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Circle 350 on inquiry card.
Forefront

A detailed description of a "trap door" algorithm

94 DESIGNING WITH DOUBLE SIDED PRINTED CIRCUIT BOARDS, by David Lamkins
This do-it-yourself technique can save you space

114 DESIGNING A ROBOT FROM NATURE, Part 2: Constructing the Eye, by Andrew Filo
Design details of the robot's eye in the second of this 2 part article

142 A STEPPING MOTOR PRIMER, Part 2, by Paul Giacomo
Interfacing to your computer, and other considerations

150 BUILD A COMPUTER CONTROLLED SECURITY SYSTEM FOR YOUR HOME, Part 3, by Steve Clarcia
Ultrasound, infrared beams and other exotic ways to make your home secure

Learn to use one of the most powerful programmables

Background

12 BUILDING THE HEATH H8 COMPUTER, by Dr Paul R Poduska
A review of a popular computer kit

14 A MAP OF THE TMS-9900 INSTRUCTION SPACE, by Henry Melton
Organizing one's approach to a machine with $2^{15.95}$ legal instructions

32 FILES ON PARADE, Part 2: Using Files, by Mark Klein
File protection systems and sundry other matters

46 A MICROPROCESSOR FOR THE REVOLUTION: THE 6809, Part 3, by Terry Ritter and Joel Boney
Final thoughts about the successor to the Motorola 6800 processor

56 CRYPTOGRAPHY IN THE FIELD, Part 1: An Overview, by John P Costas, Phd
A brief historical look at cryptography

80 PREVIEW OF THE Z-8000, by Irad Rampil
A look at Zilog's new 16 bit processor

170 COMMON MISTAKES USING WARNIER-ORR DIAGRAMS, by David Higgins
Avoiding pitfalls when using this alternate flowcharting method

194 PASSWORD PROTECTION FOR YOUR COMPUTER, by R Jordan Kreindler
How to keep data and information "for your eyes only"

230 WHAT IS AN INTERRUPT? by R Travis Atkins
Learn how to use peripherals efficiently with interrupts

238 HISTORY OF COMPUTERS: THE IBM 650, by Keith S Reid-Green
A glance at a past favorite

Nucleus

6 Don't Overlook LISP
10 Letters
26 Desk Top Wonder: Race Car for the SR-52
42 Book Review
53 Event Queue
92 Programming Quickie: Inverse Trig Functions
93 Machine Language Puzzler: Odd Tones
107 BYTE News
182 Technical Forum
206 Nybbles: Computer Assisted Flight Planning
222 Clubs and Newsletters
224 BYTE's Bits
241 What's New?
270 Unclassified Ads
272 BOMB
272 Reader Service

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The Heath H8 is part of the family of Heath computer kits. Dr Paul R Poduska describes his experience of assembling this well-documented kit in Building the Heath H8 Computer.

One way to see what the Texas Instruments TMS-9900 processor can do is to cover the instruction set using A Map of the TMS-9900 Instruction Space by Henry Melton as a guide. His short article gives a summary of the available operations plus details for all the possible operation codes of the machine.

After setting up a computer system with the hardware and software to handle files, how do you use it? In part 2 of Files on Parade, Mark Klein describes file management and programming techniques using files.

In A Microprocessor for the Revolution: The 6809, Part 3: Final Thoughts, 6809 architects Terry Ritter and Joel Boney of Motorola discuss clock speed, timing signals, condition codes and software design philosophy as they apply to the 6809.

In Cryptography in the Field, Part 1, Dr J P Costas gives a brief history of the fascinating world of cryptography, to be concluded next month with a programmable calculator encryption and decryption program.

Robert V Meushaw’s article describes the workings of and some of the theory involved with The Standard

In this BYTE

Data Encryption Algorithm, one of a class of algorithms known as “trap door” algorithms.

The Z-8000 is Zilog’s new entry into the field of 16 bit processors. In addition to its impressive speed, the Z-8000 in conjunction with an onboard memory management device allows programmers to employ virtual memory techniques. Read about it in Ira Rampil’s Preview of the Z-8000.

If you’d like to double your pleasure and double your fun, try designing with two printed circuit board sides instead of one. David Lamkins shows you how to get more for your money in Designing with Double Sided Printed Circuit Boards. Perhaps that topology course you took might come in handy after all.

Andrew Filo concludes his article Designing a Robot from Nature with an overall description of the system as well as construction details for building a net convexity detector, which mimics the frog’s ability to detect insect flight patterns.

This month Paul Giacomo concludes his 2 part Stepping Motor Primer with a look at interfacing the stepping motor to a computer as well as a discussion of damping, inertia and other related topics.

This month Steve Ciarcia completes his 3 part article Build a Computer Controlled Security System for Your Home with a discussion of burglar alarms, intrusion detectors, and the rest of the circuitry you’ll need to make your home secure.

First time users of Warnier-Orr diagrams consistently have many questions about the correct usage of the technique. David A Higgins describes some conceptual errors and other Common Mistakes Using Warnier-Orr Diagrams.

If many people have access to your computer, you may want to protect the information contained within it. One way is to implement Password Protection for Your Computer as described by R Jordan Kreindler.

This month Robert C Arp Jr begins a 2 part article about The Power of the HP-67 Programmable Calculator. Part 1 is a review of the features and performance of this powerful desk top wonder.

What Is an Interrupt? In brief, it is the act of safely stopping one process and causing your computer to start (resume) another process. For some background information on interrupt processing, see R Travis Atkins’ tutorial in this issue.

Keith S Reid-Green continues his History of Computers with a discussion of one of the early minicomputers, The IBM 650.
Suddenly everyone is talking about personal computers. Are you ready for one? The best way to find out is to read Apple Computer's "Consumer Guide to Personal Computing." It will answer your unanswered questions and show you how useful and how much fun personal computers can be. And it will help you choose a computer that meets your personal needs.

**Who uses personal computers.**
Thousands of people have already discovered the Apple computer — businessmen, students, hobbyists. They're using their Apples for financial management, complex problem solving — and just plain fun.

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Once you've unlocked the power of the personal computer, you'll be using your Apple in ways you never dreamed of. That's when the capabilities of the computer you buy will really count. You don't want to be limited by the availability of pre-programmed cartridges. You'll want a computer, like Apple, that you can also program yourself. You don't want to settle for a black and white display. You'll want a computer, like Apple, that can turn any color TV into a dazzling array of color graphics.* The more you learn about computers, the more your imagination will demand. So you'll want a computer that can grow with you as your skill and experience with computers grows. Apple's the one.

**How to get one.**
The quickest way is to get a free copy of the Consumer Guide to Personal Computing. Get yours by calling 800/538-9696. Or by writing us. Then visit your local Apple dealer. We'll give you his name and address when you call.

*Apple II plugs into any standard TV using an inexpensive modulator (not included).
Don’t Overlook LISP

Pascal has reached critical mass; it has flashed through the mainframe, minicomputer, and now the microcomputer field. It has much to support its popularity; however, it represents but one point of view about computing.

This discussion offers a contrasting position, as "personified" by LISP. I will discuss not relative expressive power or syntax, but rather that the forces and attitudes which shaped the languages (and the kinds of problems which the languages address) represent diverse views of computation. In the 1969 Software Engineering Conference, Niklaus Wirth (creator of Pascal)

I would like to discuss the trend towards conversationality in our tools. There has been, since the development of timesharing and on line consoles, a very hectic trend towards development of systems which allow the interactive development of programs. Now this is certainly nice in a way, but it has its dangers, and I am particularly wary of them because this conversational usage has not only gained acceptance among software engineers but also in universities where students are trained in programming. My worry is that the facility of quick response leads to sloppy working habits and, since the students are going to be our future software engineers, this might be rather detrimental to the field as a whole.

Wirth was addressing programming development in particular, but the question of "sloppy work habits" has a broader connotation. Many industrial and educational personnel still question the viability of interactive composition of any kind of text. Supposedly on line composition is wasteful and inefficient; one should carefully think out the text, writing it out in longhand or by typewriter, then revise and amend, cut and

Continued on page 212
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*Both systems require a video monitor, modified TV or RF converter and home television for operation. Ohio Scientific offers the AC-3 combination 12" black and white TV/monitor for use with either system at $115.00 retail.*

All prices, suggested retail.

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OF KITCHENS AND COMPUTERS

As a data processing professional of twelve years experience, I have come to have great respect for the principle: “Don’t make things more complicated than they are.” In particular, this means don’t purp-poses on a computer if you are more easily done some other way, no matter how much you like computers. I refer in particular to Richard Shuford’s “Proposal for a Kitchen Inventory System, or Don’t Byte the Wand that Feeds You!” (Decem-


An automated food inventory and ordering system might be ideal for a restaurant. Feeding large numbers of people means ordering large amounts of food; the cost of running out of an item, or of overstocking perishables is relatively high. The home kitchen, on the other hand, deals with small quantities of a virtually unlimited number of items. Impulse buying is frequent, and will menus to change. The cost of mistakes is fairly small. Automatic reordering is fraught with danger — just when you finally use up the last can of cheese soup (bought in a moment of madness), shazam! four more appear.

My own kitchen inventory system works just fine. It is made out of paper from a legal pad, with the words CHOPIN LISZT affixed to the door of my refrigerator with a bar magnet. The input device is a number

two pencil.

There are thousands of applications which lend themselves to automation very well, and many where nothing else will do — but a computerized shopping list isn’t one of them. For computers and computerists to gain the respect (and avoid the enmity) of the rest of the world, we need to be simplifiers, not complicators. So please, don’t make things any more complicated than they are!

Bob Brown
Medical Association of Georgia
938 Peachtree St NE
Atlanta GA 30309

The kitchen inventory system may be every family’s cup of tea. My own buying habits are regular enough that the system may help; perhaps yours are not. Impulse purchases do not necessarily disrupt the system. The user may simply choose not to scan a product which is not to be restocked.

In a related communication, Mr Brown advises us that a reprint of “The Characteristics and Decodability of the Universal Product Code” which appeared in the IBM Systems Journal, volume 14, number 1, is available as form G321-5002 for $0.50 from IBM’s General Systems Division offices....RSS

COMPUTER HUMOR

Perhaps your readers will enjoy the following bit of doggerel. Every one in a while my husband Pat comes up with a good one like the one below:

Count Dracula’s micro, It seems.
Would trouble his diurnal dreams.
What it felt was, you see.
Infertility.
For it got all its bytes without screams.

Leah O’Connor
6315 W Raven
Chicago IL 60646

CONCERNING CHESS AND PASCAL

As a Pascal fanatic who has waited a long time to run across a readable chess program, I was thoroughly de-

lighted to find that the excellent theo-

retical article “Creating a Chess Player” by Peter Frey and Larry Atkin (October 1978 BYTE, page 182) was to be fol-

lowed by a complete Pascal listing that put the principles into practice. Having said that, may I be allowed to voice a few minor reservations?

First, although the authors are in general admirably clear about separating machine dependent and machine inde-

pendent code, I feel they should have made clear that the contorted treatment of bit boards results from a machine dependent implementation restriction: in CDC Pascal, sets may not have more than 59 elements, so that a bit board must be represented as two sets of 32 elements. Other implementations, such as UCSD Pascal, do not have this restriction, so that the bit board manipula-

tions which form the backbone of the program may be represented much more naturally. Thus, IORRS (INRS, INRS, IMRS) could become simply INRS := INRS | IMRS.

Secondly, I find that the program does not exploit Pascal’s self-documenting potential as much as it might, be-

cause the authors chose a cryptic naming convention instead of using mnemonics. After ten hours of intensive study,

Continued on page 226
SoL. The small computer that won't fence you in.

A lot of semantic nonsense is being tossed around by some of the makers of so-called "personal" computers. To hear them tell it, an investment of a few hundred dollars will give you a computer to run your small business, do financial planning, analyze data in the engineering or scientific lab — and when day is done play games by the hour.

Well, the game part is true. The rest of the claims should be taken with a grain of salt. Only a few personal computers have the capacity to grow and handle meaningful work in a very real sense. And they don't come for peanuts.

Remember, there's no free lunch.
So before you buy any personal computer, consider SoL. It costs more at the start but less in the end. It can grow with your ability to use it. SoL is not cheap. But it's not a delusion either.

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For more information contact your nearest dealer in the adjacent list. Or write Department B, Processor Technology, 7100 Johnson Industrial Drive, Pleasanton, CA 94566. Phone (415) 829-2600.

In sum, all small computers are not created equal and SoL users know it to their everlasting satisfaction.
In response to growing public interest in microcomputing during the past several years, a number of microcomputer kits have been marketed.

The Heathkit H8 microcomputer represents a departure from the S-100 bus design mainstream. It has the full instruction set capabilities of other 8080A systems as well as an innovative, user oriented front panel control subsystem and a 10 position mother board; yet it does not use the type of large power supply found in some larger systems.

It was the kind of design I was hoping for. I was seriously considering the purchase of a computer for some time, and prior to the introduction of the H8, I almost did buy one. But I had a hunch that the Heath Company might resolve some of the design drawbacks that discouraged me from buying other 8 bit kits.

What follows are my experiences, thus far, of building, testing, and running this computer kit. By the time you've finished reading this article you should have a good feel for what the H8 is, what it can do, and how it compares with other kits on the market. In addition, I'll give you a few pointers and short programs that will enable you to take advantage of some of the H8's many features.
the Heath H8 Computer

Unpacking and Building

My first few evenings with the H8 kit were leisurely spent getting acquainted with the materials and manuals. Opening the 22 lb carton, the first thing that caught my eyes was a loose slip of paper with a notice on it. It warned me to review all of the manuals supplied with the kit before putting anything together, and that if I found it to be too complicated for my knowledge and skill level, I could return it to the Heath Company for a full refund. I know of no other computer kit manufacturer who includes that kind of built-in consumer protection from the outset.

The next items were the sets of manuals and an attractive 3 ring binder to store them in. I had assembled Heathkits before and knew how thorough their documentation has always been; and I had seen some mediocre documentation provided by other companies in the computer kit industry. I found 503 pages worth of assembly and operating manuals which were far superior to any that I had seen on the market.

In all fairness, I don't feel that this point can be overemphasized. Building a microcomputer is not like building a stereo or piece of test equipment. The technology and associated hardware of a computer are unique in many ways. You may have assembled and tested electronic kits before, but unless you've also assembled digital equipment, you probably won't be an expert on this type of hardware. If you ever need to troubleshoot your computer kit, much of your previous knowledge about conventional analog electronics won't be of use. Therefore, it is important that you know what you are assembling and how to do so correctly. You don't have to be an electronics wizard to build and operate the H8. Your chances of building a computer kit that works the first time you turn on the power are nearly 100 percent with an H8, due in part to the support services that the manufacturer provides.

After the first few evenings of studying the manuals, I found a reasonably undisturbed space and, with tools in hand, began the first stage of assembly.

The Chassis

Chassis assembly consists of installing the power supply, frame, and several accessories, including a small cone speaker. The frame is made out of heavy sheet metal on the top, bottom and back panel, and structured foam on the sides. The bottom is covered with rows of small holes necessary for the H8's convection cooling system. The ample 10 A power supply is located

Continued on page 124
A Map of the TMS-9900
Instruction Space

Now that the TMS-9900 16 bit computer is being marketed to the computer experimenter, some easy way to handle its 63,480 individual op codes at a level of "hand assembly" is going to be necessary. The standard method of programming the 16 bit machine involves higher level languages, or at the very least, a good symbolic assembler. The op codes of an 8 bit machine are smaller in number and can be fairly easily memorized by a machine level programmer confined to the limited resources of hand assembly. But nearly every instruction on the TMS-9900 has to be constructed, calculated from the instruction's format, depending on the selected options of the moment. That is the essence of the machine's power, but it makes building and analyzing programs at a machine language level difficult. The charts in this article should help simplify the matter.

The first of the op code maps (figure 1) is an expansion of the first byte of a 16 bit instruction. The second map (figure 2) is a detail of the first rank of figure 1. Notice that the most significant digits of the op codes go down and the least significant digits go across the charts. Each block contains the mnemonic of the instruction, the format type of that instruction, and the number of variations (ie: the number of different instructions that the mnemonic represents).

For example, the instruction MOV, for MOVE WORD, has a source and a destination word address, with one of four addressing codes for each, referenced to one of the 16 registers in the workspace for each. That gives 16 times 4 times 16 times 4, or 4096 possible individual instructions. Let's take a specific example. Suppose you come across a C835 instruction in a hexadecimal program dump. You look up that code on the op code space map (figure 1 in this case). It lies in the block for instruction MOV, with an instruction format of 1. Comparing C835 with format 1 in table 1, you find that:

Base op code = 1100.
Address mode of destination = 10.
Destination operand register = 0000.
Address mode of source = 11.
Source operand register = 0101.

Since the destination is indexed, the word following the C835 is an address, and thus part of the instruction. The index register, however, is 0000 and the zero register isn't allowed for index mode. Thus the following address is the destination address without address modification. If it had been one of the other registers, the following word would have been added to the register value to form the indexed address. The addressing mode for the source is register 5, indirect and autoincremented. The source operand's address is in register 5. Once the operand is fetched, the address value in register 5 is incremented by 2 (since it was a word instruction and the 9900 addresses specify bytes). Thus the end result of the instruction is that this source operand is moved to the immediate address specified by the word following C835.

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**Figure 1:** General map of all TMS-9900 instructions. This map covers operation codes from 00XX to FFXX hexadecimal, with reference to the detail of table 2 for op codes from 00XX to 0FXX. In interpreting a machine dump in hexadecimal, the first step is to look up a 2 byte operation code in this table, or in figure 2.

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**Key**

- JLE — Mnemonic
- II — Tape
- 256 — Number of possible op codes

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Circle 384 on inquiry card.
Figure 2: For operation codes 00XX to 0FXX, the details of interpreting a hexadecimal dump can be further understood with the aid of this map. Once the format is determined, refer to table 1 for details of formats V, VI, VII and VIII.

|   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
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| 02 | LI VIII 16 | AI VIII 16 | ANDI VIII 16 | ORI VIII 16 | CI VIII 16 | STWP VIII 16 | STST VIII 16 | LWPI VIII 1 |
| 03 | LIMI VIII 1 | IDLE VII 1 | RSET VII 1 | RTWP VII 1 | CKON VII 1 | | |
| 04 | BLWP VI 64 | B VI 64 | X VI 64 | CLR VI 64 | |
| 05 | NEG VI 64 | INV VI 64 | INC VI 64 | INCT VI 64 | |
| 06 | DEC VI 64 | DECT VI 64 | BL VI 64 | SWPB VI 64 | |
| 07 | SETO VI 64 | ABS VI 64 | | Illegal op codes | |
| 08 | SRA V 256 |   |   |   |   |   |   |
| 09 | SRL V 256 |   |   |   |   |   |   |
| 0A | SLA V 256 |   |   |   |   |   |   |
| 0B | SRC V 256 |   |   |   |   |   |   |
| 0C |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 0D |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 0E |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 0F |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
Introducing The SwitchBoard™ I/O Interface, the most complete interface available for S-100 systems...designed by George Morrow exclusively for Thinker Toys™.

