly the same way, with the exception that there is no displacement of the eyes above or below the centerline of the picture; in effect, E is 0, and Y is substituted for X in the equation above. That yields:

\[
Y1 = Y \times \frac{Z0}{Z}
\]

With these 2 elementary equations we can transform any point with coordinates X,Y,Z into a point X1,Y1 for each eye to view. Then, running X, Y, and Z through space to trace out a figure, we can generate the 2 pictures in terms of X1 and Y1, to produce a pair of stereo pictures.

Constructing Pictures
If you do not have an X,Y plotter, you can still make perfectly good stereo pictures using straight lines. For example, to make a cube, first calculate the coordinates of the 8 corners of the cube as X,Y,Z coordinates. Then apply the above equations to convert each X,Y,Z triple into an X1,Y1 pair. Do this twice, once with E set to about -1.25 inches and then with it set to +1.25 inches (a typical interocular [between the eyes] distance is about 2.5 inches, close enough). Z0 is set to the viewing distance you plan to use, or the focal length of the viewing lenses. Plot the 2 sets of points on graph paper. A simple BASIC program will make the conversions easy.

Finally, and with great care, use a felt-tipped pen or pencil and ruler to connect the points that correspond to edges of the cubes in the 2 views; straight lines are transformed into straight lines. Voila! View the pictures stereoscopically, and you have a 3-dimensional cube. Thick lines work better than thin ones, but try to keep the width uniform.

If you have a high-resolution graphic display such as the Apple computer has (and if the display is not too nonlinear), you can make plots and view them directly on the screen. I have a 15 year old X,Y pen plotter which shakes a little, but still produces fairly accurate lines, and the program given here is for that device. I have computed a few stereo pairs for your amazement. The program I used can make 3-dimensional Lissajous figures with a few modifications you can easily enhance, if you wish. This program is shown in listing 1.

Tips on Producing Pictures
It is difficult to get a good stereo effect if there is too much distance between near and far parts of the same object. I have found that with a viewing distance of 6 inches from the generated pictures, a good object will fit into about an 8 inch cube at an average real distance of about 30 inches.

This size limitation is also important because the object must be small enough that both eyes can see all of it. An object that is too large will have its images displaced toward each other enough to overlap, which spoils the effect. The object in real space must fit into the shaded region of figure 1. The program will do odd things if figures get outside that limit. Human binocular vision works best for objects closer than 20 feet, so place the objects accordingly.
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Sonja Richman - Age 9

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Listing 1: Stereo plotting program in North Star BASIC. The picture coordinates are first generated and stored, then the stored list of coordinates is scanned and plotted.

10 REM PROGRAM FOR GENERATING 3D STEREO IMAGE PAIRS
20 REM WILLIAM T. POWERS, DECEMBER 1978
30 REM
40 REM
50 REM SET Z0 TO FOCAL LENGTH OF VIEWING LENSES OR VIEWING DISTANCE FROM EYES IF NO LENSES USED
60 REM
70 REM Z0=6
80 H=100\K=3.141S926S4/180\K1=100\K2=2*3.141S926S4\0=2.S\M1=0
90 DIM X#9F2
100 REM * * * * * * * * * *
110 REM DEVICE 31= PEN LIFT
120 REM DEVICE 30= Y OUTPUT
130 REM DEVICE 29= X OUTPUT #1
140 REM DEVICE 28= X OUTPUT #2
150 REM * * * * * * * * * *
160 REM
170 REM * * * * * * * * * *
180 REM SET PLOTTING PARAMETERS
190 REM * * * * * * * * * *
200 OUT 31,0\Z9=SINCSINCSINCSINC1)))
210 INPUT "X, # CYCLES: ",N1\N1=N1*K2/100
220 INPUT " PHASE: ",P1\P1=R1*K\IF P1<0 THEN P1=R1+K2
230 INPUT SIZE: ",S1\ S1=S1/2
240 INPUT " POSITION: ",D1
250 INPUT "Y, # CYCLES: ",N2\N2=N2*K2/100
260 INPUT PHASE: ",P2\P2=R2*K\IF P2<0 THEN P2=R2+K2
270 INPUT SIZE: ",S2\ S2=S2/2
280 INPUT " POSITION: ",D2
290 INPUT "Z, # CYCLES: ",N3\N3=N3*K2/100
300 INPUT PHASE: ",P3\P3=R3*K\IF P3<0 THEN P3=R3+K2
310 INPUT SIZE: ",S3\ S3=S3/2
320 INPUT " POSITION: ",D3
330 INPUT " LINEAR,K4*T: ",K4
340 Q=127\GOSU8 960\HIPUT "SET PEN, HIT RETURN",A$
350 REM
360 REM * * * * * * * * *
370 REM FIGURE GENERATION
380 REM * * * * * * * * *
390 FOR E=-0/2 TO 0/2+.01 STEP 0
400 OUT 31,0\Z9=SINCSINCSINCSINC1)))
410 P1=R1\P2=n2\P3=R3\T=O\D=O\M1=n
420 G=1+KS*T
430 Z=S3*G*SINCN3*T+P3)+D3+K4*T
440 X=S1*G*SINCN1*T+P1)+D1
450 Y=S2*G*SINCN2*T+P2)+D2
460 GOSUB 770\T=T+D\IF T>100+D THEN 10 ELSE 460
470 GOSUB 770\Q=128\NEXT
480 OUT 31,40\OUT 28,Q\NEXT
490 REM * * * * * * * * *
500 REM PLOT STORED IMAGE
510 REM * * * * * * * * *
520 PRINT "Listing 1 continued on page 146"

The maximum horizontal dimension in inches for an object at a distance of Z inches is:

\[ X_{\text{max}} = 2.5 \times (Z - Z_0)/Z_0. \]

For Z0=6 inches, as in my system, this works out to a width of 10 inches at 30 inches distance, 20 inches at 54 inches distance, and 30 inches at 78 inches distance.

**How to View Stereo Pairs**

The easiest viewing method is to cross the eyes or let them diverge (either will work, although the picture turns inside out if you cross the eyes). This requires practice, and I suppose it is bad for the eyes. (I am not an ophthalmologist and neither was my grandmother.) It is less of a strain to use a pair of lenses; here is a way to do it.

To make my kludge-variety viewer, I unscrewed the objective lenses from a pair of Squire 7 by 35 binoculars. These lenses have about a 6 inch focal length. You can measure the focal length with a ruler, measuring from the lens to a sharp image of a distant scene on a sheet of paper. Support the 2 lenses above the plane where the generated stereo pair is to be placed, the distance being the focal length of the lenses. This distance becomes Z0 in the equations, in inches. Any pair of lenses about 1 to 2 inches in diameter and having about a 4 to 10 inch focal length will do. View with your eyes as close to the lenses as possible.

I supported the lenses by laying 2 rulers across 2 stacks of books, far enough apart to support the lenses without obscuring too much of the field. I taped the ends of the rulers to pieces of cardboard, so they could be moved as a unit with the lenses supported over the gap. Sliding the 2 lenses together and apart permits fairly major adjustments to be made. This will accommodate different interocular distances to get the best stereo effect with the least effort. Of course, if you have steady hands you can just hold the lenses.

It is essential to have the pictures aligned in the vertical direction, which is done by tilting your head left or right, or by moving a lens slightly up, while moving the other slightly down. Once the images are fused in your perception, you can tolerate...
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Listing 1 continued:

710 REM ******* STORE IMAGE POINTS AS ASCII STRING *******
720 REM NEXT TWO LINES PLOT STEREO POSITION
730 REM ******* MAINTAIN CONSTANT RESOLUTION *******
740 REM ON PLOT
750 U=ZO/Z
760 X=(X-E)*U*K1 \ Y=Y*U*K1
770 REM NEXT 3 LINES ADJUST STEP SIZE
780 D=D+(2.8-ABS(X-L1)-ABS(Y-L2))/K1
790 IF D<0 THEN D=0
800 L1=X \ L2=Y
810 REM BIAS X AND Y FOR CONVERSION TO ASCII
820 REM ZERO PEN FOR POSITIONING (CENTER)
830 REM FOR J=1 TO 510 OUT 29,0 OUT 30,0 OUT 28,0
840 Z9=SIN(SIN(SIN(1))) \ NEXT \ RETURN

about 5 degrees of mismatch in tilt, but that is after they fuse. Do not be impatient. Simple artificial pictures, which lack richness of detail and nonbinocular distance cues, take the brain a while to figure out. Pictures will not just suddenly jump into 3 dimensions. Instead, they gradually ooze into shape, the impression of depth growing stronger the longer you look. It gives interesting insight into the depth perception process used by the brain. Once the depth appears, you can look away and back and not lose it, and you can move your eyes all around freely. It seems that the brain gradually constructs a model of the object. When you switch from looking at one part to looking at another part, the convergence of the eyes becomes automatic, anticipating what is required for various parts of the picture.

Program Notes

The accompanying program of listing 1 is written in North Star BASIC. In order to make the plotting pen move fast enough to make clean traces without spreading the ink, I have done the process in 2 stages: first the picture is generated and stored; then the stored list of X,Y coordinates is scanned and plotted. This is done for each picture, left and right, in turn. If you want to plot directly (as you would do on a video display screen where plotting speed is essentially instant), you can eliminate the storage phase (GOSUB 770 in line 500) and substitute a call to the plotting subroutine. You would also delete the GOSUB 570 in line 510. The plotting subroutine would consist of lines 770 and 780 followed by the commands to plot X and Y, and a RETURN statement — much simpler.

My analog output is generated with a Cromemco D+7A board, which can produce 7 independent outputs. The digital-to-analog converters (DACs) have only 8 bits of resolution, and my plotter can plot about 100 points per inch. To get the maximum possible resolution I have used 2 analog outputs for the X axis. One, device 28, simply puts out either \(-2.56\) V or \(+2.56\) V; the other, device 29, puts out the same range of voltages representing the variations in Y. This makes it possible to plot each picture, left and right, with the full resolution of 256 elements. The recorder has a voltage differential input, so device 28 goes to the negative input and device 29 to the positive input.

In lines 370 and 510 you will observe a variable Q that is set to 127 for the left picture and 128 for the right picture. A value of 127 output to a converter corresponds to the maximum positive voltage of \(2.55\) V.
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Applied to the negative recorder input, this biases the pen to the left. A value of 128 (hexadecimal 80) corresponds to -2.56 V, and biases the pen to the right.

Lines 770 and 780 do the actual conversion from X,Y,Z coordinates to X,Y stereo coordinates. You will notice that the equation for the stereo value of X is not quite the same as the above equation; the added constant E has been left off. This results in the picture being plotted relative to the point straight ahead of the relevant eye in the X direction; this permits the highest possible resolution. The auxiliary X output from device 28 inserts the missing value of E into the plot. If you are plotting on a high-resolution video display, you can write the first statement in line 780 as:

\[ X = ((X - E) \times U + E) \times K_1 \]

and eliminate all statements involving Q (in lines 370, 510, 670, and 690). At the same time, the scale factor K1 (line 90) should be adjusted to reflect the actual number of points per inch on the display. I ran the recorder at 2 V per inch, which works out to K1 = 100; if I had not used device 28, I would have run at 1 V per inch and used K1 = 50.

The plotting parameters are set in lines 220 to 360. For X, Y, and Z the program asks for the number of full sine wave cycles to be plotted, the phase angle at which each variable is to start (in degrees), the size of each plot in inches (from left edge to right edge, bottom to top, or near to far), and the position of the center of the range of variation of each plot.

For the Z axis only, there is also a linear term that is requested: the constant K4 sets it. For every plot, the parameter T runs from 0 to 100, and the Z coordinate has the amount K4 \times T added to it. Thus if K4 is 1, the Z coordinate will have 100 inches added to it by the time the plot finishes. If the Z size is set to 0, the Z coordinate will move linearly away from the viewer during the plot.

The last item requested is a size factor. The size of the pattern for all 3 variables is multiplied by a variable G, computed from G = 1 + K5 \times T,

Figure 2: Pen lift circuit for use with digital-to-analog converter driver. The PNP transistor serves as switch; NPN driver transistor amplifies low-level input for high-voltage switch.

---

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where K5 is the size factor. If K5 is -0.01, G will range from 1 to 0 during each plot. That means the picture will start out full-size, and shrink to a point just as the plot finishes. If K5 is 0, there will be no change in size.

**Use of String Variables**

Some plots take many points; I have allowed for 3000, or 1500 X, Y pairs. A floating-point representation would need 15,000 bytes of storage. That is more than I have, so I converted each variable to character format and stored the results as a character string, 1 byte per coordinate instead of 5. The function CHRS will convert a floating-point number between 0 and 255 to the character format needed for strings. The ASC function will perform the reverse operation. The program scales X and Y to a positive or negative number (you must pick sizes and distances to keep this number within the range of -128 to +127 units, or 1/K1th of that amount in "real space"). This number is biased up by 128 (has 128 added to it), which is subtracted out when the stored number is recovered.

**Miscellany**

Before each plot begins, there is a pause to allow the pen to be set (with the positioning controls) to a point midway between the 2 pictures that will result. One run plots both pictures, the pen lifting as necessary. You will need some type of circuit to allow one analog output to operate the pen lift; mine is shown in figure 2.

Lines 840 thru 860 in listing 1 are a little feedback "circuit" that adjusts the step size in T (the parameter that runs from 1 to 100 during a plot) to maintain about 2 resolution elements of step size on the final plot. If the difference between the current and the last positions of the pen is larger than 2, the step size decreases. If the difference is less than 2, the step size increases. Rather than computing the square root of the sum of the squares of X and Y steps to get the actual step size, I merely summed the absolute values of the step sizes, which is close enough and much faster. This saves time that would otherwise be wasted plotting the same point over and over.

Even so, this is a very slow program. A plot with 6 loops in it takes about 10 minutes to store. Then a picture is plotted, and you must wait the same length of time for the second picture to be plotted. Practical production of 3-dimensional motion pictures requires a faster program.

Suitable lenses can be bought from the American Science Center, 5700 Northwest Hwy, Chicago IL 60646. The stock number is 95-697, which gets you a pair of lenses 23 mm in diameter and having a focal length of 136 mm (that gives a ZO of 5.35 inches). The price is $2.70. Cash orders require a minimum of $5.00 and a flat handling charge of $1.00, so you will want to order with a friend or get something else from this very interesting catalog. Edmund Scientific Co, 300 Edscorp Bldg, Barrington NJ 08007 also carries these items.

---

Figure 3: Plot of Lissajous pattern produced by BASIC program of listing 1, driving an analog recorder. Parameters follow in the order requested by the program. For X: cycles=3, phase=0, size=B, position=0; for Y: cycles=8, phase=0, size=B, position=0; for Z: cycles=5, phase=0, size=B, position=30, linear=0; size factor=0.

Figure 4: Spiral plot. Parameters in order are, for X: cycles=4, phase=0, size=B, position=0; for Y: cycles=8, phase=90, size=B, position=0; for Z: cycles=0, phase=0, size=0, position=30, linear=0.5; size factor= -0.01.

Figure 5: Plot with cardioid. Parameters are, for X: cycles=3.25, phase=0, size=9, position=0; for Y: cycles=3.25, phase=90, size=9, position=0; for Z: cycles=0, phase=0, size=0, position=30, linear=0.3; size factor= -0.03.
This article is dedicated to the small system users who are faced with multiple variable data tables and who have a desire to curve fit (regress) these data into simple functional forms. The basic software problems facing such users are:

1. The powerful general purpose statistical packages available on the large computers are often not in source code (e.g., BASIC or FORTRAN) for translation to a microcomputer language.
2. If the packages are available, they are often very complicated to use. There is a human language barrier.
3. The large machine software may not be directly compatible with translation to a small machine language (e.g., there may be calls for matrix inversions which are not internal functions in the small system).
4. There are limitations in the types of functions fitted (e.g., polynomials only) in multiple dimensions.

In the following sections we will discuss an approximate approach to the least squares fitting of multiple-dimension data. The technique presented depends only on the availability of a good one-dimensional curve fitting routine and requires some bookkeeping on the part of the user. Admittedly, the approach leads to statistical fits which are not optimal, but the ease of use and versatility of the method strongly counter this negative feature. An example will be given which quantitatively indicates the magnitude of the shortfall of the fit; the results are encouraging.

A significant advantage to the method to be discussed is that it is simple. If users understand what their one-dimensional curve fitting routine does, or at least understand how to use it, then the conceptual and practical extension to many dimensions is relatively easy.

For those who have had little experience with regressing data into functional forms, we will first consider parabolic (second order polynomial) approximations to one-dimensional data using a fairly straightforward mathematical analysis. The analysis results will then be converted into a simple computer program which will in turn be used to treat a noisy two-dimensional data set consisting of 121 data points. [Noise results from the random fluctuation of experimental data. . . .BWL] This data will be collapsed down to a set of nine coefficients belonging to the equations which represent a two-dimensional polynomial fit to the data. Extension to more dimensions will be apparent after this exercise.

Least Squares Fit of a Parabola

Although the mathematics presented in this section is reasonably simple, there are some readers who may not enjoy it. Those people may advance to the next section without great loss. For those interested in Nth order polynomial fits, see *BASIC Programming for Scientists and Engineers* by
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Listing 1 continued:

170 IF I<3 THEN GOTO 110
180 DIM X(I),Y(I)
190 PRINT
200 PRINT "THERE ARE TWO INPUT OPTIONS. ONE (1)"
210 PRINT "VALUES, LATER FOLLOWED BY THE DEPENDENT"
220 PRINT "WHICH MODE DO YOU DESIRE? (1 OR 2): ",
230 INPUT Z
240 IF Z=2 THEN GOTO 290
250 IF Z=1 THEN GOTO 220
260 GOTO 250
270 FOR M=0 TO I-1
280 PRINT M+1,
290 INPUT X(M)
300 NEXT M
310 FOR M=0 TO I-1
320 PRINT M+1,
330 INPUT Y(M)
340 NEXT M
350 GOTO 200
360 FOR M=0 TO I-1
370 PRINT M+1,
380 INPUT X(M),Y(M)
390 NEXT M
400 REM BEGINNING OF
410 A0=1\Al=0\A2=0\A3=0
420 REM U,V,W ARE THE DESIRED COEFFICIENTS
430 U=0\V=0\W=0
440 D=0
450 FOR M=0 TO I-1
460 A1=A1+X(M)
470 A2=A2+X(M)*X(M)
480 A3=A3+X(M)*X(M)*X(M)
490 A4=A4+X(M)*X(M)*X(M)*X(M)
500 B0=B0+Y(M)
510 B1=B1+Y(M)*X(M)
520 B2=B2+Y(M)*X(M)*X(M)
530 B3=B3+Y(M)*X(M)*X(M)*X(M)
540 NEXT M
550 D=D/I
560 U=U/I
570 V=V/I
580 W=W/I
590 REM BEGINNING OF LEAST SQUARE CALCULATION
600 "FIT: "
610 IF I**3 THEN GOTO 600
620 IF I**2 THEN GOTO 600
630 END


The purpose of doing a particular one-dimensional least squares example is to show how a curve fitting routine may generally be developed using brute force (no tricks) techniques which require little deep thought, just competent algebra.

It is always possible to exactly fit a reasonably well-behaved data set using a carefully chosen polynomial of the proper degree (highest power). For example, if the independent continuous variable is \( x \) (e.g., age), and the resultant dependent variable response is \( y = f(x) \) (e.g., height), it is legitimate to write (assuming that the "true" function has no poles or discontinuities):

\[
y = \sum_{m=0}^{M-1} a_m x^m
\]

To be sure that this approximation works well we may have to let \( M \) become infinitely large. However, for an \( I \) component data set, \( \{y_i, x_i\} \), where \( x_i \) is the particular independent variable value (e.g.: the age of a specific person) and \( y_i \) the particular response (corresponding height of that person), the data may be exactly fitted using a polynomial of degree \( M-1 = I-1 \).

The proof of this assertion is simple. Assume we do not know the coefficients \( a_m \). However, for each of the \( I \) data points we have:

\[
y_i = \sum_{m=0}^{I-1} a_m x_i^m
\]

Each \( y_i \) is known. Each \( x_i^m \) is known. There are thus \( I \) (simultaneous) equations in \( I \) unknowns (the \( a_m \)), and equation (2) may be exactly satisfied with a proper (and unique) choice of \( a_m \) values (coefficients). Thus the data is fitted exactly.

Although the above conclusion is very powerful, it lacks direct applicability in many real life statistical situations. For example, if there are 20 pieces of data containing noise, it would be a little foolish to fit a 19th degree polynomial to the data. Usually the objective is to smooth out large and noisy data sets into curves having only a few descriptive constants (coefficients). We will consider here only the second degree polynomial (parabolic) case:

\[
y = a_0 + a_1 x + a_2 x^2
\]
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degree of the polynomial. That is, in general $y_i \neq f(x_i)$. However, intuitively we know that there must be a best choice for $a_0, a_1,$ and $a_2$, given some fitting criteria. The criteria often used is least squares. We define the least squares error as:

$$E(a_0, a_1, a_2) = \sum_{i=0}^{l-1} \left| y_i - f(x_i) \right|^2 \quad (3a)$$

where, in this particular case,

$$f(x_i) = a_0 + a_1 x_i + a_2 x_i^2 \quad (3b)$$

Listing 2a: Sample run of listing 1 in which the data was created using $y=x$.

RUN

LEAST SQUARES CURVE FIT ROUTINE

THIS PROGRAM CALCULATES A PARABOLIC LEAST SQUARES FIT TO A GIVEN DATA SET.

INSTRUCTIONS

-------------

THE NUMBER OF DATA COORDINATES PROVIDED MUST BE GREATER THAN THREE. OTHERWISE, A DIVIDE BY ZERO ERROR MAY RESULT.

INPUT THE NUMBER OF DATA POINTS: ?10

THERE ARE TWO INPUT OPTIONS. ONE (1) INPUTS THE DATA POINTS IN COORDINATE PAIRS, AND THE OTHER (2) ALLOWS ONE TO FIRST INPUT THE INDEPENDENT VARIABLE VALUES, LATER FOLLOWED BY THE DEPENDENT WHICH MODE DO YOU DESIRE? (1 OR 2): ?1

1?1,0
2?1,1
3?2,2
4?3,3
5?4,4
6?5,5
7?6,6
8?7,7
9?8,8
10?9,9

FITTED EQUATION IS:

$Y = 0.0000 + 1.0000X + 0.0000X^2$

STANDARD DEVIATION OF FIT: 0.0000

READY

Listing 2b: Sample run similar to listing 2a, but with $y=x^2$.

RUN

LEAST SQUARES CURVE FIT ROUTINE

THIS PROGRAM CALCULATES A PARABOLIC LEAST SQUARES FIT TO A GIVEN DATA SET.

INSTRUCTIONS

-------------

THE NUMBER OF DATA COORDINATES PROVIDED MUST BE GREATER THAN THREE. OTHERWISE, A DIVIDE BY ZERO ERROR MAY RESULT.

INPUT THE NUMBER OF DATA POINTS: ?10

THERE ARE TWO INPUT OPTIONS. ONE (1) INPUTS THE DATA POINTS IN COORDINATE PAIRS, AND THE OTHER (2) ALLOWS ONE TO FIRST INPUT THE INDEPENDENT VARIABLE VALUES, LATER FOLLOWED BY THE DEPENDENT WHICH MODE DO YOU DESIRE? (1 OR 2): ?1

1?1,1
2?2,4
3?3,9
4?4,16
5?5,25
6?6,36
7?7,49
8?8,64
9?9,81
10?10,100

FITTED EQUATION IS:

$Y = 0.0000 + 0.0000X + 1.0000X^2$

STANDARD DEVIATION OF FIT: 0.0000

READY
These simultaneous equations can be solved using Cramer’s Rule (see texts on matrix algebra) to give:

\[ a_0 = \left\{ B_0(A_2A_4-A_3^2) \right\} /D + \left\{ B_1(A_3A_2-A_4A_1) + B_2(A_1A_3-A_2^2) \right\} /D \]
\[ a_1 = \left\{ B_0(A_3A_2-A_1A_4) \right\} /D + \left\{ B_1(A_0A_4-A_2^2) + B_2(A_2A_1-A_0A_3) \right\} /D \]
\[ a_2 = \left\{ B_0(A_1A_3-A_2^2) \right\} /D + \left\{ B_1(A_1A_2-A_0A_3) + B_2(A_0A_2-A_1^2) \right\} /D \]

where:

\[ D = A_0(A_2A_4-A_3^2) - A_1(A_1A_4-A_2A_3) + A_2(A_1A_3-A_2^2) \]

and:

\[ A_0 = 1 \]
\[ A_s = \sum_{i=0}^{l-1} x_i^2 / l \]
\[ B_s = \sum_{i=0}^{l-1} y_i x_i^2 / l \]

These equations are encoded into the program shown in listing 1. Listing 2a shows a sample run in which the relation \( y=x \) was used to create the data. The program correctly interpreted the data and returned \( y=x \) as the fitted function. In this example there was no \( x^2 \) term. Listing 2b demonstrates a similar test run, but this time using \( y=x^2 \) to create the data. Again, the program returns the proper coefficients.

Listing 2c displays a least squares fit to data generated using the function \( y=x+e \), where \( e \) flips back and forth between +1 and -1; very noisy data. The regression program indicates the fitted functional form to be linear with a first power (linear) coefficient near unity, and with a standard deviation approximately equal to \( e \). When the same data sets are run through a standard Nth order regression routine, the coefficient values obtained were approximately the same as shown in listings 2a and 2b. However, significantly different coefficients are obtained for the case corresponding to listing 2c. The fitted equation given by the program is:

\[ Y = - .2727 + 1.0606 x + .0000 x^2 \]

\[ \text{STANDARD DEVIATION OF FIT: 1.0380} \]

Listing 2c: Least squares fit to a noisy line: \( y=x+e \).

RUN

LEAST SQUARES CURVE FIT ROUTINE

THIS PROGRAM CALCULATES A PARABOLIC LEAST SQUARES FIT TO A GIVEN DATA SET.

INSTRUCTIONS

-------

THE NUMBER OF DATA COORDINATES PROVIDED MUST BE GREATER THAN THREE. OTHERWISE, A DIVIDE BY ZERO ERROR MAY RESULT.

INPUT THE NUMBER OF DATA POINTS: ?10

THERE ARE TWO INPUT OPTIONS. ONE (1) INPUTS THE DATA POINTS IN COORDINATE PAIRS, AND THE OTHER (2) ALLOWS ONE TO FIRST INPUT THE INDEPENDENT VARIABLE VALUES, LATER FOLLOWED BY THE DEPENDENT WHICH MODE DO YOU DESIRE? (1 OR 2): ?1

170.1, -1
271.2
372.1
473.4
574.3
675.6
776.5
877.8
978.7
1079.10

FITTED EQUATION IS:

\[ Y = - .2727 + 1.0606 x + .0000 x^2 \]

READY
Poole-Borchers regression is (when run on North Star BASIC, Release 2, Version 3):

\[ y = 0.34545452 + 0.8015152x + 0.02727268x^2 \]  

These coefficients have some interesting repeating number sequences, but that is not a good reason to condemn them. However, using the above regression equation and calculating the standard deviation between the fit predictions and the input data gives a standard deviation of 1.0869, as compared with a value of 1.0380 obtained using the Cramer's Rule algorithm shown in listing 1.

It is apparent that the program given in this article provides a better fit than that of Poole and Borchers. The discrepancy is probably due to the errors which occur when the square is evaluated using \( x \land 2 \) (as in Boolean-Borchers algorithm) instead of \( x \times x \), which is more accurate.

It is also interesting to note that although the two sets of coefficients obtained from the two different algorithms are quite disparate, the fits (as measured by the standard deviation) are similar. When data is very noisy, a range of equations may fit the data to similar precision; the polynomial coefficients obtained should not be treated as significant to very many decimal places.

Listing 3: Two-dimensional data set containing noise. This set was created in a well-defined way such that the fit obtained could be compared against the original function.
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This is one of the dangers in curve fitting and placing great value on the results, especially when mathematically exact algorithms can be waylaid by calculation error.

In the next section we will consider how to use the one-dimensional least squares routine for fits in many dimensions.

Parabolic Fits in Many Dimensions

To examine how the one-dimensional least squares routine may be used (in approximation) in many dimensions, we will first consider the two-dimensional case.

Let $x_i$ and $y_i$ be the independent variables, and $z_i$ be the dependent variable. The parabolic fit desired is:

$$ z_i = f(x_i, y_i) = b_0(x_i) + b_1(x_i)y_i + b_2(x_i)y_i^2 \quad (7) $$

where:

$$ b_0 = a_{00} + a_{10}x_i + a_{20}x_i^2 \quad (8a) $$

$$ b_1 = a_{01} + a_{11}x_i + a_{21}x_i^2 \quad (8b) $$

$$ b_2 = a_{02} + a_{12}x_i + a_{22}x_i^2 \quad (8c) $$

Ideally we would choose the nine $a_{nm}$ coefficients such that

$$ \sum_{i=0}^{I-1} \left\{ z_i - f(x_i, y_i) \right\}^2 $$

is minimized. In other words, we wish to minimize the sum of the squares of the distances between predicted and actual data points. However, if the data is arranged in a tabular form, such as shown in listing 3, a quasi-least squares fit can be obtained one dimension at a time.

The way this is done is that for each $x_i$ we regress $z_i$ (the dependent variable) against $y_i$ (the independent variable) to obtain a least squares set of $b_0(x_i), b_1(x_i)$ and $b_2(x_i)$. Next, we treat $b_0(x_i)$ as a dependent variable and regress against $x_i$ (the remaining independent variable) to get $a_{00}, a_{01}$ and $a_{02}$. The same is done for $b_1(x_i)$ and $b_2(x_i)$.

For the data shown in listing 3, the first regression step yields the $b_n(x_i)$ values given in table 1. Each coefficient column in table 1 is then regressed against $x_i$ to give the nine coefficients listed in table 2. These coefficients may be used with equations (8a), (8b) and (8c) to obtain the regression indicated by equation (7).
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Because we did the regression in two steps, the least squares criteria taken as a whole haven't been satisfied. Thus the coefficients obtained are not optimal, as will be seen shortly.

It should be noted in passing that the blocks of data (for each $x_i$) are equal in length. This is not a requirement for validity of the technique. What is necessary is that there be at least three independent data points in each $x_i$ block. Otherwise $D$ in equation (Sd) becomes 0, and a divide error will result. Also observe that the $x_i$ and $y_i$ increments need not be equal or uniform. Few restrictions are placed on the data.

The precision of the regression fit may be assessed using the standard deviation associated with the difference between the predicted data values and the actual data. This gives 0.23, or roughly 3 percent accuracy, which is encouraging.

The equation used to generate the noisy two-dimensional data was:

$$z = 6x^2y^2 - 3xy^2 + 4y^2 - 2x + 3y$$

$$-1.9 + 0.2(RND(0) - 0.5) \quad (9)$$

The standard deviation of the noise term is 0.06. Thus the 2 step fitting procedure is not as good as it could possibly be; 1 percent accuracy could be obtained using the non-random part of equation (9); a better fit.

<table>
<thead>
<tr>
<th>$x_i$</th>
<th>$b_0(x_i)$</th>
<th>$b_1(x_i)$</th>
<th>$b_2(x_i)$</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>-1.8758</td>
<td>2.9021</td>
<td>4.0807</td>
<td>0.05</td>
</tr>
<tr>
<td>0.1</td>
<td>-2.2677</td>
<td>3.1672</td>
<td>4.2349</td>
<td>0.24</td>
</tr>
<tr>
<td>0.2</td>
<td>-2.4542</td>
<td>3.2702</td>
<td>3.6614</td>
<td>0.24</td>
</tr>
<tr>
<td>0.3</td>
<td>-2.7791</td>
<td>3.7056</td>
<td>3.5807</td>
<td>0.24</td>
</tr>
<tr>
<td>0.4</td>
<td>-2.9875</td>
<td>3.5408</td>
<td>3.8768</td>
<td>0.23</td>
</tr>
<tr>
<td>0.5</td>
<td>-3.2118</td>
<td>3.5623</td>
<td>4.0746</td>
<td>0.23</td>
</tr>
<tr>
<td>0.6</td>
<td>-3.4316</td>
<td>3.5360</td>
<td>4.5941</td>
<td>0.24</td>
</tr>
<tr>
<td>0.7</td>
<td>-3.5456</td>
<td>3.2876</td>
<td>5.2203</td>
<td>0.25</td>
</tr>
<tr>
<td>0.8</td>
<td>-3.5010</td>
<td>3.3066</td>
<td>5.8698</td>
<td>0.27</td>
</tr>
<tr>
<td>0.9</td>
<td>-4.0544</td>
<td>3.1017</td>
<td>6.9178</td>
<td>0.28</td>
</tr>
<tr>
<td>1.0</td>
<td>-4.2911</td>
<td>3.4786</td>
<td>7.4185</td>
<td>0.31</td>
</tr>
</tbody>
</table>

Table 1: First level regression coefficients.

$$a_{4m}$$

<table>
<thead>
<tr>
<th>$m$</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>Standard Deviation</th>
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</thead>
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<td>1.9433</td>
<td>-2.7209</td>
<td>0.4263</td>
<td>0.05</td>
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<tr>
<td>1</td>
<td>3.0110</td>
<td>1.8648</td>
<td>-1.6931</td>
<td>0.17</td>
</tr>
<tr>
<td>2</td>
<td>4.2540</td>
<td>-3.6091</td>
<td>6.9833</td>
<td>0.18</td>
</tr>
</tbody>
</table>

Table 2: Nine regressed coefficients corresponding to equations 8a, 8b, and 8c in text.

Conclusions

The multidimensional curve fitting technique presented in this article depends only on the existence of a good one-dimensional least squares routine. The form of the least squares fitting function can be different for each dimension regressed. Often the form can be chosen by either an understanding of the causal relationships, or by simply scanning the data.

The user who has some familiarity with algebra and calculus can generate a least squares fit for other functional forms using the simultaneous equation technique shown herein. Recall that the equations were obtained by considering the error to be a function of the coefficients, and partial derivatives were taken with respect to each coefficient.

In conclusion, this article presents a general technique for generating one-dimensional least squares fitting algorithms, and shows how such algorithms may be used to regress multidimensional data.\[\text{\textcopyright October 1979 \textregistered BYTE Publications Inc}\]
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ISA/79, O'Hare Exposition Center, Chicago IL. The conference theme, Instrumentation for Energy Alternatives, will emphasize current practices in instrumentation design and implementation. Contact Instrument Society of America, 400 Stanwix St, Pittsburgh PA 15222.

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Institute of Electrical and Electronic Engineers (IEEE) Third International Conference on Computer Software and Applications, The Palmer House, Chicago IL. Contact IEEE Computer Society, POB 639, Silver Spring MD 20901.

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Low-Level Program Optimization:

Some Illustrative Cases

A program or subroutine can usually be modified so that it requires less time or space for execution.

The above observation about optimization suggests that a program or subroutine can usually be changed, so that it either runs faster or takes up less memory space, and one can often accomplish both at the same time.

Programs can be optimized for other things, such as readability, maintainability, structure, etc. This article, however, stresses optimization for time and space. This article, however, stresses optimization for time and space.

If a program written for a microprocessor can be made shorter using space optimization, less memory can be used, or more functions can be packed into the same memory. Either way, optimization pays off. If the program can be made to run faster, more functions can be performed in the same amount of time. In fact, optimization can make the difference between whether or not an application of a microprocessor is feasible.

A distinction can be made between 2 types of optimization techniques. One is code optimization and the other is algorithmic optimization. Code optimization involves concentrating on the structure of the actual code on a low level. This includes such operations as reordering instruction sequences and combining 2 instructions into 1 instruction. Algorithmic optimization is on a high level and involves rethinking the whole approach to a program or section of a program. This is much more general and powerful than code optimization, but its rules cannot easily be written down. It takes an experienced programmer or system designer to perform algorithmic optimization effectively. Examples of code optimization tricks will be given below.

In the event that a program cannot be modified so that both space and time are lessened, there is usually the possibility of a trade-off. That is, if space is decreased, time will increase, and if time is decreased, space will increase. Only the particular situation can determine which route to take.

How much optimization is possible? Experience has shown that upon careful analysis a first draft program can typically be reduced by as much as 50 percent or more in terms of memory space. Time optimization is another story. Some programs can be accelerated at the expense of using more memory. However, significant time reductions can usually be made at little expense of memory; in fact, there may even be a savings of memory.

How much optimization should be done? In the process of optimizing a program, it becomes harder and harder to discover more program reductions. How far one should go depends on the relation between the cost of the programmer's time and the savings due to optimizations.

The process of optimization has fringe benefits. In analyzing a program, the programmer gains a clearer picture of how it works and often finds bugs. It is clear that a good software engineer should spend some time optimizing code.

Before discussing the techniques themselves, it should be pointed out that not all of the ideas mentioned are always beneficial. For example, one of the tricks reduces the elegance of the subroutine structure. If this type of elegance is desired, perhaps the trick should not be used.

The ideas presented are applicable to most microprocessors. They are intended for use on assembly language programs, although some of them apply to other languages. An English assembly language is used in the examples for generality. Note that the command CALL SUB means push the return address on the stack and then jump to the subroutine.

The code optimization examples will usually be presented in the following format:

---

About the Author

James Lewis is president of Micro Logic Corp. His company has done microprocessor applications ranging from laser-beam controllers to chemical-analyzer systems. Their development lab is in Hackensack NJ.
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<table>
<thead>
<tr>
<th>Title</th>
<th>Description of optimization technique</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Example of program before optimization</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Returning a call</th>
</tr>
</thead>
<tbody>
<tr>
<td>If a call to a subroutine is followed by a return instruction, the 2 instructions can be replaced by a jump to the subroutine.</td>
</tr>
<tr>
<td>CALL ARNOLD</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Endless subroutine</th>
</tr>
</thead>
<tbody>
<tr>
<td>If the last line of a subroutine is a jump to another subroutine, as in the first example, one can often position the subroutine which is jumped to directly below the jump instruction, so that the jump instruction is not needed.</td>
</tr>
<tr>
<td>JUMP BETTY</td>
</tr>
<tr>
<td>CINDY: LOAD X</td>
</tr>
<tr>
<td>RETURN</td>
</tr>
<tr>
<td>BETTY: STORE X</td>
</tr>
<tr>
<td>RETURN</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Expanded loop</th>
</tr>
</thead>
<tbody>
<tr>
<td>To increase the speed of an important loop, one can expand the loop either partially or wholly at the expense of space. This works best when the loop has a fixed number of iterations that is relatively small.</td>
</tr>
<tr>
<td>LOOP: LOAD IMMEDIATE 10</td>
</tr>
<tr>
<td>CALL DANNY</td>
</tr>
<tr>
<td>CALL EDDY</td>
</tr>
<tr>
<td>DECREMENT</td>
</tr>
<tr>
<td>JUMP IF NOT ZERO LOOP</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Passing fixed data</th>
</tr>
</thead>
<tbody>
<tr>
<td>If a block of data has to be passed to a subroutine, rather than setting up and passing a pointer to the data, put the data directly following the call and rewrite the subroutine to look for the data at the return address. This may involve more code in the data processing subroutine, but can pay off in many cases. The subroutine must compute a new return address that follows the data, and use this altered return address instead of the original.</td>
</tr>
<tr>
<td>LOAD ADDRESS OF DATA</td>
</tr>
<tr>
<td>CALL FARRAH</td>
</tr>
<tr>
<td>DATA: BYTES 36,24,36</td>
</tr>
</tbody>
</table>
Model DMB-6400 Series dynamic 64k byte RAMS incorporate the features which are standard in the DM-6400 Series and adds bank select for multi-user-timesharing applications.

- ALPHA MICRO, CROMEMCO, and NORTH STAR output port bank select.
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**Power of two**

Short tables that have more than 1 byte per entry are easier to work with if the number of bytes per entry is a power of 2. This may waste some space in the table, but may save more space and also time in the code which handles the table. Computing an offset into a table that is a power of 2 can be done with a series of shifts instead of the integer multiplication that would otherwise be required.

<table>
<thead>
<tr>
<th>TABLE:</th>
<th>TABLE:</th>
</tr>
</thead>
<tbody>
<tr>
<td>BYTES 38,24,36</td>
<td>BYTES 38,24,36,00</td>
</tr>
<tr>
<td>BYTES 38,22,37</td>
<td>BYTES 38,22,37,00</td>
</tr>
<tr>
<td>BYTES 38,23,38</td>
<td>BYTES 38,23,38,00</td>
</tr>
<tr>
<td>BYTES 35,20,34</td>
<td>BYTES 35,20,34,00</td>
</tr>
</tbody>
</table>

**Use the stack**

Instead of saving temporary values at some memory location, they can often be saved on the stack. This usually holds true, even when manipulating data on top of the stack. The details are too machine dependent to give an example, but some of the newer microprocessors recognize this by having more than one hardware-implemented stack pointer.

**Combine instructions**

It is sometimes easy to miss the possibility of combining instructions. One situation which can be missed is when one can combine a symbolic value with a constant at assembly time rather than at execution time.

<table>
<thead>
<tr>
<th>LOAD IMMEDIATE ADDRESS</th>
<th>LOAD IMMEDIATE ADDRESS +1</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADD IMMEDIATE 1</td>
<td></td>
</tr>
</tbody>
</table>

**Multiple additions**

Normally, several ADD IMMEDIATE instructions in a row would be a bad idea. In a frequent situation, however, it can be very useful. Suppose one wants to pass a number to a subroutine and have the subroutine return 1, 2, or 3, depending on whether the passed number was 5, 12, or 13 respectively. Note that the optimization shown is of space at the expense of some time.

<table>
<thead>
<tr>
<th>COMPARE IMMEDIATE WITH 5</th>
<th>COMPARE IMMEDIATE WITH 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>JUMP IF EQUAL TO ONE</td>
<td>JUMP IF EQUAL TO ONE</td>
</tr>
<tr>
<td>COMPARE IMMEDIATE WITH 12</td>
<td>COMPARE IMMEDIATE WITH 12</td>
</tr>
<tr>
<td>JUMP IF EQUAL TO TWO</td>
<td>JUMP IF EQUAL TO TWO</td>
</tr>
<tr>
<td>LOAD IMMEDIATE 3</td>
<td>LOAD IMMEDIATE 3</td>
</tr>
<tr>
<td>RETURN</td>
<td>RETURN</td>
</tr>
<tr>
<td>ONE: LOAD IMMEDIATE 1</td>
<td>ONE: ADD IMMEDIATE 6</td>
</tr>
<tr>
<td>RETURN</td>
<td>TWO: ADD IMMEDIATE -10</td>
</tr>
<tr>
<td>TWO: ADD IMMEDIATE 2</td>
<td>RETURN</td>
</tr>
</tbody>
</table>

[Editor's note: The techniques presented here tend to produce nonstructured programs. The programmer must make a choice between readable structured code and speed optimized code. Structured programming techniques are recommended for all programs not requiring crucial space and time specifications... RGAC]
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<table>
<thead>
<tr>
<th>Rate</th>
<th>Kilobaud</th>
<th>Baud</th>
</tr>
</thead>
<tbody>
<tr>
<td>307.2</td>
<td></td>
<td>1760</td>
</tr>
<tr>
<td>153.6</td>
<td></td>
<td>1200</td>
</tr>
<tr>
<td>76.8</td>
<td></td>
<td>600</td>
</tr>
<tr>
<td>38.4</td>
<td></td>
<td>300</td>
</tr>
<tr>
<td>19.2</td>
<td></td>
<td>150</td>
</tr>
<tr>
<td>9600</td>
<td>baud</td>
<td>110</td>
</tr>
<tr>
<td>4800</td>
<td>baud</td>
<td>75</td>
</tr>
<tr>
<td>2400</td>
<td>baud</td>
<td>27.5</td>
</tr>
</tbody>
</table>

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SNOBOLs

Dr Stefan M Silverston, 23 Deerhaven Dr, Nashua NH 03060

I was pleased to see Mr Bruce Burns' letter in the June 1979 BYTE. As one of the small number of SNOBOL4 implementors (SNOBAT for IBM 360) around, I have always felt SNOBOL4 has much to offer the programmer, in many areas of application. It has some features provided by no other programming language known to me.

Without meaning to dampen anyone's enthusiasm, I should mention that SNOBOL4's syntax and control structures are rather lacking by today's standards. SNOBOL programs tend to be a bit hard to read, due largely to the ubiquitous blank, which can denote: (1) string concatenation, (2) pattern matching, and (3) separation between labels and statement subjects. Flow-of-control also is rather opaque. The prevalence of side-effect-driven programming, for example, via value assignment in pattern matches, also detracts from program readability and maintainability. These flaws could well be remedied in any new SNOBOL implementation.

As Mr Burns points out, there are good reasons why SNOBOL4 has not been implemented on microcomputers. For one thing, SNOBOL implementations usually require considerable memory, more than what is ordinarily available on microsystems. Further, SNOBOL tends to run rather slowly in many implementations, even on large machines. This could be exaggerated for microcomputers, where storage management and swapping with peripheral memory might be necessary.

Of the 8-bit microprocessors in wide use, the Z80, with its block moves and compares, would probably be the most amenable to SNOBOL4 implementation. I intend to tackle SNOBOL4 development on my own Z80 floppy disk system in the near future, incorporating some improvements as discussed above.

SNOBOL4 should be a lot easier, as well as more efficient, with the new generation of 16-bit microprocessors. A SNOBOL implementation for the Z8000, say, should be a "natural".
The May 1979 BYTE article on Tic-Tac-Toe (page 196) raises more interesting questions of programming philosophy and esthetics than those referred to in the article itself. No doubt Mr. Hinrichs' program plays an aggressive game, and never loses, as he claims. But his approach is also curiously limited in that the program is only able to play the first move side of the game, and this limitation seems the result of Mr. Hinrichs' reliance on data entries to dictate most of his move sequences. A program capable of playing the second move would be much more difficult using his methods, which are also unsatisfactory on principle because they fail to take proper advantage of the computer's most powerful capabilities.

A more rational approach, which actually involves computing each move rather than looking it up in a table, goes as follows:

- Win if possible; otherwise
- Block the opponent from winning on his next move if necessary; otherwise
- Set a trap (2 ways to win on your following move) if possible; otherwise
- Avoid any move allowing the opponent to set a trap on his next move, and then
- Make a (not previously avoided) move forcing (under threat of immediate loss) the opponent to make a move allowing you to set a trap, if possible; otherwise
- Avoid any move allowing opponent to force you into a move allowing him to set a trap, if possible; otherwise,
- Among moves not previously avoided, choose one which allows the opponent to blunder by choosing a move which allows you to set a trap, and then
- Among moves not previously avoided, choose one which allows the opponent to blunder by choosing a move which allows you to win on your following move, if possible; otherwise
- Choose randomly among moves not previously avoided.

As a suggestion to a reader interested in implementing this strategy, which evidently allows elegant use of subroutines, it is further suggested that the board be coded internally using the 3-by-3 magic square:

\[
\begin{bmatrix}
2 & 9 & 4 \\
7 & 5 & 3 \\
6 & 1 & 8 \\
\end{bmatrix}
\]

for which a win corresponds precisely to playing 3 numbers whose sum is 15.

The 9-step strategy outlined above has all the desirable properties of Mr. Hinrichs' program, including aggressiveness both in seeking wins and allowing opponent mistakes. In addition, it plays both first and second move equally well and "feels" right, in that it allows the computer to compute, instead of looking up moves in a data table.

---

Tic-Tac-Tactics
John C Miller, 110 Riverside Dr, New York NY 10024

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Drop JCL and Start with WFL

I agree with James Jones ("How to Define an OS Which Does Not Need a Wizard," April 1979 BYTE, page 245) that we must not repeat the mistakes of the past when designing operating systems for microcomputers, especially when designing the user interface. With most users writing their programs in high-level languages, it is absurd for them to be forced to write their system-interface routines in a low-level quasi-assembler designed for the convenience of the machine. What we need is an interface that is strongly based on a well-known, powerful, and easy-to-use high-level language, such as Pascal, or its progenitor, ALGOL.

Such an interface already exists — on one line of the big machines. The Burroughs Corporation Large Systems computers (series B7000/B6000) have a user interface called Work Flow Language (WFL) which is essentially a limited ALGOL with a few extensions. The basic system instructions are all handled by a few very simple commands: to run a program one simply writes RUN and the program name; to compile a program, the command is COMPIL, the program name, and the compiler's name; to copy a file, one uses the COPY command; to erase a file, simply REMOVE it; and to rename a file, just CHANGE its title. The remainder of this language consists of structures familiar to every Pascal and ALGOL user: it supports variables of type REAL, INTEGER, BOOLEAN, and STRING; for control structures there are the WHILE...DO, DO...UNTIL, IF...THEN...ELSE statements, and the ever unpopular GOTO statement. Subroutines are supported (with parameters) and values can be passed between WFL routines and the applications programs they run.

The most impressive aspect of Work Flow Language (WFL) is its handling of peripheral device assignments. Each program is permitted to have default specifications for its files in its own code, which frees the user from constantly defining his files in his WFL. But if those files in the program are not what is wanted for a particular run, the files can be redescribed in the WFL (using the ALGOL syntax for a file declaration), and the definitions in the WFL will override those in the program.

The use of a high-level user interface turns out to be more feasible for overall job construction. While working on an IBM-to-Burroughs conversion a year ago, I wrote a Job Control Language (JCL) to a WFL translator, and found that as many as 50 different JCL jobs could be algorithmically converted into only 1 WFL job.

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The numbers are statement labels, and N is an integer variable. If 1 ≤ N ≤ 5, control will be transferred to the corresponding statement. If N < 1 or N > 5, the effect of the statement is undefined; most FORTRAN systems abort the program and print a diagnostic message.

FORTRAN IV, which is the most common version of FORTRAN today, has two forms of IF statement. The older form is the "numeric IF" statement. It is confusing and not particularly useful, but it was the only form of IF statement provided in FORTRAN II. The other IF statement, the "logical IF," was introduced in FORTRAN IV, but the numeric IF was retained so that FORTRAN II programs could be compiled by FORTRAN IV compilers.

The FORTRAN "numeric IF" statement, in which E is an integer or real expression and the numbers are once again statement labels, is written in the following way:

GOTO (1,2,3,4,5),N

The following notes are written in response to his ideas and suggestions.

First, some preliminary observations. The FORTRAN statement that corresponds most closely to the case statement is not the "numeric IF" statement; it is the "computed GOTO" statement, which has the following form:

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In the design of a user interface, let us not slide back into the dark ages. With WFL as an inspiration, we can begin in a user-friendly environment and go on from there.

Case Statements and Related Topics

Peter Grogono, 73 Roxton Crescent
Montreal West Quebec, Canada H4X 1C7

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E < 0 goes to 1, E = 0 goes to 2, E > 0 goes to 3.

The motivation for the three-way branch in numeric IF statements is efficiency. All computers have instructions which compare the contents of a register with zero, but many have no instructions for directly comparing the contents of two registers. Thus, the Boolean expression A > B is usually evaluated in machine language as A - B > 0. In FORTRAN II the programmer was forced to convert all comparisons into comparisons with zero, since the compiler would not do this for him. In practice, three-way branches are required less frequently than two-way branches in most programming applications. In FORTRAN II programs, IF statements in which the three branching labels are all different are comparatively rare; in most cases, two of the labels are the same.

When a three-way branch is really required, it can be coded in an ALGOL-like language, such as Pascal, in this way:

```pascal
if E < 0 then sl
else if E = 0 then s2
else if E > 0 then s3
```

where sl, s2, and s3 are simple or compound statements. However, this kind of code in a Pascal program is usually an indication of tricky programming, which Pascal is intended to discourage. If the expression E occurs naturally in the program, and happens to have negative, zero, or positive values, the above statement is appropriate.

It is more likely, however, that E is some kind of flag, set elsewhere in the program to -1, 0, or +1. If this is the case, it is a much better use of Pascal to define a special type for the flag, enumerate its values, and use the Pascal case statement:

```pascal
type
  flag = (down, half mast, flying);
var
  mapleleaf : flag;
  ...
  case mapleleaf of
    down : s1;
    half mast : s2;
    flying : s3
  end
```

This example leads to my principal topic: case statements. First, consider the Pascal case statement. An expression (the case selector) is evaluated, and the statement within the scope of the case keyword whose label has the same value is executed. The compiler will usually compile a case statement into a table of jump instructions in the object code, so it must be possible to map the values of the expression to the integers. In the example above, the compiler would map down, half mast, and flying to the integers 0, 1, and 2, respectively. Most Pascal compilers would compile a 1000 word table for the following statement:

```pascal
case number of
  1 : sl;
  2 : s2;
  1000 : s3
end
```

Many people have commented about the absence of an "escape" clause in the Pascal case statement. How do you tell the compiler to take special action if there is no label which matches the value of the case selector? Pascal provides a very powerful and useful notation for set operations, and tests on sets can be used to guard case statements in this way:

```pascal
if selector in [1,2,3,7,8,9,10] then
  case selector of
    1,2,3 : s1;
    7,8,9,10 : s2
  end
else error
```

This statement acts in the following manner: it decides if the value of the selector is acceptable. To be acceptable it must have one of the values in the list enclosed by square brackets, which is a Pascal set constant. If the value is acceptable, the appropriate statement (s1 or s2) is selected by the case statement and executed; otherwise the procedure error is called. The example draws atten-
tion to a minor inconsistency in Pascal. The set expression \([1,2,3,7,8,9,10]\) can be abbreviated to \([1..3,7..10]\), but the case labels cannot be abbreviated in this way. It is tempting to suggest that the inconsistency be resolved by allowing case labels to be abbreviated in the same manner as set constants, but this obscures the really interesting point, which is that the case labels are, in fact, set constants themselves.

The most consistent way to write the above statement is this:

```plaintext
if selector in [1..3,7..10]
then
  case selector of
  [1..3] : s1;
  [7..10] : s2
  end
else error

This notation can be easily extended, as the next example shows. (Assume that \(ch\) is a letter, and that the three cases 'P', 'X', and "other" are to be distinguished; the set \(A - B\) contains all members of a set which are not also members of \(B\)):

```plaintext
case ch of
  ['P'] : s1;
  ['X'] : s2;
  ['A'..'Z'] \{ ['P','X'] : s3
end
```

If, however, the case statements are to be executed efficiently, the compiler must be able to evaluate the label expressions during compilation in order to generate a jump table. This implies that the case labels must not contain variables.

Enclosing the case statement in an if statement does not really solve the problem because we still have to write the acceptable case labels twice; once in the if condition, and once in the case statement itself. The only way around this is to allow an else or otherwise label, followed by a statement which is executed if there is no matching case label. Several of the more recent Pascal compilers provide this option.

As Faught pointed out in his article, the conventional if statement can also be extended in other ways. Consider the recursive definition of Ackermann's function, which can be written in Pascal in the following way:

```plaintext
if m = 0
then a := n + 1
else if n = 0
then a := a(m-1,1)
else a := a(m-1,a(m,n-1))

This could be written more elegantly using a form of the case statement in which labels are Boolean expressions:

```plaintext
case
  m = 0 : a := n + 1;
  n = 0 : a := a(m-1,1);
  (m > 0) & (n > 0): a := a(m-1,a(m,n-1))
end
```

Case statements of this kind must be defined carefully. Consider the general form of the statement:

```plaintext
case
  b1 : s1;
  b2 : s2;
  ... 
  bn : sn
end
```

in which \(b1, b2, ..., bn\) are Boolean expressions (sometimes called "guards") and \(s1, s2, ..., sn\) are statements. When this case statement is executed, there are three possibilities:

- None of the Boolean expressions are true;
- Exactly one of the Boolean expressions is true;
- More than one of the Boolean expressions is true.

In the first case we can say either that the statement has no effect or, if we are designing a strict language, that it is illegal. In the second situation there is no problem. In the third situation, we can either declare the statement il-
legal, execute only one statement, or execute all the statements whose guards are true. If we select the last alternative (executing more than one statement), we must specify the precise order in which guards will be evaluated and statements executed. The necessity for this can be seen from this example:

```plaintext
case
  x < 0 : x := 0;
  x = 0 : x := 10;
  x ≥ 0 : x := x - 1
end
```

Suppose that we execute this statement with \( x = 0 \). Afterwards, is \( x = 9 \) or is \( x = 10 \)? A language designer must consider such possibilities and specify exactly how the program will behave in each case. This is the hardest part of language design. It is quite easy to specify the syntax rules of a language, but it is much more difficult to specify the complete semantics.

The language which Dijkstra uses in his book *A Discipline of Programming* (Prentice-Hall, 1976) has a statement resembling the case statement with Boolean labels used above, although he uses different keywords and punctuation. Dijkstra uses a similar statement for loops: the entire statement is executed repeatedly until none of the guards is true.

Case statements tend to be lengthy, and it is tempting to try to abbreviate them. Faught proposes statements of (roughly) the following form:

```plaintext
case x of
  < 0 : s1;
  = 0 : s2;
  > 0 : s3
end
```

This is not general enough for all applications. For instance, it is difficult to see how Ackermann's function would be coded. There are, however, many situations in which each arm of an if or case statement makes an assignment to the same variable. In ALGOL 60, a statement has a value, and in places where other languages require a statement, ALGOL 60 allows an expression. Thus in ALGOL 60 we can write Ackermann's function in this way:

```plaintext
a :=
  if m = 0
    then n + 1
  else if n = 0
    then a(m-1,1)
    else a(m-1,a(m,n-1))

When ALGOL 60 was designed, many computers had only one arithmetic register, usually called the accumulator. A high level language compiler compiling one statement at a time would not usually, in the current statement, use the value left in the accumulator by the previous statement. The ALGOL convention was intended to get around this potential inefficiency by allowing a statement to have a value, the value being that left in the accumulator after the statement was executed.

This idea was carried over to ALGOL 68, which also has a case statement. It is less flexible than the case statements described above because there are no case labels. Instead, the introductory clause "case m in" is followed by \( n \) statements, and if \( 1 ≤ m ≤ n \), the \( m \)th statement is executed.

Thus, the ALGOL 68 case statement is very similar to the FORTRAN computed GOTO statement. Although the lack of case labels makes the ALGOL 68 case statement rather weak and sometimes hard to read, it does enable the compact expression of some algorithms. As in ALGOL 60, an expression may be used where a statement is expected. The algorithm for determining the number of days in a month can be expressed in ALGOL 68 in the following way:

```plaintext
days :=
  case month in
    31,
    if year \bmod{} 4 = 0
      then 29
      else 28
    fi,
    31,30,31,30,31,31,30,31,30,31
esac
```

Most languages since the mid sixties have a case statement of one kind or another. For a fuller description of the use of case statements in various languages, read the paper "Notes on the case Statement" by C Wrandle Barth, in *Software: Practice and Experience*, volume 4, #3, 1974, pages 289 thru 298.
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Some Laws of Personal Computing

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Computer Science Department
Oregon State University
Corvallis OR 97331

The Origins of Personal Computing

In the beginning, man created pocket calculators to do rote arithmetic, e.g.: addition, subtraction, multiplication and division. Few people involved in the pocket calculator industry realized that pocket calculation was just the initial thrust into the "computing for the millions" consumer market. Indeed, the millions of dollars made by this computer consumer product helped to pay for the development of more sophisticated devices we now call personal computers.

Computing lacks a definite starting point. The works of Charles Babbage, and possibly Alan Turing, have little impact on daily computing (some will argue that these two pioneers have everything to do with modern computing, but I speak of practical rather than theoretical computing). So where are the fundamental theorems of computing? Is there a set of "equations of motion" for programming?

This article contains ten empirical observations, dubbed "laws of personal computing," that are derived from personal experience with personal computers in the real world of business. While many of the rules are controversial, I believe most can be proven to be true.

The first law of personal computing is of the form "action equals reaction." The law is derived by historical observation.

The first electronic computers were personal computers. That is, only a few programmers had access to the ENIAC, Whirlwind, and ATLAS. This arrangement faded rapidly in favor of batch operation and multiprogrammed operating systems. Clearly, the shift was the result of economic decisions. Large corporations poured large sums of money into data processing departments, and demanded efficiency in return. Military installations required security and performance as their return on investment. Batch operation satisfied their demands.

However, users (programmers mostly) were soon able to show economics of scale and efficiency of operation by installing a limited form of interaction called remote job entry. Remote job entry moved rapidly into timesharing with terminals because this increases the man-machine interaction. Finally, we have come full circle to dispersed, stand alone, turnkey computers dedicated to a few users.

The key feature of the historical evolution of computing is "interactivity." The more we can communicate with a computer system, the more we can enjoy using the system (within limits), and the more "personal" computing becomes. This leads to the first law of personal computing:

1. Personal computing equals interactive computing: the personalness of a computer system increases in direct proportion to its interactivity.

The New Economics of Computing

Personal computing is governed by economics as much as by technology. Indeed, the directions taken by technology are governed by economics. Therefore, we must study economics in order to derive other laws of computing.

The concepts of programming, microprogramming, and integrated circuit design span the spectrum of software, firmware and hardware. Why is it more suitable to microprogram the IBM 370/168 (model 370 hardware, model 168 firmware) and not microprogram the Intel 8080? Where is the trade-off between an "expensive" system and an "inexpensive" system when all features of such a system are considered?

A system designer can choose to build a cheap processor (like the 8080, say) and save money on production, design, and maintenance of the cheap processor. The same designer can elect to build an expensive, sophisticated computer system and as a result increase the cost of hardware. Why construct an expensive computer? The
answer lies in looking at the total cost of a computer system. Let's take an example: the Intel 8080 requires that the HL registers be loaded each time a memory reference is made. This feature is simple to implement and saves hardware dollars. However, every program written for the 8080 must pay the price of this simplicity. Typically, a macro called HL is used to relieve the programmer of this chore. The Motorola 6800 includes a more sophisticated addressing mechanism using an index register for assisting in memory references. The addressability features of the 6800 often lead to 25 percent reduction in the number of instructions needed to perform the same function on the 8080. Both 6800 and 8080 architectures are more time consuming to program than the Texas Instruments 9900 chip due to the 9900's greater sophistication. Furthermore, the Microdata 32/S and Hewlett-Packard 3000 are stack machines supporting a high level language. Hence they are "easier" to program than any of the chips discussed above. But of course, the 32/S and 3000 are more expensive hardware machines than the chip machines.

Where is there a trade-off between complexity in hardware, complexity in firmware, and complexity in software? The trade-off is strictly economic, and leads to the second law of personal computing.

2. Conservation of agony: the work expended to program a computer to solve a problem plus the work expended to construct the computer system remains constant for that problem.

The second law of personal computing actually states that the problem solution remains at a constant level of complexity regardless of the system used to solve the problem.

The cost per unit of effort in building hardware may decrease (large scale integrated circuit (LSI) devices), and the cost of programming may increase (due to unsophisticated microcomputers). Therefore, in 1980, the most economical systems will be mainly firm hardware (due to its low cost) and a small share in software (due to the conservation of agony).

The results of the second law say something about the "power" of a computer system. Increasing speed or storage capacity increases power. Conversely, decreasing cost increases power of a personal computer. For example, the Intel 4040 (4 bit pocket calculator chip) increased personal computing power because it was cheap enough though it was slow and had little storage capacity.

If we look at history once again, it is clear that an acceleration force is at work: increasing capability leads to an increasing number of applications in which the computer can be useful. In turn, the increased use of computer systems in new applications results in increased sales. The sales stimulate mass production and further cost reductions. The result is to decrease the unit cost of the computer system.

We can demonstrate this counter intuitive notion as follows. In the mid-1960s, processor speed increased dramatically. This encouraged timesharing of the central proc-

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modem / mədərn / n: A device for transmission of digital information via an analog channel such as a telephone circuit.

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Micromodem 100* / mi'krō-mō'dəm wan hun'drəd trademark — a complete data communications system for S-100 microcomputers, providing all the capabilities of a serial interface card and an acoustic coupler, with the addition of programmable automatic dialing and answer. The Micromodem 100 comes with the Microcoupler and is fully S-100 bus compatible including 16-bit machines and 4 MHz processors. The Micromodem 100 operates at either of two software selectable baud rates — 300 baud and a jumper selectable speed from 45 to 300 baud.

acoustic coupler / ə'kūstık kə'pəlar / n: A modem that works through the standard telephone handset, transmitting data through the regular earphone and microphone. It can be affected by room noise and suffers from the distortion inherent in the carbon microphone.

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essor. The support of many terminals reduced both the cost per terminal and the cost of the unit of computation.

In the 1970s, the storage capacity has been increasing dramatically. There is a surge of activity in data base applications and a corresponding decrease in cost of storage. In short, we are witnessing the third law of personal computing in action:

3. As the power of a personal computer increases, its price decreases.

The third law deals only with hardware capability. Earlier we stated that hardware capability plays a decreasingly important role in personal computing. Indeed, the effects of the third law of personal computing are rapidly diminishing due to the fourth law:

4. Software is hard; hardware is soft: it is economically more feasible to build a computer than to program it.

It is economically easier to design, implement, and mass produce a machine like the Intel 8080 or IBM 360 than it is to design and implement an operating system, compiler, or sophisticated application program. The cost of a chip may run to $250,000 when design and initial production are totaled. The cost of firmware BASIC may not exceed $100,000 (many do, however), but the auxiliary costs of documents, service, training and marketing may exceed one million dollars.

A company contemplating a new hardware architecture is gravely penalized for making radical changes to the instruction set of their existing computer. Is it not to be expected that the IBM 370 is only an evolutionary departure from the IBM 360? Why is the Z80 processor nearly as successful in the market place as the 8080?

The high cost of programming as opposed to the cost of a chip is reversing the traditional roles of software and hardware. In the future, more emphasis will be placed on the software and less emphasis will be placed on the machine architecture. Indeed, much of the current software will become “hard,” by being distributed in hardware read only memories as firmware.

One result of the fourth law is corollary A, which states the rule that governs pocket calculators today:

A. Programs and data should be shared, but hardware should be replicated.

The computer business has been overly enthusiastic about timesharing in the past. We must recall that timesharing was invented to lower the cost of hardware. Now that hardware is no longer the major cost item in a system, timesharing is not justifiable in most cases. In fact, I believe that timesharing failed. It failed because people couldn’t understand it. Only computer experts are able to use MULTICS, VM/370 and other extremely capable timesharing systems. The average person will not tolerate JCL, telephone lines, computer jargon, and unreliable central computers that lose their files. In short, timeshared computers are hampered by their prerequisite of knowledge.

The computer utility concept of the late 1960s failed because of the lack of expertise on the part of the users. The high level of sophistication needed to use a utility doomed it to failure. It also put a bad name on personal computers.
In effect, the “guilt by association” syndrome plagues personal computing today. Myths (it’s too complicated), training (what is a byte?), and service (how do I get statements printed?) are three of the remnants of the computer utility that have turned people away from computing.

We can now state a conclusion called the fifth law of personal computing:

5. Knowledge costs more than software and hardware: the usefulness of personal computers increases in inverse proportion to how much people must know in order to use them.

The lesson is clear: any consumer product that is successful must be simple. The pocket calculators that solve known problems (arithmetic) are successful. The pocket calculators that solve unknown or unrecognized problems are failures.

The facts of life are even more severe for computers sold to the consumer market. The final economic law succinctly summarizes the fickle buyer's attitude:

6. The color, shape and size of a personal computer are often more important to a buyer than what is inside of it.

Once the personal computer system overcomes all other economic obstacles, it must be packaged and maintained by a reputable service organization. This means that all unnecessary buttons, switches and knobs must be eliminated. The manuals must reduce jargon and the software must be tailored to a particular industry.

The WH89 system by Heath, the C4P by OSI, the Apple II, the Commodore PET and the Radio Shack TRS-80 are all vivid examples of packaging in the personal computer hobby market. Datapoint, Wangco, and Basic-Four demonstrate the law with tailored software packages for small businesses.

Service fills the gap between the user’s knowledge and the personal computer’s lack of capability. Service rescues the user when the personal computer cannot repair itself. It is service that counts when the manuals do a poor job of explaining a feature of the system. Finally, service is performed by humans, and so far, humans understand other humans better than they understand a machine.

We can now turn to some interesting examples that lead to the final laws of personal computing. In particular, these laws affect the majority of computer experts engaged in applications implementation.
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require from three to ten times as much effort in implementing a given program as an interpreter would require.

It is little wonder that BASIC has achieved the title "language of the masses." It is a simple interpretive language, easy to implement on a modest processor. Unfortunately, it is extremely inappropriate for major applications requiring typical business data processing.

7. BASIC is to personal computing as sign language is to English.

BASIC programs are easy to write, but difficult to understand, and provide inadequate control of a personal computer system. Few dialects of BASIC permit indentation, structuring, comments (without memory penalty), or error control and recovery. Here are a few objections to BASIC as a serious, professional implementation language.

a. Poor error recovery facilities, eg: the application program must be capable of detecting file access errors, etc, and then calling an exception handling routine.

b. No dynamic overlapping or memory mapping of programs too large to fit in main memory.

c. Restricted data structures, eg: no provisions for linked lists, trees, dynamic memory allocation for data, mixed data types.

d. Limited user prompting, eg: forms handling, cursor control, scrolling and audio signals are lacking.

e. Inadequate software security and protection, eg: no file security locks, interlock mechanisms for shared files, or source code shielding.

f. Slow execution due to poor interpretation.

g. Inadequate primitives for standard data processing, eg: no sorting, file access constructs, forms handling for report generation, or communications access constructs.

In short, BASIC is useful in the development of small programs for unsophisticated applications, or for programs that will be thrown away rather than modified.

The area of system control is no better off than the system languages area of personal computing. At least BASIC is partially standardized and widely known. Operating systems, on the other hand, have no consistent basis to begin with. Indeed, we question the utility of an operating system in interactive computing. This is pointed out in the eighth law:

8. An operating system is a feeble attempt to include what was overlooked in the design of a programming language.

This heretical notion is fully obvious in systems employing interpretive BASIC to the hilt. The Wangco, Tektronix 4051, and similar small scale interpretive BASIC systems have no visible operating system. All commands normally associated in traditional operating systems are put into extended BASIC in these personal computers. In general, interpretive systems (and thus interactive systems) have no need for an operating system.

In future personal computers, it is likely that a network of loosely coupled processors will communicate data and programs to one another. In such a network concurrent processes will be allowed and will often compete for limited resources. In this situation the synchronizing primitives of today's operating systems will migrate to hardware (or firmware) and not be of concern to the language interpreter.

The Ultimate Laws

We have covered the motivations for personal computing and have stated eight laws along the way. In the final analysis we can derive two ultimate laws of computing used (knowingly or otherwise) by computer
9. The ultimate personal computer is a robot: the goal of personal computing is to reduce the differences between humans and computers.

In effect we are striving to make personal computers do what people can do, but faster, more accurately, and cheaper. We seek a partnership with personal computers akin to the symbiosis between humans and household pets.

A faster personal computer allows us to process census information in two or three years instead of 15 years. Speed is essential in a lunar landing, and so is accuracy. An air traffic control computer is much more accurate than a human operator. The result is safer air transportation for people.

10. Knowledge is power: information is the fabric of knowledge; the controller of information wields power.

While personal computers are fast, accurate and cheap, they also cause high speed propagation of errors, speed of light crime, and sometimes loss of life when they fail.

Politicians are able to push a button and disseminate campaign propaganda to the millions. Factories can replace entire vocations by automating production. Financial institutions are at the mercy of their data processing centers.

The laws of personal computing are not only important to computer scientists, but also to society as a whole. Perhaps there is a place today for the futurist, the philosopher of computer science.

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07 = ENTER/UPDATE ORDERS
08 = ENTER/UPDATE BANKS
09 = EXAMINE/MONITOR SALES LEDGER
10 = EXAMINE/MONITOR PURCHASE LEDGER
11 = EXAMINE/PRINT INCOMPLETE RECORDS
12 = EXAMINE PRODUCT SALES

**SELECT FUNCTION BY NUMBER**

13 = PRINT CUSTOMER STATEMENT
14 = PRINT SUPPLIER STATEMENTS
15 = PRINT AGENT STATEMENTS
16 = PRINT TAX STATEMENTS
17 = PRINT WEEK/MONTH SALES
18 = PRINT WEEK/MONTH PURCHASES
19 = PRINT YEAR AUDIT
20 = PRINT PROFIT/LOSS ACCOUNT
21 = UPDATE END MONTH FILES
22 = PRINT CASH FLOW FORECAST
23 = ENTER/UPDATE PAYROLL (NOT YET AVAILABLE)
24 = RETURN TO BASIC

WHICH ONE? (ENTER 1-24)

Each program goes to sub menu, e.g.:
(9) allows: A, LIST ALL SALES; B, MONITOR SALES BY STOCK CODES;
C, RETRIEVE INVOICE DETAILS; D, AMEND LEDGER FILES;
E, LIST TOTAL ALL SALES.

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BYTE’s Bits

Trees

Guy L. Steele Jr, MIT Artificial Intelligence Lab, Massachusetts Institute of Technology, Cambridge MA 02139

I think that I shall never see A matrix lovely as a tree. Trees are fifty times as fun As structures a la PL/I (Which Dijkstra claims are too baroque). And SNOBOL’s strings just can’t compare With all the leaves a tree may bear, And COMIT strings are just a joke. Vectors, tuples too, are nice, But haven’t the impressive flair Of trees to which a LISP is heir. A LISPer’s life is paradise!

Many people think that JOSS And others, too, are strictly boss; And there are many BASIC fans Who think their favorite language spans All that would a user please. Compared to LISP they’re all a loss, For none of them gives all the ease With which a LISP builds moby trees.

RPG is just a nurd (As you no doubt have often heard); The record layouts are absurd, And numbers packed in decimal form Will never fit a base-two word Without a veritable storm Of gross conversions fro and to With them arithmetic to do. And one must allocate the field Correct arithmetic to yield And decimal places represent Truncation loss to circumvent: Thus RPG is second-rate. In LISP one needn’t allocate (That boon alone is heaven-sent!) The scheme is sheer simplicity: A number’s just another tree. When numbers threaten overflow LISP makes the number tree to grow, Extending its significance With classic tree-like elegance. A LISP can generate reports, Create a file, do chains and sorts; But one thing you will never see Is moby trees in RPG.

One thing the average language lacks Is programmed use of push-down stacks. But LISP provides this feature free: A stack — you guessed it — is a tree. An empty stack is simply NIL. In order, then, the stack to fill A CONS will push things on the top;
To empty it, a CDR will
Behave exactly like a pop.
A simple CAR will get you back
The last thing you pushed on the stack;
An empty stack's detectable
By testing with the function NULL.
Thus even should a LISPer lose
With PROGs and GOs, RETURNs and DOs,
He need his mind not overtax
To implement recursive hacks:
He'll utilize this clever ruse
Because it uses CONS so much
He need his mind not overtax
With PROGs and GOs, RETURNs and DOs,
Some claim this method is too slow
And thus requires the GC touch;
One's alpha input to decode:
And rocky is the FORTRAN road
You needn't fear for overflow.
Since LISP allows its trees to grow,
Stacks can to any limits go.
The FORMAT statement is to blame,
That no two versions are the same.
The implementors play a game
They build the trees with complex code
It builds the trees with complex code.
With aid of mystic mutterings;
When typing errors do forebode
The FOCAL input's just a farce;
But on the user falls the load.
For LISP is one big advantage, though:
To help these losers is LISP's aim.
And in data structured as a tree.
Some versions have disk I/O statements and require 12K memory and host DOS.
Inherent flexibility
In data structured as a tree.

The programming language LISP offers exciting new possibilities for microcomputer applications. A highly interactive interpreter that uses list-type data structures which are simultaneously data and executable instructions. LISP features an unusual structured, recursive function-oriented syntax. Widely used for processing, artificial intelligence, education, simulation symbolic, and computer-aided design. 6800 LISP requires a minimum of 12K RAM.

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RT68MXP (2706) $55.00

6800 CHESS

Price: $50.00
When all their efforts have gone sour
To swell fixed records, losers glower.
But list reclaimers hour by hour
By setting all the garbage free
Yield CONSNequent capacity:
Thus trees indefinitely flower.
(And trees run on atomic power!)

To men of sensibility
The lesson here is plain to see:
Arrays are used by clods like me,
But only LISP can make a tree.

- The Great Quux (with apologies to Joyce Kilmer)
©Copyright 1973 Guy L Steele Jr All rights reserved.

How this poem came to be printed
Notes by C Helmers

The above parody was found on the MIT Artificial Intelligence Laboratory’s computer during a recent (July 3) visit made to Henry Baker at the University of Rochester Computer Science Department. Its content reflects the LISP orientation of our August 1979 issue, and in a humorous way summarizes the true artificial intelligence hacker’s point of view about LISP as a tool.

Henry dug up an electronic view of the poem on the computer and communicated by that means my desire to make it more widely available. The poem’s author, it turns out, is Guy Steele, who is presently connected with the MIT Artificial Intelligence Laboratory. I had in fact spent some time talking with Guy on a previous occasion, not knowing anything at all about his penchant for poetic parody. The poem was written in 1973.

One of Guy’s major technical accomplishments to date is his recent student project at MIT: design and implementation of a LISP-machine chip in silicon.

In his letter accompanying the poem, Guy points out that probably the most obscure piece of jargon is the word “moby” used as an adjective. The etymology is a reference to Melville’s whale, Moby-Dick. Thus a “moby tree” is a tree which is figuratively as large as a whale, or gigantic. Most of the other terminology referring to LISP is covered in recent BYTE issues; the references to other languages such as JOSS, RPG, FORTRAN, FOCAL, APL, the OS operating system of IBM, etc are best left undefined for the purposes of the poem.

The import of the communications network as a tool for individual computer users is signified by the practical example provided in this poem’s arrangement for use in BYTE. The file containing “Trees” was publicly available to anyone signing onto the MIT-AI computer. Henry Baker in particular was able to sign onto the computer from his usual location in Rochester, NY via the Arpanet, an electronic network connecting many research computers. Henry then got in touch with me at my office by telephone (also electronic). The arrangement was concluded with transmission of a physical copy to BYTE via the postal service.

Readers of BYTE who own personal computers with an RS-232 interface will soon be able to sign up for private services equivalent to the electronic mail functions used by Henry and Guy in arranging this over the Arpanet. At least 2 different companies now offer (see recent advertisements) private off-hours timesharing and networking services at relatively low rates. These are typically billed via Master Charge and VISA. One of these services, Telecommunications Corporation of America, promises to offer a nationwide users’ directory of identification numbers for its users, analogous to a phone directory. This arrival of individual-oriented digital communications-oriented networks will probably mark one of the great milestones of personal computing.
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Space Game

Listing 1: Altair BASIC listing for Space Game. This program allows data entry without the use of a return. This increases the real-time appearance of the game.