The SwitchBoard™ interface provides 4 parallel ports and 2 RS232/TTY serial ports. Plus, strobe and attention ports. Plus, on-board facilities for 4K of optional static RAM and 4K of user-supplied EPROM.

And every port is switch-programmable for total flexibility in interfacing complex peripherals...such as 12-bit daisywheel printers.

Each parallel port can be switched for input or latched output. Both serial ports can be switched to any of 16 baud rates from 110 to 19,200. Each strobe and attention port flip-flop can be switched for pos or neg pulsing.

And yet, The SwitchBoard™ Interface won't hang you up on price or delivery. In kit form, it's just $199. $259 assembled. 2114 4K static RAM option (4 MHz Z-80 compatible), $70.

Ask your local computer shop to place your order immediately for priority shipping. Or, if unavailable locally, order direct from Thinker Toys™, 1201 10th St., Berkeley, CA 94710.

Or call for The SwitchBoard™ at (415) 524-2101 weekdays, 10-5 Pacific Time.

*Sockets provided; chip set optional.

A product of Morrow's Microstuff for Thinker Toys™
Table 1: Instruction formats of the TMS-9900. This table details the fields of the TMS-9900 instructions and is used in decoding a machine dump once the instruction type has been determined from the two maps of tables 1 and 2.

<table>
<thead>
<tr>
<th>Type</th>
<th>Bit Number</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Op code B</td>
<td>4096</td>
</tr>
<tr>
<td>II</td>
<td>Op code D</td>
<td>256</td>
</tr>
<tr>
<td>III</td>
<td>Op code C</td>
<td>1024</td>
</tr>
<tr>
<td>IV</td>
<td>Op code Td</td>
<td>1024</td>
</tr>
<tr>
<td>V</td>
<td>Op code K</td>
<td>256</td>
</tr>
<tr>
<td>VI</td>
<td>Op code Ts</td>
<td>64</td>
</tr>
<tr>
<td>VII</td>
<td>Op code N</td>
<td>1</td>
</tr>
<tr>
<td>VIII</td>
<td>Op code W</td>
<td>1 or 16</td>
</tr>
<tr>
<td>IX</td>
<td>Op code D</td>
<td>1024</td>
</tr>
</tbody>
</table>

T — Byte or word operation (1-byte)
D — Destination operand register
S — Source operand register
W — Workspace register
Td — Address mode of destination operand
Ts — Address mode of source operand
C, K — Bit or shift count
N — Unused bits of the instruction. Set to zero.

Address Modes

<table>
<thead>
<tr>
<th>Td or Ts</th>
<th>Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>Workspace register</td>
</tr>
<tr>
<td>01</td>
<td>Workspace register indirect</td>
</tr>
<tr>
<td>10</td>
<td>Indexed memory</td>
</tr>
<tr>
<td>11</td>
<td>Workspace register indirect, autoincrement</td>
</tr>
</tbody>
</table>

Hexadecimal modifiers for the Td (format I) and Ts (formats I, III, IV, VI and IX) fields. To generate an operation code reflecting the given addressing mode, add the hexadecimal values listed in this table:

<table>
<thead>
<tr>
<th>Addressing Mode</th>
<th>Td</th>
<th>Ts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Workspace register</td>
<td>0000</td>
<td>0000</td>
</tr>
<tr>
<td>Workspace register indirect</td>
<td>0400</td>
<td>0010</td>
</tr>
<tr>
<td>Indexed memory (symbolic)</td>
<td>0800</td>
<td>0020</td>
</tr>
<tr>
<td>Workspace register indirect with autoincrement</td>
<td>0C00</td>
<td>0030</td>
</tr>
</tbody>
</table>

Shifted register or count values for D (formats I, III and IX), C (format IV) and K (format V) fields. In constructing operation codes for these formats, the modifiers for the register or count values indicated are added to the base op code from table 4:

<table>
<thead>
<tr>
<th>Register or Count</th>
<th>D (C)</th>
<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0000</td>
<td>0000</td>
</tr>
<tr>
<td>1</td>
<td>0040</td>
<td>0010</td>
</tr>
<tr>
<td>2</td>
<td>0080</td>
<td>0020</td>
</tr>
<tr>
<td>3</td>
<td>00C0</td>
<td>0030</td>
</tr>
<tr>
<td>4</td>
<td>0100</td>
<td>0040</td>
</tr>
<tr>
<td>5</td>
<td>0140</td>
<td>0050</td>
</tr>
<tr>
<td>6</td>
<td>0180</td>
<td>0060</td>
</tr>
<tr>
<td>7</td>
<td>01C0</td>
<td>0070</td>
</tr>
<tr>
<td>8</td>
<td>0200</td>
<td>0080</td>
</tr>
<tr>
<td>9</td>
<td>0240</td>
<td>0090</td>
</tr>
<tr>
<td>10</td>
<td>0280</td>
<td>00A0</td>
</tr>
<tr>
<td>11</td>
<td>02C0</td>
<td>00B0</td>
</tr>
<tr>
<td>12</td>
<td>0300</td>
<td>00C0</td>
</tr>
<tr>
<td>13</td>
<td>0340</td>
<td>00D0</td>
</tr>
<tr>
<td>14</td>
<td>0380</td>
<td>00E0</td>
</tr>
<tr>
<td>15</td>
<td>03C0</td>
<td>00F0</td>
</tr>
</tbody>
</table>
New from North Star
Double Density Performance at Single Density Prices

The new HORIZON computer and Micro Disk System now record in double density! That means each new Shugart SA-400 minifloppy disk drive accesses 180K bytes of on-line information. All double density HORIZON computers and Micro Disk Systems have a redesigned controller which allows the use of quadruple capacity disk drives as they become available in early 1979. A three-drive North Star System with quadruple capacity disk drives will access over a megabyte of on-line information. But, best of all there's no price increase for double density models.

North Star BASIC and DOS have been upgraded to accommodate the increased capacity and yet run existing programs with little or no change. The new disk system also supports single density, so existing single density diskettes can still be used. Single density SA-400 drives previously purchased with North Star systems can also be used.

Pricing
HORIZON with one double density SA-400 minifloppy (180K bytes), 16K RAM, Z80A processor and serial I/O port: $1599 kit, $1899 assembled.
MICRO DISK SYSTEM with one double density SA-400 minifloppy, controller board and power regulation: $699 kit, $799 assembled. (Cabinet and power supply $39 extra each.)

North Star Computers
2547 Ninth Street
Berkeley, California 94710
(415) 549-0858

Specifications:
S-100 compatible, MFM encoding, 35 tracks with ten 512-byte sectors per track. 179,200 bytes on double density SA-400 and North Star BASIC, DOS, and Monitor included.

For further information, write for full color catalog or contact your local computer store.
Table 2: Going the other way; this list of the complete TMS-9900 instruction set shows the format and semantics of each operation possible with the machine. The base operation code, in hexadecimal, is modified by arithmetic addition of appropriate codes for details of the instruction as shown in table 1. Thus for example, to generate the code for comparing bytes between two absolute memory addresses this table gives a base op code of 9000 with format I. For the destination address field, a modifier of 800 is added, and for the source address field a modifier of 020 is added, yielding a net instruction value of 9820 for comparing two bytes at arbitrary memory addresses. Information for this table is taken from appendix E of the January 1976 reissue of the T1 Model 990 Computer and TMS-9900 Microprocessor Assembly Language Programmer's Guide, document manual number 943441-9701, eliminating operations not applicable to the TMS-9900.
Controlling Your World
Staying on top means keeping things under control. And, when it comes to staying on top of your applications world, we've got a way for you to do it at low cost.
Whether your particular application is business, professional or scientific systems, you can stay right on top of it with the DYNABYTE DB8/2 microcomputer.

Designed For Value...
When we designed the DB8/2, we knew that it had to be a dependable performer in handling large quantities of information. So, every design decision was made with quality and dependability in mind. The DB8/2 is a first-class producer.
For example, it uses two quad density 5.25-inch disk drives with our exclusive Dual Density Disk Controller for up to 1.2 megabytes of formatted storage. That gives you more capacity than two single-density 8-inch drives which means a lower cost per kilobyte. The DYNABYTE DB8/2 is the first microcomputer to offer enough storage capacity on 5.25-inch disk drives to fully utilize CP/M,* the most widely accepted disk operating system.

We also supply and support BASIC, FORTRAN and COBOL programming languages. As for application packages, we include general ledger, accounts receivable, accounts payable, word processing and many other CP/M compatible programs.

...For Dependability
We've also built in reliability with edge connectors that meet military specifications and a regulated power supply built to U.L. standards. Your DB8/2 will be cool and dependable.
Before we ship it to you, we conduct factory test and burn-in programs to assure reliability of the entire integrated system.

...For You
You'll stay on top through our customer support too. The DB8/2 is completely modular to allow speedy support in the field; and our bonded inventory of all subsystem modules means we can deliver replacement subassemblies overnight to almost anywhere in the U.S.

There's More
The DB8/2 has a 4MHz Z-80 processing module with 10 internal timers, interrupt control, real time clock, one parallel and two RS232 or current loop serial ports with software selectable baud rates from 110 baud to 172800 baud. 32K of RAM, expandable to 64K without paging and up to 176K with paging; a 12-slot, fully-sOCKETed backplane; preregulated 30 amp power supply.

If you need more storage, our DB8/4 Disk System is the mass storage companion to our DB8/1 microcomputer and includes two 8-inch floppy disk drives in either single or double-sided configuration for up to 2 megabytes of mass storage. Like the DB8/2, the combination of the DB8/1 and DB8/4 features our Dual Density Disk Controller, CP/M, 32K of RAM expandable to 176K, 2 serial I/O Ports and 1 parallel I/O port.
All three systems are designed to help you stay on top.

For more information, call Rick Mehrlich at (415) 965-1010, or see your local computer dealer.

*CP/M is a trademark of Digital Research
1005 Elwell Ct., Palo Alto, CA 94303 (415) 965-1010

Circle 110 on inquiry card.
Why were all those
scientists of the ’30s so mad?

That’s easy. Because all they ever got was defective or missing parts, inferior workmanship, and garbled instructions. Sound familiar?

CCS: Here to Deliver

We’re California Computer Systems. We’ll deliver to you what old Doc ordered and never received. Kits without missing parts. Defect-free workmanship backed by years of solid experience. Quality engineering throughout. And easy-to-decipher support documentation.

Electronics mavericks will appreciate us. We intend to back the true computer hobbyist who wants to do his own S-100 system with everything from a bare metal box to etch and wire-wrap boards suitable for designing original circuits.

For All S-100, TRS-80* & Apple† Users

We can offer memories, I/Os and video products to S-100 users. And both TRS-80 and Apple enthusiasts are represented in our philosophy.

Remember our name—California Computer Systems—and look for our decal on display at a nearby computer store. It’s your sure sign of complete satisfaction.

For additional information about CCS or any of its fantastic products, just write:

California Computer Systems
309 Laurelwood Road, Unit 18
Santa Clara, CA 95050

So Nobody Goes Away Mad.

* TRS-80 is a registered trademark of Radio Shack, a Tandy Co.
† Apple is a registered trademark of Apple Computers, Inc.

Circle 37 on inquiry card.
# Race Car for the SR-52

Race Car is a game of skill written for the Texas Instruments SR-52 programmable calculator, in which the player maneuvers a car around a race track drawn on graph paper. The object of the game is to drive the car from the start to the finish line in the best possible time without leaving the track. The program calculates the coordinates of the car based on steering, throttle and brake information entered by the driver. Players can choose to go left, straight or right (relative to the driver's seat), and to accelerate, brake or cruise. Each time the player makes a move, 1 second of time elapses.

For each move, the program calculates the X and Y coordinates of the car’s new position and the elapsed time. The player simply plots the car’s position and makes the new move based on the present position. Using different colored pens, two or more players can race on the same track and compete for the best finishing time.

The program moves the coordinates of the car during the 1 second time interval based on a velocity vector constructed by the player’s decisions. Left and right steering increments are fixed at +15° and −15°, respectively. For example, if you go left, the velocity vector is rotated +15° from its present direction. The acceleration and deceleration constants are +1 division per second² and −1 division per second². If you wish to accelerate, the magnitude of the velocity vector is increased by one and the distance traveled during that move will be one division farther than the previous move. If you decide to cruise, the magnitude of the velocity vector remains constant and the distance traveled during that move will be the same as the previous move.

### Listing 1: The Race Car program, written for the SR-52.

<table>
<thead>
<tr>
<th>Loc</th>
<th>Keys</th>
<th>Commentary</th>
</tr>
</thead>
<tbody>
<tr>
<td>000</td>
<td>*LBL C STO 0 1</td>
<td>Store XX.YY.</td>
</tr>
<tr>
<td>005</td>
<td>INV *D, MS INV *D, MS *fix 0</td>
<td>Mask off YY and store XX.</td>
</tr>
<tr>
<td>011</td>
<td>*D, MS INV *fix</td>
<td></td>
</tr>
<tr>
<td>014</td>
<td>STO 0 3</td>
<td>Get XX.YY, mask off XX and store YY.</td>
</tr>
<tr>
<td>017</td>
<td>+ RCL 0 1 =</td>
<td>Store the starting angle.</td>
</tr>
<tr>
<td>023</td>
<td>x 1 0 0 =</td>
<td>Initialize X position.</td>
</tr>
<tr>
<td>028</td>
<td>STO 0 4 0 HLT</td>
<td>Initialize Y position.</td>
</tr>
<tr>
<td>033</td>
<td>*LBL *D STO 0 5</td>
<td>Initialize velocity angle.</td>
</tr>
<tr>
<td>038</td>
<td>0 INV *fix HLT</td>
<td>Set velocity magnitude and elapsed time = 0.</td>
</tr>
<tr>
<td>042</td>
<td>*LBL *E RCL 0 3</td>
<td></td>
</tr>
<tr>
<td>047</td>
<td>STO 0 6</td>
<td></td>
</tr>
<tr>
<td>050</td>
<td>RCL 0 4 STO 0 7</td>
<td></td>
</tr>
<tr>
<td>056</td>
<td>RCL 0 5 STO 0 8</td>
<td></td>
</tr>
<tr>
<td>062</td>
<td>0 STO 0 9</td>
<td></td>
</tr>
<tr>
<td>066</td>
<td>STO 1 0</td>
<td></td>
</tr>
<tr>
<td>069</td>
<td>GTO *A</td>
<td></td>
</tr>
<tr>
<td>071</td>
<td>*LBL A 1 5</td>
<td>Increment velocity angle</td>
</tr>
</tbody>
</table>
"If this M-XVI from CCS had been available in the '30s, I would have had the secret of invisibility wrapped up in half the time."

The Invisible Man

The place was alive with "mad doctors" 40 years ago. For good reasons. They couldn't get what they wanted. Labs were piled high with incomplete kits, defective gear, and undecipherable support documentation.

All that's history now that California Computer Systems has arrived on the computer hobbyist scene. We'll see that no electronics maverick goes away mad.

Three proofs positive: our new M-XVI Static RAM Module for S-100 bus systems...our new PT-1 Wire-Wrap Board...and our new SolderTail Prototyping Board. The M-XVI features include: fully static design, use of popular 2114 static RAMs, ability to meet IEEE proposed S-100 signal standards, full buffering, addressability in 4K blocks, and bank select by bank port and bank byte. The PT-1 Wire-Wrap Board has all S-100 signals specified and provisions for four regulators. The SolderTail Board has all S-100 signals labelled, provisions for four regulators, and can accept 16-24-and-40 pin spacing.

Take a tip from the Invisible Man. He's quit derailing trains, robbing banks, and scaring helpless damsels since CCS gave him what he wants. If you're looking for satisfaction, too, check out our new product line today at your nearby computer store.
### Listing 1, continued:

<table>
<thead>
<tr>
<th>Loc</th>
<th>Keys</th>
<th>Commentary</th>
</tr>
</thead>
<tbody>
<tr>
<td>075</td>
<td>SUM 0 8</td>
<td>by 15 degrees for left turn.</td>
</tr>
<tr>
<td>078</td>
<td>0 INV *fix HLT</td>
<td></td>
</tr>
<tr>
<td>082</td>
<td>*LBL B 1 5 INV</td>
<td>Decrement velocity angle by 15 degrees for right turn.</td>
</tr>
<tr>
<td>087</td>
<td>SUM 0 8</td>
<td>Increment velocity magnitude by 1 for acceleration.</td>
</tr>
<tr>
<td>090</td>
<td>0 INV *fix HLT</td>
<td>Decrement velocity magnitude by 1 for brake.</td>
</tr>
<tr>
<td>094</td>
<td>*LBL D</td>
<td>Increment elapsed time.</td>
</tr>
<tr>
<td>096</td>
<td>(0) (8) (HLTD CINV) (8)</td>
<td>Convert velocity vector to rectangular coordinates.</td>
</tr>
<tr>
<td>102</td>
<td>*LBL E</td>
<td>Readjust X and Y coordinates.</td>
</tr>
<tr>
<td>104</td>
<td>(1) INV SUM 0 9</td>
<td></td>
</tr>
<tr>
<td>109</td>
<td>*LBL C 1 SUM .1 0</td>
<td></td>
</tr>
<tr>
<td>115</td>
<td>RCL 0 9 STO 0 0</td>
<td></td>
</tr>
<tr>
<td>121</td>
<td>RCL 0 8 *P/R</td>
<td></td>
</tr>
<tr>
<td>125</td>
<td>SUM 0 7 RCL 0 0</td>
<td></td>
</tr>
<tr>
<td>131</td>
<td>SUM 0 6</td>
<td></td>
</tr>
<tr>
<td>134</td>
<td>*LBL &quot;A&quot; RCL 0 7</td>
<td>Convert Y coordinate to integer value.</td>
</tr>
<tr>
<td>139</td>
<td>SBR &quot;1&quot; STO 1 1</td>
<td>Convert X coordinate to integer value.</td>
</tr>
<tr>
<td>144</td>
<td>RCL 0 6</td>
<td></td>
</tr>
<tr>
<td>147</td>
<td>SBR &quot;1&quot;</td>
<td></td>
</tr>
<tr>
<td>149</td>
<td>+ . 0 .1 x</td>
<td>Combine X and Y coordinate and display result.</td>
</tr>
<tr>
<td>154</td>
<td>RCL 1 1 + .</td>
<td></td>
</tr>
<tr>
<td>159</td>
<td>0 0 0 0 0 1</td>
<td></td>
</tr>
<tr>
<td>164</td>
<td>x RCL 1 0 . =</td>
<td>Display magnitude of velocity vector.</td>
</tr>
<tr>
<td>169</td>
<td>*fix 5 HLT</td>
<td>Subroutine to convert real number to integer form.</td>
</tr>
<tr>
<td>172</td>
<td>*LBL &quot;B&quot; RCL 0 9 . =</td>
<td>Mask off fractional part of real number to convert to integer.</td>
</tr>
<tr>
<td>178</td>
<td>INV *fix HLT</td>
<td></td>
</tr>
<tr>
<td>181</td>
<td>*LBL &quot;1&quot; STO 0 1</td>
<td>If fractional part of real number is greater than 0.5, then add 1 to integer value.</td>
</tr>
<tr>
<td>186</td>
<td>INV *D.MS INV *D.MS</td>
<td></td>
</tr>
<tr>
<td>190</td>
<td>*fix 0 *D.MS</td>
<td></td>
</tr>
<tr>
<td>193</td>
<td>INV *fix STO 0 2</td>
<td></td>
</tr>
<tr>
<td>198</td>
<td>+/- + RCL 0 1</td>
<td></td>
</tr>
<tr>
<td>203</td>
<td>=</td>
<td></td>
</tr>
<tr>
<td>204</td>
<td>- . 5 = *ifpos &quot;2&quot;</td>
<td></td>
</tr>
<tr>
<td>210</td>
<td>RCL 0 2 * rtn</td>
<td></td>
</tr>
<tr>
<td>214</td>
<td>*LBL &quot;2&quot; RCL 0 2</td>
<td></td>
</tr>
<tr>
<td>219</td>
<td>+ 1 = *rtn</td>
<td></td>
</tr>
</tbody>
</table>

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ALTOS presents a new standard in quality and reliability

WE'RE ALTOS COMPUTER SYSTEMS. Our SUN-SERIES ACS8000 business/scientific computer creates a new standard in quality and reliability in high technology computers.