```
10 PRINTCHR$(26)
20 Y5=5:GOSUB670
30 PRINT"YOU HAVE BEEN ASKED TO GO ON A MISSION TO DESTROY FIVE"*
40 PRINT"ENEMY CRAFT THAT THREATEN THE GALAXY-----*
50 PRINT"YOU MUST POSITION YOUR CRAFT SO THAT THE ENEMY"*
60 PRINT"IS IN POSITION IN THE CENTER OF YOUR GUN SIGHT IN ORDER"*
70 PRINT"TO DESTROY THE ENEMY SPACECRAFT.*
80 PRINT"THE AIMING IS DONE AS FOLLOWS:*"*
90 PRINT"HIT A 'U' FOR UP MOTION*
100 PRINT"HIT A 'D' FOR DOWN MOTION*
110 PRINT"HIT A 'L' FOR LEFT MOTION*
120 PRINT"HIT A 'R' FOR RIGHT MOTION*
130 PRINT"HIT A 'F' TO FIRE ROCKETS*"
140 PRINT"HIT A 'C' TO ABORT THE MISSION (CHICKEN OUT)"*
150 PRINT"THE ENEMY RETURN FIRE WILL GRADUALLY DESTROY YOUR AIMING"*
160 PRINT"ABILITY!!!! SO DON'T DELAY!!!!*"
170 FORM=OTOI5000:NEXT
180 INPUT"TYPE 'N' FOR NOVICE PILOT; 'E' EXPERIENCED; 'A' FOR 'ACE'":VS
190 IFVS="E"THENV8=150
200 IFVS="N"THENV8=300
210 IFVS="A"THENV8=75
220 PRINTCHR$(26)
230 Y5=10:X5=10:GOSUB670
240 PRINT"GOOD LUCK ON YOUR MISSION --- ON INTO BATTLE!!!
250 FORM=OTOI500:NEXT
260 POKE3758, 18:POKE4031, 18
270 D2=1;D1=1:PRINTCHR$(26)
280 GOSUB670
290 FORM=OTOI500:NEXT
300 Y5=6:X5=0:GOSUB670:GOSUB500
310 X5=INT(10*RND(1)+7)
320 GOSUB670
330 GOSUB640
340 GOSUB690
350 GOSUB670
360 IF (INP(16) AND1)=0 THEN J50
370 D=(INP(17) AND127)
380 GOSUB670
390 IFD=76THENX5=X5+1
400 IFD=82THENX5=X5-1
410 IFD=85THENY5=Y5+1
420 IFD=68THENY5=Y5-1
430 IFD=70THEN710
440 IFD=3THEN490
450 GOSUB1050
460 GOSUB670
470 GOSUB640
480 GOTO340
490 POKE3758, 16;POKE4031, 16;END
```

If you don't have analog graphics capability but do have an 8080 computer with a video display such as the ADM-3A, you may find this program a real challenge.

For the past year or so I have been using the ADM-3A video monitor for running programs written for Teletype display, such as the early Star Trek games. Most of the new games are written with cursor control, giving a vast improvement to the display. When I utilized the cursor control feature of the ADM-3A it opened up a new world of programming enjoyment; with cursor control it is possible to write various areas on the screen without disturbing others.

For example, in business programming it is desirable to preserve various tables and enter data at the end of each line without having to rewrite the table every time new data is written. In card games such as blackjack, it is convenient to print out the various cards in a line from left to right and hold the display while other cards are being written on another part of the screen. This type of display is possible only with a terminal having cursor control. Most of the programs I have rewritten are much more pleasing in the cursor control format.

The program in Listing 1 also features capabilities not found in many of the space war games available commercially. It does not require a graphics or analog display terminal. In order to realize the full capabilities of the game it is necessary to have a 24 line by 80 character video monitor set for 9600 bps or faster, with a BASIC speaking computer. My system runs in MITS Altair, 16 K Extended BASIC, and the program itself will run in less than 4 K bytes of memory. MITS Altair 8 K Revision 3.2 BASIC can also be used and the program revisions are discussed below.

**Program Features**

Some of the features of the program are:

- The enemy craft takes evasive action during the run.
- There are three levels of difficulty: novice pilot, experienced pilot and ace.
- Final performance classification is displayed after each mission.
- Based on the skill of the pilot, the computer adjusts the degree of difficulty accordingly. Thus a novice can advance to experienced or ace by achieving a 75 percent record or better over a set time. Likewise a poor performance results in a down-
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Listing 1 continued from page 196:

```
500 PRINT * 10
510 PRINT * 10
520 PRINT * 10
530 PRINT * 10
540 PRINT * 10
550 PRINT * 10
560 PRINT "1----------1"
570 PRINT * 10
580 PRINT * 10
590 PRINT * 10
600 PRINT * 10
610 PRINT * 10
620 PRINT * 10
630 RETURN
640 PRINT "1-0-1": P=YS: Q=X5
650 RETURN
660 PRINT CHR$(27)+"= "+01R$(32+Y5)+CHR$(32+X5); 700 RETURN
680 PRINT CHR$(27)+"="+tHR$(J2)+CHR$(32); 700 RETURN
690 Y5=12: X5=30: GOSUB 670: PRINT "PON"
700 FOR N=1 TO 100: PRINT CHR$(7): NEXT
710 RETURN
720 GOSUB 800
730 GOTO 320
740 RETURN
770 Y5=2: X5=10: GOSUB 670
780 PRINT "THE HOME BASE HAS BEEN SAVED-CONGRATULATIONS!!"
790 PRINT "THE ENEMY DESTROYED=": D1
800 PRINT "NUMBER MISSED=": D2: D2=D2+1
810 PRINT "THE H, M,E BASE HAS BEEN SAVED-Congratulations!!
820 PRINT "YOU'RE SHOT DOWN!"
830 PRINT "YOU'RE SHOT DOWN!!": GOTO 490
840 PRINT "YOU WANT ANOTHER MISSION"
850 IF V8<=75 THEN QS="RATING=ACE PILOT": GOTO 170
860 IF V8>=300 THEN QS="RATING=NOVICE PILOT": GOTO 170
870 QS="RATING=EXPERIENCED PILOT"
880 PRINT QS
890 RETURN
900 T=T+1
910 IF V8>35 THEN RETURN
920 Y5=2: X5=10: GOSUB 670
930 RETURN
940 RETURN
950 RETURN
960 RETURN
970 RETURN
980 RETURN
990 PRINT "YOU WANT ANOTHER MISSION"
1000 IF (INP(16) AND 1) = 0 THEN 1000
1010 X=(INP(17) AND 127).
1020 IF X<>89 THEN STOP
1030 RETURN
1040 RETURN
1050 PRINT "THE HOME BASE HAS BEEN SAVED-CONGRATULATIONS!!"
1060 PRINT "THE ENEMY DESTROYED=": D1
1070 PRINT "NUMBER MISSED=": D2: D2=D2+1
1080 PRINT "YOU WANT ANOTHER MISSION"
1090 IF V8<=75 THEN QS="RATING=ACE PILOT": GOTO 170
1100 IF V8>=300 THEN QS="RATING=NOVICE PILOT": GOTO 170
1110 QS="RATING=EXPERIENCED PILOT"
1120 PRINT QS
1130 RETURN
1140 RETURN
1150 RETURN
1160 RETURN
1170 RETURN
1180 PRINT 01R$(32+X5)+CHR$(32+Y5); 700 RETURN
```

Program Description

At the start of the program the instructions are listed and you are asked to classify yourself in accordance with your capabilities. At this point it is best to start off with the novice classification by typing an N. If you show promise you will be upgraded as each mission is accomplished, and can advance to ace with some practice and concentration. It should be mentioned however, that no matter how good you think you are, the computer can and will speed up enemy evasive action and it will become more and more difficult to complete the mission with good results. If the enemy craft is allowed to maneuver too far off the display you will be shot down and the game will be over.

One of the features of the game is pilot data entry without use of the return key. This was programmed by using the INP function of Altair BASIC. It is possible to maneuver the plane by just hitting one key, such as the U key, for upward motion. In order to get reliable performance of the computer with the INP function it is necessary to disable the control C function of Altair BASIC. The control C is normally used for aborting program execution and returning to command mode. The control C function is temporarily disabled in Altair 16 K BASIC Revision 4.0 by poking decimal addresses 3758 and 4031 to an unused port (port 18 on my system). The program is set up for the MITS, 2510 board with the video monitor located at port number 16. If you have your monitor at another port, it is necessary to change lines 260, 360, 370, 490, 1000 and 1010. For example, if you have a video monitor at port 0 then change:

```
Line 360 to IF(INP(0)AND1)=0 THEN 350
Line 370 to D=(INP(1)AND127).
```

These changes assume that your status and data ports are 0 and 1 respectively. Also change lines 1000 and 1010 in the same way. For those of you who wish to run the program with Altair, 8 K BASIC, Revision 3.2 you may change the control C disable routine as follows:

```
Line 360 to IF((INP(0)AND1)=0 THEN 350
Line 370 to D=(INP(1)AND127).
```
Line 260 POKE1422,18:POKE1514,18
Line 490 POKE1422,16:POKE1514,16

where 18 is an unused port and 16 is the video status port. Line 490 restores the Altair BASIC control C feature, and line number 260 aborts the control C, permitting pilot control direct from the keyboard without use of the carriage return key. If you enjoy programming, try this on your Star Trek program to eliminate the need to use the return key.

Running the Game

After typing RUN, the instructions are clearly listed and time is allowed for the average reader to absorb the mechanics of the game. You are then asked what level of competence you have as a pilot. After you type in the appropriate response and hit a carriage return, the board is displayed and the enemy craft is randomly positioned in range of the gun sight. You are allowed a reasonable time to maneuver your craft (not the enemy) to where the enemy plane is in a more central position within the gun sight, but if you delay too long or fumble, the enemy will take evasive action and it will be necessary to reposition your gun sight.

Once the plane is positioned in the exact center of the gun sight you must fire the rocket by hitting the F key. If this can be done before the plane moves out of line you will have done the job and the appropriate score will be entered in the upper righthand corner of the screen. If you fire before the plane is centrally located, a miss is recorded.

Your score and rating are adjusted appropriately after each mission (five craft must be shot down). By achieving a 75 percent or better record you can increase your rating by 50 points and eventually advance to the next higher rating. The next rating also changes the degree of evasive action taken by the enemy and hence grows with the pilot's competence. In like manner, if you fail to complete your mission, your rating will be lowered and the game will become easier, in keeping with your ability as a pilot. You will be demoted only if the number of misses exceeds the number of craft shot down.

Using Other Video Monitors

For those readers who have other types of (cursor controlled) video monitors it will be necessary to change lines 670 and 690. Line 690 homes the cursor to the upper left corner of the display and whatever procedure is appropriate to do this on your monitor may be substituted for this subroutine. Line 670 positions the cursor at the X,Y location desired for the particular printout desired. The Y position is the variable YS and the X position is XS.

For example, if you want to position the printout at the exact center of the screen (24 lines by 80 characters) then YS is set to 12 and XS is set to 40. Cursor control programming involves only the additional information of where to print just before the PRINT statement is issued. By using a subroutine to locate the cursor for each print statement, you avoid having to rewrite the location for every printout. In this particular program we call a subroutine at line 670 after specifying YS and XS. In some cases the cursor should remember where it was on a previous printout, and in that case I set the variables P and Q to the original Y and X locations for storage (see line 650).

If you haven't tried a terminal having cursor control you are missing a lot. Try this game and you may be tempted to convert some of your old business or game programs using the above techniques.

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Easy to Use Hashing Function

Don Kinzer
3885 NW Columbia Ave
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Hashing, or scatter storage, is a well known and widely used technique for handling lists. Perhaps the most common usage is in assemblers and compilers where it greatly speeds the handling of symbols. This article briefly discusses the merits and drawbacks of hashing relative to other sorting and searching techniques and presents an easy to use hashing function implemented on a 6800 microprocessor.

The concept of hash tables first appeared in the literature around 1953 but it is generally accepted that hashing was used prior to that. Other names given to the same process are scatter storage, randomized storage and key transformation table. These names will be seen to be equally applicable shortly.

Using the hashing technique, a symbol (collection of alphanumeric characters) to be put in the table is processed through a hashing function to obtain an index into a storage table. This index is then used for the address of a potential storage space for that symbol. We say potential because it is possible that some other symbol could have previously hashed to the same location. Such an occurrence is called a collision and the current symbol must be reprocessed to generate a new table address which is again checked for being empty and so on until an opening is found.

When it is necessary to look up the value of a symbol a process similar to that above is performed. The symbol is processed through the same hashing function as before. Next the address is checked to make sure that it is not empty. If it is empty, the symbol is undefined. Now that we know a symbol is stored there, we must then check to see that it matches the symbol we are looking for because this may be a collision. If the symbols do not match, we have to rehash just as before until we find the symbol or an empty location.

It is possible, with a given set of symbols, a given hashing function and a specified table length, that trying to insert a particular symbol into the table will result in an infinite number of collisions indicating no empty spaces even though the table is not full. By the same token another symbol may take many attempts before being finally inserted.

It should be quite obvious that the ideal case would be an infinitely long table space. However, a real world compromise dictates that we "waste" a percentage of the table to keep the number of rehashes low. The trade-off is very evident. The lower the percentage of table utilization, the lower will be the number of collisions. As the percentage of table utilization increases, so will the number of collisions. Furthermore, the number of collisions, and therefore the number of rehashes, directly affects execution time. It's the old memory size versus speed trade-off once again. In practice, a reasonable compromise is to shoot for 50 to 80 percent table utilization and to determine the hash count (number of rehashes allowed) empirically. If the hash count is exceeded on a symbol insertion operation, the table is declared full, but on a symbol retrieval operation the symbol is declared undefined.

When the table size and hashing function are selected appropriately, the average number of hashes is generally less than \( \log_2 n \) where \( n \) is the number of symbols in the table. Compare this to a linear search which averages \( n/2 \) comparisons. An average assembly language program will contain about 100 labels and symbols. Hashing would average about seven collisions while a linear list would require about 50 comparisons on the average.

The crux of the hashing matter is finding a good hashing function which will minimize collisions. The procedure for this usually involves some complex mathematical analysis based on the characters expected in the symbols and their relative frequency of occurrence. The optimum hash function generally ends up being division by certain prime numbers or some other equally awkward scheme (for a microprocessor).

As an alternative to this, I offer an empirically determined hashing function that works well within the confines of an assembler. The reason for using it, however, was logically derived and goes something
The Electric Pencil II is a Character Oriented Word Processing System. This means that text is entered as a string of continuous characters and is manipulated as such. This allows the user enormous freedom and ease in the movement and handling of text. Since line endings are never delineated, any number of characters, words, lines or paragraphs may be inserted or deleted anywhere in the text. The entirety of the text shifts and opens up or closes as needed in full view of the user. The typing of carriage returns or word hyphenations is not required since characters may be located and/or replaced at will by variable speed scrolling as needed in full view of the user. The ters as desired.

As text is typed and the end of a line is reached, a partially completed word is shifted to the beginning of the following line. Whenever text is inserted or deleted, existing text is pushed down or pulled up in a wrap around fashion. Everything appears on the video display as it occurs, which eliminates guesswork. Text may be reviewed at will by variable speed scrolling both in the forward and reverse directions. By using the search or search and replace functions, any string of characters may be located and/or replaced with any other string of characters as desired.

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- End-of-page control
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- Centering
- Underlining
- Bold face

**Upgrading policy**

Any version of The Electric Pencil may be upgraded at any time by simply returning the original disk or cassette and the price difference between versions, plus $15 to Michael Shryer Software. Only the originally purchased cassette or diskette will be accepted for upgrading under this policy.

**Have we got a version for you?**

The Electric Pencil II operates with any 8080/280 based microcomputer that supports a CP/M disk system and uses an Imsai VIO, Processor Tech. VDM-1, Polymorphic VT1, Solid State Music V8-1B or Vector Graphic video interface. REH versions also available. Specify when using CP/M that has been modified for Micropolis or North Star disk systems as follows: for North Star add suffix A to version number; for Micropolis add suffix B, e.g., SS-IIA, DV-IB.

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<tr>
<th>Vers.</th>
<th>Video</th>
<th>Printer</th>
<th>Price</th>
</tr>
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<td>SOL</td>
<td>TTY or similar</td>
<td>$225.</td>
</tr>
<tr>
<td>SP-II</td>
<td>VTI</td>
<td>TTY or similar</td>
<td>225.</td>
</tr>
<tr>
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<td>TTY or similar</td>
<td>225.</td>
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<tr>
<td>SR-II</td>
<td>REX</td>
<td>TTY or similar</td>
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<td>275.</td>
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</tr>
<tr>
<td>NV-II</td>
<td>VDM</td>
<td>NEC Spinwriter</td>
<td>275.</td>
</tr>
<tr>
<td>NR-II</td>
<td>REX</td>
<td>NEC Spinwriter</td>
<td>300.</td>
</tr>
<tr>
<td>NI-II</td>
<td>VIO</td>
<td>NEC Spinwriter</td>
<td>300.</td>
</tr>
<tr>
<td>SSH</td>
<td>SOL</td>
<td>Helios/TTY</td>
<td>250.</td>
</tr>
<tr>
<td>DSH</td>
<td>SOL</td>
<td>Helios/Diablo</td>
<td>300.</td>
</tr>
</tbody>
</table>

Attention: TRS-80 Users!

The Electric Pencil has been designed to work with both Level I (16K system) and Level II models of the TRS-80, and with virtually any printer you choose. Two versions, one for use with cassette, and one for use with disk, are available on cassette. The TRS-80 disk version is easily transferred to disk and is fully interactive with the READ, WRITE, DIR, and KILL routines of TRSDOS 2.1.

<table>
<thead>
<tr>
<th>Version</th>
<th>Storage</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRC</td>
<td>Cassette</td>
<td>$100.</td>
</tr>
<tr>
<td>TRD</td>
<td>Disk</td>
<td>$150.</td>
</tr>
</tbody>
</table>

Demand a demo from your dealer!
Listing 1: The assembly listing of the hash function and random number generator. If the first hash of a label does not work, the routine is entered a second time through the REHASH function. The random number generator generates a 24 bit random number which is used to determine the table location of the label.

like this: it is the purpose of hashing to randomly distribute symbols about a table; why not then use a random number generator to generate the table index?

The random number generator, RANDOM, and the HASH routine used are shown in listing 1. The random number generator uses the maximal length sequence generator technique to generate a 24 bit random number. With a nonzero initial state in the three bytes, each call to RANDOM will leave them in a specific final state. Different initial states produce randomly different final states.

The HASH routine merely loads the three bytes with the symbol and calls RANDOM to generate a random bit sequence. The assembler for which HASH was written allowed six character symbols. In order to utilize every bit of symbol information to hash to an address, the six character symbol is crammed into three bytes by “folding” it in half. This is done by adding the outermost bytes (characters) together for one byte of the random number generator followed by adding together the next outermost two characters and lastly the innermost two. This can be done without losing information because the ASCII characters of the symbols have a hexadecimal value less than 7F. Two of these added together have a value less than hexadecimal FE which fits in eight bits.

The HASH routine in listing 1 assumes a 4 K byte symbol table limitation. With six bytes for the symbol name and two bytes for its value this allows 512 symbol spaces. This being the case, only nine bits are needed for a table index. Since the result of the call to RANDOM is 24 random bits we are perfectly free to choose any nine of those bits for the index. HASH does this by taking out the most significant nine of the least significant 12 bits of the generator.

Recall that HASH only returns a useful table address. In the case of a label insertion operation it is up to the calling routine to check that the returned address is empty. If not, REHASH is called which utilizes the last contents of the random number generator as a seed for the next random number. Calling HASH again will produce exactly the same address. Alternate means of handling collisions such as linear or quadratic distribution will not be discussed here.

In the case of a label retrieve operation
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BYTES October 1979 203
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S1025
For the experimenter with an eye toward saving a little money or who has a well-stocked parts cabinet, the thought of building a blank computer board can be very appealing. It is now possible to assemble an entire S-100 computer system using your own parts and commercially designed printed circuit boards which are offered with complete documentation but with no parts. Table 1 indicates how this could be done. Even if you would rather assemble an SS-50 (6800 processor) system, read on anyway since much of what is said will apply to bare boards for those systems too (even though the selection of bare 6800 based computer boards is somewhat limited at present). Savings sometimes reach as much as 30 to 50 percent over the purchase price of a kit or an assembled board if parts are purchased carefully and only as needed. Three companies, Cybercom, Solid State Music (now SSM) and Ithaca Audio, offer low cost bare printed circuit boards for S-100 experimenters who are willing to do a little shopping for parts bargains and still have a professionally designed system.

I would like to summarize a few of my experiences assembling bare computer boards. It can be a rewarding endeavor if a few minor pitfalls are avoided.

Documentation and Software

Have you ever tried to assemble a circuit board with no parts layout, schematic, silk screen mask, or other documentation? Of course it would be impossible. All blank boards come with some form of documentation as just mentioned. Normally it consists of the preceding, plus a sheet or two of instructions on how to assemble the board. Don't expect elaborate and expensive manuals with your board. My experience has been that the documentation included with most bare boards is adequate for those who have already assembled one or more kits and who have the basic skills.

Many companies also offer the documentation packages for their boards as separate packages, usually priced at a dollar or so to cover printing and mailing costs. If you're really interested in a board, this is a very good investment. Always ask if the documentation can be had separately—this isn't always advertised.

Some types of computer cards demand that software support be provided. Foremost among these are video display and modem boards, which usually require a driver program to communicate with the interface. All such bare boards that I've seen offered include such software, although usually only in a hard copy source form which must be relocated or loaded in by hand.

About the Table

Table 1 lists some of the bare S-100 compatible boards on the market today. A few words are in order concerning the bare board tabulation. Many companies act as distributors for boards produced by other manufacturers. The table attempts to list only the main or representative distributor of the product. Prices can change rapidly, and different dealers may offer the same board for varying prices. A handy address reference to these companies and a listing of hobby computer products which contains many of the boards listed in table 1 can be had by sending a business size, self-addressed, stamped envelope to S-100 Reference List, c/o Robert Elliott Purser, POB 466, El Dorado CA 95623.

Dealer Liability and Warranty

Almost without exception, you take a risk in purchasing a blank board if something goes wrong. The same is true of building a complete kit. The adage "you get what you pay for" is certainly true in the bare board business. Dealer liability is limited to the replacement of the board if it proves defective. Any parts, such as sockets, that can't be salvaged if the board proves defective in design or manufacture are the burden the buyer must accept. Be sure you understand the limitations of the warranty that the dealer offers. Also keep in mind that the dealer has no control over the quality of parts with which you choose to populate your board nor the care you take in its assembly. As a result, he or she is much less likely to provide extensive support or advice. I much prefer purchasing bare boards from companies that also offer kits and assembled versions of the same board.

Buying Parts

Purchasing parts for a blank board can be a real education. Assuming a parts list is in hand, it is a small chore to look through the prices in the advertisements, choosing which parts to order from which company. Limit yourself to purchases from no more than two or three companies if you can. If you've
had trouble or have heard of others having trouble locating a part, call the company that lists that part in their catalog and ask for a stock check. It’s nice to do business with a company that has a toll-free telephone number.

Often you can save money on parts and increase your spare parts supply at the same time. Pull-up resistors and bypass capacitors are two items that are needed in quantity. For example, I recently finished a board that needed 40 4.7 K ohm resistors, which were priced at 5¢ each for a total of $2. But the same company offered a package of 100 resistors of any one value for 1.7 cents each, totalling $1.70. It doesn’t take much to figure out the better deal. The disk ceramic capacitor often used for noise bypass on

| Table 1: A summary of available blank boards and where to obtain them. |
|---|---|---|---|
| **Description** | **Bare** | **Partial** | **Company** | **Comments** |
| 32 K static | $38.00 | 22.50 | F Reichert Sales | 16 K and 64 K dynamic |
| #300 (8 K) | 29.95 | 25.00 | Electronic Systems | |
| 8 K | 29.95 | 25.00 | Jade | |
| MB-4 (4 K) | 29.95 | 25.95 | Cybercom | |
| MB-6A (8 K) | 29.95 | 25.95 | Cybercom | |
| MB-7 (16 K) | 29.95 | 25.95 | Wameco | |
| MEM (8 K) | 25.00 | 29.95 | Ithaca Audio | |
| 8 K | 25.00 | 35.00 | Ithaca Audio | |
| 16 K | 25.00 | 35.00 | Barnes Electronics | |
| LOGOS-1 (8 K) | 21.95 | 88.00 | Digital Micro Systems | |
| 32 K | 59.95 | 99.95 | Advanced Computer Products | |
| 8 K | 29.00 | 34.95 | Advanced Computer Products | |
| **Processor Boards** | | | | |
| 8080A | 34.95 | 30.00 | Advanced Computer Products | |
| 8080A | 25.95 | 30.00 | Wameco | |
| 2-80 | 35.00 | 30.00 | Jade | |
| 2-90 | 34.95 | 30.00 | Advanced Computer Products | |
| FPZ80 | 35.00 | 30.00 | Ithaca Audio | |
| 6800 | 30.00 | 30.00 | MRS | |
| 6502 | 39.95 | 30.00 | CGRS Microtech | |
| **Input/Output** | | | | |
| MF10-1 | 49.95 | 49.95 | MSD | |
| TIDMA | 35.00 | 35.00 | Electronic Systems | |
| 80-103A | 49.95 | 49.95 | DC Hayes | |
| IC-4 | 25.00 | 25.00 | Cybercom | |
| IA-1100 | 25.00 | 25.00 | Cybercom | |
| VB-1B | 25.00 | 25.00 | Ithaca Audio | |
| SCT-100 | 95.00 | 95.00 | Cybercom | |
| **Read Only Memory** | | | | |
| Master I/O | 47.50 | 47.50 | Space Time Products | |
| Tarbell | 40.00 | 40.00 | Tarbell Electronics | |
| 16 K | 30.00 | 30.00 | Digital Research (Texas) | 2708s |
| 8 K | 29.95 | 29.95 | Jade | 2708/2716s |
| **Bytesaver** | 136.00 | 136.00 | Wameco | 4 K 1702A |
| Bytesaver | 44.95 | 44.95 | Ithaca Audio | 2708/2716s |
| MB-3 | 84.95 | 84.95 | Barnes Electronics | |
| MB-8 | 72.00 | 72.00 | Cybercom | |
| MB-9 | 30.00 | 30.00 | Cybercom | |
| 32K | 30.00 | 30.00 | Wameco | |
| **Mother Board** | | | | |
| 13 slot | 35.00 | 35.00 | Jade | Active terminations |
| 15 slot | 40.00 | 40.00 | Cybercom | Active terminations |
| 11 slot | 29.50 | 29.50 | Vector Electronic | Active terminations |
| 20 slot | 76.00 | 76.00 | Thinkertoys | Active terminations |
| 18 slot | 29.95 | 29.95 | California Industrial | |
| 12 slot | 35.00 | 35.00 | Wameco | |
| **Miscellaneous** | | | | |
| Better Bug Trap | 45.00 | 45.00 | Micronics | I/O and read only memory |
| Real Time Clock | 45.00 | 45.00 | Wameco | |
| CompuTime | 40.00 | 40.00 | CompuTime | |
| CT100 | 20.00 | 20.00 | Sargents Distributors | |
| S-4 Front Panel | 20.00 | 20.00 | Pinnacle Products | |
| Digital/Analog | 21.95 | 21.95 | VAMP | |

October 1979 © BYTE Publications Inc 207
memory boards is another item that is sometimes more cheaply purchased in bulk, especially the 0.1 and 0.01 µF varieties. And 16 pin socket prices really start to drop if you buy in slightly larger quantities, too.

One rule of thumb holds true: it only takes one back ordered or hard to find part to keep your board inoperable. A catalog listing of a part does not necessarily indicate that that company has those parts.

Why Companies Sell Blank Boards
You might think that a company marketing bare boards as well as kits and assembled units would be competing against itself, particularly since you can almost always save money over the kit price by purchasing your own parts separately. Volume and exposure seem to be the two big reasons. First, circuit boards, like everything else, are cheaper in larger production runs. Selling off the extra boards for a proven product reaches the additional market of do-it-yourself computerists who like to go to the extra trouble of purchasing parts separately for the promise of saving a few dollars. Secondly, marketing the bare board doesn’t increase the support demand at nearly the rate that support must be provided to the kit or assembled board purchaser. Finally, for some types of boards, exposure can be increased dramatically by offering the board blank. A case in point is the DC Hayes modem board listed in Table 1. Offering it bare significantly increases the number of people who have the board. Wide customer acceptance and use is what communications and computer interface standards are all about.

A Few Final Dos and Don’ts
While undertaking the project of populating a bare board without first obtaining a copy of the parts list and pricing the needed parts. Write or call the company and ask for a parts list in advance of purchasing the board. A self-addressed, stamped envelope when requesting the list is a nice gesture.

Don’t get caught on a special “secret” deal of blank boards being dumped on the market because one of the chips it used is no longer available, or has become prohibitively expensive, or the board needs extensive foil cutting and jumpers to work. Buy bare boards as you would a kit or completed board: only from a reputable company.

Many companies offer “partial kits” which consist of the bareboard and especially hard to find components, or, in the case of memory boards, 16 K byte and 32 K byte boards with only a partial complement of memory on them. Table 1 includes a column of some boards that are presently offered as partial kits. Plan ahead so that the parts will be there when you need them, and substitute parts sparingly. Don’t buy more blank boards than you need right away, hoping to store the extras away for a rainy day. The market is changing too quickly. Most of the boards listed in table 1 have appeared within the last year. As an example, I purchased extra 4 K byte and 8 K blank memory boards over a year ago with the idea of slowly populating them with 2102 memory chips. The boards still sit gathering dust, obsoleted by the newer 16 K byte boards, and higher density, lower power, lower cost per bit memory chips. It’s not cost effective to populate my old boards anymore.

Buying and populating blank boards can be a significant money saver. I figure that, having populated about a dozen bare boards in the past two years, my savings have equalled at least the price of a fully populated 16 K byte memory board, if not more. In almost all cases, I would never have been able to afford the cash outlay for such a board if it were only offered as a kit or fully assembled. Spend a little time considering the above, and you’ll be generously rewarded in savings on your board purchase. For more information about the companies in table 1, contact me or your local computer store.
Errors

A typographical error occurred in 2 program listings in the article "Three Types of Pseudorandom Sequences" by C Brain Honess in the June 1979 BYTE, page 234. In listing 1 on page 236, line 150 should have been:

```
150 LET A = \frac{N}{10000}.
```

In listing 2 on page 238, line 200 should have read as follows:

```
200 PRINT "DEGENERATION AFTER"; I; "NUMBERS."
```

A note on a BOMB card mailed from Greenville SC brought these errors to our attention.

Marsport Bugs Defeated

Dr Reimut Wette has informed us of several typographical errors which occurred in "Marsport, Here I Come" (April 1979 BYTE, page 84). The corrected segments of code for listing 1 are shown here circled.

```
024 *LBL A
      STO I
026 *LBL 0
027 GSB d
028 CF 0
114 *LBL c
115 - P
116 R I
117 X = Y
118 R I
130 - P
121 "RTN"
122 7
123 X = I
124 ST O 0
```

Gravitational Problems

Mr Hinrichs seems to have developed a much better than average planetary landing program ("Marsport, Here I Come," April 1979 BYTE). He is especially to be congratulated on his adaptation of the physics of celestial mechanics to a program on a programmable calculator! However, on page 100 he has made a common physics error in saying, "The attraction of gravity is exactly balanced by the centrifugal force at all times." The attraction of gravity is not balanced by anything. In fact, if it were balanced at all times, it would not have any effect and there would be no orbit — only straight line motion at constant speed. What Mr Hinrichs in his equations on page 104 implies is that the attraction of gravity interferes with the tendency of a body to maintain a constant speed and direction just enough to continuously change the direction (circular orbit) without changing the speed. This is true only for a circular orbit. In other cases, the unbalanced force of gravity can change speed as well as direction.

Fortunately this confusion between inertia and a force (called centrifugal) has no effect on the workings of what is an excellent program.

Robert Reiland
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The listings follow this form:
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4. Meeting algorithm
5. Newsletter or publication
6. Contact person
7. Contact phone number
8. Dues or subscription fees
9. Special interests
10. Other comments

DIREKTORY

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2. Mailing address
3. Meeting location
4. Meeting algorithm
5. Newsletter or publication
6. Contact person
7. Contact phone number
8. Dues or subscription fees
9. Special interests
10. Other comments

Clubs

Zips: 00000 - 10000

1. MUMPS Users Group
   2. POB 208
   3. Newton MA 02158
   4. Yearly in June
   5. MUG Quarterly
   6. R E Zapolin, Executive Director
   7. (617) 271-2534
   8. $25 per year
   9. US Branch - Exchange of information among users of ANSI Std MUMPS (and other dialects), offer tutorials and publications on MUMPS language.
   10. ANSI MUMPS is used worldwide on maxis, minis, microcomputers in medical, commercial and educational applications. A large number of public domain programs exist. A list of publications is available.

2. New England Computer Society
   3. POB 198
   4. Bedford MA 01730
   5. Mitre Corp, Cafeteria, Rt 62, east of Rt 3, Bedford MA
   6. First Wednesday of the month
   7. NEC Newsletter
   8. Dave Milton, Secretary
   9. (617) 493-3154 days
   10. $6 per year

3. TRUGEM (TRS-80 Users Group of Eastern Massachusetts)
   4. 61 Lake Shore Rd, Natick MA 01760
   5. Cohituate MA (call or write first)
   6. Second Wednesday of each month at 7 PM
   7. TRUGEM Newsletter (monthly)
   8. A Richard Miller, President
   9. (617) 653-6136 (9 AM to 9 PM)
   10. $10 per year local or remote. Send fees to: Ed Robinson, TRUGEM Treasurer, 11 Leighton Rd, Auburndale MA 02166.

7. TRS-80 Club of Arlington
   8. 96 Dothan St, Arlington MA 02174
   9. Same as above
   10. Write for details
   11. Yes; send $1 donation and 2 long, self-addressed, stamped envelopes for 2 issues.

6. Poi Pow
   7. TRS-80 disk business software; library includes: data base management, word processor, inventory, mailing list, stock, accounting, etc.
   8. Interested in good business software at lowest costs; we review business software written for the TRS-80. No games. We review new developments in software and hardware for the small business system.

1. RICH (Rhode Island Computer Hobbyists)
   2. POB 599, Bristol RI 02809
   3. Various locations around Providence
   4. Third Tuesday of the months of March, April, and November
   5. Yes
   6. Emilio D Iannuccillo
   7. (401) 253-5450
   8. $3 per year

10. We are a small active group dedicated to keeping abreast of current technology, plus lending a hand to each other regarding hardware and software. We also give help and advice to new comers into the world of microprocessors.

1. Connecticut Computer Club
   2. c/o Leo Taylor, 18 Ridge Ct W, West Haven CT 06516
   3. Suffield Library, Suffield CT 06078
   4. First Thursday of each month
   5. Connecticut Computer Club Newsletter
   6. Leo Taylor, Secretary
   7. (203) 389-6551
   8. 1980 dues $6

10. We have 2 talks per meeting; generally one on software and one on hardware. The club does not specialize on any one machine. We have 65 members at the moment with a turn-out of about 40 per meeting. The club was featured in the first issue of onComputing magazine in an article by one of our members.
"SARGON II — Buy this program, when it becomes available — ... an evaluation routine that enabled it to beat the giants! ... unequalled in the endgame...." Personal Computing, July, 1979.

Because new algorithms have been added, the program is able to: push passed pawns toward queening; play a stronger end game; and range into deeper play levels at end game without user direction. And, the computer displays the levels of play at which it is thinking and also shows the move it is currently thinking of making, changing the move shown until its final choice is made. SARGON II has 7 levels of play, and levels 0-3 play in tournament time. It has a randomized opening book up to 7 levels of play for 3 moves. When setting up the board, the user can scan up and down, left and right. And finally, you can use the hint option at any level but 0 and request SARGON II to tell what the best next move is. Available now — #03403, TRS-80 Level II; #03404, Apple II; $29.95. Coming soon for CP/M, SORCERER, and PET.

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Circle 161 on inquiry card.
1. Amateur Computer Group - New Jersey Inc
2. U.C.T.I. 1776 Raritan Rd, Scotch Plains NJ 07076
3. Union County Technical Institute, Rutgers University, County College of Morris and Middlesex County College.
4. ACG-NJ News
5. Sol Libes or Marty Nichols
6. (201) 277-2063 or (201) 361-7180, respectively
7. $8 per year
8. Have following User (212) 580-3589 (re :BUG)
9. (212) 212 Oc tober 1979 © BYTE Publications Inc
10. BUG Newsletter

1. Data Processing Club
2. c/o Dennis M Lloyd
3. Business Studies Division
4. Gloucester County College
5. Tanyard Rd, Sewell NJ 08080
6. Same as above
7. Dennis M Lloyd
8. (609) 468-5000 Ext 242
9. $5
10. All data processing areas.
11. We wish to expand data processing education outside of the classroom.

Zips - 10000 - 20000

1. Microcomputer Business Users Group
2. 161 W 75 St, New York NY 10023
3. Baruch College, Manhattan
4. Third Thursday of the month
5. BUG Newsletter
6. Dr Laird Whitehill
7. (212) 580-3589 (re:BUG)
8. No dues, subscription $10 for '79
9. A group for vendors of software and users of software who are serious about using or vending microcomputers for business purposes. Guest lecturers and panel discussions concentrate on application and system software evaluations, as well as such topics as how to develop and sell microcomputer software products. Group publishes a newsletter which keeps those who did not attend informed about meeting content and exact place of next meeting.

1. Long Island Computer Association
2. 35 Irene Ln E, Plainview NY 11803
3. New York Institute of Technology
4. Second Friday of the month for the 8080 subgroup; third Friday of the month for the regular meeting and subgroups
5. The Stack
6. Aileen Harrison
7. (516) 938-6769
8. $10 per year
9. Pascal, 8080, 6800, PET, TRS-80, North Star, etc.
10. We meet the third Friday of the month with guest speakers, show and tell, hands-on demonstrations etc. We have many subgroups, and have 170 members.

1. Mohawk Valley Microcomputer Club
2. POB 331, RFID 1, W Carter Rd, Rome NY 13440
3. Varies
4. Third Tuesday of the month
5. Micros Along the Mohawk
6. Mike Troutman
7. (315) 336-0986
8. $2 per year (includes newsletter)
9. Several special interest groups: 6800, 8080/Z80, and beginners.
10. Membership of approximately 100. Very high predominance of SwTP 6800 systems (=75% versus 25% for all others).

1. Apple Byte's Corps
2. 225 Walton Dr, Snyder NY 14226
3. Buffalo Savings Bank, Sheridan-Harlem Branch, 3980 Sheridan Dr, Amherst NY 14226
4. Every third Friday at 7:30 PM
5. Monthly, no particular title

1. AM-100 Users Group
2. 616 Long Pond Rd, Rochester NY 14612
3. Local meetings arranged by invitation.
4. Newsletter for AM-100 Users Group
5. Leftford F Lowden
6. (716) 227-0841
7. $15 in US and Canada,
8. $36 International
9. System software and user developed software; bugs and their fixes; programming techniques; and feedback among members.
10. Aimed at owners, users, and potential owners of the Alpha Microsystems AM-100 computer system.

1. Central Pennsylvania Computer Club
2. 3263 Bull Rd, York PA 17404
3. Varies, York-Lancaster area
4. Third Friday of even months, and the fourth Wednesday of odd months
5. Data Dump
6. Cletus Hunt III, York area
7. Joseph Pallas, Lancaster area
8. (717) 764-4977, (717) 569-3137 respectively
9. Currently being re-evaluated
10. Many 6800 users, but no organized special interest group.
11. Emphasis is on informal exchange of information among club members and display of members' computers.

1. Philadelphia Area Computer Society (PACS)
2. POB 1954, Philadelphia PA 19105
3. LaSalle College Science Building
4. Third Saturday of each month
5. The Data Bus (monthly)
6. Dick Moberg
7. (215) 923-3299
8. $10 per year, $5 for students
9. Subgroups in the following areas: Apple; TRS-80; PET; Robotics; spaceflight simulation; and others. Courses in BACH; Pascal; home-breeding; computers for kids; Selective repair; and others.
10. Current membership is approximately 350. Average meeting attendance is over 100 people. Meetings consist of courses and subgroups followed by the main meeting at 2 PM. A mini flea market and mapping session follow the meeting. For more information call the PACS Hotline (215) 925-5264.

ZIPS 20000-30000

1. Washington Amateur Computer Society
2. 4201 Massachusetts Ave, #168, Washington DC 20016

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Circl e 331 on inquiry card.
3. First floor hall, Keane Hall, Catholic University of America
4. First Friday of the month at 7:30 PM
5. JWAC
8. $3.50 per year
9. Organized to provide a forum for the computer hobbyist and student of computing science.

1. Amateur Radio Research and Development Corp (AMRAD)
2. 1524 Springvale Ave, McLean VA 22101
3. Patrick Henry Branch Library, 101 Maple Ave E, Vienna VA 22180
4. First Monday of each month at 7:30 PM
5. AMRAD Newsletter
6. Paul L. Rinaldo, President
7. (703) 356-8918
8. Regular $10; second in family $5; full-time students $2.
10. AMRAD operates a Computerized Bulletin Board System (CBBS) in the Washington, DC area. Phone No. (703) 281-2125.

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1. The Birmingham Microprocessor Group (BMG)
2. 3548 Stonehenge PI, Birmingham AL 35210
3. South Side library
4. Fourth Sunday of each month at 2 PM
5. The Printout
6. Tom Bowen
7. Home (205) 956-9576
   Business (205) 870-1367
8. $6 per year
9. The BMG is a general interest organization with special interest as follows: Apple Corp — Apple II owners and users; TRS-Can—TRS-80 or Radio Shack Users; Hardware Hackers — Homebrew.
10. We currently have 116 members on the books with 25-30 being active participants in the general interest area and another 25 that are active in special interest activities.

1. Central Alabama TRS-80 Computer Society
2. c/o Lewis E Garrison, Secretary, 6375 Pinebrook Dr, Montgomery AL 36117
3. Normandale Community Center
4. Third Tuesday of each month
5. None
6. Lewis E Garrison or Walter Bray
7. (205) 272-8462 or (205) 272-3621 respectively
8. $2 per month or $24 per year
9. TRS-80

Zips 40000-50000

1. Amateur Computer Society of Central Ohio
2. 2589 Brookwood Rd, Columbus OH 43209
3. Center of Science and Industry
4. First Wednesday of each month
5. I/O
6. Fred Hatfield K8VDU
7. (614) 888-9287
8. $10 per year

1. Akron Digital Group
2. 107 7th St NW, Barberton OH 44203
3. Kenmore Public Library, 2200 14th St SW, Akron OH
4. Fourth Wednesday of the month at 2 PM
5. Lou Laurich
6. The club programs are planned toward the small systems hobbyist with tips on programming and hardware application.

1. Goodyear Computer Club
2. c/o J F Derry D-109E PLT1, Goodyear T and R Co, Akron OH 44316
3. I McLeod or R Flower D-471 G3, Goodyear Aerospace Corp, Akron OH 44315
4. Goodyear Hall
5. The Late Edition
6. J F Derry or R Flower
7. (216) 794-4010 or (216) 794-3573 respectively
8. $10 per year
9. Hardware - modem design and building etc; investment analysis; new hardware/software developments; and education.
10. Personal computers used by members: TRS-80, Apple, OSI C28P, IMSAI, KIM, PET, Homebrews, North Star Horizon, RCA 1802, and M-6800. Have had joint meetings with Akron chapters of the Association of Computing Machinery (ACM) and the Institute of Electrical and Electronic Engineers (IEEE) Computer Society.

1. Alliance Micromonputer Club
2. 2885 Norwood Ave, Alliance OH 44601
3. Harter Bank Community Room
4. First Tuesday of each month at 7 PM
5. None
6. Gary S Fix, President
7. (216) 823-8996
8. None
9. About 20 members currently with about half owning a personal microcomputer system including several TRS-80s.

1. Dayton Microcomputer Association
2. c/o Dayton Museum of
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You've probably heard about CP/M. But if you haven't, it's the world's most popular operating system. CP/M is considered the "software bus" for 8080 and Z80 microcomputers because it gives you the hardware-independent interface you need to make your computer work for you. Because it's hardware-independent, you can get programming languages, word processing software, and business applications packages from scores of suppliers at affordable prices.

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If you want, you can run simultaneous editors, program translators, and background printer spoolers. Or you can use MP/M for data entry or data-base access from remote terminals. Or you can use MP/M real-time features to monitor an assembly line and automatically schedule programs for execution throughout the day. MP/M makes an excellent focal point for a cluster of connected microcomputers. The possibilities are limitless.

Like CP/M, MP/M is especially built to adapt to most 8080 or Z80 microcomputers, with an 8086 version on the way. You can operate your I/O devices either interrupt-driven or polled, and you can even write your own system processes which are combined with MP/M through a simple system generation. It's an exciting new product from the most experienced systems software supplier in the microcomputer industry. Contact us for details, or ask your dealer about MP/M availability for your computer system.

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Natural History, 2629 Ridge Ave, Dayton OH 45414

3. Same as above
4. Last Tuesday of the month at 7:30 PM
5. DMA Data Bus
6. Dan Watson
7. (513) 223-2348
8. $10 dues
9. 8080 Users - First Sunday 1 PM - 274-1149; 6800 Users - First Tuesday, 7 PM - 435-9297; 6502 Users - First and Third Monday, 7:30 PM - 426-1601; TRS-80 Users - Second Wednesday 7:30 PM - 223-2348.

10. A special session for novices is held at 6 PM immediately before the regular meeting on the last Tuesday of the month. All other special groups meet at various locations - call for information. Visitors always welcome.

1. Evansville Computer Club
2. c/o National Sharedata Corp, POB 3895, Evansville IN 47737
3. Blind Association, Second Ave and Virginia
4. Second Wednesday of the month at 7:30 PM
5. Robert Heerdink
6. (812) 426-2725
7. The group is varied with interest in several types of microcomputers.

1. Purdue University Computer Hobbyist Club (PUNCH)
2. Rm 67 Electrical Engineering Building, West Lafayette IN 47907
3. Rm 117 Mathews Hall
4. Mondays at 7 PM
5. None
6. John Eaton
7. (317) 742-8521
8. None at present
9. Various microcomputer systems; predominately M6800 users.

1. Detroit Personal Computer Network
2. 13043 McNichols, Detroit MI 48219
3. Andrew Fellman
4. (313) 865-4374
5. erw!.
6. Jeff Stanton
7. (616) 763-9685

1. Eastern Iowa Computer Club
2. POB 164, Hiawatha IA 52233
3. REC building in Marion
4. The last Sunday of the month at 7 PM
5. Yes
6. Mark Bergemann
7. (319) 377-1959
8. $10 per year
9. Just started bit-slice microprocessor special interest group with plans to build one sometime in the future.

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3. REC building in Marion
4. The last Sunday of the month at 7 PM
5. Yes
6. Mark Bergemann
7. (319) 377-1959
8. $10 per year
9. Just started bit-slice microprocessor special interest group with plans to build one sometime in the future.
10. Working on a club
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MICRO-AP
9807 Davona Drive, San Ramon, CA 94583
(415) 828-6697

Circle 213 on inquiry card.
modem to use in a personal computer network.

1. Fox Valley Computer Society
2. POB 2742, Appleton WI 54913
3. Room D-104, Fox Valley Technical Institute
4. Second Tuesday of the month
5. Daniel K Dannells
6. $5 initially
7. Diversified.

1. Mini 'App'les
2. 13516 Grand Ave S, Burnsville MN 55337
3. Minnesota Federal Savings and Loan, Hopkins MN
4. Third Wednesday of the month
5. Mini 'App'les
6. Daniel B Buchler, President
7. (612) 890-5051
8. $10 per year
9. Apple users group; user presentations; communications; Northstar; PET; Apple; LSI-11; robotics; ham; Pascal; programming languages (not BASIC or Pascal).

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Our meetings consist of general business speakers, show and tell, and special interest groups.

1. Minnesota Computer Society
2. POB 35541, Minneapolis MN 55435
3. Future location to be announced.
4. MCS Newsletter
5. Jean Rice
6. (612) 941-1051
7. $7 regular; $5 student
8. Special interest group projects; general interest computer presentations; technical presentations; presentations to civic groups.
9. Our meetings consist of general business speakers, show and tell, and special interest groups.
10. XXX-11
11. 514 So 9th St, Moorhead MN 56560
12. Moorhead MN
13. First and third Wednesdays of the month
14. XXX-11 Newsletter
15. C R Corner
16. (218) 233-7894
17. $9 per year
18. Languages.

1. CACHE (Chicago Area Computer Hobbyists Exchange)
2. POB 52, South Holland IL 60473
3. Northern Illinois Gas Building, Golf and Shermer, Glenview
4. Third Sunday of the month, main meeting at 1 PM
5. CACHE Register
6. POB 52
7. Recorder on (312) 849-1132
8. $10 per year
9. Business; TRS-80; C P/M; communications; Northstar; PET; Apple; LSI-11; robotics; ham; Pascal; programming languages (not BASIC or Pascal).

ASSEMBLERS

ARIAN - A complete 8080 assembler that interfaces directly to your DDS. ARIAN is completely 'load and go'. Features include: dynamic file and RAM allocation, custom disc and RAM command capability, several library routines directly accessible by the user. Also, a complete text editor, and system executive. ARIAN is both powerful and easy to learn and use. It is an assembler that you can grow with. Comes complete with a 51 page users manual (ARIAN requires RAM from 0000H to 2000H) $150.00 (manual alone: $110.00)

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Circle 357 on inquiry card.
PASCAL

UCSD Pascal, the powerful general purpose language system, developed for large and complex systems is now available for your TRS-80.

The FMG/UCSD Pascal system opens a new generation of value for your TRS-80. Package includes:
- Operating System
- Screen Editor
- Z80 Macro Assembler
- Library
- Pascal Compiler
- Utilities and System Reference Book
(Requires 48K system with 2 drives.)

Price $150.00

Available without Macro Assembler
- Linker and Library (for Run-Time use only)

Price $100.00

MANUALS:
- UCSD Reference Manual ........ $25.00
- Problem Solving using Pascal ...... $14.95
- (The beginner’s book for UCSD Pascal)
- Programming in Pascal ........... $14.95
- Pascal Primer .................. $17.95

TEXTWRITER II

Exclusively from FMG

A text formatting program that prints files created by an editing program. Contracts, personalized form letters and other documents can be printed from a stored library of standard paragraphs.

Specially priced $ 75.00
Regular Price $130.00

Manual .......................... $ 25.00

CP/M OPERATING SYSTEM

New 1.46 Version

Includes RS-232 and I/O Byte implementation, Editor, Assembler, Debugger and Utilities for 8080 and Z80 systems. For up to four TRS-80 floppy disks. Package includes:
- CP/M System Diskette 5/4"
- CP/M Features and Facilities Manual
- CP/M Editor’s Manual
- CP/M Assembler Manual
- CP/M Debugger Manual
- CP/M Interface Guide

Price $150.00

(Updates for 1.4 Version owners ... $ 15.00)
(Requires 16K and one drive minimum)

Set of 5 Manuals ............. $ 25.00

NEW TRS-80

COMMUNICATOR

RS-232 Communication Program allows the TRS-80 to transmit or receive programs or data files. Also makes the TRS-80 into a remote terminal. Requires Radio Shack RS-232 and CP/M

Price $25.00

NEW Z80 SID

Symbolic Instruction Debugger


Z80 SID Diskette and Manual  Price $150.00

MICROSOFT BASIC

An extensive implementation of BASIC for the TRS-80 Z80 microprocessors. Its features are comparable to those of BASICS found on minicomputers and large mainframes. Requires TRS CP/M

Price $110.00

FMG for High Level Languages — BASIC — FORTRAN — COBOL & now PASCAL

FMG is a registered trademark of Digital Research Corp.
TRS-80 is a registered trademark of Radio Shack
We cater to all brands of computers and deal with software and hardware.

1. St Louis Area Computer Club Inc
2. POB 28924, St Louis MO 63132
3. Thornhill Branch of St Louis County Library, Fee Fee and Willowyck Roads
4. First Thursday of month at 7 PM
5. SLACC Stack
6. Noel Moss
7. Days (314) 862-4040 or (314) 367-3189 evenings
8. $5 per year
9. 8080 homebrew; modems; 8080/280 and 650X.
10. Club serves as an information clearing house. Approximately 1/2 of the members own 6800 systems; the balance have other processors, especially 8080/Z80 and 650X.

<table>
<thead>
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Creative Software introduces: Programs & Products for the TRS-80 (16K level II)

**Household Finance I & II**

Part I: Inputs data on each household expenditure; lists, adds, updates, changes or deletes previously input items. Writes data to cassette tape.
Part II: Reads data tape. Provides monthly and yearly summaries of financial data, single category summaries, and graphs a spending profile.

**Also: New Programs for the PET:**

**PET Word Processor**

Complete word processing capabilities including upper/lower case, string search, string change and many other features found on commercial word processors. Package includes both text editor and formatter and requires 16K or 32K PET.

**PET Space War II**

Fantastic real-time action. Be the spaceship as you fend off aliens to search the universe for colonizable planets. Requires the Creative Software single joystick for the PET.

**PET Road Race**

Another great machine language program gives you a choice of three different tracks as you battle with your opponent to finish the race. Includes oil slicks, automatic lap counters, and an elapsed time clock showing time to tenths of seconds.

**NEW! A super JOYSTICK interface for the TRS-80!**

Three sockets allow you to use one Fairchild** or two Atari** joysticks with no modifications to the TRS-80. Joystick interface with two programs, separate power supply and instructions.

Only **Joysticks (Fairchild** or Atari**), each**

$65.00

**Household Utility 1**

(Includes Calendar, Loans and Buy or Rent Programs)

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**Household Utility 2**

(Includes Compound Interest, Amortization and Car Costs Programs)

$12.00

Many other Creative Software products are available for the PET and TRS-80. If your local dealer doesn’t carry Creative Software products or program information, write directly to the address below. When placing an order please note:

Specify computer & program(s). Add $1.50 shipping for each program ordered, $2.50 for joystick interface. California residents add 6% sales tax. VISA MASTERCHARGE accepted. Include card number and expiration date.

Creative Software
P.O. BOX 4030, MOUNTAIN VIEW, CA 94040
Now!  
For the  
S-100 bus  
8086 Power  
WITH 16-BIT WORD LENGTH

8086 CPU
This card brings state-of-the-art performance to the S-100 bus. It may be used to upgrade existing 8-bit systems by "swapping" the CPUs or it may form the foundation for a high performance 16-bit system. It will operate with 8-bit, 16-bit, or mixed memory and peripherals. It has a 1-megabyte addressing range. It can be factory upgraded at nominal cost from 4 Mhz. to 8 Mhz. when the faster CPU chip is available. Price — $895.

CPU Support Card
This is a companion to our 8086 CPU. It includes a 2K monitor with machine language debugger and disk bootstrap loader, serial port with software-selected baud rate, time-of-day clock with battery backup capability, two general purpose timers/counters, and a vectored interrupt controller with 7 interrupts generated on board and 8 accepted from the bus. Price — $395.

8/16 Memory Card
Through the use of the sXTRQ line of the proposed IEEE Standard, this memory board will appear to be 8K by 16 bits to our 8086 CPU or 16K by 8 bits to 8-bit CPUs. It is offered with 250 nsec. memory chips only and will perform without wait states with our 8086 CPU using an 8 Mhz. clock. It has 24-bit extended addressing. Price — $595.

Z80/8086 Cross Assembler
This cross assembler runs under CP/M and its derivatives. Its mnemonics are the same as or similar to Intel's ASM-86. It is available in 5" soft-sector, 5" North Star, or 8" soft-sector (IBM) formats. Price — $250.

Microsoft BASIC-86
Microsoft's BASIC interpreter for the 8086 is essentially identical in features to their 5.0 release for the 8080 and is ANSI compatible. It is a "stand-alone" version and includes all disk and terminal I/O drivers. Programs written for any earlier version of Microsoft BASIC will run under BASIC-86 with little or no modification. Price — $350.

MCS-86 User's Manual
By Intel — Feb., 1979, edition. This is the primary hardware and software reference manual for the 8086 CPU. Price — $6.25. (Includes shipping)

AVAILABLE NOW!
STOCK TO TWO WEEKS
Call for more information or the name of our nearest dealer

Seattle Computer Products, Inc.
1114 Industry Drive, Seattle, WA. 98188
(206) 575-1830

Circle 330 on inquiry card.
program, and service business systems.

1. Permian Basin Computer Group
2. c/o Ector School District, POB 3912, Odessa TX 79760
3. Midland Chapter: Student Union Building, Midland College, Odessa College: Electronic Technology Building, Room 209, Odessa College.
4. Midland Chapter: monthly, the second Tuesday, 7:30 PM. Odessa Chapter: monthly, the second Saturday, 1 PM.
5. None
6. John Rabenaldt
7. (915) 697-4607 (after 6 PM), (915) 332-9151 Ext 43 (9 AM to 5 PM)
8. No dues
9. Selectic interfaces, color displays, and MECA tape.

1. TRS Users - Permian Basin Group
2. Rt #4, POB 1455, Odessa TX 77963
3. Rm 209, Electronics Technology Building, Odessa College
4. Second Saturday of the month at 1 PM.
5. None
6. Allan D Emert
7. (915) 381-3138
8. None
9. Information and software exchange.

Zips 80000-90000

1. Denver Amateur Computer Society
2. 1380 S Santa Fe, Denver CO 80223
3. Same
4. Third Wednesday of every month. General board meeting - first Wednesday of every month.
5. Interupt
6. Carl Grimes
7. (303) 759-8969
8. $12 per year membership fee

1. Southern Nevada Personal Computing Society
2. 1405 Lucille St, Las Vegas NV 89101
3. Society Headquarters, 1405 Lucille St
4. Second Saturday of each month at 12 noon.
5. Hard Copy (monthly)
6. Cy Wells, President
7. (702) 642-0212
8. Corporate: $12 per year; family: $18 per year; corresponding: $6 per year; student: $3 per year
9. Both hardware and software; exchange of information and experience; and guidance and encouragement for the new hobbyist.

1. Northern Nevada Computer Club
2. c/o Mathematics Dept University of Nevada, Reno NV 89557
3. University of Nevada
4. (TBA)
5. Meeting Announcements
6. Professor Al Brady
7. (702) 784-6831
8. None
9. Personal computing and educational computing.

1. San Fernando Valley 6502 Users Club
2. 3816 Albright Ave, Los Angeles CA 90066
3. Computer Components Inc of Burbank, 3808 W Verdugo Rd, Burbank CA 91505
4. Second Tuesday of every month at 8 PM.
5. SVF 6502 Users Club Notes
6. Larry Goga
7. (213) 398-6086
8. None at this time
9. The club is open to all owners of 6502-based computers including KIM, SYM, and AIM. PET and APPLE owners are also welcome. Formerly known as the San Fernando Valley KIM-1 Users Club.

1. Compucolor and Intecolor Users Group
2. 5250 Van Nuys Blvd, Van Nuys CA 91401
3. Same as above.
4. First Saturday of each month from 12 to 3 PM.
5. Users Bulletin (quarterly)
6. Stan Pro
7. (213) 788-8850 10 to 6 PM weekly
8. $25 per year; foreign add $8
9. Business; games and graphic programs exchange; unpublished ports; poke positions and machine data; addition of peripherals to Compucolor and Intecolor; and machine updates.
10. International in scope.

1. Ventura County TRS-80 Club
2. 567 W Loop Dr, Camarillo CA 93030
3. Camarillo Public Library, 3100 Ponderosa Dr, Camarillo
4. First Tuesday of the month at 7 PM.
5. Yes
6. Lee Steinmetz
7. (805) 484-1724
8. $10 per year
9. The group's main purpose is to share information relating to the practical applications as well as the entertainment possibilities of the TRS-80.

1. Homebrew Computer Club
2. POB 626, Mountain View CA 94040
3. Fairchild Auditorium, Stanford Medical Center
4. Meeting dates are published in the club newsletter.
5. Homebrew Computer Club Newsletter
6. Robert Relling, President
7. (415) 967-6754
8. Donation requested
9. Information exchange on all systems and providing "vectors" to people and groups with similar interests.
10. A newsletter copy will be sent upon request, include a self-addressed stamped envelope. Anyone interested in computers is invited to attend Homebrew Computer Club meetings.

1. Apple Core
2. POB 4816, San Francisco CA 94101
3. Homestead Savings, 22nd and Geary St, San Francisco
4. First Saturday of each month at 10 AM.
5. Cider Press
6. Ken Silverman
7. (415) 878-5382
8. $15 per year
9. Apple owners only.

1. Pacifica TRS-80 Users Group
2. 637 Brussels St, San Francisco CA 94134
3. Eureka Square Shopping Center
4. Second and Fourth Thursdays of the month.
5. John F Strazzarino

1. Solano TRS-80 Users Club
2. 550 Marigold Dr, Fairfield CA 94533
3. Owens-Illinois, 2500 Huntington Dr, Fairfield CA
4. Third Thursday of the month.
5. Steve Irwin
6. (707) 422-3347
7. Informal group that gets together to discuss mutual TRS-80 problems and experiences.

1. ABACUS (Apple Bay Area Computer Users Society)
2. Hayward BYTE Shop, 1122 B St, Hayward CA 94541
3. Same as above.
4. Second Monday of the month.
5. Yes
6. Ed Avelar, President
7. (415) 583-2431
8. Have an active membership of 40, and have developed a club library of 200-plus programs.
9. RETUG (Redwood Empire TRS-80 Users Group)
10. Have an active membership of 40, and have developed a club library of 200-plus programs.
We Specialize in High Technology at Low Prices.

Econoram* boards are generally available in 3 forms: unkit (sockets and bypass caps are pre-soldered in place for simple, one-evening assembly), assembled and tested, or qualified under our high-reliability Certified System Component (CSC) program (200 hour burn-in, immediate replacement in event of failure within 1 year of invoice date). 1 year limited warranty on all products. Refer to chart below for pricing.

<table>
<thead>
<tr>
<th>Name</th>
<th>Storage</th>
<th>Bus</th>
<th>Configurations</th>
<th>Notes</th>
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<tr>
<td>Econoram IIA</td>
<td>8K X 8</td>
<td>S-100</td>
<td>2-4K blocks, 1-16K</td>
<td>$149, 179, 239</td>
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<td>Econoram IV</td>
<td>16K X 8</td>
<td>S-100</td>
<td>2-4K, 1-16K, 2-8K, 1-8K</td>
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<td>Econoram VIIA-16</td>
<td>16K X 8</td>
<td>S-100</td>
<td>2-4K, 1-16K, 2-8K, 1-8K</td>
<td>$279, 339, 439</td>
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<td>24K X 8</td>
<td>S-100</td>
<td>2-4K, 1-16K, 2-8K, 1-8K</td>
<td>$398, 485, 605</td>
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<td>Econoram IX-16</td>
<td>24K X 8</td>
<td>Dig Grp</td>
<td>2-4K, 1-16K, 1-4K</td>
<td>$319, 379, n/a</td>
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<td>Econoram IX-32</td>
<td>32K X 8</td>
<td>S-100</td>
<td>2-4K, 1-16K, 1-4K</td>
<td>$559, 639, n/a</td>
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<td>Econoram X</td>
<td>32K X 8</td>
<td>S-100</td>
<td>2-4K, 1-16K, 1-4K</td>
<td>$529, 649, 789</td>
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<tr>
<td>Econoram XI</td>
<td>32K X 8</td>
<td>SBC/BLC</td>
<td>1-4K, 1-16K</td>
<td>n/a, n/a</td>
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<td>Econoram XII-16</td>
<td>16K X 8</td>
<td>S-100</td>
<td>1-4K, 1-16K</td>
<td>$329, 419, 519</td>
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<tr>
<td>Econoram XII-24</td>
<td>24K X 8</td>
<td>S-100</td>
<td>1-4K, 1-16K</td>
<td>$429, 539, 649</td>
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<tr>
<td>Econoram XIII</td>
<td>32K X 8</td>
<td>S-100</td>
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<td>$559, 689, 849</td>
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<tr>
<td>Econoram XV-16</td>
<td>16K X 8</td>
<td>H8</td>
<td>1-4K, 1-16K</td>
<td>$329, 395, n/a</td>
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<tr>
<td>Econoram XV-32</td>
<td>32K X 8</td>
<td>H8</td>
<td>2-16K</td>
<td>$599, 729, 219</td>
</tr>
</tbody>
</table>

Notes:
1. Works at 5 MHz with 8085 or at 4 MHz with Z-80.
2. Bank select board — 2 independent banks addressable on 8K boundaries.
3. Bank select board — 2 independent banks addressable on 16K boundaries.
4. Bank select board — 1 bank addressable on 4K boundaries.
5. 24 address lines for extended addressing.
6. Bank select option for implementing memory systems greater than 64K.

*Econoram is a trademark of Bill Godbout Electronics.

This month, we are announcing the Econoram XIV with extended addressing, two new Econorams (XV-16 and XV-32) for the H8 bus, and our Memory Management Board. In the next few months, we’ll be introducing...