HIGH TECHNOLOGY  The ACS8000 is a single board, Z80® disk-based computer. It utilizes the ultra-reliable Shugart family of 8 inch, IBM compatible, disk drives. A choice of drives is available: single or double density, single or double sided. Select the disk capacity you need, when you need it: ½M, 1M, 2M, or 4M bytes. The ACS8000 features the ultimate in high technology hardware: a fast 4 MHz Z80 CPU, 64 kilobytes of 16K dynamic RAM, 1 kilobyte of 2708 EPROM, an AMD 9511 floating point processor, a Western Digital floppy disk controller, a Z80 direct memory access, Z80 Parallel and Serial I/O (two serial RS232 ports, 1 parallel port), and a Z80 CTC Programmable Counter/Timer (real time clock). In essence, the best in integrated circuit technology.

BUILT-IN RELIABILITY  The ACS8000 is a true single board computer. This makes it inherently reliable and maintainable. The board and the two Shugart drives are easily accessible and can be removed in less than five minutes. All electronics are socketed for quick replacement. Altos provides complete diagnostic utility software for drives and memory.

QUALITY SOFTWARE  Unlimited versatility. The ACS 8000 supports the widely accepted CP/M®** disk operating system and FOUR high level languages: BASIC, COBOL, PASCAL and FORTRAN IV. All available NOW.

PRICE  ACS 8000-1, single density, single-sided [½ Mb] $3,840
ACS 8000-2, double density, single-sided [1 Mb] $4,500
ACS 8000-3, single density, double-sided [1 Mb] $4,800
ACS 8000-4, double density, double-sided [2 Mb] $5,300

Brackets show disk capacity per standard two drive system. All models come standard with 32 Kb RAM and two 8" disk drives as shown above. Expansion to 64 Kb is $363 per 16 Kb. FPP, DMA, software optional. Dealer/OEM discounts available. Delivery: 30 days ARO, all models.

*Z80 is a trademark of Zilog, Inc.
**CP/M is a trademark of Digital Research, Inc.

Circle 6 on inquiry card.
Remember that you are steering the race car as if you were sitting in the driver’s seat, so don’t confuse your left and right directions. The degree of difficulty can also be set in the layout of the race track. Hairpin turns and straightaways will test your skill and make the game exciting. I’ve had hours of fun racing with my friends and family; I hope you will, too.

User Accessible Labels:

<table>
<thead>
<tr>
<th>Label</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Left</td>
</tr>
<tr>
<td>B</td>
<td>Right</td>
</tr>
<tr>
<td>C</td>
<td>Cruise</td>
</tr>
<tr>
<td>D</td>
<td>Accelerate</td>
</tr>
<tr>
<td>E</td>
<td>Brake</td>
</tr>
<tr>
<td>A'</td>
<td>X.YT</td>
</tr>
<tr>
<td>B'</td>
<td>Vel</td>
</tr>
<tr>
<td>C'</td>
<td>X.Y Start</td>
</tr>
<tr>
<td>D'</td>
<td>0 Start</td>
</tr>
<tr>
<td>E'</td>
<td>Init</td>
</tr>
</tbody>
</table>

Register Utilization:

<table>
<thead>
<tr>
<th>Register</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>P/R conversion</td>
</tr>
<tr>
<td>01</td>
<td>Work area</td>
</tr>
<tr>
<td>02</td>
<td>Work area</td>
</tr>
<tr>
<td>03</td>
<td>Initial X coordinate</td>
</tr>
<tr>
<td>04</td>
<td>Initial Y coordinate</td>
</tr>
<tr>
<td>05</td>
<td>Initial velocity angle</td>
</tr>
<tr>
<td>06</td>
<td>X coordinate</td>
</tr>
<tr>
<td>07</td>
<td>Y coordinate</td>
</tr>
<tr>
<td>08</td>
<td>Angle of velocity vector</td>
</tr>
<tr>
<td>09</td>
<td>Magnitude of velocity vector</td>
</tr>
<tr>
<td>10</td>
<td>Elapsed time</td>
</tr>
<tr>
<td>11</td>
<td>Work area</td>
</tr>
<tr>
<td>12</td>
<td>Work area</td>
</tr>
</tbody>
</table>

Figure 1: A typical route for one player in the game of Race Car, written for the Texas Instruments SR-52 programmable calculator. Players must stay within the bounds of the track (which is arbitrarily drawn on graph paper) or risk disqualification. Increments of change to acceleration and steering are deliberately restricted in order to make the game more challenging, but players have free choices within these limitations.

Race Car Operating Instructions

1. Draw the race track on a suitable piece of graph paper, preferably ten divisions to the inch. Figure 1 shows an example of a typical race track. The race track must be located in the area bound by the lines X=0, X=100, Y=0 and Y=100. It is a good idea to leave space between the edge of the race track and the boundaries, since the car might leave the track. Select the combination start and finish line on the track and the initial direction of the car.
2. Enter sides A and B of the program.
3. Set the D/R switch to D.
4. Enter the starting coordinates of the car in the form XX.YY, where XX is the initial X coordinate and YY is the initial Y coordinate. Both numbers must be positive integers between 0 and 100. Press "C".
5. Enter the initial direction of the car. This is a positive angle in degrees measured from the positive X axis to the initial direction of the car. This angle should equal n x 15°, where n = 0, 1, 2, 3, …, 23. Press "D".
6. Press "E" to initialize the game. The initial X and Y coordinates will be displayed in the form XX.YY000.
7. Select the direction in which you will steer the car.
8. Press A to steer left. Zero will be displayed.
9. Press B to steer right. Zero will be displayed.
10. If you want to go straight, skip this step and proceed to step 8.
11. Select the throttle and brake conditions.
12. Press C to cruise.
13. Press D to accelerate.
14. Press E to brake.
15. The position of the car and the elapsed time will be displayed in the form XX.YYTTT, where:
   
   XX = X coordinate of the car.
   YY = Y coordinate of the car.
   TTT = Elapsed time in seconds.
16. Repeat steps 7 and 8 for each move. If the car should leave the track, the player is disqualified. Once the car passes the finish line, the winning time is read from the display.
17. To display the magnitude of the velocity vector, press "B". To return the display back to XX.YYTTT, press "A".
18. To play a new game on the same race track, press "E".

Refer to page 10 of the Operating Instructions.
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Files on Parade

Part 2: Using Files

File Management

In part 1 we discussed the concept of the file. In part 2 we conclude with some practical techniques for using files.

Getting a list of the files on your system is a task you probably perform often. Table 6 is a sample directory (which also appeared in part 1 as Table 4a). Notice the command string used to produce the table just above the directory itself. In Table 6 the first asterisk is the prompt, the computer's signal to enter a command. The letter Q is the Query command, used to produce file directories. The next asterisk is a wild card name instead of the file name: it means "give me (a list of) all the files on this device." Finally there is a software switch, /1, specifying floppy disk drive number 1.

Depending on the operating system, wild card characters can also be used. The PerSci controller, for example, allows a command string like:

Q [Q] FIL???.MPK/1

which means:

List [Q] all files on drive number 1 whose extension (version) is MPK, and whose file name begins with the letters FIL, regardless of what the next few letters are.

This article was produced on a text editor and for convenience the different parts were given different file names: FILFIG.MPK held the list of figures; FILCAP.MPK held the figure captions; FILAR1, FILAR2, etc., held text proper. The extension .MPK identified the files as belonging to me. Thus the command string above would produce a directory listing of all files holding parts of this article.

Using Defaults

If parts of a command string are omitted the operating system automatically inserts a proper type of specification chosen from a preprogrammed list. This preprogrammed list is called the system default specification or just defaults. If the /1 is left off the microcomputer command string in Table 6, that system would automatically search for the files on floppy disk drive 0, which happened to be the default device when the directory was made.

Defaults are used as a convenience not just in specifying file devices but also in file names. Large and small timesharing systems usually assign to each user some identifying code number, referred to by terms like account number, user ID, or programmer number. This number is incorporated into the file name, to associate a particular file with a particular user. A common system default lets a user omit this part of the file specification when the user is referencing his or her own files.

Another useful and common kind of default provides extensions to the file name according to the program that produced the file. For example, data files created in Multiuser BASIC have a default extension beginning with .D. Other data files might have an extension .DAT; FORTRAN files could have default extensions .FOR; input files for a macroassembler could be expected to have the extension .MAC; and that assembler might produce binary object files with a default extension of .OBJ.

File Names

T S Eliot understood the complexities of a similar subject when he wrote, in Old Possum's Book of Practical Cats, that:

"The Naming of Cats is a difficult matter.

It isn't just one of your holiday games;"
You may think at first I'm as mad as a hatter
When I tell you, a cat must have THREE DIFFERENT NAMES."

As it is with cats, so it is with files. First, it's good to give a file a family (or group) name. The extension is one place for this, and some of the default extensions make good group names. Properly chosen extensions or family names will allow the use of wild card file names and thus greatly accelerates getting directories of groups of files.

Old Possum can help with the other two names. "First of all," he says, "there's the name that the family use daily." These should be "sensible, everyday names" such as Spacewar, Mastermind, Payroll, Heatplan or Help. They can be plain or fancy, but they must be descriptive. Often these everyday names actually refer to a system of programs, perhaps linked together. The user may not even be aware of this linkage and might refer to this system of programs by its everyday name. "Run the Help program" one user might advise another, without considering or needing to consider that this is really a collection of programs, subprograms and data files.

Finally, a file:

"... needs a name that's particular,
A name that's peculiar, and more dignified. . . ."

If each file on a device does not have a unique name there will be serious problems. Further, computer operating systems put stringent restrictions on file names, restrictions necessary if the operating system is to efficiently handle requests dealing with files. A common restriction is the one on the number of characters in a file name. In

<table>
<thead>
<tr>
<th>Position</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>FILE</td>
<td></td>
</tr>
<tr>
<td>NAME</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>determines access for all users in same group</td>
</tr>
<tr>
<td>2</td>
<td>determines access for all other users</td>
</tr>
<tr>
<td>3 thru 6</td>
<td>no special significance</td>
</tr>
<tr>
<td>*</td>
<td>separates name and extension</td>
</tr>
<tr>
<td>EXTENSION</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>B -&gt; BASIC program; D -&gt; data file</td>
</tr>
<tr>
<td>8</td>
<td>group identifier</td>
</tr>
<tr>
<td>9</td>
<td>positions 8 and 9 together form the user's ID</td>
</tr>
</tbody>
</table>

You may think at first I'm as mad as a hatter
When I tell you, a cat must have THREE DIFFERENT NAMES."

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If each file on a device does not have a unique name there will be serious problems. Further, computer operating systems put stringent restrictions on file names, restrictions necessary if the operating system is to efficiently handle requests dealing with files. A common restriction is the one on the number of characters in a file name. In TDL's 8 K BASIC, names must be one character. DEC's RT-11 permits six characters, the PerSci controller allows eight, and the latter two provide for additional extensions. Thus keeping the name particular and peculiar requires some thought.

File Protection Systems

Another consideration in choosing a particular and peculiar file name is how it fits into the local file security system. As soon as more than one person begins using a computer system there should be some way of controlling access to files. A simple way is to have users keep their files on their own cassettes or disks. But when user A creates a splendid new program and user B borrows A's cassette to copy the program, problems begin.

It is painful to remember how many times I thought the file I wanted to erase was on drive 0, and the good version was on drive 1.

Physically controlling your media gives good file security, but we often loan out our tapes and disks. Write protecting the media or device helps also, but is often impossible, inconvenient or overlooked. Carefully chosen file names are a further protection. There are several degrees of file access which can be controlled in part on many systems by the file name. These degrees of access might be:

<table>
<thead>
<tr>
<th>Character</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>read, run and update (only useful for virtual arrays)</td>
</tr>
<tr>
<td>7</td>
<td>read and run</td>
</tr>
<tr>
<td>8</td>
<td>run only</td>
</tr>
<tr>
<td>9</td>
<td>run only, but allows program to perform any privileged file operation</td>
</tr>
<tr>
<td>any other character</td>
<td>for group library file, your group, or a public library file: read and run</td>
</tr>
<tr>
<td></td>
<td>— any other file: no access</td>
</tr>
</tbody>
</table>

Table 7: A multiuser file protection system. Table 7a summarizes the significance of position in the file name. If position 9 is blank, it is assumed to be a group library file. If positions 8 and 9 are blank, a public library file is assumed. Table 7b shows the characters in file names that affect file access when they are used in positions 1 and 2. The number 8 causes the user's storage area to be erased when the program terminates.
choose names in Multiuser BASIC to control user access. When working with several files at once, on different devices or media, it is good practice to use procedures similar to those in table 7, and to make sure your file names are uniquely chosen. Mastermind might now have to be called 7MASTR.BAS, but it will still be there tomorrow after others finish using it today.

So choose your file names well. Many times I have seen a programmer who has created a file and is about to name it. He sits in front of his terminal:

"... in profound meditation,
The reason, I tell you, is always the same:
His mind is engaged in a rapt contemplation
Of the thought, of the thought, of the thought of his name:
His ineffable effable
Effaninnifiable
Deep and inscrutable singular Name."


Manipulating Files

There are many file operations besides the assembling of directories that are performed at the command level. Most of these operations fit into the general framework of moving a file from one place (device, library, etc) to another. The transfer can be represented symbolically as:

DESTINATION: FILENAME.
EXTENSION ←SOURCE: FILENAME.
EXTENSION.

Copying a file from one floppy disk to another, listing a file on a terminal, and moving a file from cassette to primary memory are examples of file transfer. The specific commands vary greatly from system to system, and even within a system, from one language or utility tool to another. Table 8 illustrates a small selection of these commands.

Deleting a file is also a kind of file transfer; the file is moved to "nowhere." On a directory device, the directory reference to the deleted file is usually removed; the file itself is probably still on the medium and can often be recovered if its absolute location is known.

Another file transfer operation, the media pack, eliminates gaps on disks and tape due to deleted files, and packs together the remaining files to make room for more. A disk can usually be packed without the use of a second disk drive, but cassettes often require repacking on another medium.

Finally, renaming a file can be thought of as a file transfer within the symbolic format above. The destination and source do not change, but the file name and extension do. Table 9 compares typical minicomputer and microcomputer pack, delete and rename operations.

<table>
<thead>
<tr>
<th>Computer</th>
<th>Operation</th>
<th>Microcomputer (PerSci DOS)</th>
<th>Minicomputer (DEC RT-11, PIP)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FILE DELETION</td>
<td>D BAGELS.MPK/1 (delete BAGELS.MPK from floppy drive #1)</td>
<td>CT1: *.MPK/D (delete all files with extension .MPK from cassette drive #1)</td>
</tr>
<tr>
<td></td>
<td>DIRECTORY SQUISH</td>
<td>G /1 (&quot;Gap&quot; drive 1)</td>
<td>SY:/S (Squish the system disk)</td>
</tr>
<tr>
<td></td>
<td>RENAME</td>
<td>N BAGELS.B 9BAGELS.B</td>
<td>BAGELS.B=9BAGELS.B/R (rename 9BAGELS)</td>
</tr>
</tbody>
</table>

Table 9: Comparison of some microcomputer and minicomputer file housekeeping functions. DEC uses the term squish rather than pack.
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File Control

In addition to the file manipulations previously described, there are several kinds of file control statements designed to be part of an application program. Instead of a file handling operation happening in response to a command from the keyboard, using perhaps the monitor system or operating system commands, this second kind of file control happens in response to a program statement. Again, the specific format varies from language to language; unfortunately it also seems to vary within a language like BASIC from manufacturer to manufacturer. However, the functions performed in response to these statements are fairly standard. Table 10 is a summary of these functions, with examples from BASIC.

Assigning a unique channel, or data path, to each active file is one way for the operating system to allow simultaneous (or at least parallel) access to several files. Obviously this is necessary in a timesharing system, but it is also convenient for a single user reading text from one file, editing it, and then writing it into an output file. In the first example in table 10, the file 9VISR0 is assigned to channel number 2. (The maximum number of channels will depend on the system configuration.)

The file status can be open or closed. Here again the requirements vary from system to system, and within systems according to file access types. The PerSci disk operating system, for example, allows stream access regardless of file status. But stream access usually happens at command level. Refer to table 10.

Table 10: Types of program file control statements. The line numbers used in the examples are to emphasize that these are statements within a program.

<table>
<thead>
<tr>
<th>Function</th>
<th>Multiuser BASIC Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>assign a status;</td>
<td>10 OPEN &quot;9VISR0, BS3&quot; FOR OUT-</td>
</tr>
<tr>
<td>assign a mode;</td>
<td>PUT AS FILE #2</td>
</tr>
<tr>
<td>assign a channel</td>
<td></td>
</tr>
<tr>
<td>write on a file</td>
<td>20 PRINT #2: L$</td>
</tr>
<tr>
<td>read information from a file</td>
<td>30 INPUT #2: A, B1, T3</td>
</tr>
<tr>
<td>test for end of file</td>
<td>40 IF END #2 THEN 100</td>
</tr>
<tr>
<td>move data pointer within the file</td>
<td>50 RESTORE #2</td>
</tr>
<tr>
<td>make the file permanent; deassign the channel; change the file status</td>
<td>60 CLOSE #2</td>
</tr>
</tbody>
</table>

File access, used for data base applications, requires a file status of open to store or retrieve file data.