- 4 MHz Z-80 CPU Board
- 5 MHz 8085 CPU Board
- Triple Parallel + Single Serial board, with 3 full duplex parallel ports and serial port with full RS-232 handshake
- 12 and 18 slot motherboards — double sided, shielded, and actively terminated
- A rack mount or desk top enclosure, with power supply, to hold all this neat stuff

Just thought you ought to know.

16K Memory Expansion

Chip Set $87.20 (regular $109; 20% off while they last)

This Godbout quality product expands memory in Radio Shack 80, Apple and Eddy Sorcerer computers. Our chip set features low power, high speed (250 ns) parts that work with 4 MHz systems. DIP shunts included. Easy-to-follow instructions for Radio Shack-80 modification make conversion simple.

“INTERFACER” S-100 I/O Bd

$189 unkit, $249 assm

Dual serial port with 2 full duplex parallel ports for RS-232 handshake; EIA232C line drivers and receivers (1488, 1498) along with current loop (20 mA) control signals on both ports. Onboard crystal-controlled timingbase with independently selectable baud rate generators for each port (up to 19.2 Kbaud). This board has hardware LSI UARTs that don’t tie up the CPU and TIL signals on both ports. Onboard crystal-controlled timebase operates with 2 to 5 MHz systems, includes software programmable UART parameters and interrupts, enables/handshaking lines, offers provision for custom frequency compensation on both receive and transmit sides to accommodate varying speed/noise situations or unusual cable lengths and even all this isn’t the full story on what this no-excuses board can do for you.

SEE COMPUPRO™ AT A STORE NEAR YOU.

Many Godbout computer products are available under the Compupro name at leading computer stores worldwide. Want to see for yourself exactly what kind of quality and effort we put into turning out cost-effective, high performance boards? Then see our products in person at a computer store near you.

FREE FLYER: We’ll be glad to tell you more than the space of this ad permits. Just send your name and address, and we’ll take care of the rest. If you’re in a hurry, enclose 41c in stamps for 1st class delivery.

Circle 150 on inquiry card.
1. **68000 System Software**

**Unmatched • Field Proven • Documented • Industry Wide**

**SDOS™**
A totally interrupt-driven (both disk and other peripherals) disk operating system, including type-ahead. Provides device independence. Further the use of 68000(X) computers in personal applications. Mutual aid in hardware and software problems.

**IDB**
A RAM or EPROM-based assembly language debugger. Provides single-step with register display, multiple real-time conditional breakpoints, memory dump, multiple data display and entry modes. Can be used to debug interrupt-driven code. 99 pages of documentation.

**8000 Hardware supported:**
- Conrac Model 480 (AMI MDC) + ICOM floppy
- WaveMate + Persci floppy (1771 + DMA)
- Electronics Product Associates + ICOM floppy
- Motorola EXORcisor + EXORdisk I or II
- SWIP + mini or DMAF floppy (FLEX)
- CMI 6800 + Winchester (18M) + Calcomp floppy (171 + DMA)
- MSI 6800 + FD-8 mini-floppy or 10M cartridge disk
- Mizar Labs + double density Micropolis drives (1791 + DMA)
- SSB ChiefTain—mini or 8-inch floppy
- Computer and Data Machines (England)

**Bussiness Basic Compiler**
Super fast application oriented BASIC, 10 digit BCD for values to 100 million dollars with pennies. Random access to variable size, variable content records. Long, meaningful variable names, formatted output, IF-THEN-ELSE with multiple statements per line, and error-trapping make this BASIC extremely powerful. Compiled code, automatic integer optimization, and fast floating point make applications written in SD Basic run faster than on virtually any other microcomputer, and protect the source code of the application. 104 pages of documentation.

**EDIT**
A powerful and easy to use text editor with change, delete, insert, and remove commands. Automatic display of text or context changes, macro facilities for complex or repetitive editing. 44 pages of documentation.

**ASM**
A lovely 2 pass assembler with conditional assembly, long labels, symbol table dump and cross-reference, error cross-reference, extensive arithmetic and listing control. 103 pages of documentation.

Write for a free catalogue or contact the hardware manufacturer. All SD software comes with a 1 year warranty.

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**Newsletters**

**Zips 00000-10000**

2. Harvard University
Laboratory for Computer Graphics, 520 Gund Hall, Cambridge MA 02138
6. William Nisen
8. $125 per year, $45 for 9 issues
10. The newsletter monitors important commercial, technological, and product developments, as well as market, application and learning opportunities.

1. Sorcerer Users Group
2. 1395 Main St, Waltham MA 02154
3. None as of yet
5. The Exidy Monitor
6. Bruce R McGlothlin
7. (617) 899-4540
8. $10 per year
9. The main purposes of the group are to make hardware and software developments known and available to the Sorcerer user, to supply software to the user, and to initiate an information service.

1. Computers in Psychiatry/Psychology
2. 26 Trumbull St, New Haven CT 06511
5. Computers in Psychiatry/Psychology (formerly Micro-Psych)
6. Marc Schwartz MD
7. (203) 562-9873
8. $15 per year for membership and 6 issues of the 13-page newsletter

1. Physicians Microcomputer Report
2. POB 6483
3. Lawrenceville NJ 08648
6. Dr Gerald M Orosz
8. $25 per year; $12.50 for students
9. Monthly publication for doctors who wish to become better informed about the computer and its application in the field of medicine.
Zips 10000-30000

1. Digital Group Independent Users Group
2. POB 316, Woodmere NY 11598
5. BRIDGE (Bi-directional Reflection for the Illumination of Digital Group Enthusiasts)
6. Lloyd Kishinsky
8. $10 for 10 issues of newsletter
9. A newsletter devoted to helping digital group users over the voids.
10. Newsletter published every 6 weeks. Vol. III starting in Fall '79. Newsletter includes helpful hints from users, items for sale, software exchange, applications, hardware and software fixes, Phideck special interest group, and articles submitted by members.

1. BUSS
2. 325 Pennsylvania Ave SE, Washington DC 20003
5. BUSS: The Independent Newsletter of Heath Company Computers
6. Charles Floto
7. (202) 544-0484
8. $8.50 for 12 issues
9. Software and hardware compatible with computers made by the Heath Company.
10. Sample issue available upon request mentioning BYTE.

1. ARESCO
2. POB 1142, Columbia MD 21044
6. Rick Simpson or Terry Laudereau
7. (301) 730-5186
8. $15 for 10 issues
9. The Paper - for owners of the Commodore PET. The VIPER - for owners

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INCOME TAX PROGRAMS FOR TRS-80™

Accountants, lawyers, tax consultants nationwide, prepared over 30,000 1978 Federal tax returns using our system.
Displays and fills in Form 1040 and related schedules on the screen, then prints out the completed forms automatically.
Change your mind? Make an error? Correct a single entry and you have a brand new form with all re-computations made automatically.
No tax system, running on any computer anywhere, has all the features of our professional system, and yet—

Our base program, which does 1040 and Schedule A costs only $189.95
And! You can add schedules for only $37.95 each, customizing your system to your requirements.

CONTRACT SERVICES ASSOCIATES

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ANAHEIM, CA 92802

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FREE CATALOG AND BROCHURE TO PROFESSIONALS

Circle 82 on inquiry card.
The Comprint 912 printer. No one else can match our speed, our print quality, our quiet operation, or our reliability. Not for $660 they can't.

Our Comprint 912 is the best printer for the money. Period. Any printer that can match our price can't even begin to match our performance. And any printer that boasts performance like ours doesn't even come close to our price. No matter what your application; computer reports, listings, CRT hard copy, message receiving, scientific/industrial data logging, or anything you can think of, the Comprint 912 is the performance leader in printers under $1000.

First consider our performance.

**Speed.**
At 225 characters per second (170 LPM) the Comprint 912 is up to 4 times faster than impact printers costing hundreds of dollars more. With our printer you don’t waste time and money waiting for your print-out.

**Print Quality.**
Our 9x12 matrix provides sharp, crisp characters. Compare that with our competition. Their very best is a 9x7 matrix, which means no lower case descenders and cramped letters. With the Comprint 912 you don’t have to put up with the irritation of fuzzy, hard to read computer printing. This
Exceptional print quality in every Comprint 912 printout. Twice the industry standard, 6 month parallel I/O and 8 1/2" wide, have been shipped to happy customers.

The superior print quality provided by the Comprint 912 is obvious in this actual size sample.

means increased productivity. And because the Comprint 912 makes better originals, our originals make better Xeroxes.

Quiet Operation.
Most computer printers are irritatingly noisy. They can disrupt concentration and reduce the efficiency of anyone working near them. They're noisy because they're impact. The Comprint 912 has no mechanical print head banging on the paper. It's electronic. It's quiet.

Reliability.
Since the Comprint 912 prints electronically, rather than mechanically like ordinary impact printers, we have fewer moving parts and less vibration. The Comprint 912 has fewer things to go wrong and less wear. That's why we offer a 6 month warranty, twice the industry standard. The key to all this superior performance is our special paper. This aluminized "silver paper" works just like ordinary paper. It won't fade or discolor and actually costs less than plain paper and one time ribbons. For the vast majority of printing applications it's just plain better than plain paper. Especially when you consider the hidden costs of plain paper printers due to their inferior performance compared to the Comprint 912. And on those rare occasions when you really do need a plain bond paper copy, just run your Comprint 912 printout through your plain bond copy machine and you've got it. Even though our paper is special, it's available everywhere; from your dealer or distributor, or from us.

Now consider our price.
The Comprint 912.
$660 with parallel interface, $699 with serial interface.

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1. 6502 User Notes
2. POB 33093, N Royalton OH 44133
5. Yes
6. Eric C Rehnke, Publisher
7. (216) 237-0755
8. $13 for Volume 3 in N America, $19 for Volume 3 elsewhere.
9. The newsletter supports KIM, SYM, AIM, and OSI 6502-based machines. We have special sections dealing with BASIC, Forth, FOCAL, Tiny BASIC, KIMSI, interface, music, etc.
10. The International Institute for Robotics

1. Microcomputer Investors Association
2. 902 Anderson Dr, Fredericksburg VA 22401
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5. The Microcomputer Investor
6. J Williams
7. (703) 371-5474
8. $30 per year
10. Each participating member is required to publish one article per year in The Microcomputer Investor.

1. TRS-80 Users Group
2. 7554 Southgate Rd, Fayetteville NC 28304
3. TRS-80 Users Group Newsletter
4. Mr Robert G Lloyd
5. (919) 867-5822
6. Each participating member from more than 20 countries.
7. An association of persons who utilize microcomputers to assist in making and managing investments.
8. $1 per issue of 52-NOTES ($1.67 abroad, excluding Canada and Mexico).

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2. 9459 Taylorsville Rd, Dayton OH 45424
3. 3. 9459 Taylorsville Rd, Dayton OH 45424
4. No meetings
5. 52-NOTES
6. Richard C Vanderbilt
7. (513) 233-3698
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8. Membership is free; subscription to newsletter is $5 for 12 issues (minimum 8 pages, each). All subscriptions must start with Volume #1, Issue #1.

9. The CUG is a user’s group for all 1802-based microcomputers, including Basic ELF, ELF-II, Super-ELF, UC-1800, DSD-1802, VIP, homebrews, etc.

10. The CUG is a nonprofit, national syndicate of 1802-based computer owners and users. Our members provide copies of their own software and hardware to other CUG members, charging only for actual copying and postage costs. Each member receives a detailed listing in our newsletter, which publishes both software and hardware articles and reviews.

1. Poly 88 Users Group
2. 1477 Barrington #17, Los Angeles CA 90025
3. None
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5. Pat or Roger Lewis
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2. POB 55056, Valencia CA 91355
3. None
5. Business Computing Newsletter
6. Alan Bartholomew, Publisher, Greg Scott, Editor
7. (805) 255-8543 or (213) 881-8076 respectively
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9. A balance between hobbyist and commercial interests: tutorial articles, hardware reviews, software reviews, news, group discounts, program library, tape recorded lectures, and communication among members.
10. Formerly known as Solus, we are now open to anyone owning a Sol, CUTS, or Helios, or any compatible hardware. Send $2 for a sample issue of the newsletter.

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4. Third Saturday of the month.
5. Newsletter (monthly); magazine (quarterly).
6. Andrew Stewart, Secretary
7. (03) 277-1613
8. $7.50 per year
9. None; we try to interest all microcomputer enthusiasts.

1. Australian 9900 Users Group
2. GPO Box 835, Melbourne, Victoria 3001 AUSTRALIA
3. None - correspondence only
4. None - direct contact
5. Barry Day
6. (03) 661-2523
7. None
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9. The main language is Japanese. We have about 2500 members in our 7 branches in Japan.
10. The main goal of the HCC is to increase contacts between computer amateurs, to exchange ideas and experiences.

1. Microtel-Club
2. 9 rue Huysmans, 75006, Paris FRANCE 0 544 70 23
3. Yes
4. $35 per year
5. Our A5-sized bimonthly Nieuwsbrief will be a full-sized monthly in 1980. Once a year we organize the HCC Day with a complete exhibition and a program of readings. Our yearly members list shows which computer is used and each member's applications. The HCC now has over 2300 members in Belgium and the Netherlands.

1. Microcomputer Club
2. 6 rue de Quijote #5, MEXICO 10, D.F.
3. Alfredo Buzali
4. 5-89-22-79 between 7 and 8 PM
5. Primarily concerned with the Apple II and Ohio Scientific products.
6. Hobby Computer Club
7. Christinastraat 171, 5615 IC0, THE NETHERLANDS
8. 784-3532 and 793-1576,
9. No special favor for any computer or microprocessor. The main goal of the HCC is to develop and encourage by all appropriate means the wider understanding and general use of microcomputers and related systems in new and productive applications. The HCC has over 2300 members in Belgium and the Netherlands.
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1. Singapore Microcomputer Society
2. 43K, Pongolg Rd, Singapore, 19, REPUBLIC OF SINGAPORE
3. Jack Page
4. 4680944
5. $25 per year
6. To develop and encourage by all appropriate means the wider understanding and general use of microcomputers and related systems in new and productive applications.
7. Hobby Computer Club Nieuwsbrief (Dutch)
8. Erik Visser, Secretary
9. At 12 places throughout Belgium and the Netherlands.
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Practical Microcomputer Programming: The Intel 8080

by W J Weller, A V Shatzel, and H Y Nice
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Practical Microcomputer Programming: The Z80

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Review

Practical Microcomputer Programming is a series of books begun in 1976 and masterminded by Walter Weller. Mr. Weller is an applications software consultant specializing in the industrial, medical, and educational uses of small computers, and is the founder of Northern Technology Books, the publishers of this series.

It is quite obvious that Mr. Weller has a natural feel for how to present such technical material. Each book is presented in lucid, readable terminology, and the layout is carefully designed to treat each topic separately and completely. This gives the reader not only a tutorial workbook to learn more about the art of assembly language programming, but also an excellent reference text which will be used time and again in preparing new projects.

The objective of the series is to directly address the difficulties of microcomputer application programming in assembly language as simply as possible. Although many programmers see little need to get embroiled in the complexities of an assembly language when a higher level language such as BASIC is available, there are indeed many applications in which a program in assembly language is desirable. In some applications it is absolutely necessary. Two important considerations in choosing to use an assembly language are necessary memory restrictions and speed.

First, recall that this series was begun in 1976. At that time most programmers doing work on microcomputers did not have the amount of memory thought of as common today. Presently programmers think nothing of talking about 64 K byte systems, and while such a large amount of memory is still not cheap, nonetheless it is within the realm of affordability, or at least will be in the very near future. In 1976, however, it was rare to think in terms of more than 4 K bytes of memory, consequently, getting a program to execute with the least amount of memory was paramount. A high-level language was a luxury few could afford. Therefore, in 1976 minimum memory requirements were quite important. But what about now, when a 64 K byte chip is within the foreseeable future?

Obviously there are still many times when a minimum amount of memory should be used. There are many industrial applications which still require strict conservation of available memory. Today there is hardly a major home appliance or piece of office equipment that does not have a microprocessor controlling it, and it certainly is not cost effective to provide each of these machines with the 16 or 32 K bytes of memory necessary to support programming in a high-level language. But there is one other consideration for using assembly language: speed.

Speed is one of the major reasons that assembly language programming retains strong adherents. Assembly language programming is often a must for the transfer of data between any of several devices at a rate consistent with the speeds at which these devices operate.

There is another good reason for wanting to learn assembly language programming. There isn’t an exact term to describe it, but words like fun, self-fulfilling, and fascinating partially describe the feeling one has after mastering assembly language programming. It lets you into that mystical world of the system programmer, it allows you to become intimate with the most inner workings of your computer, it lets you feel in total control of the sometimes awesome power the computer engenders. All in all, the individual becomes a more effective, confident, and efficient programmer.

What has all this to do with this series of books? It is Walter Weller’s contention that learning to program in an assembly language should be a painless, rewarding...
experience. There is nothing inherently intimidating about assembly languages, yet they have acquired a reputation guaranteed to frighten the novice programmer. It was apparently Mr. Weller’s goal from the beginning to present the fundamental concepts of assembly language programming in a completely non-threatening way. He has accomplished this goal better than any other author to date.

Each book of this series is a completely self-contained guide to the assembly language of a particular microprocessor. Each is packed with examples of assembly language routines which perform real functions useful to the novice programmer. These routines not only supply the reader with instant software for a variety of applications, but also abundantly illustrate the usefulness of assembly language programming. I found each book of the series to be logically designed, including chapters detailing one particular area of assembly language programs, appendices with source listings of significant software, and a comprehensive index making it easier to use the books as reference texts.

These books are not exhaustive discussions of the programming characteristics of a particular microprocessor, nor do they represent complete details on all possible assembly language programming techniques. What these books do represent is a suitable cross-section of techniques that will aid the novice assembly language programmer in sharpening skills, while serving as an excellent reference resource for the experienced programmer. As for the particular microprocessor each book covers, the discussion is specific and to the point, not theoretical or general.

One final comment on the series as a whole before discussing particular details of each book: every line of code printed in each book has been checked and rechecked, right up to the moment before the book is actually printed. This helps eliminate annoying typesetting errors in the listings. While this does not absolutely guarantee the correctness of the examples or programs listed, it certainly goes much further in doing so than most publishers care to pursue. This represents a tremendous plus to the reader.

The Intel 8080 is the first book of the series, published in 1976. Although the 8080 is one of the older microprocessors on the market, there are several manufacturers (including Heath Company and Compucolor Corp) still basing their systems on this chip. In other words, this book still applies to a large number of machines currently available.

There are over 80 example programs used to illustrate the solutions to common problems facing the assembly language applications programmer. These examples are practical as well as explanatory and can often be used directly to form parts of applications programs.

The authors cover a lot of territory in the 18 chapters, 3 appendices, and index of this book. They naturally begin with binary arithmetic and logical (AND, OR, NOT) operations, bringing the programmer familiar with high-level languages, but not assembly language “down” to the proper level of thinking. Next, a definition of what constitutes memory and how it is accessed in a microcomputer is covered, which gives the novice assembly language programmer a basic idea of where things are located inside the machine.

After the preliminaries are out of the way, the authors describe the parts of an assembly language program, such as labels and operands. Also discussed are assemblers, cross-assemblers, and loaders. Chapter 4 begins the detailed descriptions of 8080 instructions, including moving data, binary arithmetic, software multiplication and division, and using the stack pointer. Chapter 8 then employs what has been learned so far to construct a number of commonly required subroutines.

Next, binary-to-decimal and decimal-to-binary conversions are covered, allowing the programmer to form input and output which is the subject of the next chapters: communicating with a terminal, and controlling a printer. Other types of communication to the physical world, such as digital and analog output, are also discussed.

Chapters 16 and 17 cover a topic usually omitted from a programming guide, interrupt-driven processes. First, the concept of a real-time clock and its uses are discussed, then the necessary considerations of real-time input and output are detailed. While the novice programmer may not be able to use the information in these 2 chapters immediately, the authors clearly show that progressing to that level is not that difficult, and the added flexibility of being able to take real-time events into account is of great benefit to the assembly language programmer.

The final chapter discusses many helpful ways to debug assembly language programs, the bane of many a programmer. Techniques here are illustrated using the authors’ own debugging program, a tool serious programmers can not afford to be without. It allows inspection and modification of memory, single-step execution via breakpoints, and many other handy techniques. The authors have included the source code of this program in the book, which is a real bonus.

In addition to the debug program listing in the appendices, the authors have also included the source listings of the cross-assembler and loader used on the Computer Automa-
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different mnemonics for certain instructions. "For

 clarity." An example is ReSet Carry (RSC) instead of ORA A. The authors' intentions are certainly appreciated, but it is unclear whether or not this offers an advantage to the programmer just learning 8080 assembly code, especially if one has access to an assembler which uses Intel mnemonics. Certainly it is easier to remember that RSC means reset carry (as opposed to ORA A), but is it realistic to assume that the reader will be in a position to take advantage of the improvement?

Only a few of the dozens of mnemonics were "improved," so hand translation is not difficult. The authors have been careful to identify which ones were changed, and the comprehensive index makes locating references in the text simple.

Once author Weller had put together a winning combination of information, he knew not to tamper with success. The M6800 and Z80 books have essentially the same information that the 8080 book does, but naturally there are specific differences for these microprocessors. There are a few differences in the conclusions, such as chapters on floating point arithmetic in the M6800 and Z80 books, and graphic output in the Z80 book, but by and large, each book covers the same general territory. In essence, then, Weller has written the same book 3 times. This certainly has its advantages, because now it is easy to compare the performance and instruction characteristics of these 3 microprocessors.

In the M6800 book, Weller again provided a listing for a debugging program as part of the appendices. As in the 8080 book, a number of the instruction mnemonics as defined by Motorola were found not suitable, and so Weller made a few substitutions of his own mnemonics (for example, DATA instead of FCB). As long as the reader is aware that this is happening (which the author points out in the preface), he or she will not have any trouble following the discussions.

Weller's Z80 book turned out to be a more ambitious project, however. It includes a complete description and source code listing of an assembler of Weller's own design, in addition to the now anticipated debugging monitor. These programs are available in paper tape or TRS-80 cassette form from the publisher, free of charge with the return of the coupon from the book.

In the Z80 book, Weller also chose to go his own way with the assembly language mnemonics, even more so than with the M6800 and 8080 instruction sets. Essentially, he felt that Zilog did a great disservice to 8080 owners by completely redefining the mnemonics of their chip, even though a great part of the instruction set is exactly the same as that of the 8080. In actuality, the Z80 instruction set is an extended 8080 instruction set, except that Zilog used a different set of mnemonics for the instructions the Z80 has in common with the 8080.

All this means is that those who are experienced in 8080 assembly language are forced to learn an entirely new set of mnemonics for the Z80, even though the actual execution of the instructions would be exactly the same as before. Weller perceived this as an injustice to 8080 users; that being the case, his assembler merely extends the 8080 instruction set to include the full use of Z80 instructions. This approach will obviously alienate some Z80 users, but I doubt will please those upgrading from an 8080 based system to a Z80. The author also provides a complete table which translates the mnemonics he uses in his assembler and debugger to the Zilog mnemonics. I prefer not to take sides in this matter, but I cannot help but admire Weller for taking a stand for simplicity.

Practical Microcomputer Programming is a very powerful series. It is well written and full of essential techniques for the assembly language programmer. The final question is: "What is next for Walter Weller?" The author intends to continue the format used for the Z80 book and provide a complete assembler for the 6502. He is hard at work on this assembler, and hopes to publish the book around the beginning of 1980. At last the 6502 users will have a definitive resource for this much neglected microprocessor. I am sure that the book will be well worth the wait.

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PET WORD PROCESSOR

This program permits composing and printing letters, flyers, advertisements, manuscripts, etc., using the COMMODORE PET and a printer. Script directives include line length, left margin, centering, and skip. Edit commands allow the user to insert lines, delete lines, move lines and paragraphs, change strings, save onto cassette, load from cassette, move up, move down, print and type. The CmC Word Processor Program addresses an RS-232 printer through a CmC printer adapter. The CmC Word Processor program is available for $29.50. Add $1.00 for postage and handling per order.

Order direct or contact your local computer store.

Circle 76 on inquiry card.
An ASCII String Program

William Comer, 419 Blackman St, Lake Charles LA 70605

Programming long American Standard Code for Information Interchange (ASCII) strings or a large number of strings can be a tedious job. The Motorola 6800 program in listing 1 simplifies the task by automatically setting up the proper hexadecimal codes in the ASCII string. This program assumes you are using a 6800 system with the Motorola MIKBUG monitor program. You simply type in the statements you want printed during execution of a machine language program. The starting address of the ASCII string is stored in hexadecimal locations A000 and A001 (high- and low-order byte respectively) before executing the program.

Using the Program
When a point is reached where you want to insert the text in your machine language program:

- Load the program starting at hexadecimal memory location 0100.
- Load the starting address of the ASCII string at hexadecimal address A000 and A001.
- Load the starting address of the program into hexadecimal memory locations A048 and A049 (01 in A048, 00 in A049).
- Start the program by typing G.
- Type in the statements exactly as you want them printed.
- Return to MIKBUG control by hitting the reset button.

Listing 1: M6800 program to load ASCII characters into memory using MIKBUG and MP-C Interface.

<table>
<thead>
<tr>
<th>Address</th>
<th>Hexadecimal Code</th>
<th>Label</th>
<th>Op Code</th>
<th>Operand</th>
<th>Commentary</th>
</tr>
</thead>
<tbody>
<tr>
<td>0100</td>
<td>CE 80 04</td>
<td>START</td>
<td>LDX</td>
<td>#PIAD</td>
<td>Look for start bit.</td>
</tr>
<tr>
<td>0103</td>
<td>A6 00</td>
<td>IN1</td>
<td>LDAA</td>
<td>0.X</td>
<td>Set counter for ½ bit.</td>
</tr>
<tr>
<td>0105</td>
<td>2B FC</td>
<td>BM1</td>
<td>BSR</td>
<td>DE</td>
<td>Start timer.</td>
</tr>
<tr>
<td>0107</td>
<td>6F 02</td>
<td>CLR</td>
<td>O</td>
<td>2.X</td>
<td>Delay ½ bit time.</td>
</tr>
<tr>
<td>0109</td>
<td>8D 28</td>
<td>BSR</td>
<td>DEL</td>
<td>#4</td>
<td>Set delay full bit time.</td>
</tr>
<tr>
<td>010B</td>
<td>8D 22</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>010D</td>
<td>C6 04</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>010F</td>
<td>E7 02</td>
<td>STAB</td>
<td>2, X</td>
<td></td>
<td>Set up counter with 8.</td>
</tr>
<tr>
<td>0111</td>
<td>58</td>
<td>ASLB</td>
<td>BSR</td>
<td>DEL</td>
<td>Wait 1 character time.</td>
</tr>
<tr>
<td>0112</td>
<td>8D 1B</td>
<td>IN3</td>
<td>BSR</td>
<td></td>
<td>Mark commentary line.</td>
</tr>
<tr>
<td>0114</td>
<td>0D</td>
<td>SEC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0115</td>
<td>69 00</td>
<td>ROL</td>
<td>0, X</td>
<td></td>
<td>Get bit into CFF.</td>
</tr>
<tr>
<td>0117</td>
<td>46</td>
<td>RORA</td>
<td></td>
<td></td>
<td>CFF to AR.</td>
</tr>
<tr>
<td>0118</td>
<td>5A</td>
<td>DECB</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0119</td>
<td>26 F7</td>
<td>BNE</td>
<td>IN3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>011B</td>
<td>8D 12</td>
<td>BSR</td>
<td>DEL</td>
<td></td>
<td>Wait for stop bit.</td>
</tr>
<tr>
<td>011D</td>
<td>84 7F</td>
<td>ANDA</td>
<td>#7F</td>
<td></td>
<td>Reset parity bit.</td>
</tr>
<tr>
<td>011F</td>
<td>81 7F</td>
<td>CMPA</td>
<td>#5F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0121</td>
<td>27 E0</td>
<td>BEQ</td>
<td>IN1</td>
<td></td>
<td>If rubout, get next character.</td>
</tr>
<tr>
<td>0123</td>
<td>FE A0 00</td>
<td>LDX</td>
<td>ASSA</td>
<td></td>
<td>ASCII string start address.</td>
</tr>
<tr>
<td>0126</td>
<td>A7 00</td>
<td>STAA</td>
<td>0, X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0128</td>
<td>08</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0129</td>
<td>FF A0 00</td>
<td>STX</td>
<td>ASSA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>012C</td>
<td>7E 01 00</td>
<td>JMP</td>
<td>START</td>
<td></td>
<td></td>
</tr>
<tr>
<td>012F</td>
<td>6D 02</td>
<td>DEL</td>
<td>TST</td>
<td>2, X</td>
<td>Is time up?</td>
</tr>
<tr>
<td>0131</td>
<td>2A FC</td>
<td>BPL</td>
<td>DEL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0133</td>
<td>6C 02</td>
<td>DE</td>
<td>INC</td>
<td>2, X</td>
<td>Reset timer.</td>
</tr>
<tr>
<td>0135</td>
<td>6A 02</td>
<td>DEC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0137</td>
<td>39</td>
<td>RTS</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Listing 2: To print an ASCII string during a machine language program, insert these 2 instructions into the program.

<table>
<thead>
<tr>
<th>Hexadecimal Code</th>
<th>Op Code</th>
<th>Operand</th>
<th>Commentary</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE XX XX</td>
<td>LDX</td>
<td># String</td>
<td>Memory location. XXXX is the starting address of the ASCII string.</td>
</tr>
<tr>
<td>BD E0 7E</td>
<td>JSR</td>
<td>PDATA 1</td>
<td>MIKBUG subroutine to print on ASCII string.</td>
</tr>
</tbody>
</table>
Circle 314 on inquiry card.

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**Table of Subroutines**

Peter W Meek, 1788 Miller Ave, Ann Arbor MI 48103

If you have a subroutine in a program, it is very likely you wrote the first line on a nice even number like 5000 or 10000. Now the program is finished, and it is time to neaten it up. You type the RENumber command, but where is your subroutine now?

If you put a table of subroutines at the end of every program, as shown below, the renumber command will keep track of them for you.

```
10 REM START OF PROGRAM
. . .
4999 END : REM END OF PROGRAM
5000
. . .
5900 RETURN : REM END OF SUBROUTINE #1
10000 REM START OF SUBROUTINE #2
. . .
10900 RETURN : REM END OF SUBROUTINE #2
20000 REM TABLE OF SUBROUTINES
20010 GOTO 5000 : REM SUBROUTINE #1
20020 GOTO 10000 : REM SUBROUTINE #2
99999 END
```

Now the destinations of the GOTOs will be changed along with the actual line numbers. A program listing will end with a clear statement of where to look for that line which seems to have a bug in it.

Of course, this can be used to keep track of any part of a program that you like.
Sharp Introduces Alphanumeric Calculators

Sharp Electronics Corp has introduced two handheld scientific calculators in which alphanumeric formulae can be entered as written without being translated into machine language. The most complicated formulae can be entered into the machine and displayed, and can be visually edited, corrected, or tested without going through any translation phase. The key to the versatility of both machines in an exclusive "rolling writer" dot matrix liquid crystal display which shows numbers, letters and symbols. Because the entries roll across the liquid crystal display, as many as 80 entries can be made.

The EL-5100 has a 24-character display which can enter and store up to 80 steps, because of the rolling writer feature. It has 61 keyed functions, 10 data memories, and Memory Safe Guard to maintain data and programs even when the power is off. The EL-5100 accepts the input of complicated formulae with up to 15 levels of parentheses and 8 levels of pending operations. Complex formulae can be stored as long as needed. Five formulae, with up to 80 steps, can be stored for easy calculations and recalled at the touch of a key. Ten variables can be stored and used in the formulae.

The EL-5101 has capabilities similar to the EL-5100. It has a 16-character display which can roll to 80 characters, storage up to 48 steps, and six data memories. Both models are wafer-thin, horizontally held, weigh just over 5 ounces, and come in a brushed metal finish. The EL-5100 is priced at $99.95 and the EL-5101 is $79.95. For further information, contact Sharp Electronics Corp, 10 Keystone Pl, Paramus NJ 07652.

Circle 622 on inquiry card

Encryption Device Secures Data in TRS-80

CRYPTEXT is a hardware encryption device designed to plug directly into the back of the Radio Shack TRS-80 Model 1 or into the expansion interface via an optional cable. The device allows users to secure virtually any data stored on cassette tapes or on disks against unauthorized access. Used with a modem, CRYPTEXT allows data or messages to be transmitted by telephone or other communication channels in complete privacy. Other uses include generating pseudorandom numbers for games or scientific programs.

Prior to encoding data, CRYPTTEXT requires a user to enter a 10-character key; each of the 2^10 possible keys results in a different and completely incoherent version of the data submitted for encryption. To decode secured data, four elements are essential: the encrypted data, the CRYPTTEXT unit, the software, and the correct user-supplied key. The lack of any of these elements prevents access to the original data.

The price is less than $300 and includes demonstration software and user-oriented documentation. Optional cable and additional tape or disk software are available for a small additional charge. For further information, contact CRYPTTEXT Corp, POB 425 Northgate Sta, Seattle WA 98125.

Circle 623 on inquiry card
Daisy Printwheels

These plastic daisy printwheels with 96 character positions are available from AGT Computer Products Inc, 10906 Rochester Ave, Los Angeles CA 90024. They presently offer 27 Qume compatible and 13 Diablo compatible typestyles, including those which are more commonly used. These printwheels have rubber buttons with a plastic disk on the top for ease of handling. All printwheels have a metallized period, extra heavy underscore, and reinforced hub and spoke stress-points. In addition, 2 IBM compatible printwheels in Orator and OCR-B typestyles with the flip-top clasp for use in the IBM 6240 system are available. The company manufactures special wheels to order, and will modify existing molds in order to accommodate special characters or logos.

Circle 586 on inquiry card.

Microbench 8086 Software

A series of computer programs to support applications development for the Intel 8086 16-bit microprocessor, Microbench 8086, has been announced by Virtual Systems Inc, 1500 Newell Ave #406, Walnut Creek CA 94596. These programs operate in conjunction with PDP-11 and LSI-11 computers to provide an economical program development capability for the Intel 8086.

Included in Microbench 8086 software are a relocating assembler, linking loader, librarian, and object file formatter. The assembler supports extensive macro and conditional assembly capabilities, cross reference listings, and provides for memory addressing beyond 64 K bytes. The loader provides linkage facilities, selective loading from libraries, and directives for specifying read-only and programmable memory alignment boundaries.

The object file formatter produces binary modules in compatible formats for use with programmable read-only memory programmers and emulation systems. Microbench software is coded in Macro-11 for high throughput, and operates under RT-11, RSX-11M, RSX-11D and RSTS/E operating systems. Perpetual license fees start at $1695 including documentation and first-year maintenance.

Circle 588 on inquiry card.

Portable Computer System

Called the MAScot, this complete computer system is housed in a portable carrying case. The system contains the following modular components: a 5-inch, 7 by 9 dot matrix video displaying all 128 characters of the American Standard Code for Information Interchange (ASCII) set, single or dual 5-inch floppy disk drives offering 80 to 320 K bytes of data storage, 40 or 80 column dot matrix printer, 300 or 1200 bits per second (bps) modem with built-in acoustical coupler, and 8- or 16-bit microprocessor featuring up to 1 M bytes of programmable memory. The carrying case also contains extra storage space, and the top cover is removable. The design highlights minimum size and weight combined with durability. MAScot firmware is extended BASIC, featuring integrated assembly instructions using a high-level incremental compiler. The operating system handles multiskit files.

Depending upon configuration, the price ranges from $3999 to $9999. For further information, contact Micro Application Systems Inc, 4345 Lyndale Ave N, Minneapolis MN 55412.

Circle 587 on inquiry card.

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**64 K Byte Microcomputer System**

This 2 board microcomputer system utilizes DEC's LSI 11/2 central processing unit model KD11-HA with power fail and auto restart, 16-bit I/O (input/output) direct memory access (DMA) port, real-time clock input, vector interrupt handling, and Chrislin Industries' CL-1103 32 K byte by 16 memory board. The programmable memory module has an access time of 300 ns from synchronous active and the cycle time is 525 ns. On-board memory select is available in 2 K byte increments up to 128 K words. Complete power consumption is under 6 W. The memory is tested and burned in and warranted for a full year. The single quantity price is $1250. For further information, contact Chrislin Industries, 31312 Via Colinas # 102, Westlake Village CA 91361.

**Single-Board Microcomputer System Designed as Learning Aid**

The TM990/189M, a self-contained memory module has an access time of 300 ns from synchronous active and the cycle time is 525 ns. On-board memory select is available in 2 K byte increments up to 128 K words. Complete power consumption is under 6 W. The memory is tested and burned in and warranted for a full year. The single quantity price is $1250. For further information, contact Chrislin Industries, 31312 Via Colinas #102, Westlake Village CA 91361.

**Single Read-Only Memory and I/O Timer**

This read-only memory and I/O (input/output) timer can be used with the S6802 microprocessor to form a complete S6800 microcomputer with only 2 integrated circuits. The new device will also work with the S6800, S6801, S6808, S6809 or the 6500 family microprocessors.

Designated the S6846, the device combines 2 K bytes of read-only memory, an 8-bit bidirectional data port with 2 control lines for a parallel interface, a programmable interval timer and counter, and programmable registers for peripheral I/O data and control. The S6846 is the first part in the S6800 family to feature an automatic hardware power on reset capability.

The mask programmable device is fully compatible with transistor-transistor logic as well as with other members of the S6800 family. It operates from a single +5 V DC power supply. Read-only memory code for the device can be developed on the AMI MDC-100 Microcomputer Development Center using 6800 assembly language, though specific control software for the S6846 must be user developed.

Contained in a 40-pin dual-in-line package, the S6846 is priced at $7 in plastic and $8.95 in ceramic. For further information, contact American Microsystems Inc, 3800 Homestead Rd, Santa Clara CA 95051.

The board is self-contained with 1 K bytes of programmable memory (expandable on board to 2 K bytes) and 4 K bytes read-only memory (expandable on board to 6 K bytes). The read-only memory contains the system monitor (UNIBUG) and a symbolic assembler. Mass memory storage can be accomplished with the audio cassette interface. Built into the TM990/189M is a 45 key alphanumeric keyboard and a 10 digit, 7 segment display. The display has a 32 character buffer. It may be shifted right or left to view any 10 digits of the 32 character buffer. Provisions are on the board to add an external, standard EIA terminal or teletypewriter interface.

Other features of the TM990/189M include a series of addressable light-emitting diodes (LEDs). Coupled with these visual indicators is a piezoelectric speaker for audio signals.

The TM990/189M is priced at $299 and the optional power supply (TM990/519) is $65. For further information, contact Texas Instruments Inc, POB 1443 M/S 663, Houston TX 77001.

The TM990/189M, a self-contained single-board microcomputer system, has been announced by Texas Instruments Inc. This microcomputer system is designed as a completely assembled learning aid for hands-on experience, plus instruction in microcomputer fundamentals, assembly and machine language, and microcomputer interfacing.

The board is self-contained with 1 K bytes of programmable memory (expandable on board to 2 K bytes) and 4 K bytes read-only memory (expandable on board to 6 K bytes). The read-only memory contains the system monitor (UNIBUG) and a symbolic assembler. Mass memory storage can be accomplished with the audio cassette interface. Built into the TM990/189M is a 45 key alphanumeric keyboard and a 10 digit, 7 segment display. The display has a 32 character buffer. It may be shifted right or left to view any 10 digits of the 32 character buffer. Provisions are on the board to add an external, standard EIA terminal or teletypewriter interface.

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The TM990/189M is priced at $299 and the optional power supply (TM990/519) is $65. For further information, contact Texas Instruments Inc, POB 1443 M/S 663, Houston TX 77001.

Circle 594 on inquiry card.
Microcomputer With Large Characters Ideal for Instruction

The EduCALC 189 GD is a 16-bit printed circuit board designed specifically for instruction. The instructor has an onboard 45-key alphanumeric keyboard and gets input, output and status information from the light-emitting diode display. Large characters on the other side of the unit repeat this display to the audience.

Assembly-language programming is featured with minicomputer instruction set; read-only memory resident software (including system monitor for program debug and symbolic assembler); single step execution; cassette interface; EIA and TeleType interface; 1 K byte programmable memory and 4 K byte read-only memory (expandable); 16-bit programmable I/O (input/output) controller and interrupt monitor; 2 MHz clock; also software and firmware compatibility with the entire TI 9900 family of microprocessors.

The price of the EduCALC 189 GD is $1074 which includes TM 990/189 board and power supply, a 570-page tutorial text, a 300-page user’s guide, and a rigid carrying case. There is a one-year warranty on the neon display and interface and a 90-day warranty on the TM 990/189. Contact Educational Calculator Devices Inc, POB 974, Dept 14B, Laguna Beach CA 92652.

Manual Aids TRS-80 Users in Utilizing Level II BASIC Read-Only Memory

The Software Technical Manual has been written by the technicians at Houston Micro-Computer Technologies Inc to provide the assembly programmer with documentation of the TRS-80 Level II BASIC read-only memory entry points and provide working examples of their use. The manual is for the person that understands and programs in Z80 assembly language and is interested in writing fast, computer-oriented programs. It is organized in sections which emphasize different aspects of computation. The Software Technical Manual sells for $49.95. The address of the company is 5313 Bissonnet, Bellaire TX 77401.

Acoustically Coupled Modem

CAT is an acoustic modem which is designed to transmit data over all telephone lines. It allows one computer or terminal to talk to another. Data exchange can occur at any speed up to 30 characters per second (300 bps). The device offers features that include Bell 103 compatibility; answer, originate, and test modes with full and half duplex; and light-emitting diodes for displaying unit status. Standard on the modem are an acoustic self-test and a compact power supply that plugs directly into wall sockets to reduce heat and voltage hazards. For further information, contact Advanced Computer Equipment Inc, 3 Republic Rd, N Billerica MA 01862.

High-Quality 5-100 Cabinet

Designated the Model 2150, this industrial-quality electronics cabinet is for hobbyists and system designers using the S-100 bus. The Model 2150 features a split construction design permitting rapid, easy access to all components by the removal of two screws. Heavy duty, 22-gauge steel is used throughout. A louvered front panel and lowered sides plus a fan facilitate air flow for efficient thermal characteristics. Components are mounted on a separate, removable chassis enabling rapid troubleshooting. One or two 5-inch disk drives are mounted in electrically shielded enclosures protecting media from spurious noise. A fully shielded and terminated 8-slot backplane is totally compatible with the S-100 bus. The Model 2150 electronics cabinet is priced at $795. For further information, contact Advanced Computer Equipment Inc, 3 Republic Rd, N Billerica MA 01862.
Video Timer and Controller Device from Texas Instruments

This single device video timer and controller has been announced by Texas Instruments Inc, POB 1443 MIS 6404, Houston TX 77001. A silicon gate, N-channel metal-oxide semiconductor (MOS) device, the TMS9927, offered in a 40 pin dual-in-line package, generates video display timing signals for standard and nonstandard video monitors that incorporate both interlaced and non-interlaced formats.

The TMS9927 may be used with either 8- or 16-bit processors, including the TMS9900 family as a memory mapped I/O (input/output) device. It can also communicate with the communications register unit (CRU) interface of the TMS9900 family via the TMS9901 programmable systems interface.

Five sections comprise the new video timer and controller: processor interface, cursor control, horizontal control, vertical control, and self-load. The video timer and controller provides 9 user programmable control registers. Seven registers control horizontal and vertical formatting, and 2 control the cursor address.

The architecture of the TMS9927 is intended to allow maximum design flexibility. Most raster scan videos may be controlled by the TMS9927 by appropriately programming the control registers. The TMS9927 is interchangeable with Standard Microsystem Corporation's (SMC) CRT 5027.

Priced in 100 piece quantities, the TMS9927 video timer and controller is $22.50 in plastic and $27 in ceramic. Circle 595 on inquiry card.

Control System for TRS-80 and PET Computers

Able to sense up to 24 inputs and drive 16 medium power outputs, the SY-16 is a plug compatible turnkey control system with all software and hardware furnished. The 16 output devices can be any 6 V or less on/off mechanism using less than 1/4 A. Relay coils can be driven directly. By selecting a 6 V relay with appropriate contacts, AC signals and power can be switched, controlling most equipment originally designed for manual operation.

Input devices can be transistor-transistor logic (TTL) gates, or any form of switch contacts, including thermostats, reed switches, microswitches, joysticks, keyswitches and numeric keypads. The SY-16 can sense open or closed conditions. Up to 8 switches can be wired for fast operation. A switch closure can be captured and held, or noisy contacts can be debounced.

A software timing and control program (STAC) allows the user to specify and execute complex timing, sensing, and control sequences without having to program or write programs which call STAC as a subroutine. An interactive program is also furnished to help design sequences and experiment with them.

The SY-16 comes completely assembled, tested and ready to plug into TRS-80s (model T) or PETs (Model P) with software and comprehensive instruction manual describing sequence design, I/O (input/output) device control, STAC operation, and example applications for $289. The instruction manual is available at $12 and refundable upon SY-16 purchase within 60 days. For further information, contact Cooper Computing, POB 16082, Clayton MO 63105.

Circle 597 on inquiry card.

48 K Byte Dynamic Programmable Memory Board

This 48 K byte dynamic programmable memory board featuring complete compatibility with Z80 based S-100 bus microcomputer systems has been introduced by Vector Graphics Inc, 31364 Via Colinas, Westlake Village CA 91361. The board incorporates the Z80 refresh mode for problem free, transparent refresh, and consumes less than 4 W of total power. Superior reliability is ensured because of a low parts count and low operating temperature. It is also tested with over 400 million error-free read and write cycles before being thermally cycled and aged. Fully assembled, the Vector Graphics 48 K byte dynamic programmable memory board is priced at $695.

Circle 596 on inquiry card.
Apple II Disassembler

Apple II Tiny Business Software

Suppose you want to rewrite, debug, modify, analyze, and understand the workings, functions and operation of inadequately documented programs for which there are no available source listings. The disassembler will be valuable to anyone who wants to rewrite, debug, modify, analyze, and understand the workings, functions and operation of inadequately documented programs for which there are no available source listings.

The disassembler is available on cassette with instructions for $29.95. For further information, contact Micro- Products, 2107 Artesia Blvd, Redondo Beach CA 90278.

Circle 577 on inquiry card.

Cross-Assembler for 6800s

The 2-pass Macro Cross-Assembler from Hemenway Associates generates relocatable and linkable code. It requires the LINKEDT68 which is described below. Resident on a 6800 system, XA6809 lets the user immediately produce code for a 6809. It produces a listing, a sorted symbol table, a cross-reference list, and relocatable object code. This program features fast execution, full macro facility, relocation, and linking.

The LINKEDT68 system utility manipulates the relocatable file produced by the cross-Assembler and Hemenway Associates’ RA6800ML assembler and

Super BASIC for 6800 Computers Using PerCom 5-Inch Floppy Disk Systems

PerCom Data Company has announced Super BASIC for 6800 computers using PerCom’s LFD-400 or LFD-1000 5-inch floppy disk systems.

An extended disk BASIC, similar in dialect to Southwest Technical Products’ (SwTPC) 8 K byte BASIC, Super BASIC supports 42 commands and 31 functions. The program requires 12 K bytes of memory. Super BASIC is compatible with programs written in SwTPC 8 K byte BASIC (versions 2.0, 2.2, and 2.3). Besides additional commands and functions, it includes refinements that reduce program run times by 35 to 40 percent. Other enhancements include direct random access to disk file data; optional use of the question mark in lieu of the Print command; 9 digit binary-coded decimal (BCD) arithmetic; named disk file and batch processing capability when Super BASIC is used with PerCom miniDOS; line and character position error reporting; and fast execution of function calls.

Super BASIC is supplied on 5-inch disks and, together with a users manual, sells for $49.95. Upgrade kits for using Super BASIC with SwTPC or Smoke Signal Broadcasting Co disk systems are also available. For further information, contact PerCom Data Co, 318 Barnes, Garland TX 75042.

Circle 580 on inquiry card.

Apple II Tiny Business Software

Tiny Business Inventory Management System, Accounts Receivable and Accounts Payable for the Apple II offer a realistic approach to the capabilities of the Apple II in a Tiny Business environment. Each software package requires a minimum system configuration of 48 K bytes and 1 disk drive and an optimum configuration of 2 disk drives and floating point firmware.

The Inventory Management System supports 820 separate inventory items and quantities to assist the user in evaluating stock sales. The Accounts Payable and Accounts Receivable software handle 150 accounts each. All software packages have password protection to allow the user security on sensitive portions.

The Inventory Management System is priced at $100, while the Accounts Payable and Accounts Receivable software is $75 each. For further information, contact Custom Computing Systems Inc, 204 2nd Ave N, Saskatoon, Saskatchewan CANADA S7K 2B5.

Circle 578 on inquiry card.

All States Payroll System

A fully user defined, all states payroll system has been announced by Payne, Jackson, and Associates (PJA), 447 E Fifth Ave, Anchorage AK 99501. Simultaneous multistate processing of up to 4 states is also possible. All standard reports with current, month, quarter, and year to date amounts, plus a limited report generator are included. The system supports 3 and in some cases 4 levels of control to permit the maximum in flexibility within a given payroll. The standard controls are used for company-wide items, while the exception controls and override controls are used for specific employees. Small and simple payrolls are also easily handled.

The system runs on an Alpha Micro and is part of the PJA Accounting System which is currently available for $500.

Circle 579 on inquiry card.

STRUBAL+ compiler as well, producing runable binary files with the desired relocations and linkages performed. More sophisticated than a simple linking loader, LINKEDT68 is a 2-pass, disk-to-disk program. The user can build output files without regard for the amount of programmable memory available at load time.

Circle 579 on inquiry card.

Versions are available for Percom, ICOM, SwTPC, Smoke Signal Broadcasting and Tano systems. The XA6809 is priced at $149.95, and the LINKEDT68 is $49.95. For further information, contact Hemenway Associates Inc, 101 Tremont St, Suite 208, Boston MA 02108.

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Educational Software

This educational software for the Radio Shack Level II TRS-80 and Commodore PET is designed for educators utilizing computer-assisted instruction. Currently available software includes:

- Introduction to Microcomputers—6 programs, 3 tapes plus teacher's guide; grades 1 through 8, at $49.95.
- Basic Math Skill Games—12 programs, 6 tapes plus teacher's guide; grades 1 through 8, at $89.95.
- Word Problems, 6 programs, 3 tapes plus teacher's guide; primary grades, at $54.95.
- Spelling I and II—12 programs, 6 tapes, plus teacher's guide; primary grades, at $54.95.
- Problem Solvers—5 programs, 3 tapes plus teacher's guide; middle grades, at $54.95.
- Basic Geography—4 programs, 2 tapes including overhead transparencies; grades 1 through 8, at $49.95.
- English Language—8 programs, 4 tapes including overhead transparencies; grades 1 through 8, at $49.95.
- Arithmetic Skill Games—8 programs, 4 tapes plus teacher's guide; primary grades, at $54.95.
- Math Games—10 programs, 5 tapes; grades 1 through 8, at $49.95.
- Science Skill Games—7 programs, 3 tapes plus teacher's guide; grades 1 through 8, at $54.95.
- Social Studies Skill Games—9 programs, 4 tapes plus teacher's guide; grades 1 through 8, at $49.95.
- Geography Skill Games—7 programs, 3 tapes plus teacher's guide; grades 1 through 8, at $54.95.
- Art—4 programs, 2 tapes; grades 1 through 8, at $49.95.
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- Foreign Language—4 programs, 2 tapes; grades 1 through 8, at $49.95.
- Business Education—7 programs, 4 tapes; grades 9 through 12, at $49.95.
- Business Management—4 programs, 2 tapes; grades 10 through 12, at $49.95.
- Computer Science—3 programs, 2 tapes; grades 11 through 12, at $49.95.

These complete supported programs make full use of the microcomputer's graphic capabilities and contain safeguards to minimize accidental program loss. All programs are loaded in individual cassette tapes and stored with support materials in a 3-ring notebook.

For more information, contact The Software Factory, 515 Park St, Anoka MN 55303.

Circle 603 on inquiry card.

T-Ball Jotter Disk for TRS-80

The T-Ball Jotter Disk contains software for use with 32 K byte TRS-80 disk and line printer systems. It contains a collection of business and professional programs which make many types of computations and prints out many forms used in the business and investment fields such as amortization schedules and financial statements. The disk has its own master control program which enables rapid selection among operations. The T-Ball Jotter Disk is priced under $100. For more information, contact Contract Services Associates, 706 S Euclid, Anaheim CA 92802.

Circle 604 on inquiry card.

Pascal for the TRS-80

FMG Corp has announced a UCSD Pascal developmental package for Radio Shack's TRS-80. The FMG Pascal user's package is capable of running most business applications, such as word processing, payroll, accounting, and bookkeeping.

The system supports up to four floppy disk drives, line printer and RS-232 serial interface. It also supports user-implemented peripherals. The FMG Pascal developmental package includes a compiler, Z80 assembler and screen editor. It is priced at $130. For further information, contact the company at Suite 14, 5280 Trail Lake Dr, Ft Worth TX 76133.

Circle 605 on inquiry card.

File Management System

Called a Self-Indexing Query System, WHATSIT (Wow! How'd All That Stuff Get In There?) this file management system answers simple questions by referring to disk data that it stores and revises as instructed in short pidgin English sentences. Its entry-oriented indexing scheme is especially designed to combine maximum storage capacity with full cross-indexing. Applications of WHATSIT include desktop indexing of investment portfolios, music or hobby collections, customer lists, and household or professional files. Entries are automatically cross-indexed under any desired headings. Typical response time is 3 to 10 seconds.

Models are available for the Apple II and North Star systems ($100) as well as for CP/M systems ($150). Supplied on a ready-to-run disk, WHATSIT comes with a 150-page manual containing step-by-step instructions and numerous examples. Contact Computer Headware, POB 14694, San Francisco CA 94114.

Circle 606 on inquiry card.

PDP-11 Compatible Floating Decimal Software

Provides 14 Digit Accuracy

The FPA-11 Floating Decimal Arithmetic Package is a DEC PDP-11/LSI-11 compatible software program that generates answers as true decimal representations and completely eliminates strings of 9s. Offering 14 digit accuracy, it associates a scaling factor with each number to keep track of the decimal point as each calculation is performed. For fast execution, all calculations are conducted in binary form.

With a range of 10^14, the package is characterized by compact internal representation, and manipulated numbers are internally represented by 4 words (8 bytes). Work space is defined local to an application, and several applications can use the package on a time-shared basis. A general purpose mode lets users bypass the decimal orientation when required.

The FPA-11 Floating Decimal Arithmetic Package is priced at $75 on a floppy disk or cassette, and $135 for RK-05 compatible media. Other media can be specified. Contact Path Systems Inc, The Millyard Bldg, 333 N Turner St, Manchester NH 03102.

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16K - $995,
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DUAL DRIVE FLOPPY DISK 2040

The Dual Drive Floppy is the latest in Disk technology with extremely large storage capability and excellent file management. As the Commodore disk is an “intelligent” peripheral, it is none of the RAM (user) memory of the PET. The Floppy Disk operating system used with the PET computer enables a program to read or write data in the background simultaneously transferring data over the IEEE to the PET. The Floppy Disk is a reliable, low-cost unit and is convenient for high speed data transfer.

Due to the latest technological advances incorporated in this disk, a total of 360K bytes are available in the two standard 5½ -inch disks without the problems of double tracking or double density. This is achieved by the use of two microprocessors and fifteen memory IC’s built into the disk unit.

Features Include:

• 360K bytes storage
• 4K encoder and decoder in ROM
• 6504 microprocessor-controlled
• 4K RAM
• 8K operating system in ROM

SUPER WORD PROCESSING SYSTEM

Model 2040
$1295

Model 2022
$995

FULL SYSTEM NOW IN STOCK FOR IMMEDIATE DELIVERY!

BUSINESS SOFTWARE FOR PET BUSINESS SYSTEM

• Super Word Processing Package
  (Disk $19.95, Tape $14.95)
• Real Estate
• Statistics
• Banking & Finance
• Mail List Management...
• Data Base System...
• 6504 microprocessor-controlled

PET MUSIC BOX FROM SOUNDWARE

Add music and sound effects to your programs. Complex, play, and hear music on your PET. Completely self-contained Free programs $29.95

PERIPHERALS FOR PET

• MIDI Memory Expansion
  $149
• PET 16/32K Ram
  $195
• PET 8512 Serial Communication
  $375
• Mostror Stand for PET
  $275
• MOD-722 Digitizer
  $275
• 1850 Character Printer
  $152
• Enhanced PRINTER Speeds

PET SPECTRUM ANALYZER

• 2 channels
• 199 KHz
• 100Hz
• 15 dB

MARK SENSE CARD READER

• Automatic turn-on and card feed
• Ideal for marking test scores
• Accepts any size card
• Perfect for schools & business

NEW!! from Eventide

AUDIO SPECTRUM ANALYZER

• Mounts inside the PET
• Third-Octave
• audio spector analysis
• Complete with software
• Takes standard cards for $595

MARK SENSE CARD READER
$750

Add music and sound effects to your programs. Complex, play, and hear music on your PET. Completely self-contained Free programs $29.95

PET MUSIC BOX FROM SOUNDWARE

Add music and sound effects to your programs. Complex, play, and hear music on your PET. Completely self-contained Free programs $29.95

TO ORDER CALL TOLL FREE 800-223-7318

485 Lexington Avenue 750 Third Avenue New York, N.Y. 10017
(212) 687-5001 (212) PET-2001 Foreign order desk - Telex 640055

The COMPUTER FACTORY

PET BUSINESS SYSTEM

The PET is now a truly sophisticated Business System with the announcement of the Floppy Disk and Printer. This is an ideal business system for most professional and specialized fields: medicine, law, dental, research, engineering, toolmaking, printing, education, energy conservation, etc. The PET Business System as a management tool, delivers information to all levels of Business, previously available only with equipment many times more expensive. The PET Business System is one of the most cost efficient business tools today. Here are just a few of the cost-saving uses in the corporation, professional office or small business: stock control, purchasing, forecasting, manufacturing, costing, customer records, mailing lists, etc.
TEXAS INSTRUMENTS TI-99/4 Home Computer
Many Peripherals. Coming soon!

A complete self-contained computer system with APPLESOFT floating point BASIC in ROM, full ASCII keyboard in a light weight molded carrying case.

Features Include:
• auto-start ROM
• Hi-Res graphics and 15 color video output
• Expandable to 48K

Disk ...................... $595
Add-on Disk ............... 495
Pascal Card ................ 495
Business Software .......... 525
Monitor .................... 155
Printer Card ............... 165

Programmer's Aid ........... 50
Speechlab ........................ 225
Communication Card .......... 250
Modern ..................... 200
EPROM Programmer .......... 105

NEW D. C. Hayes MICROMODEM II
• Combines the capabilities of a communications card and acoustic coupler.
• Puts directly into Apple II and modular telephone jack.

NEW Mountain Hardware SUPERTALKER
• Digitized speech recording and playback.
• Foreign language teaching pack available.

DATA GENERAL micro NOVA
• The ultimate in small Business Computers
when matched with COMPUTER FACTORY's minicomputer. Software

SOFTWARE
MUSIC BOX
Music and Sound Effects for PET, TRS-80
A Computer's Add music and sound effects to your programs. Compose, play, and hear music on your computer! Completely self-contained

This fantastic program disk allows the economist, mathematician, trader in stocks, money or commodities, the ability to maintain 30 databases of up to 300 values and plot 3 different moving averages of a series at the same time, in 3 different colors. Files can be updated, deleted, changed, extended, etc.

A sure value disk at only $49! Word Processing For Apple on disk...$50

ANDERSON JACOBSON

More than an intelligent terminal, the SuperBrain outperforms many other systems costing three to five times as much. Endowed with a hefty amount of available software (BASIC, FORTRAN, COBOL), the SuperBrain is ready to take on your toughest assignment. You name it! General ledger, Accounts Receivable, Payroll, Inventory or Word Processing... the SuperBrain handles all of them with ease.

Features Include:
• two dual-density mini-floppies with 320K bytes of disk storage
• 64K of RAM to handle even the most sophisticated programs
• a CP/M Disk Operating System with a high-powered text editor, assembler and debugger.

FREE $35 of Software with purchase of any computer on this page.

The COMPUTER FACTORY's extensive CENTRONICS 779 inventory and wide selection of computer printers assures you of finding the printer best suited for your needs and specifications. The following printers work with all known personal computers:

CENTRONICS 779
TRENCHCOM 200
INTEGRAL DATA
PAPER TIGER 40...
COMPRINT.
Wire Wrap Tools

BATTERY HOBBY TOOL*
- Auto Indexing
- Anti-Overwrapping
- Modified Wrap

<table>
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<th>Tool</th>
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<td>BT2628 #26 Bit</td>
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<td>BC1 Batteries &amp; Charger</td>
<td>$11.00</td>
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*Requires 2 "C" Niced Batteries

BATTERY INDUSTRIAL TOOL*
- Accepts Industrial Bits and Sleeves (Gardner Denver or equiv.)
- Industrial Motor for Production Wire-wrapping
- Backforce Avail. (Recommended for #30).

<table>
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<td>$11.00</td>
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ELECTRIC INDUSTRIAL TOOL
- Accepts Industrial Bits and Sleeves (Gardner Denver or equiv.)
- Industrial Motor for Production Wire-wrapping
- Backforce Avail. (Recommended for #30).

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IC Sockets

RN HIGH RELIABILITY eliminates trouble. "Side-wipe" contacts make 100% greater surface contact with the wide, flat sides of your IC leads for positive electrical connection.

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SOLDER TAIL

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ORDERING INFORMATION
- Orders under $25, add $2 handling
- Blue Label or First Class, add $1 (up to 3 lbs.)
- CODs, VISA & MC orders will be charged shipping
- Most orders shipped next day.

OK PRODUCTS

<table>
<thead>
<tr>
<th>Product</th>
<th>Description</th>
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<td>WD 30</td>
<td>50 ft. Wire Dispenser, Red, White, Blue or Yellow</td>
<td>$3.75</td>
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<td>19&quot; Color Dispenser</td>
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<td>Refill for TRI Color</td>
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<td>14 &amp; 16 pin Insertion Tool</td>
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<td>EX-1</td>
<td>IC Extractor Tool</td>
<td>$1.49</td>
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<td>H-PBC-1</td>
<td>Hobby PC Board</td>
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<td>WSU 30</td>
<td>Hand Wrap/Unwrap/Strip Tool</td>
<td>$6.66</td>
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<tr>
<td>WSU 30M</td>
<td>Same as WSU 30 with Modified Wrap</td>