The file mode requirements (input or output) depend on access type too. For this function, though, the distinction is clearer. Once random access files are open, the mode does not usually need to be specified because individual bytes can be changed without touching other parts of the file. However sequential files must be updated as a unit, and therefore a sequential file must generally be set into either input or output (read or write) mode. Remember that input and output refer to the direction of information flow relative to the processor, and not to the storage medium: information comes into the processor from the disk; information goes out of the processor to the disk.

Testing for the end of a file and moving a data pointer within a file are operations characteristic of sequential access files. A random access file has a fixed length, so presumably one knows where the end of it is. Similarly, since individual bytes of a random access file are directly addressable, it is unnecessary to move a data pointer. In practice these functions are performed by program logic statements.

Some kinds of files are more rugged than others; they stand up better to programmer or user abuse. Aborting an information transfer to a sequential file in the midst of the transfer can cause the loss of the whole file, for example. The close command, for both access types, puts a lock on the file door and frees up a data channel, too. Other BASIC program statements (such as CHAIN, END) will often do the same thing. Good programming practice is to do it explicitly, with statements such as CLOSE.

Explicit file initialization is also good practice. Random access files, occupying a specific part of a disk, could contain information left on the disk by a previous program. (Recall that file deletion usually means that the directory entry, not the file itself, is deleted.) At the other end of the line, it is wise to erase a file containing sensitive information when its usefulness is over. These operations can all be done with file control statements in programs.

Programming Techniques Using Files

Whole articles, even whole books, are written to discuss file programming techniques. This final section is not meant to be that comprehensive. Rather, it is a quick dip into the programmer's bag of tricks—a look at some of the methods used to deal with the limitations of smaller systems. The em-
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Circle 342 on inquiry card.

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phrases are on techniques available in versions of BASIC that support named files which can be called from secondary memory devices such as cassettes or floppy disks.

**Shortening Program Size**

For student programmers at Sanborn Regional High School, where I teach, and especially for students with grandiose plans and unprivileged user numbers, the most frustrating error message is PTB, which means the program is too big. There are three file related approaches to this problem that we urge on the students—approaches that fit into our push for modular program design.

First, for programs that have a linear logical flow, we encourage breaking the program into small segments that can be connected by CHAIN statements. A CHAIN statement such as

110 CHAIN "WUMPS2.BAS"

erases the program currently in memory (perhaps called WUMPSUS.BAS), and replaces it with the program file WUMPS2.BAS. Variables whose values are needed in the second, or chained-to, segment, can be declared in a COMMON statement in the first segment. A typical usage of the CHAIN statement is to segment some long game. The first segment might request information from the user: "Do you want instructions?" If yes, instructions are given; if no, there is a branch directly to the end of segment 1. In either case, the logical flow reaches the end of the first segment, where there is a CHAIN statement to a program file that contains the code for the main body of the game.

A second method works well for application programs that give the user a choice of options. This method puts the menu of choices in one program file and each of the various options, or "meals," in separate program files. Listing 2 shows the code for a typical option menu. The menu code and the meals files could be connected by CHAIN statements or by OVERLAY statements.

The OVERLAY statement calls a named program file from secondary memory and "lays it on top of" the program currently in memory. Suppose the original program has a line 100. After the OVERLAY statement in the original program is executed, line 100 in memory will be the one from the overlay file. A line with a number either in the original program or in the overlay file, but not in both, will always be in memory after the overlay.

For the multiple branch logical flow characteristic of the menu and meal method, the decision to use CHAIN or OVERLAY to connect the program files usually depends on how much logic and code can be shared by the various meals. If several of the options utilize the same set of subroutines, or if the options access the same set of data files, it makes sense to use overlay files. Then, in lines that will not be overlaid, the original program can hold the shared subroutines or statements opening and closing the shared data files. If the meals are quite disjoint, and there is little need to pass information back and forth, chaining the segments will increase the modularity of the code.

In either case the goals are to keep the modules small and the interface between them independent of the module used. Smaller segments fit into more machines and are easier to understand. The interface should allow adding options or replacing an option with an improved version without having to modify all of the other options. This plug-in quality facilitates writing code that is easy to change and easy to use.

**Data Files**

The third technique for using files to achieve modular program design is to separate the data from the program operating on it. An example is the payroll program mentioned in part 1. Another application is to the tutorial, drill and practice, and testing programs used in computer assisted instruction. A common type of program in this group is one that gives a multiple choice quiz. Variety can be added by putting a large bank of questions and accompanying choices in a data file. The main program can then pick five or ten numbers randomly and call...

---

**Listing 2: BASIC code for an option choice menu. When the option is chosen, the required code is chained into main memory by line 300.**

```
100 PRINT 'TYPE THE LETTER CORRESPONDING TO YOUR CLASS:'
110 PRINT 'A--PRACTICAL BIOLOGY, PER. A'
120 PRINT 'B--PRACTICAL BIOLOGY, PER. B'
130 PRINT 'C--BISCI'
160 PRINT 'E--PRACTICAL BIOLOGY, PER. E'
170 PRINT 'CLASS': INPUT $'
200 PRINT 'THE NUMBER OF THE OPTION YOU NEED:'
210 PRINT '1--ENTER SCORES FOR WHOLE CLASS'
220 PRINT '2--ENTER SCORES FOR SOME STUDENTS'
230 PRINT '3--LIST STUDENTS WHO HAVE COMPLETED A GIVEN ITEM'
240 PRINT '4--LIST STUDENTS WHO HAVEN'T COMPLETED A GIVEN ITEM'
250 PRINT '5--DISPLAY SCORES PROFILE FOR AN INDIVIDUAL STUDENT'
260 PRINT '6--DISPLAY PROFILE FOR A SELECTED GROUP OF STUDENTS'
270 PRINT '7--DISPLAY CUMULATIVE TOTALS FOR ALL STUDENTS'
280 PRINT '8--LIST OR MODIFY STUDENT NAMES OR ITEM HEADERS'
290 PRINT '9--CREATE BACKUP FILES'
300 F$='9VISRO.B8'+SS $ CHAIN F$
```
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A TRS-80® compatible Megabox plugs directly into the TRS-80. This version of Megabox includes provision to add up to 32K of RAM to your TRS-80 system, so you can have up to 4 Megabytes of disk storage and 48K of RAM without an expansion interface. This Megabox brings big system performance to your system at one-third the cost per byte of mini-floppy systems.

Our SOL®-version of the Megabox installs without modification, and the software is ready to go. Micromation's double density recording gives you nearly twice the storage of the Helios® at a substantially lower price—and most importantly, you can run CP/M® so you have access to the broadest range of software available in microcomputing.

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Our DOUBLER double density floppy disk controller features true double density recording with a capacity of 512K bytes on each side of the diskette. Doubler systems are easy to install and use. A hardware UART is included on the controller to provide instant system communications. The controller can do a power-on-jump to the on-board PROM bootstraps. And its fast and reliable because the board's hardware includes a phase-lock oscillator and CRC error detection circuitry.

Micromation disk systems are designed to run CP/M® the industry standard operating system. You can choose higher level languages such as MBASIC, CBASIC, FORTRAN, COBOL, or PASCAL. And there's a wide selection of business application packages to choose from.

Megabox systems open new opportunities for owners of today's most popular microcomputers. They feature the highest available capacity, performance, and reliability. And they are compatible with your system. But best of all, at $2295 a Megabox is priced for value. Ask for details at your local computer store or contact Micromation, 1620 Montgomery St., San Francisco, CA 94111 or phone (415) 398-0289.

The Megabox with 1,000,000 existing software to easily keep a

Circle 223 on inquiry card.
storage on files, an ideal arrangement for a data base.

Files as Buffers

Finally, one more data file technique deserves mention: using files as buffers, as temporary collection boxes for string or numeric information. The names of the elements for the chemistry tutorial and the text for a Help program are examples of data stored in files on a relatively permanent basis. In contrast to this kind of use, files can provide transient storage for data. They might be used as extra workspace for calculations or manipulations like sorts or holding intermediate results.

Perhaps the chemistry tutorial program creates three problems for the student to do at home using random numbers. A file could contain the answers to those problems, to be accessed once the next day when the student checks his or her answers against those in the file. The answers would then be erased.

The list of books or equipment loaned to friends can be placed in the buffer file of a home information program, with items removed from the file as they are returned. Buffer files can also be used to hold messages taken by a computer interfaced to an automatic answer phone modem, or by a computerized suggestion box (a gripe file), or to hold mail in a computer conference.

Sometime there will be a secondary program to examine, modify, and erase these buffer files. At our high school, for instance, a secondary program reads the gripe file and removes meaningless or obscene comments before the file is posted on the bulletin board.

A Qualification

This article, an introductory tutorial, has skimmed the surface of the concept of files. The richness of file structures and the power of the many techniques have led to varied implementations, only a few of which are illustrated here. Readers are urged to study the manuals for the systems they use both to learn the capabilities of those systems and to find the exact syntax for the techniques described in this article. With respect to file structures and types, microcomputer systems in particular are closer to the Tower of Babel end of the spectrum than they are to any monolithic standard. Now is the time to write about files, to learn about files and to build file systems.

---

**TRS-80**, Sol*, Sorcerer.**

Byte storage capacity can be operated with general ledger, accounts receivable, and payable.
Your Own Computer

by Mitchell Waite and Michael Pardee
Howard Sams Co Inc
Indianapolis IN, 1977
80 pages
$1.95

The last three books I read were Passages, Star Wars and Your Own Computer. You see, in between the second and third books a rather futuristic friend loaned me a copy of BYTE, saying, "You won't believe this!"

I didn't. A computer in every home? In department stores? Right now? Being a writer with a science fiction orientation, I was shocked and simultaneously exalted to find that companies were already selling all kinds of low cost home computers, and that perhaps I could buy and use one.

After devouring BYTE in less than two hours, I called my friend and asked him if he knew of any books that explained these personal computers in simple terms, something a nontechnical person like me could understand.

Two days later I went to the local computer store and picked up a copy of Your Own Computer, a book that has completely changed my viewpoint about the future of technology. I thanked the universe for being so kind, told my friend, "May the force be with you," and hid myself away for the next day to learn what this home computer thing was all about.

In the preface, the authors informed me that the invention of the personal computer is the most historic event since the automobile, television and transistor combined. This book was designed to remove the stigma of complexity and mystery that surrounds computers, and would probably be my first investment on the road to acquiring my own computer. That made me rather suspicious from the start. How do they know I'll like computers? I might hate them, but I'll admit I was interested.

Chapter 1 was quite interesting. Called "Introduction," it defined what computers
BEFORE YOU BUY COMPUTER #1, VISIT #1 COMPUTERLAND

If the truth is that you want a computer...then we want to be your computer store.

We’re ComputerLand, the #1 computer store chain in the U.S. What’s meaningful about that fact is, that ComputerLand has been chosen by more people as having what they’ve been looking for. And, since you’re looking, let us tell you what you’ll find, when you visit a ComputerLand store.

You’ll find a product line that’s continually evaluated to provide you with the widest and best selection in quality, brand name microcomputers anywhere. You’ll find an enthusiastic and knowledgeable staff able to interpret all the equipment specifications, in terms of how they apply to you, and in a way you’ll understand. You’ll find demonstration areas where you can get a firsthand experience of running a computer yourself.

Computers for Business

You’ll find educational materials to give you a total insight into the world of microcomputers.

You’ll find a fully equipped service department to provide whatever assistance is required to keep your computer running in top-notch condition. You’ll find computer user’s clubs to join, where you can share ideas with people as enthusiastic as yourself. And, with each new visit, you’ll find excitement—from the people you deal with, the equipment they offer, and from your own ever-growing personal involvement.

Enough about us. How about what computers do. To attempt to describe all the things your computer might do, would be to describe your imagination. So instead, we’ll briefly list some of the many things for which small computers are already being used.

In business, the advent of the versatile and compact microcomputer has put the benefits of computing within reach of small companies. With systems starting at less than $6000, the businessman can computerize things like accounting, inventory control, record keeping, word processing and more. The net result is the reduction of administrative overhead and the improvement of efficiency which allows the business to be managed more effectively.

In the home, a computer can be used for personal budgeting, tracking the stock market, evaluating investment opportunities, controlling heating to conserve energy, running security alarm systems, automating the garden’s watering, storing recipes, designing challenging games, tutoring the children...and the list goes on.

In industry, the basic applications are in engineering development, process control, and scientific and analytical work. Users of microcomputers in industry have found them to be reliable, cost-effective tools which provide computing capability to many who would otherwise have to wait for time on a big computer, or work with no computer at all.

Computers for Industry

And now, we come to you, which leads us right back to where we started: If you want a computer, then we want to be your computer store.

Whether you want a computer for the home, business or industry, come to ComputerLand first. We’ll make it easy for you to own your first computer. Because, simply put, we really want your business. When you come right down to it, that’s what makes us #1.

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for the average consumer were like, and where they evolved (a natural evolution of big computers, the further miniaturization of electronic components due to the space race, the development of large scale integration [LSI] by the semiconductor makers, the pocket calculator, the digital watch and the TV game).

Chapter 2, called "Personal Computer Applications," goes into just what personal computers can do for you. Applications for the home, business, classroom and just plain fun are explained, using cartoons for punctuation.

What really impressed me was that one computer could do so many different things. The examples that turned me on the most were: "In the Office," where the computer would automatically display my next appointment while it balanced the company's books; and "Organizing Your Hobby," where the computer would maintain a cross file of my photography collection. I was definitely getting turned on.

The next chapter, "Program for Your Computer," made it clear that it takes a great deal of concentrated thought to write computer programs, and that I probably wouldn't need to know much about programming, since thousands of people were already available to do the programming for me. However, I would need to learn to communicate my needs to a programmer if I wanted to do something special with my computer that wasn't already available from a manufacturer, or someone else. Still, I was assured that most of the programs I would ever want would be furnished by the people who sold me the computer; so the pressure to learn programming apparently was off. That's good because then I began to see a computer as just another consumer product, rather complex but still quite manageable.

In the next chapter, "Nuts and Bolts," I learned what kinds of things make a computer tick. Computers have many hookup parts and equipment. In a way, they are a lot like cameras. Just as camera owners buy lenses and other attachments to enhance the power of their equipment, computer owners may purchase "peripherals" to beef up their systems and give them more flexibility.

Although the authors promised to give me enough information to enable me to walk into any computer store and not be snowed by the equipment, I felt rather rained upon during one such visit. The range of products offered in these computer stores is amazing. I didn't see any two computers that looked, worked, or even cost the same. However, after I finally started talking to the store owner, I was very glad that I had read the chapter about nuts and bolts. Each time he would show me a particular computer system, I would say something like, "Does it have a software front panel?", or "How much memory and read only memory is there in the minimum system?" My questions seemed to elicit surprise, and I found the owner gleefully explaining everything in fine detail.

One of the nicest things about the nuts and bolts chapter was that I learned about the most often used computer I/O devices: keyboards, video displays, front panels, Teletypewriters, cassette tape mass storage, floppy disk mass storage, etc. Photographs of each device were included.

The final chapter in the book, entitled "Getting Started," explains how one goes about taking the next logical step in understanding, or perhaps even buying, a personal computer. Like the others, this chapter is illustrated with our friendly computer enthusiast trying his luck at learning more about personal computers by going to conventions, reading books and magazines such as BYTE, visiting computer clubs, and of course going to a store.

For me one of the most useful parts of the book was the appendix called "Glossary of Computer Buzz Words." Here I quickly learned the meanings of the crazy words used by computer people. I read the entire glossary from A to X; it was very interesting. Each word was defined and then used in a typical sentence. I memorized a few of these buzz words and used them on the computer store owner. For example, while he showed me a computer game called Star Trek that didn't seem to be working right, I informed him that perhaps his "buffer had overflowed." All I got was a chuckle, and then a sigh.

Well, I finished the book and can honestly say that for someone who previously knew nothing about computers, I really got my money's worth. Besides learning that computers are here to stay, I discovered that the future of home computing is changing fast and furiously. Although delaying my purchase for a few years may save me a lot of money, it will also mean I'll miss out on a whole lot of fun and excitement.

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Superior to other microprocessor learning aids, the Instructor 50 is a COMPLETE package—including a built-in power supply (50/60 Hz), an LED prompting display, and both functional and hexadecimal keyboards. You also get S-100 compatibility for adding memory and other peripherals. This lets you expand the machine's capability—and your microprocessing applications knowledge. Moreover, you can easily build a program library by recording your own audio cassettes.

The Instructor 50 comes complete with a Users' Guide, along with step-by-step instructions for those with no previous microprocessor experience.

Signetics offers one of the broadest choices of microprocessors in the industry. This knowledge stands behind the Instructor 50. When you need to learn about microprocessors, start with Signetics. Start with the Instructor 50. Send for your descriptive brochure today.

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A Microprocessor for

Terry Ritter and Joel Boney
Motorola Inc
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Austin TX 78721

Part 3:

Clock Speed

In part 3 we conclude our discussion of the Motorola 6809 processor with some thoughts on clock speed, timing signals, condition codes and software design philosophy for the 6809.

We expect that our logic and circuit design cohorts will be able to get significant production at a 2 MHz bus rate (and possibly faster) with the 6809. But this value alone means next to nothing as a figure of processor merit (we did consider using a very high frequency on chip oscillator so we could win the clock rate race, but decided at the last minute that a resonant cavity would not be acceptable to most users).

Other processors use an internal state machine to implement the required internal operations. These processors frequently require multiple states and multiple clock edges to implement operations which are done in one cycle on 6800 class processors.

The 6800 class machines are all random logic machines with multiple dynamic sequencers. This method of microprocessor design selects a different set of engineering trade-offs as opposed to the state machine approach. In particular, less critical timing is necessary, but suspending the processor for a long time is difficult. We provide two external methods of stopping the machine: DMAREQ (which has a maximum asynchronous latency of 1.5 bus cycles, and which will recover the bus from DMA (direct memory access) periodically to allow the dynamic microprocessor to perform a refresh cycle) and HALT (which has a maximum latency of 21 cycles, but releases this bus completely).

Signals

The 6809 processor will be made in two versions: the on chip clock version (for small systems) and the off chip clock version (with extra signal lines for additional processor status information). This will allow a cost-effective utilization of pins for each proposed market.

The bus timing signals are E and Q. E is
the Revolution: The 6809

Final Thoughts

the same as on 6800 systems (previously called 92), a square wave clock with a period equal to one bus cycle. Q is the quadrature clock, and leads E by one quarter bus cycle. Good addresses should be available from the processor on the leading edge of Q; data is latched (by the processor or selected memory or peripheral) on the trailing edge of E.

Two signals are used for clock control in the on chip clock version. DMAREQ halts the processor internally (and puts the output lines of the processor in the high impedance state using three state circuitry) but allows E and Q to continue to run to provide system clocks for a DMA transfer. MREADY being low extends a memory access in increments of the high frequency oscillator period until MREADY is brought high.

If BA=0 (the processor is running) BS=1 means that a vector fetch is occurring (IACK). This signal can be used to develop vector-by-interrupting-device hardware that transfers control directly into the desired interrupt handler without polling.

Two signals are available in the off chip clock version to assist in multiprocessor systems. The last instruction cycle (LIC) pin is high during the last execution cycle of any instruction, thus giving bus arbitration a head start. BUSY is high during read modify write, (from the read through to modify) to indicate that memory exclusion is required. Exclusion is required in multiprocessor systems.

Condition Codes

The 6809 condition code flags are the same as those used in the 6800 (N, Z, V and C), and are affected similarly by most operations. Some exceptions are the double byte operations, since the flags are always set to represent the result of the entire operation, whether single or double byte. (This is implied by the fact that both data length operations have the same root mnemonics).

While very simple in concept (the condition flags being mere by-products of arithmetic and logic unit [ALU] operations), their use with various data representations
and the rich set of conditional branch conditions can seem quite complex. First, we will define the flags as follows.

N: set if and only if the most significant bit of the result is set (this would be the 2's complement "sign" bit).
Z: set if and only if all bits of the result are clear (the result is exactly 0), set
V: if and only if the operation causes a 2's complement overflow. Notice that the expression (N ⊕ V) will give the correct sign, even if the sign is not properly represented in the result.
C: set if and only if the operation causes a carry from the most significant bit (for ADD, ADC) or,
set if and only if the operation does not cause a carry from the most significant bit of the arithmetic and logic unit (for subtract-like operations – SUB, SBC, CMP – carry flag represents a borrow) or,
set according to rules for rotate or shifts or,
set if and only if bit 7 of the result is set (for MUL).

- Notice that the C flag is not the simple result of the carry in the 8 bit arithmetic and logic unit, but depends on the type of operation performed.
- Notice also that the carry flag represents a borrow after subtract-like operations. This was done on the 6800, for convenience.

Next, let's define the use of the branches. Simple conditional branches:

<table>
<thead>
<tr>
<th>Test</th>
<th>True</th>
<th>False</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z=1</td>
<td>BEQ</td>
<td>BNE</td>
</tr>
<tr>
<td>N=1</td>
<td>BMI</td>
<td>BPL</td>
</tr>
<tr>
<td>C=1</td>
<td>BCS</td>
<td>BCC</td>
</tr>
<tr>
<td>V=1</td>
<td>BVS</td>
<td>BVC</td>
</tr>
</tbody>
</table>

Signed conditional branches:

<table>
<thead>
<tr>
<th>Test</th>
<th>True</th>
<th>False</th>
</tr>
</thead>
<tbody>
<tr>
<td>(N ⊕ V) ∧ Z=1</td>
<td>BGT</td>
<td>BLE</td>
</tr>
<tr>
<td>(N ⊕ V) =1</td>
<td>BGE</td>
<td>BLT</td>
</tr>
<tr>
<td>Z=1</td>
<td>BEQ</td>
<td>BNE</td>
</tr>
<tr>
<td>(N ⊕ V) ∨ Z=1</td>
<td>BLE</td>
<td>BGT</td>
</tr>
<tr>
<td>(N ⊕ V) =1</td>
<td>BLT</td>
<td>BGE</td>
</tr>
</tbody>
</table>

Unsigned conditional branches:

<table>
<thead>
<tr>
<th>Test</th>
<th>True</th>
<th>False</th>
</tr>
</thead>
<tbody>
<tr>
<td>C ∧ Z=1</td>
<td>BHI</td>
<td>BLS</td>
</tr>
<tr>
<td>C=1</td>
<td>BHS</td>
<td>BLO</td>
</tr>
<tr>
<td>Z=1</td>
<td>BEQ</td>
<td>BNE</td>
</tr>
<tr>
<td>C ∨ Z=1</td>
<td>BLS</td>
<td>BHI</td>
</tr>
<tr>
<td>C=1</td>
<td>BLO</td>
<td>BHS</td>
</tr>
</tbody>
</table>

Note: The unsigned branches are not, in general, useful after INC, DEC, LD, ST, TST, CLR or COM.

And finally, the flag results of known conditions of comparison are as follows. After SUB, SBC, CMP:

If register is less than memory value (2's complement values) (N ⊕ V)=1.
If register is lower than memory value (unsigned values) C=1.
If register is equal to memory value (signed or unsigned) Z=1.

Because some instructions do not (and should not) affect carry, only the equal and not equal branch tests (BEQ, BNE) are useful after these instructions (INC, DEC, LD, ST, TST, CLR, COM) operate on unsigned values. When operating on 2's complement

Photo 5: Diffusion. Into the furnace goes another batch of wafers in the process of becoming integrated circuits. Operating near 1000° C, the quartz liner glows incandescent.
Since Intertec introduced its new INTERTUBE Video Terminal, a lot of OEM's (and dealers, too) are saying “good-bye” to their high cost, low performance terminals. The INTERTUBE is such a good buy that OEM's find it almost impossible to justify using anything else.

You'll say good-bye too when you compare INTERTUBE's price/performance ratio with any other terminal on the market today. Standard INTERTUBE features include: a 12" display in a 24 line by 80 column format, 128 upper and lower case ASCII characters, reverse video, blinking, complete cursor addressing and control, an 18 key numeric keypad, separate backspace, tab, shiftlock, local, on-line and print keys, special user-defined function keys, protected and unprotected fields, line insert/delete and character inserting/deleting, eleven special line drawing symbols, 15 selectable baud rates from 75 to 9600 BPS, half and full duplex operation, an RS-232 interface, and... would you believe it... there is more! A special “Status Protect” key allows you to enable only those features required in your system and “lock-out” all others, thereby assuring flexible operation in both “smart” and “dumb” environments.

By now you're probably becoming very uneasy if your last terminal purchase wasn't an INTERTUBE. Brace yourself. You're going to become sick! OEM's realize there are no hidden costs of ownership with the INTERTUBE. You can have all the performance you need without having to add expensive options. Standard user-oriented features are: an RS-232 printer port, “block” transmission modes, parity and baud rate error detection, a self-test mode, a 25th “STATUS” Line which displays the current status of the terminal, a transparent mode to simplify program debugging, and selectable display intensities for “easy-on-the-eyes” operation with minimized operator fatigue.

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Call or write us now. We'll show you what a “good buy” the INTERTUBE really is and why more and more OEM's are saying “good-bye” to the competition.

Circle 174 on inquiry card.
values, all signed branches are correctly available.

Some Software Design Philosophy

The design of successful software differs from other types of engineering design in that good software can be easily changed, but is exceedingly unforgiving. The creation of working software involves intimate contact with quality.

Any program, working or unworking, is a representative of the philosophy of truth; the machine will execute the program, good or bad. Only applicable programs are useful, however, and utility is where we encounter quality. Many individuals indoctrinated into a society founded upon truth can scarcely understand why such truthful programs do not work, for isn’t one truth just as good as another?

Any program that is to be fixed or changed must be analyzed: the written code must be read and understood. Reading is a problem — most computer languages are very difficult to read simply because so many options are possible from each statement. Finding the coherent design of a program is nearly impossible when, as it is being read, thousands of options exist. It is the paradox of programming that a disciplined, restricted, structured programming language gives programmers greater freedom to understand their programs.

Consider the analysis of programs: any program segment having multiple conditional branches that cannot be separated must be analyzed for all possible conditions of input data before we can be assured that the program will operate correctly.

Program segments having branch paths that cross may be impossible to analyze rigorously due to the combinatorially larger number of paths that the program may execute. Where control structures are always properly nested, crossed branch paths cannot occur and analysis is easier.

Programming structures which have basically one entry point and one exit are easily detached from surrounding code and are easier to understand and test. This is the fundamental tenet of structured programming.

Every attempt should be made to code in modules. Modules are self-contained entities (usually subroutines) which allocate and deallocate their own local storage. Naturally, the actual code should be heavily commented to allow a reader to understand what is being attempted. But one mark of a good module is that it contains a header block which fully describes all aspects of the inputs to the module and results from it. This description should be so detailed as to allow the module to be totally recoded from this information alone. We hope that the description was arrived at before the module was written. It is a mark of good software design that the actual coding is but a minor part of the project; it occurs after all modules have been completely described. The finished modules should be individually tested for all possible input values, and should demonstrate that error handlers will operate when a supposedly invalid input value occurs. Modules which are recoded at a later date must pass the original tests.

Software in the Revolution

The microprocessor revolution is fueled by continual technical advancement that produces hardware with ever higher capability and ever lower cost. Yet, it is a requirement of the revolution that software be written to make that cheap hardware do anything.

Most present microprocessor software is custom software written for a specific project. Project specific software is rarely published, partly in the (unreasonable) hope of maintaining trade secret protection, and partly because finished project software is rarely of publication quality. Commercial software is rare for a number of reasons:
MicroPro International Corporation proudly announces the incorporation of SUPER-SORT™ into Microsoft COBOL, FORTRAN and BASIC. Now, exclusively from MicroPro you can have the full level 2 COBOL sort verb implemented by joint cooperation between Microsoft and MicroPro. Enjoy the fastest, most flexible sort/merge/extract available together with Microsoft’s compilers! COBOL/S™ $850, FORTRAN/S™ $600, BASIC/S™ $450.

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  - $75.00

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EPROMs out at the touch of a finger.

After programming a 2708 or 2716 EPROM you won't need a screwdriver to pry it out of SSM's new PBI board equipped with Textool sockets. Just flip the lever and lift it out. And on the same board there are 4 sockets waiting for 2708 or 2716 EPROMs that can be independently addressed to any 4k or 8k boundary above 8000 hex. Two boards in one.

PBI has two separate programming circuits so 2708 or 2716 (5V) type of EPROMs can be programmed without modifying the board. Programming voltage is generated on-board by a DC-DC converter; no need for an external power supply. Programming sockets are Dip Switch addressable to any 4k boundary. And complete software is provided for programming and verifying EPROMs.

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PBI 2708/2716 Programmer & 4k/8k EPROM Board

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there must be a market for the (machine specific) software before the investment in program development is made, but the customer base may not exist until good programs are available. It is also difficult to consider investing in software that can be so easily copied (stolen) and used.

The copying problem is not new; musical reproductions have long coexisted with the possibility of consumer recording and reproduction for a close circle of friends. This occasionally happens, but it is usually too much bother to tape the music you want (assuming that the original product is available at a reasonable cost). Software should be distributed as a reasonably priced physical product that is useful to a broad consumer base.

This is an old idea, but it just hasn't worked. The problem is not in the idea, but in the second generation microcomputer architectures which limit the applicability of any particular program read only memory. The 6809 microprocessor is designed specifically — through the use of position independent code, stack indexing, and indirect addressing — to allow the creation of standard program read only memories. This creates a market opportunity for a brand new standard software industry. We knew this when we included these features; you're welcome, entrepreneurs!

Summary

We wrote this series of articles not only to disclose the 6809 but mainly to put down in print the rationale and reasoning behind the 6809. It would have benefited us if the designers of the 6800 had documented their rationale. We would also like to think we have stimulated some interest in the personal computing community for solutions to the software problem and for the study of computer architecture. The big challenge for architects in the next decade and beyond will be to design computers that can effectively utilize the huge number of devices — 1,000,000 transistors by 1985 — that semiconductor technology will be able to put on one 25 mm² piece of silicon.

No computer is designed in a vacuum, and we would like to thank all of our customers and the people at Motorola who gave us valuable input. Special thanks go to the dozen of people — too many to enumerate — who have been or are still actively involved in the design, implementation and production of the MC6809. Without their individual talents and dedication to what seemed to be impossible tasks and impossible schedules, the MC6809 could not have been realized.
March 3-4, Micro-Expo '79, Texas A and M University Memorial Student Ctr, College Station TX. Sponsored by The Texas A and M Microcomputer Club, the activities at the third annual Micro-Expo '79 will include exhibits by dealers and hobbyists, a programming contest, and a computer chess tournament, as well as seminars on topics of interest to both the novice and the experienced computer enthusiast. Contact Larry Brown at (713) 693-5748 or Scott Edwards at (713) 845-5531.

March 10-11, Personal Computer Fair, Pacific Science Ctr, Seattle WA. The fair will acquaint people with personal, home and hobby computer applications. Visitors will see a variety of nontechnical demonstrations and have numerous opportunities for hands-on experimentation. Contact Susan Stocker, Pacific Science Ctr, 200 Second Av N, Seattle WA 98109.

March 17, The Computer Faire, Delaware State College, Dover DE. This faire will deal with current technology of computers for the classroom and personal use. Contact Lynda Baker, New Castle County School District Area II, Henry B duPont Middle School, Benge and Meeting House Rds, Hockessin DE 19707.

March 19-20, Microcomputers: Operating Principles, Hardware and Software Seminar, Holiday Inn, Palo Alto CA. Polytechnic Institute of New York and the Institute for Advanced Professional Studies are presenting this 2 day seminar for engineers, programmers, and technical managers involved with selection of microprocessors and design of microprocessor-based systems. The seminar will cover the underlying concepts governing microprocessor operation, architecture, and systems design. Microcomputer elements and their inter-relationships will be discussed, emphasizing features important in determining whether a particular microcomputer will be suitable for a given task. Contact Prof Donald D French, Institute for Advanced Professional Studies, 1 Gateway Ctr, Newton MA 02158, (617) 964-1412.

March 19-21, Federal DP Expo Conference and Exposition, Sheraton Park Hotel, Washington DC. This fifth annual government show will feature computer related hardware, software and service.

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Cryptography in the Field

Part 1: An Overview

Cryptography could be described as the science or art of transforming messages into forms that render them unintelligible to outsiders. This is an old and fascinating field and the interested reader could hardly do better than to read a most remarkable book on this subject by David Kahn called The Codebreakers.

A few definitions are needed before proceeding. Plaintext is the message to be put into secret form. The message, after cryptographic transformation, is known as a cryptogram. An authorized individual who is privy to the secrets of the system is said to decode or decipher the message when converting the cryptogram to plaintext. Cryptanalysis is the science or art of extracting the meaning of a cryptogram without the key. Cryptology is the science or art encompassing both cryptography and cryptanalysis.

A code is a cryptographic transformation in which no fixed relationship is maintained between the number of symbols in the plaintext and the corresponding cryptographic transformation or codetext. An example of a code is shown in table 1. To encode a message the plaintext word or phrase is found in an alphabetical listing in the encoding section and the corresponding codetext group (in this case 5 digit numbers) is entered into the cryptogram. Note that commonly used words (eg: ballistic) may have more than one codetext equivalent. These are known as homophones. There may also be codetext groups that have no plaintext equivalent; these are known as nulls. The coding clerk is encouraged to select at random from a group of homophones and also to throw in an occasional null in an effort to frustrate the work of the cryptanalyst.

In the decoding section, the codetext groups appear in their numerical order. The security of a code is enhanced when the codetext numerical order is scrambled relative to the plaintext alphabetical order. When this is done the codebook contains separate encoding and decoding sections. Such codes are known as 2 part codes. The resulting codetext is often given a further cryptographic transformation (encipherment); the overall process is then known as superencipherment.

In many applications, a cipher is preferred to a code. A cipher is a cryptographic transformation in which a fixed relationship is maintained between the number of plaintext symbols and the number of symbols in the resulting cryptographic transformation (ciphertext). An example of a simple cipher would involve replacement of each plaintext letter by the next letter in alphabetical order. Plaintext A becomes ciphertext B, plaintext B becomes ciphertext C, etc. Some feeling for the difference between codes and ciphers may be obtained by noting that linguists are often assigned to break codes while mathematicians handle the ciphers.

This article deals mostly with field ciphers, of which there are two main classifications: substitution and transposition. In the former, new symbols are substituted for the plaintext symbols to form the ciphertext. In the latter, the original symbols are

### Table 1: A simple 2 part code example. The encoding section is alphabetically arranged and the decoding section is numerically arranged. To further frustrate the efforts of anyone intercepting the message, nulls are frequently used (a null is a portion of ciphertext having no plaintext equivalent).

<table>
<thead>
<tr>
<th>plaintext</th>
<th>codetext</th>
<th>nulls</th>
<th>codetext</th>
<th>plaintext</th>
</tr>
</thead>
<tbody>
<tr>
<td>BALANCE</td>
<td>78452</td>
<td>17593</td>
<td>17590</td>
<td>AFTERBURNER</td>
</tr>
<tr>
<td>BALANCE SHEET</td>
<td>43987</td>
<td>43874</td>
<td>17591</td>
<td>DETACHED</td>
</tr>
<tr>
<td>BALL</td>
<td>19638</td>
<td>12958</td>
<td>17592</td>
<td>UNLIKELY</td>
</tr>
<tr>
<td>BALLAST</td>
<td>29457</td>
<td>84355</td>
<td>17593</td>
<td>(NULL)</td>
</tr>
<tr>
<td>BALLISTIC</td>
<td>12953</td>
<td></td>
<td>17594</td>
<td>JAMMING</td>
</tr>
<tr>
<td>BALLISTIC</td>
<td>87465</td>
<td></td>
<td>17595</td>
<td>STATUTE OF LIMITATIONS</td>
</tr>
<tr>
<td>BALLISTIC</td>
<td>72589</td>
<td></td>
<td>17596</td>
<td>BALLOON</td>
</tr>
<tr>
<td>MISSILE</td>
<td>17596</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BALLOON</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1: A simple 2 part code example. The encoding section is alphabetically arranged and the decoding section is numerically arranged. To further frustrate the efforts of anyone intercepting the message, nulls are frequently used (a null is a portion of ciphertext having no plaintext equivalent).
Table 2: This relatively simple cryptographic procedure can be used as a field cipher. First the plaintext alphabet is written, then the ciphertext is written underneath it. The message is coded by using the ciphertext alphabet in place of the plaintext alphabet. The former is arrived at by using a keyword. In this case, the keyword Patricia Zlotnik is written followed by the unused letters of the alphabet. No letters are allowed to repeat.