<td>$7.60</td>
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available at selected local distributors

135 E. Chestnut Street 5A, Monrovia, California 91016 Phone (213) 357-5005

Circle 298 on inquiry card.
### Exciting New Kits

**JE600 Hexadecimal Encoder Kit**

**Features:**
- Selectable output format
- Four check lights for mask protection
- LED readout to write digits
- LEDs provided for easy visibility
- Internal circuitry for accurate display
- 30° off centering for better visibility

**Digital Thermometer Kit**

**Features:**
- Dual sensors switching control
- Continuously integrates LED's with 5.5°C or 5°C
- Graduations in °C or °F
- LED display for Fahrenheit or Celsius reading
- 3 1/4" x 1 1/2" LED display

**Cost:**
- JE600: $99.95
- JE300: $39.95

---

### Discrete LEDs

**XCE259**

- Red: 5/1
- Green: 5/1
- Yellow: 5/1

**XCE225**

- Red: 5/1
- Green: 5/1
- Yellow: 5/1

---

### Resistors

- 1/4 Watt Resistor Assortments - 5%
- 4.7K 1/4 Watt Resistor Assortment: 4.7K - 47K
- 10K 1/4 Watt Resistor Assortment: 10K - 100K

---

### Price List

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### Transistor Checker

- Completely Assembled - New
- The AG-1 Transistor Checker is capable of checking a wide range of transistors. To operate, simply insert the transistor to be checked into the front panel socket, or connect it with the 100-µm test clip, and automatically identifies low, medium, and high-level transistors.
- "C" cell battery not included.

#### Product Details
- **Part No.** 2S52-8
- **Price** $19.95 ea.

### Custom Cables & Jumpers

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<th>Product Description</th>
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<td>6-Key ASCII Encoder Keyboard Kit</td>
<td>$19.95</td>
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<tr>
<td>6-Volt AC Power Supply</td>
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<tr>
<td>Digital Stop Watch</td>
<td>$19.95</td>
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<td>Micro-Miniature Joystick</td>
<td>$4.95</td>
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<tr>
<td>16K Conversion Kit</td>
<td>$39.95</td>
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### Microprocessor Components

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### Microcontroller Components

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<th>Product Description</th>
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<tr>
<td>6800 - 8080A CPU</td>
<td>$100.00</td>
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<tr>
<td>6802 - 8080A Timer</td>
<td>$12.95</td>
</tr>
<tr>
<td>6803 - 8080A Watch</td>
<td>$9.95</td>
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<tr>
<td>6804 - 8080A Stack</td>
<td>$7.95</td>
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</table>

### Computer Cassette

- **Model** MOD II
- **Price** $29.95

### Transistor Checker

- **Part No.** 2S52-8
- **Price** $19.95 ea.

### Custom Cables & Jumpers

<table>
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<td>150 Key ASCII Encoder Keyboard Kit</td>
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<td>6-Volt AC Power Supply</td>
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<td>Micro-Miniature Joystick</td>
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<td>16K Conversion Kit</td>
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### Microprocessor Components

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### Microcontroller Components

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### Computer Cassette

- **Model** MOD II
- **Price** $29.95

### Transistor Checker

- **Part No.** 2S52-8
- **Price** $19.95 ea.
SYSTEM 2 with 64k RAM-$3195

TORREY PINES BUSINESS SYSTEMS
14260 Garden Rd., Suite BA
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hardware. We carry the full Cromemco line.
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products.

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dependent simultaneous equations. Also per-
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tion: BK: $17.50

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Also computes area of any polygon: BK: $15.00

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program for the homeowner, small in-
vester or interested in an active face with
difficult financial decisions. Computes amora-
tization schedule, present or future values of
a series of cash flows, days between dates, plus
more: BK: $17.50

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putes exact amounts of all ingredients
necessary for any number of servings for
eight Louisiana soup and gumbo recipes.
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P.O. Box 73043
Metairie, Louisiana 70033

Circle 366 on inquiry card.

Circle 216 on inquiry card.

Circle 365 on inquiry card.

Circle 208 on inquiry card.

Circle 366 on inquiry card.

Circle 218 on inquiry card.

Circle 207 on inquiry card.

Circle 208 on inquiry card.

Circle 218 on inquiry card.

Circle 216 on inquiry card.

Circle 207 on inquiry card.

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System 3 with 32k RAM-$4795
with 64k RAM—add $595
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Circle 328 on inquiry card.

Circle 363 on inquiry card.

Circle 359 on inquiry card.
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MPB-100 Z80 CPU Board Kit

**$190.00**

---

**COMPLETE KIT INCLUDES ALL SOCKETS FOR 64K**

- Memory access time: 375ns
- Cycle time: 500ns
- No wait states required
- 16K boundaries and Protection via Dip Switches
- Designed to work with Z-80, 8080, 8085 CPU's

**EXPANDORAM 64K Kit (16K Ram)**

- 16K .................................. $19.00
- 32K .................................. $27.00
- 48K .................................. $35.00
- 64K .................................. $41.00
- WITHOUT MEMORY ............... $159.00

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**VERSAFLOPPY** Kit

The Versatile Floppy Disk Controller

**Only $139.00**

**FEATURES:** IBM 3740 Soft Sectored Compatible, S-100 BNS Compatible for Z-80 or 8080. Controls up to 4 Drives (single or double sided). Directly controls the following drives:
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2. Shugart SA800/850 Standard Floppy
3. PERSCI 70 and 277
4. MPE 70/750
5. CDC 9404/9406

---

**MINIATURE SPEAKER SPECIAL!**

2 INCH — 8 OHM. PERFEKT FOR CLOCKS! **$79.00**

**TO-5 HEATSINKS**

Similar to Thermolloy 2205G Fitted with insert.
5 for $1

**ROCKER SWITCH**

HEAVY DUTY S.P.D.T. 3A 125 V.A.C.
New, modern styling! 5 for $1

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**ANNOUNCE: THE RETURN OF RADIO HUT SUPER SPECIALS!**

**SBC-100 SINGLE BOARD COMPUTER**

- *CPU's*
  - Z80 .................................. 10.99
  - Z80A .................................. 13.99

**RELATED CHIPS**

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<td>270B</td>
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<tr>
<td>4115</td>
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<td>4116</td>
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**DISC CONTROLLER**

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<td>29.95</td>
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---

**Z80 STARTER KIT**

SD System's Z80 Starter Kit enables the novice to build a complete microcomputer on a single board. Featuring the powerful Z80 microprocessor the Z80 Starter Kit features: **KeyBoard and Display** • Audio Interface • PROM Programmer • Expansion and Wire Wrap Area • On Board RAM • 4 Channel Counter/Timer • Z-BUG Monitor in PROM • I/O Ports.

**This month's special:**

**$219.95 Kit**

**SBC-100 KIT**

**$210.00**

---

**TELE TAPE**

Record important telephone conversations now with Tape and your recorder. Each time your receiver is picked up your recorder will automatically start! When you hang-up the recorder stops. Tape will be extra clear so you can refresh your memory at a later date. Kit includes everything except the case and phone plugs.

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**VDB-8024 Video Display Board**

The VDB-8024 features its own board-Z80 microprocessor. This gives the capability of using software (included in ROM) to control functions and enhancements without interference with the computer's CPU. Included in the special features 80 characters by 24 lines display. Keyboard, power and interface, Composite and separate video output, 2K on-board RAM, a total of 256 available characters, full cursor control, Forward and Reverse Scroll, Underlining, Field Reverse, Field Protect enhancements, programmable characters.

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4 Jumbo .50" Digits in One "Stick!" The Bowmar Opto-Stick. The best readout bargain we have ever offered. Has four common cathode jumbo digits with all segments and cathodes brought out. Increased versatility since any of the digits may be used independently to fit your applications. Perfect for any clock chip, especially direct drive units like 50380 or 701 O. Also use in frequency counters independently to fit your applications. Perfect for any clock chip, especially direct drive units like 50380 or 701 O. Also use in frequency counters.

**PROM-100 PROM Programmer Board**

The PROM-100 Programmer is a development tool for S-100 Bus computer systems. The Zero Insertion Force Programming Socket extends above the card cage height for easy access to PROM devices. Software verifies PROM erasure, verifies program loading and provides for reading of object file from Disk or PROM and programming into PROM/EPROM. Features include: On-board generated 25Vdc Programming pulses, TTL compatible, maximum programming time for 16,389 bits is 100 seconds. Programs: 2708, 2718, 2728, 2732 and T1 2516. DIP Selectable EPROM type.

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**Expand the PET Computer**

A combination memory I/O (input/output) expander and floppy disk system for the PET computer is now available from CGRS Microtech. The PEDISK provides both a high-speed floppy disk and an S-100 expansion chassis in one unit. The S-100 expansion will hold extra I/O and memory, such as printer, telephone interface, modem and voice I/O cards. The floppy disk is available with up to 3 5-inch floppy disk drives (total capacity of 80 K bytes) or up to 4 8-inch disk drives (total capacity of 1 M bytes). System prices range from $799.95. For further information, contact CGRS Microtech, POB 368, Southampton PA 18966.

Circle 582 on inquiry card.

**Low Cost Selectric Typewriter Interface**

The MP-WP Selectric Interface is a simple, low cost interface that allows the user to connect an unmodified IBM model 50 Selectric typewriter to an SS-50 bus 6800 or 6809 computer system. Interfacing is made to the typewriter through a cable assembly that plugs into a connector provided on the typewriter. No solenoids or typewriter modifications are required. The typewriter may be used for both input and output, and will still function as a normal typewriter when not being driven by the computer. The interface and interconnecting cable (MP-WP) are fully assembled and sell for $59.95 postage paid. For further information, contact Southwest Technical Products Corp, 219 W Rhapsody, San Antonio TX 78216.

Circle 583 on inquiry card.

**Free Brochure Describes Houston Instrument’s Hi Pad Digitizer**

An 8 page, 4 color brochure describing the Hi Pad Digitizer is available from Houston Instrument, One Houston Sq, Austin TX 78753. This 11 by 11 inch active surface digitizer offers user-controllable features such as metric and inch capability, binary and binary-coded decimal outputs, RS-232C 8-bit parallel interface, all selectable at the interface connector. The Hi Pad is accurate to ±0.015 inches with a resolution of either 0.01 or 0.005 inches. The data rate may be set to input up to 100 coordinate pairs per second. Four buttons on the edge of the table allow the user to relocate the origin and select point or stream modes of operation. The magnified cursor allows coordinate updating of the curve or line being traced by depressing the cursor button at points being considered.

The brochure includes prices and specifications for the Hi Pad and accessories as well as complete technical descriptions of the multiple output formats available with the Hi Pad.

Circle 584 on inquiry card.

**Random Access Video Digitizer**

The DS-80 Digisector is a random access digitizer with high-resolution and speed. The board provides the following features: a 256 by 256 picture element scan; 64 levels of grey scale; conversion times as low as 4 µs per pixel; accepts either interlaced (NTSC) or noninterlaced (industrial) video input; and uses 1 bus slot in any S-100 system conforming to the Institute of Electrical and Electronic Engineers (IEEE) standards. The computer sends the Digisector 2 8-bit addresses (X and Y coordinates), and the Digisector returns the digitized brightness of the image at the specified location. For set-up and monitoring purposes, the Digisector produces an output comprised of the camera's video signal plus a superimposed cursor, showing exactly where the DS-80 is looking. The software supplied will digitize 1 pixel every other horizontal scan-line, filling 8 K bytes of memory with 2 4-bit grey scale values per byte in a little less than 2 seconds. It provides spatial resolution of 128 by 128 elements, optimum for computer-portraiture and slow-scan television. This software is compatible with the Vector Graphic High-Resolution Graphics Display Board. Additional routines are provided to drive both graphics and American Standard Code for Information Interchange (ASCII) printers. The Digisector comes fully assembled, tested, and burned-in and is priced at $349.95. For further information, contact Micro Works, POB 1110, Del Mar CA 92014.

Circle 585 on inquiry card.
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Your own TRS-80 system at tremendous savings

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**Centronics 730**

Same as Line Printer II

* Special 1st 25 units sold Similar to Line Printer III

**$ 850** Reg. **$ 895**

Anadex 9500

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* All printers include cables

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**TOLL FREE**

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 EDGE CARD CONNECTORS: GOLD PLATED. (Not Gold Flash)


ABBREVIATIONS: S/T Solder Tail; S/E Solder Eyelot: W/W Wire Wrap; 2 SWIVt Short W/ W/Wrap;

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<th>DESCRIPTION</th>
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**100° Contact Center Connectors**

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Polarizing Keys: For Above

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<td>2.20</td>
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<tr>
<td>1710</td>
<td>36/72 S/E</td>
<td>.140</td>
<td>3.90</td>
<td>3.70</td>
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<tr>
<td>1710</td>
<td>36/72 S/E</td>
<td>.140</td>
<td>3.90</td>
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<td>3.90</td>
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</tr>
<tr>
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<tr>
<td>1730</td>
<td>43/86 S/E Mot. 6800</td>
<td>.200</td>
<td>4.65</td>
<td>4.45</td>
<td>4.25</td>
</tr>
</tbody>
</table>

Polarizing Keys: For Above

**274 BYTE October 1979**
### 10-DAY FREE TRIAL

**WE BUY USED PET, APPLE and TRS-80 COMPUTERS**

**$100 FREE ACCESSORIES WITH 16K OR 32K PET**

Buy our 16K or 32K PET and we will give you your first $100 worth of accessories FREE. Just indicate on your order that you want the reduced cost of your accessories by $100.

**FREE Terminal Package with PETs**

**PET ACCESSORIES**

<table>
<thead>
<tr>
<th>Accessory</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commodore Dual Floppy Drive</td>
<td>$195.00</td>
</tr>
<tr>
<td>Commodore Printer (tractor feed)</td>
<td>$395.00</td>
</tr>
<tr>
<td>Commodore Printer (flotation feed)</td>
<td>$395.00</td>
</tr>
<tr>
<td>Second Cassette – from Commodore</td>
<td>$395.00</td>
</tr>
<tr>
<td>Commodore PET Service Kit</td>
<td>$395.00</td>
</tr>
<tr>
<td>Beep – Tells when tape is loaded</td>
<td>$19.95</td>
</tr>
<tr>
<td>Petunia – Play music from PET</td>
<td>$19.95</td>
</tr>
<tr>
<td>Video Buffer – Attach another CRT</td>
<td>$19.95</td>
</tr>
<tr>
<td>Combo – Petunia and Video Buffer</td>
<td>$19.95</td>
</tr>
<tr>
<td>5-100 PET Interface was $299.00</td>
<td>$395.00</td>
</tr>
<tr>
<td>New Serial Printer Interface for PET</td>
<td>$295.00</td>
</tr>
</tbody>
</table>

**Call for Availability**

PET – Compatible Selectric in Desk $295.00

---

### SUPER SALE PRICE TOO LOW TO ADVERTISE

Immediate Delivery — 2-Year Factory Warranty

You may have seen the Hazeltine advertised at $850. You may have seen it at sale prices at $749 or even $699; but our new prices are so low that we can't even advertise it! Call us for a quote. Hurry, we have a limited quantity at this price. The Hazeltine has a 12" screen, 24 x 60 display, 80-column text entry, and comes with over $200 in free accessories.

Hazeltine 1450 — $695
Hazeltine 1510 — $1195
Hazeltine 1500 — $1695

**NEW! 400K DISK & MEMORY EXPANSION**

You can instantly turn your PET into a speedy and efficient professional computer! It's easy with the new 400K Disk Drive and Memory Expansion from Commodore! Add up to 400K internally and load 400K program in only 3 seconds!

**40K Disk Memory Expansion**

- Includes 40K Disk Drive
- Memory expansion for PET
- Brand new
- Retail $285
- Now $195

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### EDUCATORS ORDER YOUR FREE PET TODAY!

Between now and Nov. 30th any educational institution which buys 2 PET's at list price will receive a 3rd PET ABSOLUTELY FREE! That's right, FREE. For example, buy 2 16K at $995 each and get 1 32K PET FREE. Buy 1 16K at $995 and 1 32K at $1,295 and your school will receive 2 PET's ABSOLUTELY FREE! For the hundreds of schools and institutions which have bought from us with confidence. Look at our PET box in the upper left hand corner of this ad for descriptions and prices of the Commodore PET product line. If you need more information just call, we love questions.

---

### IMPORTANT ORDERING INFORMATION

All orders must include 4% shipping and handling. Michigan residents add 4% shipping and handling.

---

**The new Apple II with AppleSoft BASIC built-in eliminates the need for a $200 Firmware Card and includes new custom ROM for easy operation. This combined with the free accessories from NCE could save you up to $400 on a 4K Apple II system!**

**16K Apple II Plus—$1,195 (takes $195 in free accessories)**

**32K Apple II Plus—$1,595 (takes $395 in free accessories)**

**48K Apple II Plus—$1,985 (takes $595 in free accessories)**

---

**PET OWNERS REMOTE TERMINAL for only $69**

Access modules, program case, cable, and start terminal on PET to function at a baud rate of 300 baud. This new module has a complete system where top-quality printing was required. The IBM keyboard and printer are separated by a three foot cable and each has its own enclosure great for IBM keyboard and printer are separated by a three foot cable and each has its own enclosure. The 4862 interface uses ASCII interface for the IBM model. 14.6 cps, 134.5 baud, 14 line length, pica. In "ASIS-15" condition. Pre-sale preparation includes:

- Motors checked and guaranteed before sale.
- The machines are complete.
- All indicator lights work.
- New ribbon & cleaned type element, on/off switches, tab & carriage return cards, & tab set clear.

There is a 3-day return privilege on these machines and any missing parts will be replaced.

---

### IN STOCK NOW!

**NOW Graphics printer for Apple II $1,098**

Now you can print high resolution graphics from your Apple using the IP-225 printer and graphics option from IDS. The IP-225 is a tractor feed printer which 96 possible characters. Line length is 80/132 col. with a speed of 90 cps. We include software which allows it to use either parallel or serial interface at 1200 baud. ABSOLUTELY FREE (you save $500).
ATTENTION ELF OWNERS
ANNOUNCIING QUEST SUPER BASIC

At last a Full Size Basic for 16C2 systems. A complete function Basic including two dimensions arrays, string variables, floating point arithmetic and 32 bit signed integer arithmetic (10 digit accuracy) with 16 routines. Easily adapts model to other system, etc. 12K RAM minimum for Basic and user programs. Cassette version in stock now for immediate delivery. ROM versions coming soon with exchange privilege allowing credit for cassette version. Basic on Cassette $48.00.

RCA Cosmac Super Elf Computer $106.95

Compare features before you decide to buy any computer. There is no other computer on the market today that has all the desirable features of the Super Elf. The Super Elf is a small board computer that does many big things. It is an excellent computer for training and for programming into the machine language and yet it is easily expanded with additional memory, Full Basic, ASCII (Printer, Keyboard, Voice character generation, etc.). Before you buy another small computer, see it if it includes the following features: ROM monitor: State and Mode displays; Right step: Optional address displays: Power Supply: Audio Amplifier and Speaker: Fully socketed for all IC's: Real cost of warranty repairs: Full documentation.

The Super Elf includes a ROM monitor for program loading, editing and execution with SINGLE STEP program execution. The CPU is not included in the price plus a detailed 27 pg. instruction manual which now includes over 45 pg. of software info., including a series of lessons to help get you started and a music program and graphics target game.

Many schools and universities are using the Super Elf as a course of study. OEM's use it for research and development.

Remember, other computers only offer Super Elf features at additional cost or not at all. Compare before you buy another small computer, see if it is worth the investment. Think of all the things you can do with the Super Elf.

Many big things. II is an excellent computer for program debugging which is not in the board and it fits neatly into the hardwood cabinet which is included in the price plus an additional 12 pg. instruction manual which now includes over 45 pg. of software info., including a series of lessons to help get you started and a music program and graphics target game.

Before you buy another small computer, see if it is worth the investment. Think of all the things you can do with the Super Elf.

Tiny Basic Source now available $19.00

S-100 Slot Expansions. Add 3 more S-100 slots to your Super Expansion Board or use as a 4 slot S-100 Mother Board. Board without connectors $3.95. Coming Soon: High resolution alphas/numerics with color graphics expandable up to 256 x 192 resolution for less than $100. Economical version for software for popular 1602 systems also.

16K Dynamic RAM board expandable to 32K for less than $190.

Multi-volt Computer Power Supply 8.5 x 5 amp, 16 x 5 amp, 5v, 1.5 amp, $5.95, 12 x 5 amp, 3.5 amp, 12 x 5 amp, 16 x 5 amp, 5v, 1.5 amp, $5.35, 12 x 5 amp, 3.5 amp, 12 x 5 amp, 16 x 5 amp, 5v, 1.5 amp, $5.35. All regulated. Kit $29.95. Kit with punched frame $37.45. Woodgrain case $10.00.

60 Hz Crystal Time Base Kit $4.40

Converts digital clocks from 200Hz crystal (or equivalent) to 60 Hz crystal for use in the time base of your projects. Convertible to 200Hz crystal for $1.95. S-100 connector set with ribbon cable is available at $12.50 for easy connection between the Super Elf and add-on Expansion box (4 pin S-100 slot). The Power Supply Kit for the Super Expansion Board is a 5 amp supply with multiple positive and negative voltages $25.95. Add $4.00 for shipping. Preassembled frame $7.50. Case $10.00. Add $5.00 for shipping.

Keyboards:

Rockwell AM 65 Computer

5000 voltage divider board w/120 volt keyboard $10.95 on ROM $3.90. Original Elf kit board $14.95. RCA Cosmac Super Elf Computer $106.95. Woodgrain case $10.00.

Hickok 3Y2 Digit LCD Multimeter

Batt/AC oper. 0.1mv-1000v, 5 ranges. 0.5% held, accur. Resistance 6 to power ranges 0.1 %.

Stopwatch Kit

Full six digit battery operated, 2-5 volts. 3.2768 kHz crystal accuracy. Times to 50 min., 50 sec., 90.1 sec. Times @0.1 sec., split and T:10, 250 chip, all components minus case.

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Saves charged cells that won't hold a charge and then charges them up, in all the kit's original parts and instructions.

Hickod 3% Digil LCD Multimeter

Batt/AC oper. 0.1mv-1000v, 5 ranges, 0.5% held, 0.2% max., 6 to power ranges 0.1%. 0 ohm-20m ohm, DC curr. 0 to 100mA. Hand held, 1" LCD displays, auto zone, polarity, overrange. $49.95.

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Indoor and outdoor. Up to 100 ft. back lit. Beautiful 500,000 LED readouts, Nothing like it available. New!! 5 minute average, 5000 reading memory, 0.1 degree, 0.1% accuracy, complete, full operation. Will measure -100° to +220°, tenths of a degree, air or liquid. Beautiful woodgrain case with new Thermometer $71.95.

FREE: Send for your copy of our NEW 1979 QUEST CATALOG. Include 25¢ stamp.

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For will call only: (408) 988-1840

BYTE October 1979 277

Circle 311 on inquiry card.
NEW! POWER SUPPLY AND TERMINATOR BOARD. PROVIDES UP TO 12 REGULATORS TO DRIVE ALL THOSE PERIPHERALS FROM THE COMPUTERS POWER SUPPLIES. TERMINATES THE MOTHER BOARD. SPECIAL OCT. PRICE $28.95. AFTER OCT. 30 $30.95 AT YOUR DEALER NOW!

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DEALER INQUIRIES INVITED, UNIVERSITY DISCOUNTS AVAILABLE AT YOUR LOCAL DEALER
16K EPROM CARD-S 100 BUSS

$59.95 KIT

OUR BEST SELLING KIT!

USES 2708's!

ASSEMBLED AND FULLY TESTED
ADD $25

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 soldermask and silk-screened PC board and first run parts and sockets. All parts (except 2708's) are included. Any number of EPROM locations may be disabled to avoid any memory conflicts. Fully buffered and has WAIT STATE capabilities.

16K STATIC RAM KIT-S 100 BUSS

$279 KIT

FOR 250NS ADD $20

FULLY STATIC, AT DYNAMIC PRICES

WHY THE 2114 RAM CHIP? We feel the 2114 will be the next industry standard RAM chip like the 2102 was. This means price, reliability, and availability will all be good. Next, the 2114 is FULLY STATIC! We feel this is the ONLY way to go on the 8-100 Bus. We've all heard the horror stories about some Dynamic RAM Boards having trouble with DMA and FLOPPY DISC DRIVES. Who needs these kinds of problems? And finally, even among other 4K static RAM's the 2114 stands out! Not all 4K static RAMs are created equal! Some of the other 4K's have slowed down timing windows just as critical as Dynamic RAM's. Some actually use four competitor's 15K boards to use their "tricky" devices. But not us! The 2114 is the ONLY logical choice for a trouble-free, straightforward design.

S-100 280 CPU CARD

ASSEMBLED AND TESTED! READY TO USE! Over 3 years of design efforts were required to produce a TRUE S-100 280 CPU at a genuinely bargain price! 4 MHZ! $159.95

FEATURES:
- 2 or 4 MHZ Operation.
- Generates WRITe, so no front panel required.
- Plus all other S-100 signals.
- Top Quality PCB, Silk Screened, Solder Masked, Gold Plated Contact Fingers.

8K LOW POWER RAM KIT-S 100 BUSS

SALE

PRICE CUT!

$119.50 KIT

2 FOR $225

(450 NS RAMS)

Thousands of computer systems rely on this rugged, work horse, RAM board. Designed for error-free, NO HASSLE, systems use.

KIT FEATURES:
1. Doubled sided PC Board with solder mask and silk screen layout. Gold plated contact fingers.
2. All sockets included.
3. Fully buffered on all address and data lines.
4. Phantom is jumper selectable to pin 67.
5. Four 7805 regulators are provided on card.

16K STATIC RAM SS-50 BUSS

$295 KIT

FULLY STATIC AT DYNAMIC PRICES

KIT FEATURES:
1. Addressable on 16K Boundaries
2. Uses 2114 Static Ram
3. Runs at Full Speed
5. All Parts and Sockets included
6. Low Power: Under 2 Amps Typical

FOR SWATPC 6800 BUSS!

ASSEMBLED AND TESTED - $30

BLANK PC BOARD - $33

SUPPORT ICS & CAPS - $19.95

16K S-100 Dynamic Ram Board - $149.95

ORIGINALLY PRICED AT $429 each!

We purchased the remaining inventory of PT's popular 16K Ram Board when they recently closed their plant. Don't miss the boat! These are brand new, fully tested, ASSEMBLED and ready to go. All are sold with our standard 90 day limited warranty!! 72 Page Full Manual, Included Free!

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Full Duplex Synchronous Intelligent Modem

SuperModem transmits data thousands of miles at 9600 bits per second (bps) over unconditioned voice band data channels. By using an unconventionally low data rate it achieves a substantially higher tolerance to the transient noise-hits inherent in communication networks. It uses a transmitter that simultaneously generates a large number of individual carriers, modulating each to represent only a portion of the total data stream. The modem's receiver demodulates each carrier independently, and its data is combined with that from the other carriers to reconstruct the original data stream.

Three compact plug-in modules make up SuperModem: the program memory, 24-bit data processor, and the I/O (input/output) control. The program module includes a program built around algorithms which perform real-time analysis of the received signal. The 24-bit data processor uses pipelined architecture to attain an operating speed of 10 million instructions per second. It also is used to analyze circuit parameters while on-line and to perform diagnostic routines. Front panel controls provide the operator with mode selection, and enable configuration of the channel status indicators and the 3 digit diagnostic display.

For further information, contact Gandalf Data Inc, 1019 S Noel, Wheeling IL 60090.

General Purpose Data Acquisition and Process Control System

The Real World Interface System is a general purpose data-acquisition and process control system designed for use with mini and microcomputers. It features many different plug-in modules which give the user the flexibility and power to configure the system according to the user's needs. Applications include environmental control, peak demand limiting, robotics, and automated assembly line testing.

The unit has its own cabinet which includes a power supply, card cage, and motherboard with slots for up to 12 plug-ins. Each plug-in card has at least 8 channels of input or output (except for a maximum of 4 channels on the current probe), and some have 16 or even 32 channels.

All plug-ins can be purchased in either kit form or assembled and tested. The modules range in price from $65 a kit ($79.50 assembled) for the 8 channel DC controller card to $125 a kit ($150 assembled) for the 8 channel AC controller card. A cabinet, complete with motherboard, power supply, and parallel processor interface, is $299 for the kit ($360 assembled). For further information, contact General Computer Technology, 400 S Lipan, Suite 2, Denver CO 80223.

Voice Synthesizer for the TRS-80 Computer

The TRS-80 Voice Synthesizer is an accessory for Radio Shack's TRS-80 microcomputer system. It translates a computer output into recognizable, intelligible speech. The synthesizer includes a volume control, built-in speaker and cable assembly that permits easy plug-in connection to the TRS-80. Programming the TRS-80 for speech is done in BASIC. About 60 phonemes, representing units of speech, can be entered via the computer keyboard. This will even enable the computer to speak in foreign languages or with an accent, by integrating the various phonemes to produce the desired sounds. The voice synthesizer is especially useful in the field of education where it is used to supplement the displayed video information in a variety of learning situations such as spelling, reading, language arts, and mathematics.

The Radio Shack TRS-80 Voice Synthesizer is priced at $399 complete with detailed instruction manual and demonstration cassette. For further information, contact Radio Shack, 1300 One Tandy Ctr, Fort Worth TX 76102.
5¼" BASF Magical Miniature Mini drive only 2/3 the size of others is reliable and durable and quickly gaining in popularity with our customers. Single or dual density fast access times $274.00

Tarbell Controller may be re-configured to control 5¼" drives and includes short cable for one drive. KIT $179.00, ASM $265, but only $219 with purch. of 2 drives.

Cable Kits For 8" Drives with 10' 50 cond. cable and connectors. Also power cable and connectors. Flat cable assem if you wish. For one drive 27.50, two 33.95, three 38.95.

"Power One" Model CP206
Power Supply adequate for at least two drives 2.8A/24V 2.5A/5V, 0.5A/-5V beautiful quality. $99.00

32K / 16K Static RAM, 4MHz. (Showing Amazing Similarity to Tarbell's unit) (16K Shown in photo)

32K - $549.00 16K - $349.00

"BACK TO SCHOOL" KEYBOARD SPECIAL

CHERRY "PRO" Keyboard $119.00
Streamlined Custom Enclosure $34.95
BOTH ONLY $124.95 !!!!!!!!

For the first time in something like 10 years, a new STANDARD in removable media has evolved. Selected by Datapoint, and others who have not yet announced, this drive is beautifully simple and easy, if not trivial to maintain. 920XBy/sec, transfer rate, 3600 RPM 39 lbs and only 125 Watts.

Daisy Wheel Printers

**Qume Sprint 3x45**

PRINTER (factory warr.) $1199.00
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(shown mounted on rear of printer)
COMBINATION SPECIAL $1499.00

**DATA DISPLAY MONITORS**

Used 12" Sylvania monitors. Composite Video, 15 MHz, 120VAC. Re-built with NEW P39 anti-glare tube $119.00 New P4, 109.00, used P4 79.00.

"OEM STYLE" as above, will fit any case. Both versions serviced by qualified tech. Identical to above but subtract $12.00

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Doppler Motion Sensor
Intrusion Detector
Extremely effective microwave motion detector for detecting unwanted visitors. Ignores mice and other non-larcenous creatures. Operates on 12VDC or from small transformer supplied. Output is relay closure for alarm control interface, or to switch on lights annunciators. Will operate THROUGH door of closet or thin wall. Best application seems to be to turn on outside lights to help invited guests, and to intimidate unwanted ones. $159.00
Water Repellent Cover $24.95

**SOCKET SPECIAL**

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Low Profile
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1 CENT/ Pin!! (0.75/1000's)
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**Printer Terminals**

- ASCII SELECTRIC PRINTER/TYPewriter: Why settle for less than letter-quality printout from your computer? IBM Model 750 can be used as off-line typewriter or on-line printer. Complete with solenoids, power supply, case and ASCII interface card (TTL to CPU parallel port). Interface includes programmable ASCII translation table on EPROM with up to 8 tables (one type sphere) for use as memory typewriter, printer or as data entry device. Wide-carriage, interchangeable type heads available. Optional built-in modem. All units are interchangeable. Options include: adjusted & warranted. Model 5541
  - IBM Correspondence code
  - $795.00
  - Model 5550
    - (corres. code, built-in cassette drive)
    - $1195.00
  - Model 5560
    - (ASCII code, built-in cassette drive)
    - $1295.00

**System Terminals**

- DIABLO TERMINALS by GTE/Norma1 Information Systems:
  - Models in stock usually include Diablo 1550, DT 300 & 3000, GenCom 300 & 3000, and others.
  - All equipment is shipped insured FOB Palo Alto within 14 days after check clears or COD order is received.

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  - POS 103 MODEM
    - $179.95
  - POS 202 MODEM
    - $179.95
  - POS 202 MODEM (Auto-Answer)
    - $179.95
  - POS 103/202 MODEM
    - $179.95
  - POS 103/202 MODEM
    - $179.95

**POS 100 NRZI TAPE DRIVE CONTROLLER/FORMATTER:** Designed as an interface between S-100 bus mCPU and 9-track, 800 BPI, NRZI tape drive. Allows microcomputers to read and write IBM-compatible 8" mag tapes. Software provided for 8080 or Z-80 systems. Requires modification for drives of various infra. Std. version: 2 MHz 8080/2-Z-80 CPU for use with 12 FDC PERTEC-style Tape Drive.
  - Price: Includes S-100 card, controller card, 10" cable, software listing.
  - $500.00

**ASCII SELECTRIC PRINTER/TYPewriter: Why settle for less than letter-quality printout from your computer? IBM Model 750 can be used as off-line typewriter or on-line printer. Complete with solenoids, power supply, case and ASCII interface card (TTL to CPU parallel port). Interface includes programmable ASCII translation table on EPROM with up to 8 tables (one type sphere) for use as memory typewriter, printer or as data entry device. Wide-carriage, interchangeable type heads available. Optional built-in modem. All units are interchangeable. Options include: adjusted & warranted. Model 5541
  - IBM Correspondence code
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  - Model 5550
    - (corres. code, built-in cassette drive)
    - $1195.00
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    - $1295.00

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  - $895
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    - 16K DISPLAYABLE CHARACTERS
    - INTERCHANGEABLE IPM FACES
    - RESIDENT 4K MONITOR ROM
    - SERIAL, PARALLEL, MIDI
    - COMPLETE OPERATORS MANUAL
    - $895

- TI 810 PRINTER
  - 90 CHARACTERS PER SECOND