Field Ciphers

Field ciphers are traditionally relatively simple cryptographic procedures which can be implemented readily in the field using only pencil and paper. The definition of pencil and paper is updated here to include the ubiquitous electronic pocket calculator. Common to these systems is the use of an easily remembered word or phrase which serves as a key in the cryptographic process. In the illustrative examples that follow we will use as a demonstration keyphrase:

PATRICIA ZLOTNIK

and as a demonstration message:

MAY UP BID PRICE TWENTY PERCENT ON TRACT ONE ONLY.

In one form of a monoalphabetic substitution, the key is first written by eliminating repeated letters, followed by the remainder of the alphabet in order as shown in table 2. By substitution from this table, M becomes D, A becomes P, etc. The following cryptogram results for the demonstration message:

DPXSG AORGJ
OTIQVIEQXG
IJTIEQFEQJ
PTQFEIFEBX

The ciphertext is represented here in the standard form used by cryptographers, in groupings of five characters. The ciphertext should be read across both columns rather than across one (eg: the ciphertext in this example would be DPXS GAO R G J I T I Q V).

The cryptogram purposely does not preserve word groupings. How good is this cipher? It is both unbreakable and worthless. If the only message ever sent is the single 3 letter word:

CAT

then the cryptogram:

TPQ

is beyond rational cryptanalysis. On the other hand, even very light usage (such as the demonstration message) allows simple frequency analysis to begin the destruction of the cipher. The fact that the letter I has been used to replace the plaintext E will not remain a mystery for long. By any practical measure, monoalphabetic ciphers of this type are clearly useless.

Useless or not, one can present a superficially convincing argument for monoalphabetic substitution. It could be correctly noted that there are approximately $4 \times 10^{26}$ possible plaintext to ciphertext alphabet equivalents using this system. (This, of course, is the number of permutations possible in a 26 character alphabet.) Therefore, even if a fast computer could be found that would check, say, one billion trial solutions per second, it would still take over ten billion years to exhaust all the possibilities. These are impressive but totally meaningless statistics. Presenting the cryptanalyst with a large number of possibilities is a necessary but not a sufficient condition for cryptographic success.

Improved security may be obtained by the use of polyalphabetic ciphers, which may be demonstrated using the Vigenère tableau of table 3. (The Vigenère tableau is named after the French cryptographer Blaise de Vigenère who popularized the

<table>
<thead>
<tr>
<th>plaintext alphabet</th>
<th>A B C D</th>
<th>E F G H</th>
<th>I J K L</th>
<th>M N O P</th>
<th>Q R S T</th>
<th>U V W X</th>
<th>Y Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>plaintext alphabet</td>
<td>--------</td>
<td>---------</td>
<td>---------</td>
<td>---------</td>
<td>---------</td>
<td>---------</td>
<td>-----</td>
</tr>
<tr>
<td>ciphertext alphabet</td>
<td>A B C D</td>
<td>E F G H</td>
<td>I J K L</td>
<td>M N O P</td>
<td>Q R S T</td>
<td>U V W X</td>
<td>Y Z</td>
</tr>
<tr>
<td>ciphertext alphabet</td>
<td>A B C D</td>
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<td>I J K L</td>
<td>M N O P</td>
<td>Q R S T</td>
<td>U V W X</td>
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<td>Q R S T</td>
<td>U V W X</td>
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<td>I J K L</td>
<td>M N O P</td>
<td>Q R S T</td>
<td>U V W X</td>
<td>Y Z</td>
</tr>
</tbody>
</table>

Table 3: The Vigenère tableau is used to generate a polyalphabetic cipher. To encipher, the plaintext message is first written out. Then the keyword is repeatedly written on top of the plaintext. The ciphertext is obtained by selecting the letter which is at the intersection of the plaintext alphabet column and the keyword character row.
method although he did not invent it.) This table is bordered by the plaintext alphabet at the top and ciphertext alphabet designators at the left. The ciphertext alphabets in the body of the table are merely rotations of the normal alphabet. Enciphering is done by writing the key phrase repeatedly over the plaintext and enciphering each plaintext character by the corresponding keyphrase alphabet designator.

In the example shown in Table 4, letter M is enciphered from alphabet P, letter A is enciphered from alphabet A, letter Y from T, etc. By switching alphabets in this way we frustrate the simple frequency analysis which was so effective in the previous cipher example. Clearly, any given plaintext letter (such as E) has a different ciphertext equivalent in each of the different alphabets.

The cryptanalyst can attack this system by searching for the repeating key length (in this case 15). Once the keylength is established, he or she will rearrange the ciphertext in matrix form in which the row length is equal to the keylength. The columns of this matrix each involve the same ciphertext alphabet. Frequency analysis by columns soon reveals the specific key used and the whole structure then collapses.

One ploy sometimes used to frustrate the cryptanalyst is to use a coherent running key. The key could be taken from a readily available book, for example. By this method, the repetitions of the key are eliminated and the cryptanalyst is forced to work harder for a solution, which he or she can get, given enough cryptogram material and time.

A very significant advance in cryptography was introduced by a concept which may be generally described as autokey. In this system, the plaintext itself is used as the key. A given plaintext character selects the alphabet for encipherment of the next plaintext character, and so forth. One of the problems of using autokey is that the key and the recovered plaintext are one and the same. Thus the system tends to self-destruct after the first error. The error propagation properties of autokey are often cited as the reason for not using this technique in field ciphers.

Transposition Ciphers

An important cipher class is the transposition cipher. As the name implies, the meaning of the message is hidden because the order of the characters is scrambled in the ciphertext. To demonstrate transposition, we again call upon our friend Patricia, but this time her name is written out completely to form the keyphrase. The letters in the keyphrase are then numbered according to alphabetical order. When two or more identical letters exist, they are sequentially numbered from left to right. When this is done, there exists a scrambled set of integers from 1 to the number of characters in the keyphrase (in this case 15). The message is then written under these column designators in rows of keyphrase length. An example for the demonstration key and message is shown in Table 5.

Once this is done, the ciphertext is read out in column order: ANC, DCN, BEE, etc. When put in the standard 5 letter groups, the cryptogram becomes:

\[
\text{ANCDCNBE}
\]
\[
\text{PINOROTTWR}
\]
\[
\text{NYENITMEAU}
\]
\[
\text{YOYTTCPLE}
\]

Since the deciphering clerk knows both the key and message lengths, he or she can quickly determine the length of each column in the original matrix. The cryptogram is then copied in column form and the message read out by rows. Multiple transpositions are often done using the same or different keyphrases. Null cells in the transposition matrix are sometimes used to strengthen the cipher.

Substitution ciphers replace characters but leave them in their original positions. The cryptanalyst can use this invariant to advantage. Transposition destroys the order but does not hide the content. Combinations of transposition and substitution can provide complementing strengths to produce very effective ciphers.

Playfair Cipher

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Table 6: The two messages shown here were sent by coast watchers in the South Pacific during World War II. The first message uses "ROYAL NEW ZEALAND NAVY" as the key and the second message uses "PHYSICAL EXAMINATION." These messages follow the Playfair cipher rules except that letter pairs, when falling in a digraph, were left unciphered.

![Image of Table 6]

important contribution to cryptography made by Charles Wheatstone of electrical measurement fame. Reference is made here to the famous Playfair cipher (named, ironically, after the man who enthusiastically promoted Wheatstone and his idea). The ciphertext alphabet is written as in the monoalphabetic example but is reformatted to a 5 by 5 square with I,J occupying the same cell and used interchangeably. Our demonstration key would yield:

\[
P A T R I/J
C Z L O N
K B D E F
G H M Q S
U V W X Y
\]

Enciphering is done by letter pairs with the following four rules:

- If the plaintext pair falls in the corners of a square, use as the ciphertext the other two corner characters taken in corresponding row order.
- If the plaintext pair falls in the same row, take as the ciphertext the characters immediately to the right of each plaintext character in order. Consider each row to have cylindrical continuation so that the character to the right of the last character in a row is the first character of that row.
- If the plaintext pair falls in the same column, take as the ciphertext the character immediately below each plaintext character in order. Consider each column to have cylindrical continuation so that the character below the last character in a column is the first character in that column.
- Encipher double letters by inserting an X between the letter pair in the plaintext.

Deciphering merely reverses the above procedure. We have here one of those operations that is quicker to execute than to explain. Using the demonstration keyword square and the demonstration message yields:

\[
H T U V A K T F A I
P N D R X D L I U I
Q O O K L I N C R I
P Z R L O F N C N W
\]

This digraphic substitution procedure can be very effective considering its relative simplicity. The reasons for this may be seen from the fact that while there are only 26 characters in the alphabet, there are 676 digraphs (combinations of two letters). The highest letter frequencies are 12% (E) and 9% (T). The highest digraph frequencies are 31% (TH) and 22% (HE). The cryptanalyst thus faces many more entities with a much more uniform frequency distribution in the Playfair than in the character-for-character processing examples given previously.

The Playfair can, of course, be broken, and had the Japanese done this in World War II for the two cryptograms in table 6, the course of contemporary American history might have been radically changed. These cryptograms were sent by coast watchers in the South Pacific. There is no clear call to action as far as the first message is concerned. However, the reader must surely agree that the second message required immediate action. This is especially true since the Japanese had adequate vessels and troops in the area to resolve the matter without difficulty. Both messages follow the Playfair rules except that letter pairs, when falling in a digraph, were left unciphered. Even though these messages were (apparently) not deciphered and acted upon, military history is replete with examples in which the course of events was dramatically changed by poor cryptographic practice or by brilliant cryptanalysis. (These messages are taken from the Kahn reference which contains fascinating stories of this type.)

Vernam Cipher

The only cipher generally accepted as being absolutely secure is the invention of an American, Gilbert S Vernam. His system is known in the trade as the onetime key or onetime pad. Some perspective on the contribution made to cryptography by this man may be gained by noting that his system, for which patents were filed in 1918, is the standard system used today, 61 years later, on the Washington to Moscow hot line. Vernam's work involved Exclusive OR operations with a random binary key. An equivalent set of operations is presented
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Table 7: When all letters of the alphabet are numbered sequentially, messages may be enciphered and deciphered by adding together the numerical values of the plaintext and the key (modulo 26) to obtain the ciphertext. The deciphering process is performed by subtraction.

<table>
<thead>
<tr>
<th>encipher key:</th>
<th>15(P)</th>
<th>0(A)</th>
<th>19(T)</th>
<th>17(R)</th>
<th>8(I)</th>
</tr>
</thead>
<tbody>
<tr>
<td>plaintext:</td>
<td>+12(M)</td>
<td>+0(A)</td>
<td>+24(Y)</td>
<td>+20(U)</td>
<td>+15(P)</td>
</tr>
<tr>
<td>ciphertext:</td>
<td>1(B)</td>
<td>0(A)</td>
<td>17(R)</td>
<td>11(L)</td>
<td>23(X)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>decipher key:</th>
<th>-15(P)</th>
<th>-0(A)</th>
<th>-19(T)</th>
<th>-17(R)</th>
<th>-8(I)</th>
</tr>
</thead>
<tbody>
<tr>
<td>plaintext:</td>
<td>12(M)</td>
<td>0(A)</td>
<td>24(Y)</td>
<td>20(U)</td>
<td>15(P)</td>
</tr>
<tr>
<td>ciphertext:</td>
<td>1(B)</td>
<td>0(A)</td>
<td>17(R)</td>
<td>11(L)</td>
<td>23(X)</td>
</tr>
</tbody>
</table>

Table 7: When all letters of the alphabet are numbered sequentially, messages may be enciphered and deciphered by adding together the numerical values of the plaintext and the key (modulo 26) to obtain the ciphertext. The deciphering process is performed by subtraction.

here except that a different base for the residue arithmetic is used.

Return now to table 3. Let the letters of the alphabet be replaced by the numbers 0 through 25. That is, A = 0, B = 1, C = 2, ..., Y = 24, Z = 25. When this is done it will be immediately noticed that in numerical form each of the ciphertext alphabets is equal to the plaintext alphabet plus the value of the ciphertext alphabet designator, modulo 26. In residue arithmetic all numbers lie in the range of 0 to 1 minus the base value. The base is repeatedly added to or subtracted from any arithmetic result until this range is achieved. For example, alphabet D (value 3) equivalents are obtained by adding 3 to the plaintext or alphabet A values. Once this numerical format is established, tables such as that of table 3 are no longer needed, since encipherment and decipherment may be done as shown in table 7 by simple addition and subtraction. The arithmetic used in this case is modulo 26.

Vernam realized that under heavy traffic loads substitution ciphers all broke down via the Achilles heel of the key, be it repeating keyphrase, coherent running key, or autokey. His solution to the problem was to generate a truly random key, make two or more copies, and arrange for the used key to be destroyed at both ends of the system after first use. In some cases the key is in paper tape format and a knife is provided at the exit position of the paper tape reader so that the keytape is destroyed automatically as soon as it is read (ie: a onetime tape). In other cases the key is written on pads of paper (digits 0 thru 9, base 10 system) and the sheets of the pad are torn off and destroyed as soon as each is used (ie: a onetime pad).

Trap Door Operations

The bulk of the open literature in the field of cryptography today takes us chronologically to the end of World War II. The state of cryptographic art at that time was represented by the mechanical and electromechanical cipher machines. Some punch card sorting mechanization for cryptanalysis is also occasionally referenced. The security curtain has since fallen, and quite obviously that curtain hid a revolution in cryptography brought about by solid-state digital data processing technology. Until very recently this concrete curtain quietly separated two coexisting computer user groups. The emergence of large commercial data networks and the need for preserving the privacy of data in transmission and storage has resulted in cryptographic work on both sides of that curtain. Topics such as the one reviewed in this section have apparently opened an uneasy dialog between these two groups.

Residue arithmetic, as used by Vernam and demonstrated in the simple example of the previous section, plays a key role in some recent cryptographic techniques that have been disclosed. In these techniques the encryption key (which can be made public) is comprised of a pair of positive integers (E,N). The message is first converted by any consistent means to some integer number M between 0 and N-1. The encryption process is then:

\[ C = M^E \pmod{N} \]  \hspace{1cm} (1)

The message number M is raised to the power E, the result is divided by N and the remainder forms the ciphertext number C, which represents the cryptogram. (In one published example, E = 9007 and N is 129 decimal digits in length. This is residue arithmetic with a vengeance!)

The deciphering key (which is kept secret) involves two integer numbers (D,N), and the decryption process is:

\[ M = C^D \pmod{N} \]  \hspace{1cm} (2)

The ciphertext value C is raised to the power D, division by N is then done, and the remainder is the original message number M. This can be converted back to alphanumeric format for final delivery.

A 3 step process is used to generate N, D and E.

- Generate two random prime numbers P,Q (of the order of 100 decimal digits each in a practical system) and let N = PXQ. Thus N is typically a 200 decimal digit composite number.
- Select number D to be relatively prime to (P-1) X (Q-1). Any prime number greater than both P and Q is a possible selection.
- Select an E value such that the product E x D equals unity, modulo the product (P-1) x (Q-1).
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This cryptographic process is novel in that knowledge of the enciphering process \((E,N)\) does not reveal the deciphering process \((D,N)\). The terms one-way and trap door have been applied to such operations. This is to be compared to the cryptographic processes we have been discussing in which knowledge of the key allows one to go in either direction between plaintext and ciphertext with equal ease. Consider now two parties to a transaction: a customer \(C\) and a bank \(B\). Let \(E_c\) and \(E_b\) be the (public) encryption processes of the customer and bank, respectively. Let \(D_c\) and \(D_b\) be the (secret) corresponding decryption processes.

The customer may take a funds transfer order \(T\) in plaintext and apply his secret decoding operation to it to produce \(D_c(T)\). This transformation may be converted by anyone back to \(T\) by applying the public \(E_c\) operation. For transmission to the bank, however, the customer encrypts \(D_c(T)\) by applying the bank's (public) encryption operation \(E_b\). Thus

\[
E_b[D_c(T)]
\]

is transmitted to the bank. Interception of the message at this point may be tolerated since only the bank can decipher the \(E_b\) operation. Once this is done the bank has \(D_c(T)\) to which the bank may easily apply the customer's public encryption operation, \(E_c\), to obtain the plaintext \(T\). That is:

\[
T = E_c[D_c(T)]
\]  

is done at the bank.

Three important features are to be noted. First, the data was protected in transit by the bank \(E_b\) operation. The bank is sure of the sender's identity from equation (3) because only \(c\) knows the backward \(D_c\) operation which was applied to \(T\). Also the bank cannot alter \(T\) after receipt since \(D_c(T)\) stands as verification. The bank cannot produce a \(D_c(T')\) to correspond to some altered \(T'\) funds transfer order.

The security of these systems is dependent to a great extent on the computational difficulty of factoring the compound number \(N\). It is claimed that this procedure is computationally infeasible for sufficiently large values of \(N\) using the best algorithms and the fastest computers. (The presentation in this section follows very closely material recently published by R L Rivest and his associates at MIT.)

In part 2 of this article I will discuss program Crypt which performs substitution and transposition. This part shows how a calculator can be converted to a field cipher machine of significant capability.
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BYTE March 1979 65
The Standard
Data Encryption Algorithm

Part 1: An Overview

Recently, I have seen many articles describing new commercial encryption equipment using the Standard Data Encryption Algorithm. There have also been recent announcements of integrated circuits, like the Intel 8294, which implement the standard. The Standard Data Encryption Algorithm has been published by the National Bureau of Standards for use in the protection of computer data. The algorithm is described in FIPS Publication 46, available from the US Department of Commerce. After months of being bombarded with publicity regarding the encryption method, it finally struck me that I had found a perfect project for my KIM. The challenge became to implement the algorithm with the basic memory provided and to achieve sufficient processing speed to make it practical for use by others. Along the way, I hoped to investigate the advantages and disadvantages of the 6502 in performing the necessary tasks.

Cryptography Basics

Cryptography involves the use of a scheme to transform intelligible text into an unintelligible form and to later recover the original text. The transformation process is known as encryption and the recovery process is known as decryption. Cryptographic techniques have been used for centuries to allow individuals to communicate without fear of outsiders discovering what they are saying. The individuals who communicate generally possess a cryptographic key which controls the encryption and decryption process. Unless someone knows the key used to encrypt the data, he or she will not be able to correctly decrypt the data. The number of possible keys is usually made so large that it is impractical to try decrypting the data using all key possibilities. It must be clear that the critical factor in protecting the data is the secrecy of the key used.

The cryptographic technique employed in the Standard Data Encryption Algorithm is known as a codebook. In this case, a 64 bit block of data is transformed to a corresponding 64 bit block of data known as a cipher. Each time a particular set of data is provided as input, the same cipher will result: assuming the same key is used. The Standard Data Encryption Algorithm uses a 56 bit key to control the encryption. As mentioned before, this was chosen to give a large number of possible keys (ie: \(2^{56}\)). Some estimates have been made that it would require, on the average, approximately 2500 years on a general purpose computer significantly faster than a CDC 7600 to examine all \(2^{56}\) (ie: \(7.2 \times 10^{16}\)) possible keys in order to determine the particular key used to encrypt a block of data.

Restrictions

The National Bureau of Standards position on the implementation of the Standard Data Encryption Algorithm is that software implementations are not in compliance with the standard. The standard, however, applies to use on federal systems, not private com-
Algorithm Overview

A very simple diagram of the operations involved in the encryption algorithm is shown in figure 1. The input (plaintext) is first subjected to an initial permutation operation, which reorders the bits. Most of the work of the encryption is done in the box labeled product transformation. Details of this transformation will be described later. The block transformation is a simple exchange of the left and right 32 bits of data. The last step is a permutation operation which is the inverse of the initial permutation operation. The output of this step is the ciphertext.

In case you’re wondering where the key comes in, it is the controlling factor in the product transformation. Note also the relationship of the initial permutation to its inverse. The fact that they are inverses means that if you perform an operation using a function and then reorder again using the inverse of the function, the result will be the original word. Of course the same thing occurs if the inverse and then the function is applied to the word. Tables 1a and 1b show the permutation tables for the initial permutation and its inverse. The permutation operation should be interpreted as follows: proceeding from left to right, bit 1 of the permuted word is bit 58 of the input, bit 2 of the permuted word is bit 50 of the input, etc. I was originally confused about the numbering scheme chosen for the bits, since I was accustomed to bits being numbered 0 thru 7 going from right to left. The correspondence between the Standard Data Encryption Algorithm numbering scheme and typical computer numbering is depicted in figure 2.

Algorithm Operation

A more detailed diagram of the encryption algorithm is provided in figure 3. The basic operations are quite straightforward. What is shown is basically an expansion of the product transformation box from figure 1.

Let’s look at the basic operations involved after the initial permutation. The 64 bits of permuted input are split into two groups of 32 bits each, called left (L) and right (R). The subscripts on L and R indicate the iteration of the algorithm. The first thing that occurs is the generation of K1. K1 is known
as the *subkey*, and is generated directly from the encryption key. In fact, each $K_i$ is generated from the key. Don't worry yet about exactly what each $K_i$ is or where it comes from — that will soon be explained. A function, $f(R_0, K_1)$, is now generated using $K_1$ and $R_0$ as inputs (again, the details will be explained shortly). The next operation is the modulo 2 addition (i.e: exclusive OR) of $f(R_0, K_1)$ to $L_0$. Therefore, $L_0 \oplus f(R_0, K_1)$ replaces the old $L_0$. Finally, the current leftmost 32 bits are exchanged with the current rightmost 32 bits. This completes one iteration of the algorithm and involves all the basic operations. To complete the product transformation, the steps above are repeated as shown in figure 3. The encryption process is completed by performing the block transformation and the inverse initial permutation operation.

An important fact about the modulo 2 addition step is that it is reversible. This reversibility allows the decryption process to recover the original plaintext. In fact, as I will show, you can use the same algorithm steps to do the decryption as you used for encryption.

**Something for Nothing?**

In case my arguments of the simplicity of the Standard Data Encryption Algorithm haven’t convinced you, I should point out that it wouldn’t be fair to expect 2500 years of protection from an algorithm which wasn’t somewhat involved. Figures 4a and 4b provide illustrative examples of the encryption and decryption processes. I have used only two iterations in the product transformation, but the principle is the same for 16 iterations. Note in particular how the same algorithm is used for decryption, except that the subkeys are applied in reverse sequence. In figure 4b, the results of each transform are shown after the modulo 2 addition. For example, the first transform results of $L_1$ are obtained by computing $R_2 = f(L_2, K_2) = [L_1 \oplus f(R_1, K_2)] \oplus f(R_1, K_2) = L_1$. Remember how modulo 2

![Figure 3: A detailed operation of the Standard Data Encryption Algorithm encryption process. Note that this flow diagram (and the following flow diagrams) do not use standard flowchart symbology.](image-url)
Figure 4: A simplified encryption and decryption process using the Standard Data Encryption Algorithm. Figure 4a shows a plaintext message being processed into a ciphertext and figure 4b shows the inverse process. Although only two iterations of transformation and swapping are shown, 16 are actually performed.
addition works. Following the decryption through figure 4b, you can see how the encryption steps are reversed. The result is the original plaintext.

Algorithm Details

In order to program the encryption algorithm, it is necessary to understand the details of two operations that I have alluded to. The first is the generation of the subkeys K1, K2, ..., K16; the second is the generation of the function f(R,K).

Subkey generation is depicted in figure 5. The process starts with the 64 bit key that you provide for the encryption. Actually, only 56 of these bits are used; the remaining eight can be used as parity bits. The first transformation of the key is called permuted choice 1. Permuted choice 1 permutes the 56 bit key and also regroups it into two 28 bit words, called C0 and D0. The generation of subkey K1 is done by circular shifting both C0 and D0 left and then permuting

![Figure 5: A process flow diagram showing how subkeys K1 thru K16 are produced from a single key.](image-url)
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Table 2: Tables for using permuted choice 1 and permuted choice 2 (table 2a and 2b respectively). The permuted choice 1 table (table 2a) is used to develop CO and DO from the key. Bits 8, 16, 24, 32, 40, 48, 56, and 60 of the key are not used. The permuted choice 2 table (table 2b) is used to develop subkey Ki from Ci and Di.

(2a)

$$\begin{align*}
57 & \quad 49 & \quad 41 & \quad 33 & \quad 25 & \quad 17 & \quad 9 \\
1 & \quad 58 & \quad 50 & \quad 42 & \quad 34 & \quad 26 & \quad 18 \\
10 & \quad 2 & \quad 69 & \quad 51 & \quad 43 & \quad 36 & \quad 27 \\
19 & \quad 11 & \quad 3 & \quad 60 & \quad 52 & \quad 44 & \quad 36 \\
\end{align*}$$

(2b)

$$\begin{align*}
14 & \quad 17 & \quad 11 & \quad 24 & \quad 1 & \quad 5 \\
3 & \quad 28 & \quad 15 & \quad 6 & \quad 21 & \quad 10 \\
23 & \quad 19 & \quad 12 & \quad 4 & \quad 26 & \quad 8 \\
16 & \quad 7 & \quad 27 & \quad 20 & \quad 13 & \quad 2 \\
41 & \quad 52 & \quad 31 & \quad 37 & \quad 47 & \quad 56 \\
30 & \quad 40 & \quad 51 & \quad 45 & \quad 33 & \quad 48 \\
44 & \quad 49 & \quad 39 & \quad 56 & \quad 34 & \quad 53 \\
46 & \quad 42 & \quad 50 & \quad 36 & \quad 29 & \quad 32 \\
\end{align*}$$

Table 3: A summary of the number of left circular shifts applied to Ci and Di at each iteration of subkey generation.

$$\begin{align*}
\text{Iteration Number} & \quad \text{Number of Circular Left Shifts} \\
1 & \quad 1 \\
2 & \quad 1 \\
3 & \quad 2 \\
4 & \quad 2 \\
5 & \quad 2 \\
6 & \quad 2 \\
7 & \quad 2 \\
8 & \quad 2 \\
9 & \quad 1 \\
10 & \quad 2 \\
11 & \quad 2 \\
12 & \quad 2 \\
13 & \quad 2 \\
14 & \quad 2 \\
15 & \quad 2 \\
16 & \quad 1 \\
\end{align*}$$

Figure 6: Details of the function $f(R, Ki)$. Note that each mapping function $S1$ thru $S8$ changes a 6 bit input to a 4 bit output.
C1 and D1 using permuted choice 2 to form a 48 bit subkey. Permutated choice 1 and permuted choice 2 are shown in tables 2a and 2b. Each successive subkey is generated in the same way: by shifting C1 and D1 left (by one or two bits) and then using permuted choice 2. Table 3 shows the number of left shifts to be applied to C1 and D1 for each iteration in the subkey generation.

Once K1, K2, ..., K16 have been generated, it is not necessary to generate them again until the key is changed. The same set of subkeys is used for each encryption and decryption operation shown in figures 4a and 4b.

The final operation to understand is f (R,K), depicted in figure 6. The first operation is called select E. This is really a permutation operation similar to the initial permutation operation previously discussed, except that the result has more bits than the input. Table 4 shows the select E permutation table. The 48 bit result of this operation is then added to the subkey. This result is reduced to a 32 bit result using a set of mapping functions known as S1, S2, ..., S8. These are used as shown in figure 6. Each group of six bits, going left to right, is mapped into a 4 bit word using a distinct mapping function. The mapping functions are shown in figure 5, and an example of how they are used is shown in figure 6. The six bits input to each S mapping function are used to generate a row address and column address as shown. The selected matrix entry is converted from its

| S1 | 14 4 13 1 2 15 11 8 3 10 6 12 5 9 0 7 |
| 0 15 7 4 14 2 13 1 10 6 12 11 9 5 3 8 |
| 4 1 14 8 13 6 2 11 15 12 9 7 3 10 5 0 |
| 15 12 8 2 4 9 1 7 5 11 3 14 10 0 6 13 |
| S2 | 15 1 8 14 6 11 3 4 9 7 2 13 12 0 5 10 |
| 3 13 4 7 15 2 8 14 12 0 1 10 6 9 11 5 |
| 0 14 7 11 10 4 13 1 5 8 12 6 9 3 2 15 |
| 13 8 10 1 3 15 4 2 11 6 7 12 0 5 14 9 |
| S3 | 10 0 9 14 6 3 15 5 1 13 12 7 11 4 2 8 |
| 13 7 0 9 3 4 6 10 2 8 5 14 12 11 15 1 |
| 13 6 4 9 8 15 3 0 11 1 2 12 5 10 14 7 |
| 1 10 13 0 6 9 8 7 4 15 14 3 11 5 2 12 |
| S4 | 7 13 14 3 0 6 9 10 1 2 8 5 11 12 4 15 |
| 13 8 11 5 6 15 0 3 4 7 2 12 1 10 14 9 |
| 10 6 9 0 12 11 7 13 15 1 3 14 5 2 8 4 |
| 3 15 0 6 10 1 13 8 9 4 5 11 12 7 2 14 |
| S5 | 2 12 4 1 7 10 11 6 8 5 3 15 13 0 14 9 |
| 14 11 2 12 4 7 13 1 5 0 15 10 3 9 8 6 |
| 4 2 1 11 10 13 7 8 15 9 12 5 6 3 0 14 |
| 11 8 12 7 1 14 2 13 6 15 0 9 10 4 5 3 |
| S6 | 12 1 10 15 9 2 6 8 0 13 3 4 14 7 5 11 |
| 10 15 4 2 7 12 9 5 6 1 13 14 0 11 3 8 |
| 9 14 15 5 2 8 12 3 7 0 4 10 1 13 11 6 |
| 4 3 2 12 9 5 15 10 11 14 1 7 6 0 8 13 |
| S7 | 4 11 2 14 15 0 8 13 3 12 9 7 5 10 6 1 |
| 13 0 11 7 4 9 1 10 14 3 5 12 2 15 8 6 |
| 1 14 11 13 12 3 7 14 10 15 6 8 0 5 9 2 |
| 6 11 13 8 1 4 10 7 9 5 0 15 14 2 3 12 |
| S8 | 13 2 8 4 6 15 11 1 10 9 3 14 5 0 12 7 |
| 1 15 13 8 10 3 7 4 12 5 6 11 0 14 9 2 |
| 7 11 4 1 9 12 14 2 0 6 10 13 15 3 5 8 |
| 2 1 14 7 4 10 8 13 15 12 9 0 3 6 8 11 |

Table 5: Matrices for the selection functions S1 thru S8. Each Si maps a 6 bit input into a 4 bit output.
decimal representation to binary. A final 32 bit permutation, P, is then performed as shown in figure 6 to give the output \( f(R, K) \). Table 7 shows this permutation table.

This completes the details of the Standard Data Encryption Algorithm and should allow you to develop your own implementation. My particular implementation for the 6502 on the basic KIM-1 is given in part 2. It should provide you with some interesting insights into program optimization.

Table 6: Illustration of the use of S1 mapping function. The middle four bits of input give the column index. The first and last bits are the row index. The binary value of the selected table entry is output.

Table 7: Table for permutation \( P \).
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March 26-30, Data Base Concepts and Design, AMA Management Center, Chicago IL. Sponsored by the American Management Associations, this course will feature practical information to help the participant understand structure, concepts, design, software, and management. Contact American Management Associations, 135 W 50th St, New York NY 10020, (212) 586-8100.

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April 5-6, Computers in Ophthalmology, St Louis MO. This is a course in application of computers to ophthalmic patient care and clinical research. Sessions dealing with data bases, automated patient testing, artificial intelligence, and image processing are being planned. Contact Robert Greenfield, DSc, Biomedical Computer Center, School of Medicine University of School, 700 S Euclid Av, St Louis MO 63110.

April 5-6, 1979 Computer Users Conference, East Texas State University, Commerce TX. The theme of this conference is "Educating in a Computer Society." Contact Henrietta Gale, conference coordinator, Dept of Computer Science, East Texas State University, Commerce TX 75428.

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April 23-26, Middle Eastern Electronic Communications Show and Conference, Bahrain Exhibition Ctr, Bahrain. The exhibition will consist of companies marketing communication systems, products, and services. Contact Gerry Dobson, MECOM ’79, Arabian Exhibition Management, 11 Manchester Sq, London W1M 5AB.

April 23-27, Data Base Concepts and Design, San Francisco CA. See March 26-30, Chicago IL.


May 7-11, Data Base Concepts and Design, Kansas City KS. See March 26-30, Chicago IL.

May 15-17, Micro/Expo ’79, Centre International de Paris, Paris FRANCE. Contact Sybex Inc, 2020 Milvia St, Berkeley CA 94704.

May 15-17, First Education Computer Fair, Detroit Plaza Hotel, Detroit MI. This fair will be held in conjunction with 1979 Association for Educational Data Systems 17th Annual Convention. The theme of the fair will be the use of microprocessors in education. Contact Bruce G Alcock, Riverdale Country School, W 253 St and Fieldston Rd, Bronx NY 10471.

May 15-18, 1979 Association for Educational Data Systems 17th Annual Convention, Detroit Plaza Hotel, Detroit MI. The convention program will focus on computer applications, computer resources, computer related curriculum, application development methodologies, and futures. Exhibits, user group meetings and vendor sessions will also be offered. Contact Arthur W Daniels Jr, 31202 Dorchester, Madison Heights MI 48071.

May 21-24, Eighth Annual Incremental Motion Control Symposium, Ramada Inn, Urbana IL. Contact Dr B C Kuo, POB 2772, Station A, Champaign IL 61820.

Northeast Personal and Business Computer Show, Hynes Auditorium, Boston MA. See BYTE’s Bits, page 224, for information concerning change from previously published date.
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**APPENDIX A**

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**APPENDIX B**

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**APPENDIX C** — FAVORITE PROGRAM CONVERSIONS

**APPENDIX D** — LIST OF PROGRAM BRIEFS
Preview of the Z-8000

Figure 1: Pin diagram of Zilog's new Z-8000 16 bit processor. The device is both fast and versatile, with over 110 instructions in its instruction set. The Z-8000 is available in two versions: segmented and unsegmented. The segmented version uses an outboard auxiliary integrated circuit called a memory management device to provide memory segment mapping or relocation and memory protection (the memory in the Z-8000 is divided into 64 K byte blocks called sections).

<table>
<thead>
<tr>
<th>BUS TIMING</th>
<th>ADDRESS/DATA BUS</th>
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<tbody>
<tr>
<td>AS</td>
<td>AD15-AD0</td>
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<tr>
<td>MREG</td>
<td>AD9-AD3</td>
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<td>READ/WRITE</td>
<td>AD2</td>
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<td>NORMAL/SYSTEM</td>
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<td>WORD/BYTE</td>
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All figures in this article are courtesy of Zilog.

The Z-8000 (shown in figure 1) is Zilog's new entry in the field of 16 bit processors. It is a single chip processor with more raw processing power than many popular minicomputers. Benchmarked against the popular PDP-11 family, the Z-8000 is between the 11/45 and the 11/70 in speed for many simple instructions. The processor also introduces several sophisticated minicomputer hardware techniques such as memory management, separate system/user operation modes, separate memory space for data, stack contents and code, and long word instructions. The remainder of this review will offer a very brief description of the Z-8000 so that future thinking personal computer experimenters can begin planning applications for it.

Architecture

The Z-8000 is a general register machine with 1 and 2 address instructions, faintly reminiscent of a PDP-11. It comes in two varieties: segmented or nonsegmented, in reference to the memory management capability which will be discussed later. I will discuss only the segmented processor.

AD15-AD0 Address/data (inputs/outputs, active high, 3 states). These multiplexed address/data lines are used both for I/O and to address memory.

AS Address strobe (output, active low, 3 state). This line indicates addresses are valid.

MREG Bus acknowledge (output, active low). A low on this line indicates the processor has relinquished the bus.

BUSAK Bus request (input, active low). When this line is driven low, the bus is requested by the processor.

BUSRO Data strobe (output, active low, 3 states). This line times the data in and out of the processor.

NMI Memory request (output, active low, 3 states). This line is a timing signal that tells the processor to check for interrupts.

µO Multimicro out (output, active low).

NVI Nonvectored interrupt (output, active low).

RESET System clock is a positive transistor logic level clock input.

R/W Read/write input (low = write, 3 states). Provides early status information for a read or write cycle.

SEG Segment number (inputs, active high, 3 states).

ST3-ST0 Status outputs, active high. When these signals are high, the processor will cause the memory or I/O device to not ready for data transfer.

STOP Stop (input, active low). Single step instruction execution.

VI Vector interrupt (input, active low).

WAIT Wait (input, active low). Indicates processor is not ready for data transfer.

W/B Word/byte reference (input).

N/S Normal/system mode (output).
since the nonsegmented processor is a functional subset of the former. Nonsegmented mode is a software selectable option in the segmented processor.

The processor has sixteen 16 bit registers which are logically subdivided (figure 2) into sixteen 8 bit registers, eight 32 bit registers and four 64 bit registers. All of the 8 and 16 bit registers are available as general purpose accumulators. Fifteen of the 16 bit registers are available as index registers. Registers 14, 15 and 16 serve as stack pointer depending on the segmentation mode in effect. There are two sets of these registers to provide for separate system and user stacks. There is a 64 bit status register which contains the program counter and various flags. There is also a rate programmable refresh counter for servicing dynamic memories.

There are seven discrete data types recognized by the Z-8000. In ascending order of size they are bits, BCD (binary coded decimal) digits (4 bits), bytes (8 bits), words (16 bits), long words (32 bits), byte strings (8n + 8 bits), and word strings (16n + 16 bits). The string types consist of sequential bytes or words preceding by a word count. Strings may be accessed in either ascending or descending address order. Bytes are the smallest directly addressable data type. Bits and binary coded decimal are dealt with using special instructions such as SET B (set bit), and DAB (decimal adjust).