  - RB 232 SERIAL INTERFACE
  - ADJUSTABLE FORM TRACTOR
  - $1595

- SOROC IQ 120
  - SERIAL RS23C
  - FULL ASCII 1/0 LOWER CASE
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  - COMPOSITE VIDEO INPUT
  - $129.00

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- A complete single board Z80A CPU and selectable I/O system
- IBM 3580 compatible, MESA/AILAIR
- Z80A CPU (4 MHz version of the 280)
- 256 instructions — superset of Z80 and upward compatible to the 8080's 78 instructions
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- 2 MHz or 4 MHz operation is switch selectable
- 0 or 1 wait state for all cycles is switch selectable
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- Fully S100 compatible, uses National's Low Power 5257
- Inputs fully low power Shottky
- On-board single 5 amp regulator
- 24 programmable parallel I/O lines (uses 8255)
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- Fully warranted for 120 days from date of shipment

**Microbyte 16K Static Ram Board**
- Fully $100 Bus Compatible, IMSAI SOL, ALTAIR, ALPHA MICRO
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- 4K x 1 Static RAMs
- 2 MHz or 4 MHz operation
- On-board single 5 amp regulator
- Thermally designed heat sink
- Active Diode termination
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- Compatible with ALPHA MICRO, with extended memory management for selection beyond 64K
- No DMA restriction
- Low power consumption 1.3 amp
- Fully warranted for 120 days from date of shipment
- Extended addressing up to 1 megabyte of addressable ram

**Microbyte 32K Static Ram Board**
- Fully $100 Bus Compatible, IMSAI SOL, ALTAIR, ALPHA MICRO
- Uses National's Low Power 5257
- 4K x 1 Static RAMs
- 2 MHz or 4 MHz operation
- On-board single 5 amp regulator
- Thermally designed heat sink
- Active Diode termination
- Will operate with or without front panel
- Compatible with ALPHA MICRO, with extended memory management for selection beyond 64K
- No DMA restriction
- Low power consumption 1.3 amp
- Fully warranted for 120 days from date of shipment
- Extended addressing up to 1 megabyte of addressable ram

**Microbyte Motherboard**
- Active Diode termination
- Slot for IMSAI front panel
- Terminal block connection for easy hook-up
- 9 slot kit $70.50 &T $100.40
- 20 slot kit $125.70 &T $155.50
- Bare Board 9 slot $30.40 20 slot $50.80

**Microbyte Disk Controller**
- IBM 3740 Soft Sectored Compatible
- IBM or 9060 compatible on S-100 Bus
- Single density runs both mini and full size drives, runs CPM, on IMSAI, Sol, ALTAIR, Microboards etc.
- Selectable portaddress
- On-board 2708/2716 for bootstrap monitor program
- No hardware jumpers, uses plug in modules for different drives
- Uses 1718 01 controller chip
- Assembled and tested
- Specify disk drive used when ordering by mail

**Microbyte 801-Disk Drive**
- With cabinet & Power supply
- Assembled & tested
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**SHUGART**
- 810-Disk Drive
- Dual Cabinet & Drives Available

**SCANBE/RN**
- SOCKETS — LO PROFILE

**Cable Assembly**
- For 8" disk drives

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- 8088 — CPU BOARD
- Double Density Controller

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**BYTEx** October 1979 283
Circle 354 on inquiry card.

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>
<th>TAPS</th>
<th>SECONDARY WINDING OUTPUTS</th>
<th>SIZE</th>
<th>UNIT PRICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO.</td>
<td>KIT NO.</td>
<td>(2x8 Vac)</td>
<td>(2x14 Vac)</td>
<td>(2x24 Vac)</td>
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<tr>
<td>T1</td>
<td>0V, 110V, 220V</td>
<td>2x7.5A</td>
<td>2x2.5A</td>
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</tr>
<tr>
<td>T2</td>
<td>0V, 110V, 220V</td>
<td>2x12.5A</td>
<td>2x3.5A</td>
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</tr>
<tr>
<td>T3</td>
<td>0V, 110V, 220V</td>
<td>2x9A</td>
<td>2x2.5A</td>
<td>2x4.5A</td>
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<tr>
<td>T4</td>
<td>0V, 110V, 220V</td>
<td>2x4.5A</td>
<td>2x2.5A</td>
<td>2x4.5A</td>
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POWER SUPPLY KITS (OPEN FRAME WITH BASE PLATE, 3 HRS. ASSY. TIME)

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<tr>
<th>ITEM</th>
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<th>(2+8 Vdc)</th>
<th>(2-8 Vdc)</th>
<th>(2+16 Vdc)</th>
<th>(2-16 Vdc)</th>
<th>(2+28 Vdc)</th>
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<th>UNIT PRICE</th>
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<tr>
<td>KIT 1</td>
<td>18 CARDS SOURCE</td>
<td>15A</td>
<td>2.5A</td>
<td>2.5A</td>
<td>12&quot; x 6&quot; x 4/&quot;</td>
<td>46.95</td>
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<tr>
<td>KIT 2</td>
<td>SYSTEM SOURCE</td>
<td>25A</td>
<td>3A</td>
<td>3A</td>
<td>12&quot; x 6&quot; x 4/&quot;</td>
<td>54.95</td>
<td></td>
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<tr>
<td>KIT 3</td>
<td>DISC SOURCE</td>
<td>18A</td>
<td>1A</td>
<td>2A</td>
<td>3A</td>
<td>14&quot; x 6&quot; x 4/&quot;</td>
<td>62.95</td>
<td></td>
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<tr>
<td>KIT 4</td>
<td>DISC SOURCE</td>
<td>8A</td>
<td>1A</td>
<td>1A</td>
<td>8A</td>
<td>10&quot; x 6&quot; x 4/&quot;</td>
<td>44.95</td>
<td></td>
</tr>
</tbody>
</table>

Each kit includes: Transformer, capacitors, resistors, bridge rectifiers, fuse & holder, terminal block, base plate, mounting parts and instructions.

REGULATED POWER SUPPLY "R2" ASSY. & TESTED, OPEN FRAME, SIZE: 9" (W) x 5" (D) x 5" (H) ......... $69.95

SPECS: +5V, +1%, @ 5A; +24V, +1%, @ 5A. OVERCURRENT PROTECTION AND 5% ADJ. FOR BOTH VOLTAGES.

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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 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
- Made with 1st quality 2114 static ram chips
- All IC's are socketed
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*Product of MOS Technology
Pascal for 6800 Processor

A new Pascal compiler is available which runs under the TSC Flex Version 1.0 operating system on a SwTPC 6800 system (or equivalent) with sufficient hardware. It is possible to compile and run Pascal programs in as little as 16 K bytes using a 5-inch floppy disk. The run-time system interfaces fully with Flex, permits user device handling, and includes a paging facility which is invoked automatically if there is sufficient real memory for a large program.

In a 32 K byte, 1 MHz clock frequency system with dual floppy disks, Pascal programs can be compiled at over 80 lines per minute. With 20 K bytes, compilation is at 35 lines per minute, under the paging mode of execution. The P-code generated by the compiler is compact and efficient, so that programs execute much faster than is possible with conventional interpreters.

The compiler is written in the subset of Pascal which it supports, and includes files, procedures, functions, recursion, sets, arrays, and CASE statements as well as the looping and branching constructs.

Release Version 1.0 of the Pascal compiler and P-code interpreter and run-time system are provided on a Flex Version 1.0 format 5-inch floppy disk. User documentation, useful utilities, and specimen programs are also supplied. Contact Lucidata (Pascal Div), Oosteinde 223, Voorburg 2271 EG (ZH), NETHERLANDS.

C Compiler for 8080 Microcomputer

A full C compiler for 8080-based microcomputer systems is available from Whitesmiths Ltd, 127 E 59th St, New York NY 10022. Provided with the compiler are a complete set of runtime support routines; the Whitesmiths Portable C Library, an interface library for operation of C under either CP/M or ISIS-II operating systems; and a translator for the narrative assembly language A-Natural.

The 8080 compiler is currently available as a cross-compiler running on the PDP-11 under UNIX, RSX-11M, RT-11, RSTS/E, and IAS operating systems. Operating in three sequential passes, it produces A-Natural code, which is then translated to assembly language that is compatible with Intel's asm80 and Microsoft's Macro-80. Source code may also be written in A-Natural for processing by the same translator.

 Owners of the Whitesmiths PDP-11 C Compiler will find that the 8080 implementation is highly compatible. Programs written using only the Portable C Library should run unchanged on the 8080, permitting extensive code checking on the PDP-11.

A standard cross-compiler package is available at a price of $700 for object code to be run on a single processor. This package includes the C compiler and PDP-11 support routines, the A-Natural translator, and the runtime library for use on a single 8080 processor. Use of the minimal machine-interface library on additional microcomputers is available for as little as $10 per processor.

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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.

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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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  - 5257-3L 4K x 300ns Low Power: $9.00
  - 2708 8K 450ns EPROM: $35.00
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The EXPANDORAM is available in versions from 16K up to 64K, so for a minimum investment you can have a memory system that will grow with your needs. This is a dynamic memory with the invisible on-board refresh, and IT WORKS!

- Interfaces with Altair, IMSAI, SOL-8, Cromenco, SBC-100, and others.
- Bank Selectable
- Phantom
- Power 8VDC, 16VDC, 5 Watts
- Low cost, FRD Price
- Uses Popular 4116 RAMS
- Bank Selectable
- Phantom
- Interfaces with Altair, IMSAI, SOL-8, and IT WORKS!

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- Low cost, FRD Price
- Uses Popular 4116 RAMS
- Bank Selectable
- Phantom
- Interfaces with Altair, IMSAI, SOL-8, and IT WORKS!
Shugart SA400, housed in an attractive metal case, provide power supply and termination network. All you need to do is connect the drives to your expansion interface.

The primary difference between the two models is the inclusion of an RS232C interface and 192 character FIFO buffer in the Model S1.

**FEATURES**

- Separate integral 12 key Numeric Pad
- At 129 ASCII Codes
- 64 Displayable Characters
- 24x80 Screen Configuration
- High Resolution using a 5x7 Dot Matrix
- TTY-Style Keyboard Layout
- Cursor Addressing and Sensing
- EIA Interface
- Eight Selectable Transmission Rates up to 9600 Baud
- Microprocessor Based
- Remote Commands
- Attractive Styling for Contemporary Environments

**Specifications**

- 150 Lines Per Minutes
- 96 Characters — Upper and Lower Case
- 810/20 Characters/Inch — Software Selectable
- Elongated Characters — Underlining
- Simplified Operation — Quiet
- Audio Alarm — Long Life — Only 4 Moving Parts
- Small Size and Light Weight
- No Toners/Ribbons Required

**Model S1 Features**

- 192 character FIFO buffer
- RS232C serial interface
- 150 LInes Per Minutes
- 192 Orbit Character Set
- Small size and light weight
- No Toners/Ribbons Required

**Model S2 Features**

- Separate integral 12 key Numeric Pad
- 64 Displayable Characters
- 24x80 Screen Configuration
- High Resolution using a 5x7 Dot Matrix
- TTY-Style Keyboard Layout
- Cursor Addressing and Sensing
- EIA Interface
- Eight Selectable Transmission Rates up to 9600 Baud
- Microprocessor Based
- Remote Commands
- Attractive Styling for Contemporary Environments

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- Buy a MICROPRINTER and get a CASE OF PAPER FOR 1c. Reg. $25.00 value.

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- 810/20 Characters/Inch — Software Selectable
- Elongated Characters — Underlining
- Simplified Operation — Quiet
- Audio Alarm — Long Life — Only 4 Moving Parts
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- Small Size and Light Weight
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- 0-300 baud
- Bell 103
- Answer, Originale

**Price**

- Reg. $198.00
- Sale $189.00

**3M Scotch® Brand DISKETTES**

**Part #**

<table>
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<th>Price</th>
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<td>$51.00*</td>
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**CASE Diskettes for TRS-80**

- *Price Includes Kie-ette/10 Storage Box a $5.00 Value
- DON'T SETTLE FOR ANYTHING LESS THAN SCOTCH*

**SALE**

**LOGIC MONITOR 1**

- Trace signals through all types of digital circuits. Unit clips over any DIP IC up to 16 pins. Each of its 16 contacts connects to a single-bit level detector that drives a high-intensity, numbered LED readout activated when the applied voltage exceeds a fixed 2 V threshold. Logic "1" turns LED on; logic "0" keeps LED off. A power-seeking gate network automatically locates supply leads and feeds them to the LM-1's internal circuitry. Saves minutes, even hours in design, troubleshooting, debugging of equipment. Voltage Threshold: 2 V ± 0.2 V. Input Impedance: 100,000 ohms. Input Voltage Range: 4.5V max. across any two or more inputs. Current Drain: 200mA at 10 V. Size: 4" L x 2" W x 1.75" D when open. Weight: 3 ozs.

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SAN CARLOS, California — Jim-Pak Components today announced the addition of another innovative kit to their growing line of quality electronic kits for the home enthusiast. The JE610 62-key ASCII Encoder Keyboard is now available through JIM-PAK distributors.

**62-Key ASCII Encoder Keyboard Kit**

THE JE610 62-KEY ASCII ENCODER KEYBOARD KIT CAN BE INTERFACED INTO MOST ANY COMPUTER SYSTEM. THE JE610 KIT COMES COMPLETE WITH AN INDUSTRIAL GRADE KEYBOARD SWITCH ASSEMBLY (62 KEYS), IC'S, SOCKETS, CONNECTOR, ELECTRONIC COMPONENTS AND A DOUBLE SIDED PRINTED WIRING BOARD. THE KEYBOARD ASSEMBLY REQUIRES +5V @ 150mA AND -12 V @ 10mA FOR OPERATION.

**FEATURES:**
- 60 KEYS GENERATE THE FULL 128 CHARACTERS, UPPER AND LOWER CASE ASCII SET
- FULLY BUFFERED
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**JE610**

Circle 202 on inquiry card.
What's New?

PERIPHERALS

8-Inch Floppy Disk Drive for TRS-80 Computer

This Shugart 800-based floppy disk system, called Maxi-Disk, is fully compatible with existing TRS-80 5-inch floppy disk drives, and can be mixed and matched with smaller drives. The system plugs into the TRS-80 expansion interface. The user has only to remove the disk controller device from the expansion interface, and replace it with a specially designed circuit board. In this circuit board is a socket where the controller device is reinserted. All necessary parts and instructions are provided. No soldering or trace cutting is necessary.

The system also allows the user to use the expansion interface as it is designed since the only change is to turn the disk controller from a 5-inch only controller to an 8-inch and/or 5-inch controller.

The Maxi-Disk system sells for $995 which includes the 8-inch drive, the interface board, and a patch to the TRS-DOS that allows the user to access a variety of drives. For more information, contact Parasitic Engineering, POB 6314, Albany CA 94706.

Circle 608 on inquiry card.

Dual Serial Interface for TRS-80 Computer

The DSI-80 is a dual serial interface for use with the Radio Shack TRS-80 computer. It provides 2 serial output ports with both current loop and RS-232 interface. Speed selections of 110, 150, 300; 600 and 1200 bits per second (bps) are accomplished by jumpers which require no special tools or soldering.

The unit is built to MIL specifications and burned-in for a minimum of 120 hours before shipment. All integrated circuits are socketed and the timebase is crystal controlled.

The cassette tape provided with the DSI-80 contains several I/O (input/output) programs written in BASIC, intended to show how other BASIC programs can use the interface. The tape also contains system programs written in assembly language to patch the BASIC interpreter in the TRS-80, so that common time-sharing type terminals can be used to run BASIC and to receive output from the LPRINT AND LLIST commands.

The unit, complete with manual, cassette tape, and 6 month warranty is available for $199.95. For further information, contact Polytronics, Methodist Hill, Lebanon NH 03766.

Circle 609 on inquiry card.

S-100 Four Channel 12-Bit Digital-to-Analog Converter

The Tecmar S-100 D/A board is designed for applications requiring high-speed accurate digital-to-analog conversion including real-time applications. This board supports four independent high-speed digital-to-analog converters (DACs) with associated latches. Each DAC operates independently of the rest. The DACs have a conversion time of 3 µs which enables them to operate at maximum computer speed. A 12-bit latch drives the inputs of each DAC. Another 4-bit latch for each DAC holds the four new most significant bits waiting for the arrival of the new least significant byte. This allows the DAC to hold its previous value until an entire new word is presented to it. All the latches are set to zero by reset. To modify the contents of a latch, and hence the output of a DAC, it is necessary to send two bytes to the device. The input is a 12-bit in a two's complement format. The board may be addressed as I/O ports or memory mapped.

The S-100 D/A Converter Board is priced at $395 and comes complete with documentation; the S-100 D/A Technical Manual is $15. All boards are assembled and tested and have a 90-day warranty. For further information, contact Tecmar Inc, 23414 Greenlawn Ave, Cleveland OH 44122.

Circle 610 on inquiry card.
Sankyo Magnetic Card Reader

$59

These Sankyo I/O units are capable of storing and retrieving over 600 characters of data in under two seconds. The flexibility of this device lends itself to numerous applications. As an input reader to a computerized security system, the computer has the ability of identifying the card holder and assembling other pre-registered data. The device is also suitable for maintaining customer information files, or any other application where small amounts of information must be quickly entered into a data processing system. Accepts 2" by 4" style tag cards. Motorized reader pulls the magnetic card across the reading frame.

TELEFAX

50-8138

Certified Digital Cassettes

$60

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SPECIAL CIRCUITS

PORTABLE DATA ENTRY SYSTEM

These used data terminals were originally designed for chain store inventory control and order entry systems. The operator enters the inventory control number, merchandise on hand and the unit price. After all pertinent data has been entered into the recorder, the main warehouse is telephoned. The handset is placed on the acoustic coupler and the recorded information is transmitted back to the master computer. All units were removed from service in working condition. Original cost $2,500. Each system comes complete with:

* Portable Cassette Drive Unit
* Removable Keyboard
* LED Display

$1395

SYSTEM X-10

It's not often that California Digital ventures into the domain of consumer products, but we have recently come across a product that appears so unique that we felt we had to add it to our product line. This is the System X-10 manufactured by the BSR turntable company. The System X-10 consists of three space age sub-systems which can remotely control any light or appliance in your home or office. Command signals are transmitted from the command console over your existing wiring. From your bed or easy chair you can control up to 16 different electrical devices inside and outside your home. Use the System X-10 to control your stereo, television or any light fixture on the premises.

The basic system comes complete with command console, battery operated control unit, one each of the appliance modules, lamp module and wall switch module. The basic system is priced at only $29.95. Additional modules are available for $13.95 each.

$29.95

SA800-R Floppy Disk Drive

The most cost effective way to store data processing information. The floppy drive is our prime factor. The SA800 is fully compatible with the IBM 3740 format. Write protect circuitry, low maintenance & Sankyo quality.

$1024

PORTABLE DATA ENTRY SYSTEM

These used data terminals were originally designed for chain store inventory control and order entry systems. The operator enters the inventory control number, merchandise on hand and the unit price. After all pertinent data has been entered into the recorder, the main warehouse is telephoned. The handset is placed on the acoustic coupler and the recorded information is transmitted back to the master computer. All units were removed from service in working condition. Original cost $2,500. Each system comes complete with:

* Portable Cassette Drive Unit
* Removable Keyboard
* LED Display

$1395

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JADE Computer Products

JADE'S NEW MAINFRAME

THE PIGGY IS HERE!

This sleek new mainframe is beautifully designed around JADE'S six slot ISO-BUS motherboard and an 18 amp power supply with provisions for up to 3 mini-floppy drives. This is a practical, state-of-the-art design whose looks just can't be beat! ENS-106320 (without drives) $475.00

VISTA V80

TRS-80 MINI-DISK SYSTEM

The V80 out-performs standard Radio Shack drives—23% more storage capacity, 8 times faster access time, more reliable, and much less expensive. Includes disk drive, power supply, regulator board, and case. MSM-358000 $395.00 Interface cable for V80 WCA-3421 $24.95

DISKETTE SPECIAL

5.25" SOFT. 10. OR 16 SECTOR 10 for $29.95 8" SOFT SECTOR IBM COMPATIBLE 10 for $34.95

S-100 CONNECTOR SALE

100 PIN IMSAI TYPE SOLDER-TAIL CONNECTOR 6 for $17.50 12 for $29.95

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DB-25S. DB-25P, DB-25 COVER

DB-25S (FEMALE) $3.85

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DB-25C (COVER) $1.50

RJ-11 DIP SWITCHES

PART NUMBER NO. OF SWITCHES PRICE

SWD-103 3 $1.18

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SWD-107 7 $1.30

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ZIP* DIP II SOCKETS

16 PIN ZIP* DIP II $5.50

24 PIN ZIP* DIP II $7.50

40 PIN ZIP* DIP II $10.25

*TZRO INSERTION PRESSURE

JADE'S NEW INTELLIGENT CONTROLLER

THE DOUBLE-D

Read/write in single or double density, 8" or 5 1/4" drives. CP/M compatible in either single or double density. On-board Z-80 CPU allows universal compatibility. Programmed data transfer. No DMA. Controls up to 8 drives. Software selectable density. Our new controller utilizes the IBM standard formats for proven reliability. Data recovery is enhanced through the use of a phase-locked-loop data separation circuit and write precompensation. Single and double density disk drives can be mixed in the same system.

KIT $220.00

ASSEMBLED & TESTED $239.00

FLOY DISK DRIVES

NEW BASF MINI-FLOPPY $319.95 Shugart SA400 compatible but only two-thirds the size! 40 track, double density 5 1/4" drive. Very low power consumption!

MPI 851 5 1/4" DRIVE $295.00 Single or double density, up to 40 tracks, track-to-track access time of 5ms, Shugart SA400 compatible.

MPI 852 5 1/4" DRIVE $450.00 Double-sided version of MPI 851.

SHUGART SA400 5 1/4" DRIVE $325.00 Single density, 30 track

SIEMENS FDD100-8 8" DRIVE $495.00 Certified double density Shugart 801R replacement. Runs much cooler and quieter.

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PERSCI 277 8" DRIVE $1595.00 Limited quantity with slim line case & power supply

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For Rockwell AIM-65 PSX-02A $55.95

For KIM-I or SYM-I PSX-02A $59.95

INTEGRAL DATA SYSTEMS MODEL 440 PRINTER

THE PAPER TIGER

Up to 120 CPRS 10-15 inch adjustable tractor feed Parallel and serial interface

95 Character ASCII set 132 columns- 6 or 8 lines/ inch

Display Software selectable character sizes. 110, 300, 600, 1200 baud.

PRM-33440 $975.00

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FREE 12 INCH B & W MONITOR WITH EVERY 16K SORCERE

Flexibility is the key. The Sorcerer Computer gives you the flexibility of using ready-to-run, pre-packaged programs or doing your own thing and personalizing the programs for yourself. Whichever you choose. The Sorcerer is the personal computer that speaks your language.

The Sorcerer also provides full graphics capabilities. Each character formed by an 8 x 8 dot set, can be programmed as a graphic symbol set. High resolution (512 x 240 addressable points) gives a total of 122.880 characters for super animation and extremely light plotting curves. The alphanumeric set gives 64 character terms by an 8 x 8 dot cell. can be programmed as a replacement. Runs much cooler and quieter. 132 columns ASCII set, Software selectable density. 15 1/4 inch adjustable tractor feed. No OMA. Interface, Controls up to 8 drives. No OMA.

LEEDX MONITOR $139.00 12 Black and White 12 MZH Bandwidth 13/8inches Personal Case

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MINI-DISK CABLE KIT Connects two 5 1/4" mini-floppies to your disk controller board and power supply. Includes 5" signal cable with three 4 pin connectors, plus power supply connectors and cables. WCA-9341K $34.95

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For 20-300 12000 baud

Circular 195 on inquiry card.
# JADE Memory Expansion Kits for TRS-80 Apple Exidy

Everything you need to add 16K of memory to your computer. Your full computer tape packaged with easy to follow instructions. In just minutes your computer is ready to tackle more advanced software.

### $82.00

### THE BIG Z

THE NEW Z-80 CPU BOARD FROM JADE

Features include 5-100 Compatible available in 2MHz or 4MHz versions. On-board 135,016, 211 or 2552 EPROM can be addressed on any 1K, 2K or 4K boundary with power-on jump to EPROM. On-board EPROM may be used in SHADOW mode, allowing full 64K RAM to be used. Automatic UART connection in front panel is not used. On-board USART for synchronous or asynchronous RS232 operation (on-board baud rate generator). All character channel capability on USART allows use with buffered peripherals or devices with not-ready signals.

**2MHz Kit:** $149.95
- Assembled and Tested
- CPU-3020A 2K, 2M
- Addressed and Tested CPU-3020A 2K
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**SD-Systemsavors**

**EXPANDORAM**

Expandable to 32K or 64K

**EXPANDO-32K KITS**

Uses 4115 (8K X 1.25ma) Dynamic RAMs can be expanded in 8K increments up to 32K

- **8K** $159.95
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Uses 4116 (16K X 1.25 ma) Dynamic RAMs can be expanded up to 64K in 16K increments

- **16K** $249.95
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### STATIC RAM BOARDS

**VDB-8024**
An 80 by 24 I/O mapped video board for S-100 systems. An on-board Z-80 processor is used to control all functions. A total of 256 users programmable characters are available, including 128 characters that are supplied with the board. This is virtually a stand-alone terminal.

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**ASSEMBLED AND TESTED**

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This 64 by 16 memory-mapped video board is ideal for use with word processing software such as the Electric Pencil.

- **KIT**
  - **ASSEMBLED AND TESTED**
    - **BARE BOARD/MANUAL**
      - **ASSEMBLED AND TESTED**
        - **VECTOR GRAPHICS**
          - **FLASHWRITER II**

**TERMINAL**

The ultimate memory-mapped 64 character by 24 line video board, the Vector Graphics PWL has many advanced features. Onboard parallel keyboard port. Power-on jump circuit, 8 X 10 dot character matrix, and the optional ability to program your own characters and/or graphics symbols is the **THE PERFECT board for text editing systems.**

- **ASSEMBLED AND TESTED**
  - **$320.00**

**NOVATION CA**

**ACOUSTIC MODEM**

Features include 300 baud Answer/Disconnect Bell 103
- **Assembled and Tested**
  - **$199.95**
Venus 2001 Video Board

Assembled & Tested $259.95 • Complete Unit with 4K Memory and Video Driver on Eprom assembled and tested $339.95

OPTIONAL:
- Sockets $10.00
- 2K Memory $30.00
- 4K Memory $60.00
- Video Driver Eprom $20.00
- S-100 plug-in • Parallel keyboard port

On board 4K Screen Memory (Optional), On board Eprom (Optional) for Video Driver or Text Editor Software.

Up and down scrolling through video memory Reverse Video, Blinking Characters.

Display: 128 ASCI1 Characters 64 X 32 or 32 X 16 Screen format (Jumper Selectable), 7 by 11 Dot Matrix Characters.

American or European TV Compatible (CRT Controls Programable) Dealer Inquiries Invited

32-K Static RAM $499.95 KIT
- S-100 Plug-In • Kit includes P.C. board, all parts and assembly manual
- Uses 2114L, 450 nS.
- I.C. sockets - $20.00

P.C. BOARD BY S-100 CO.

16-K Static RAM $249.95 KIT
- S-100 Plug-In Kit includes P.C. board, all parts and assembly manual. Uses 2114L 450 nS.
- Sockets - $10.00
- Add $40.00 for 300 nS (4MHz) RAMS

P.C. BOARD BY WAMECO

Z-80 CPU $125.95 KIT
- S-100 Plug-In Kit includes P.C. boards, all parts and assembly manual.

FEATURES: 2MHz operation • S-100 plug-in • Power-on Jump • On board provision for 2708 (optional at $12.95).

P.C. BOARD BY ITHACA AUDIO

ASCII Keyboard Kit $79.95

Assembled and Tested $95.95

- Single +5V Supply • Full ASCII Set (Upper and Lower Case) • Parallel Output • Positive and Negative Strobe • 2 Key Rollover • 3 User Definable Keys • P.C. Board Size: 17-3/16" X 5" • Control Characters Molded on Key Caps • Optional Provision For Serial Output

OPTIONAL: Metal Enclosure $27.50 • Edge Con. $2.00 • Sockets $4.00 • Upper Case Lock Switch $2.50 • Shift Register (For Serial Output) $2.00

Dealer Inquiries Invited

Apple II I/O Board Kit

Plugs into Slot of Mother Board
- 18 Bit Parallel Output Port (Expands to 3 Ports) • 1 Input Port • 15mA Output Current Sink or Source • Can be used for peripheral equipment such as printers, floppy discs, cassettes, paper tapes, etc. • 1 free software listing for SWTP PR40 or IBM selectric.

PRICE: 1 Input and 1 Output Port $49.00
1 Input and 3 Output Ports $64.00

Dealer Inquiries Invited

NEW! A DREAM COME TRUE!

Introducing: 30 MHZ DUAL Trace PORTABLE SCOPE for an amazing $555.

- Dual trace 2-channel; separate, chopped or alternate modes. • 30 megahertz bandwidth. • External and internal trigger.
- Time base - 0.05, Microseconds to 0.2 SEC/div 21 settings. • Battery or line operation.
- Line synchronization mode.
- Power consumption less than 50W. • Vertical gain - 0.1 to 50 volts/div- 12 settings. • Size: 2.9” H 6.4” W 8.5” D. • Weighs only 3.5 lbs, with batteries.
- Complete with input cable and rechargeable batteries and charger unit.

OPTIONAL: Leather case $45.00 • 10:1 probe $27.00 (2 for $49.00)

MS-215 15 MHz Dual Trace Portable Scope $399.

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SHIPPING $3.50 / California residents add 6% sales tax

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FOR SALE: Phillips Model P M 3240 Dual-trace, dual time base, Y plate, with 8 inch oscilloscope. Will consider for TRS-80, L II, L 18, K George Colby, R R 1 POB 95, Central City IA 52254, (319) 842-2653.

FOR SALE: Color monitor, Conrac 19 inch RGB studio monitor. All solid state, long life tube picture tube, $1700 or trade for TV set. Jim McCord, 330 Vereda Leyenda, Goleta CA 93107, (805) 969-6681.

FOR SALE: 2 reels of 1 inch tape for ASR33 computer terminal. $15 plus shipping. Engineering Dynamics International, 4200 Detmar Blvd, St Louis MO 63124, (314) 991-1800.

FOR SALE: TRS-80 printer interface. An RS-232 printer interface which works off of cassette port number 2. May be used with or without the expansion interface. 110 thru 9600 bps and other options. Excellent software support. Tape version $39.9S. Disk version only $49.9S.

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FOR SALE: Eight u410D 250 ns memory chips at $7.50 each (or will swap with 4200A); SA400 minifloppy drive including power supply, $300. C Tinaztepe, 206 East 131st St, New York NY 10035.

FOR SALE: I have 16 K static memory $100-bus from Digital Research Corp, uses Intel 2114, 4SO ns, featuring one card cage or may be boxed. ECT 8080 FORTRAN MITS disk version for 8080 COBOL or MITS timesharing BASIC. K R Roberts, 10560 Main St Suite S 15, Fairfax VA 22030, (703) 379-7286, 591-6008.

FOR SALE: MAIL 4 K static, $70. MITS 4 K dynamic, $40. Seals 5 K static, $140. read only memory with MITS DLS and MBL, $200. Digital group standard floppy Interface card. FOR SALE OR TRADE FOR HIGH END EQUIPMENT: RCA Councel Super ELF expanded 8 K of programmable memory with lots of extras like high and low address readouts, video monitor, Ni-Cad battery memory saver and power cord with space for ten more memory/pinout cards. This plus complete manuals and many programs for only $150 or best offer. Must sell. Call Dave at (319) 322-6211 or 324-3017.

FOR SALE: A fully populated OSI Challenger III system. Includes 32 K, dual 8 inch floppy drives, keyboard, video, cassette, graphics, monitor, 6 serial I/O (input/output) boards, two 64 kbit digital boards, one 8 bit digital board, one 512 character player, one 16 bit digital addressing and modem, one 16 character monitor, one 16 character display, one 16 character converter to digital, with 8 channel multiplexer, three parallel IQs, 1 M byte memory management, software switch, address for all three micros, with controllers, all data cables. Fully operational. Will sell for $450. Five free disks of software with purchase includes BASIC, Assembly Editor, Challenger III, Checkpoint and nothing but iP- A, OSI Level 1 and much more. Patricia A Reynolds, (713) 674-8367.

FOR SALE: OSI C2-4P with connected RS-232 port and switch selectable baud rates, works perfectly. Cost $595, will sell for $495. Pat Reynolds, (713) 674-8367.

FOR SALE: F5 evaluation kit (MK3850, 386, 1204 bytes MK-102 programmable memory); edge connector; RS-232, C2-4P Interface card. $15. Excellent condition. Includes 8080A power supply; Lambda LTS-60-volt series pass power supply 6 V DC plus or minus 14, 32 A. $100 or best offer plus shipping. Paul Snigier, 68 Phyllis Rd, Raynham MA 02767.

FOR SALE: OSI Challenger III with dual floppy disks, 32 K programmable memory, three processors (6020, 2800, 6030), FIDOS, BASIC, Assembler, Dissembler, word processing. Original cost $3700, sell for $3000. Bill Gale, 439 Orange Ave, Orange CA 92670, (714) 762-9729.

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On-line capabilities enable you to make a single entry and update all affected files. An inquiry into a file at any time provides up-to-date information — no batching or sorting of input data.

The programs are easy to use. Messages on the video display guide you each step of the way. Programs make use of indexed sequential and chained files for fast and convenient retrieval of data with efficient use of disk space.

Order in standard eight-inch disk either double or single density, or various mini-floppy formats. Each program contains a free CBASIC-2, plus user's manual and hard copy source listing.

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The Microcomputers you should take seriously.

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.

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

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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 the tremendous number of programs offered by independent suppliers and publishers. 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.

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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 that can compete directly with dedicated word processor systems.

There are specialized application packages for specific businesses, plus the vast general library of standard BASIC, FORTRAN and COBOL software.

OS-DM5, the new software star.

Ohio Scientific has developed a remarkable new Information Management system which provides end user intelligence far beyond what you would expect from even the most powerful minisystems. 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-DM5 allows many applications to be computerized without any programming.

The new "GT" option heralds the new era of sub-microsecond microcomputers.

Ohio Scientific now offers the 6502C microprocessor with 150 nanosecond main memory as the GT option on all Challenger III Series products. This system performs a memory to register ADD in 600 nanoseconds and a JUMP (65K byte range) in 900 nanoseconds. The system performs an average of 1.5 million instructions per second executing typical end user applications software (and that's a mix of 8, 16 and 24 bit instructions!).

Mini-system Expansion Ability.

Challenger III systems offer the greatest expansion capability in the microcomputer industry, including a full line of over 40 expansion accessories. The maximum configuration is 788K bytes RAM, four 80 million byte Winchester hard disks, 16 communications ports, real time clock, line printer, word processing printer and numerous control interfaces.

Prices you have to take seriously.

The Challenger III systems have phenomenal performance-to-cost ratios. The C3-S1 with 32K static RAM, dual 8" floppy's, RS-232 port, BASIC and DOS has a suggested retail price of under $3600. 80 megabyte disk based systems start at under $12,000. Our OS-CP/M software package with BASIC, FORTRAN and COBOL is only $600. The OS-DM5 nucleus package has a suggested retail price of only $300, and other options are comparably priced.

To get the full story on the Challenger III systems and what they can do for you, contact your local Ohio Scientific dealer or call the factory at (216) 562-3101.

SEE OHIO SCIENTIFIC INSTRUMENTS AD SECTION STARTING ON PAGE 33.