One of the most unusual features of this processor is the large memory space. The segmented Z-8000 has 24 address lines yielding 16,777,216 directly addressable bytes. The system and the user may both have their own memory, as may program code, data, and data stack, for a grand total of 96 M bytes of on line memory. The memory is arranged in 64 K byte blocks called segments. An outboard support integrated circuit, called the memory management unit (MMU), is available to provide, transparently to the user, segment mapping or relocation and memory protection. To access this mountain of memory, there are eight addressing modes, illustrated in figure 3.

The Z-8000 has over 110 different instructions, many of which have several possible addressing modes. The instruction set is summarized in table 1. There are many

![Figure 2: Z-8000 registers. The Z-8000 has sixteen 16 bit registers logically subdivided into sixteen 8 bit registers, eight 32 bit registers, and four 64 bit registers. The 8 and 16 bit registers are available as general purpose accumulators, and 15 of the 16 bit registers are available as index registers.]
powerful instructions which are not usually seen in microcomputers. Not many microcomputers or small minicomputers have extended precision multiply and divide, or translate, increment, and repeat. There are string comparison operations and block move operations. The decrement and jump-on-nonzero instruction of the Z-80 has been extended to allow any word or byte length

Figure 3: Z-8000 addressing modes.

REGISTER

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INDIRECT REGISTER IR

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cularly interesting subset of instructions concerns the use of a pair of pins on the Z-8000 packaged called \( \mu I \) and \( \mu O \). These pins, and the instructions which govern them, allow for the combination of Z-8000 into efficient multi-processor or network systems. The only regrettable lack I’ve noticed thus far is the absence of memory-to-memory instructions.

Performance, in terms of execution speed, is a major factor in the selection of a processor. In table 2, I have tabulated the approximate speed of several common processors for simple tasks. Obviously, the Z-8000 is way out in front, competing very favorably with a popular medium sized minicomputer whose processor’s cost is more than two orders of magnitude greater. The Z-8000’s speed and memory make it the best thing yet for personal applications which involve number crunching. I can easily imagine it as the heart of a personal FORTRAN or

Memory Management

Memory management, as the name implies, is a clever technique to handle large amounts of memory in a flexible fashion. In most computer systems, this management requires the large memory to be broken up into smaller (eg: 64 K byte) chunks. Each program or task residing in memory is assigned into its own unique chunk or segment. In general, segments may vary in length, but a program residing in a particular segment may not exceed that segment in length. Often a program will not need to directly address a vast amount of memory, and if a particular application program or set of programs will fit into segments, then management can be used. Management provides three main advantages in the Z-8000:

1. Since programs are constrained to fit in 64 K bytes or less, a 16 bit address is sufficient instead of the 24 bits required to address 16 M bytes. This obviously leads to a more compact and efficient code.

2. Programs residing in segments are mapped into what is known as logical or virtual address space. Virtual addresses are simply the addresses of locations in a segment from hexadecimal 0000 to FFFF. They are called virtual because they are relative only to the start of their segment and need not bear any relation to the actual physical addresses in the memory circuitry. Programs in segments are thus totally relocatable, needing only to inform the memory management device of the physical starting address of the particular segment. Figure 4 demonstrates this principle. Note that consecutive segments need not appear consecutively mapped into physical memory and also that segments may overlap physical memory.

3. Segmenting easily provides for memory protection. Since the memory management device knows the length of each segment, any attempt by a user task to access physical memory outside of its segment causes a segment violation and a software interrupt to the operating system. This is very useful when running a time-sharing system or debugging a new program.

The memory management device works simply by adding a constant base address for each segment to any memory references issued by that segment. The device in the Z-8000 also checks a number of conditions such as system versus user state, code versus data, read write versus read only, and valid base address in addition to the segment size. If any mismatches or faults occur, the operating system is informed.

Text continued on page 91
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  b. Word pattern sensitivity.
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- Organized in 8 independently addressable 4K byte increments at 4K boundaries.

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Table 1: Summary of the Z-8000 instruction set, slightly condensed.

The instruction set table is somewhat abridged due to space considerations. For example, almost all data manipulation type instructions (i.e., data transfers, or arithmetic) have associated forms for the handling of byte length and long word length operands. The mnemonic for an alternate length operand is created by appending a B (for byte) or an L (for long word) to the standard op code mnemonic. For example, a byte length COMPARE (CP) would be CP B = CBP.

**Operands**
- **b** - bit number
- **CC** - condition code
- **CTR** - a control register
- **dst** - destination
- **FLGR** - flag register
- **int** - any interrupt enable bit
- **src** - source

**Addressing Modes**
- **BA** - base address
- **BX** - base index
- **DA** - direct address
- **IM** - immediate
- **IR** - indirect register
- **RA** - relative address
- **X** - index

**Miscellaneous**
- SBC = Subtract with carry
- SUB = Subtract
- R = immediate

### Loads and Exchanges

<table>
<thead>
<tr>
<th>Op code</th>
<th>Operands</th>
<th>Operation</th>
<th>Addressing Modes</th>
<th>SBC</th>
<th>R,src</th>
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<td>CLR dst</td>
<td>dst</td>
<td>Clear dst-0</td>
<td>R,IR,DA,X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EX src</td>
<td>R,src</td>
<td>Exchange</td>
<td>R,IR,DA,X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LD src</td>
<td>R,src</td>
<td>Load src to dst</td>
<td>R,IR,DA,X,IM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LD dst,R</td>
<td>R,src</td>
<td>Load to dst</td>
<td>BA,DX,RA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LD dst,IM</td>
<td>dst,IM</td>
<td>Load to memory immediate</td>
<td>R,IR,DA,X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LDA src</td>
<td>R,src</td>
<td>Load address</td>
<td>DA,BA,DX,RA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LDM src,n</td>
<td>IR,DA,X</td>
<td>Load multiple memory to register</td>
<td>IR,DA,X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LDM dst,R,n</td>
<td>R,src</td>
<td>Load multiple register to memory</td>
<td>R,IR,DA,X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>POP dst,IR</td>
<td>IR,src</td>
<td>Pop dst-IR (autoincrement)</td>
<td>R,IR,DA,X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PUSH src</td>
<td>IR,src</td>
<td>Push (autoincrement)</td>
<td>R,IR,DA,X,IM</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Arithmetic

<table>
<thead>
<tr>
<th>Op code</th>
<th>Operands</th>
<th>Operation</th>
<th>Addressing Modes</th>
<th>SBC</th>
<th>R,src</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADC src</td>
<td>R,src</td>
<td>Add with carry</td>
<td>R = R + src + carry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADD src</td>
<td>R,src</td>
<td>Add</td>
<td>R = R + src</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CP</td>
<td>R,src</td>
<td>Compare</td>
<td>R = src</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CP dst,IM</td>
<td>dst,IM</td>
<td>Compare memory with immediate</td>
<td>IR,DA,X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DAB dst</td>
<td>dst</td>
<td>Decrement by n</td>
<td>dst-1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DEC dst,n</td>
<td>dst,n</td>
<td>Decrement by n</td>
<td>dst-n</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DIV src</td>
<td>R,src</td>
<td>Divide (signed)</td>
<td>R_{n+1} = (R_n, R_{n+1}/src</td>
<td>R_{n+1}, remainder</td>
<td></td>
</tr>
<tr>
<td>EXTS dst</td>
<td>dst</td>
<td>Extend sign</td>
<td>R = IR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INC dst,n</td>
<td>dst,n</td>
<td>Increment by n</td>
<td>dst+n</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MULT src</td>
<td>R,src</td>
<td>Multiply (signed)</td>
<td>R = R_{n+1} = (R_{n+1} x src + R_{n+1})</td>
<td>R,IR,DA,X,IM</td>
<td></td>
</tr>
<tr>
<td>NEG dst</td>
<td>dst</td>
<td>Negate</td>
<td>dst-0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

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Circle 286 on inquiry card.
NEW!

"INDUSTRIAL" WIRE-WRAPPING TOOL

MODEL BW928

$49.95

BATTERIES NOT INCLUDED
BIT & SLEEVE NOT INCLUDED

BATTERY OPERATED
(2) Standard "C" Ni Cad Batteries (not included)

INTERCHANGEABLE BITS & SLEEVES
(not included)

REVERSIBLE ROTATION
For unwrapping, reverse batteries

BACKFORCE OPTIONAL
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*LEXAN™ Housing

*LEXAN™ GENERAL ELECTRIC

OK MACHINE & TOOL CORPORATION
3455 Conner St., Bronx, N.Y. 10475 • (212) 994-6600 • TELEX 125091
Table 1, continued:

**Bit Manipulation**

<table>
<thead>
<tr>
<th>Op code</th>
<th>Operands</th>
<th>Operation</th>
<th>Addressing Modes</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIT</td>
<td>b,dst</td>
<td>Test bit static Z flag — NOT dstn.</td>
<td>R,IR,DA,X</td>
</tr>
<tr>
<td>BIT</td>
<td>R,dst</td>
<td>Test bit dynamic Z flag — NOT dstR.</td>
<td>R</td>
</tr>
<tr>
<td>RES</td>
<td>b,dst</td>
<td>Reset bit static dstn = 0.</td>
<td>R,IR,DA,X</td>
</tr>
<tr>
<td>RES</td>
<td>R,dst</td>
<td>Reset bit dynamic dstR = 0.</td>
<td>R</td>
</tr>
<tr>
<td>SET</td>
<td>b,dst</td>
<td>Set bit static dstn = 1.</td>
<td>R,IR,DA,X</td>
</tr>
<tr>
<td>SET</td>
<td>R,dst</td>
<td>Set bit dynamic dstR = 1.</td>
<td>R</td>
</tr>
<tr>
<td>TSET</td>
<td>dst</td>
<td>Test and set S flag — sign of dst dstn = All &quot;1s.&quot;</td>
<td>R,IR,DA,X</td>
</tr>
</tbody>
</table>

**Rotate and Shift**

<table>
<thead>
<tr>
<th>Op code</th>
<th>Operands</th>
<th>Operation</th>
<th>Addressing Modes</th>
</tr>
</thead>
<tbody>
<tr>
<td>RLD8</td>
<td>R,src</td>
<td>Rotate digit left.</td>
<td>R,IR,DA,X</td>
</tr>
<tr>
<td>RRDB</td>
<td>R,src</td>
<td>Rotate digit right.</td>
<td>R</td>
</tr>
<tr>
<td>RL</td>
<td>dst,n</td>
<td>Rotate left by n</td>
<td>R,IR,DA,X</td>
</tr>
<tr>
<td>RLC</td>
<td>dst,n</td>
<td>Rotate left through carry by n</td>
<td>R</td>
</tr>
<tr>
<td>RR</td>
<td>dst,n</td>
<td>Rotate right by n</td>
<td>R</td>
</tr>
<tr>
<td>RRC</td>
<td>dst,n</td>
<td>Rotate right through carry by n</td>
<td>R</td>
</tr>
<tr>
<td>SDA</td>
<td>dst,R</td>
<td>Shift dynamic arithmetic</td>
<td>R</td>
</tr>
<tr>
<td>SD</td>
<td>dst,R</td>
<td>Shift dynamic logical</td>
<td>R</td>
</tr>
<tr>
<td>SLA</td>
<td>dst,n</td>
<td>Shift left arithmetic by n</td>
<td>R</td>
</tr>
<tr>
<td>SLL</td>
<td>dst,n</td>
<td>Shift left logical by n</td>
<td>R</td>
</tr>
<tr>
<td>SRA</td>
<td>dst,n</td>
<td>Shift right arithmetic</td>
<td>R</td>
</tr>
<tr>
<td>SRL</td>
<td>dst,n</td>
<td>Shift right logical by n</td>
<td>R</td>
</tr>
</tbody>
</table>

**Block Transfer and String Manipulation**

<table>
<thead>
<tr>
<th>Op code</th>
<th>Operands</th>
<th>Operation</th>
<th>Addressing Modes</th>
</tr>
</thead>
<tbody>
<tr>
<td>CF DR</td>
<td>Rx,src,Ry,CC</td>
<td>Compare and decrement Rx = src Autodecrement src Ry = Ry - 1.</td>
<td>IR</td>
</tr>
<tr>
<td>CPDR</td>
<td>Rx,src,Ry,CC</td>
<td>Compare, decrement and repeat Rx = src Autodecrement src Ry = Ry - 1.</td>
<td>R</td>
</tr>
<tr>
<td>CP I</td>
<td>Rx,src,Ry,CC</td>
<td>Compare and increment Rx = src Autodecrement src Ry = Ry - 1.</td>
<td>IR</td>
</tr>
<tr>
<td>CPIR</td>
<td>Rx,src,Ry,CC</td>
<td>Compare, increment and repeat Rx = src Autodecrement src Ry = Ry - 1.</td>
<td>IR</td>
</tr>
<tr>
<td>CPSD</td>
<td>dst,src,R,CC</td>
<td>Compare string and decrement dst = src Autodecrement dst and src Ry = Ry - 1.</td>
<td>IR</td>
</tr>
<tr>
<td>CPSDR</td>
<td>dst,src,R,CC</td>
<td>Compare string, decrement and repeat dst = src Autodecrement dst and src Ry = Ry - 1.</td>
<td>IR</td>
</tr>
<tr>
<td>CPSI</td>
<td>dst,src,R,CC</td>
<td>Compare string and increment dst = src Autodecrement dst and src Ry = Ry - 1.</td>
<td>IR</td>
</tr>
</tbody>
</table>

**Input Output**

<table>
<thead>
<tr>
<th>Op code</th>
<th>Operands</th>
<th>Operation</th>
<th>Addressing Modes</th>
</tr>
</thead>
<tbody>
<tr>
<td>IN</td>
<td>R,src</td>
<td>Input</td>
<td>IR,DA</td>
</tr>
<tr>
<td>IND</td>
<td>dst,src,R</td>
<td>Input and decrement dst = src Autodecrement dst R = R - 1.</td>
<td>IR</td>
</tr>
<tr>
<td>INDR</td>
<td>dst,src,R</td>
<td>Input, decrement and repeat dst = src Autodecrement dst R = R - 1.</td>
<td>IR</td>
</tr>
<tr>
<td>INI</td>
<td>dst,src,R</td>
<td>Input and increment dst = src Autodecrement dst R = R - 1.</td>
<td>IR</td>
</tr>
<tr>
<td>INIR</td>
<td>dst,src,R</td>
<td>Input, increment and repeat dst = src Autodecrement dst R = R - 1.</td>
<td>IR</td>
</tr>
<tr>
<td>OUT</td>
<td>dst,R</td>
<td>Output</td>
<td>IR,DA</td>
</tr>
<tr>
<td>OUTD</td>
<td>dst,R</td>
<td>Output and decrement dst = src Autodecrement dst R = R - 1.</td>
<td>IR</td>
</tr>
<tr>
<td>OTDR</td>
<td>dst,src,R</td>
<td>Output, decrement and repeat dst = src Autodecrement dst R = R - 1.</td>
<td>IR</td>
</tr>
</tbody>
</table>
SYM-1, 6502-BASED MICROCOMPUTER

- FULLY-ASSEMBLED AND COMPLETELY INTEGRATED SYSTEM that's ready-to-use
- ALL LSI IC's ARE IN SOCKETS
- 26 DOUBLE-FUNCTION KEYPAD INCLUDING UP TO 24 "SPECIAL" FUNCTIONS
- EASY-TO-VIEW 6-DIGIT HEX LED DISPLAY
- KI M-1* HARDWARE COMPATIBILITY

The powerful 6502 8-Bit MICROPROCESSOR whose advanced architectural features have made it one of the largest selling "micros" on the market today.

- THREE ON-BOARD PROGRAMMABLE INTERVAL TIMERS available to the user, expandable to five on-board.
- 4K BYTE ROM RESIDENT MONITOR and Operating Programs.
- Single 5 Volt power supply is all that is required.
- 1K BYTES OF 2114 STATIC RAM onboard with sockets provided for immediate expansion to 4K bytes onboard, with total memory expansion to 65,536 bytes.

USER PROM/ROM: The system is equipped with 3 PROM/ROM expansion sockets for 2316/2332 ROMs or 2716 EPROMs

- ENHANCED SOFTWARE with simplified user interface
- STANDARD INTERFACES INCLUDE:
  - Audio Cassette Recorder Interface with Remote Control (Two modes: 135 Baud KIM-1* compatible, Hi-Speed 1500 Baud)
  - Full duplex 20mA Teletype Interface
  - System Expansion Bus Interface
  - TV Controller Board Interface
  - CRT Compatible Interface (RS-232)

APPLICATION PORT: 15 Bi-directional TTL Lines for user applications with expansion capability for added lines

EXPANSION PORT FOR ADD-ON MODULES (51 I/O lines included in the basic system)

SEPARATE POWER SUPPLY connector for easy disconnect of the d-c power

AUDIBLE RESPONSE KEYPAD

QUALITY EXPANSION BOARDS DESIGNED SPECIFICALLY FOR KIM-1, SYM-1 & AIM 65

These boards are set up for use with a regulated power supply such as the one below, but, provisions have been made so that you can add onboard regulators for use with an unregulated power supply, but, because of unreliability, we do not recommend the use of onboard regulators. All I.C.'s are socketed for ease of maintenance. All boards carry full 90-day warranty.

All products that we manufacture are designed to meet or exceed industrial standards. All components are first quality and meet full manufacturer's specifications. All this and an extended burn-in is done to reduce the normal percentage of field failures by up to 75%. To you, this means the chance of inconvenience and lost time due to a failure is very rare; but, if it should happen, we guarantee a turn-around time of less than forty-eight hours for repair.

Our money back guarantee: If, for any reason you wish to return any board that you have purchased directly from us within ten (10) days after receipt, complete, in original condition, and in original shipping carton; we will give you a complete credit or refund less a $10.00 restocking charge per board.

VAK-1 8-SLOT MOTHERBOARD

This motherboard uses the KIM-4* bus structure. It provides eight (8) expansion board sockets with rigid card cage. Separate jacks for audio cassette, TTY and power supply are provided. Fully buffered bus.

VAK-1 Motherboard $129.00

VAK-2/4 16K STATIC RAM BOARD

This board using 2714 RAMs is configured in two (2) separate addressable 8K blocks with individual write-protect switches.

VAK-2 16K RAM Board with only 8K of RAM (1/2 populated) $239.00
VAK-3 Complete set of chips to expand above board to 16K $175.00
VAK-4 Fully populated 16K RAM $379.00

VAK-5 2708 EPROM PROGRAMMER

This board requires a +5 VDC and ±12 VDC, but has a DC to DC multiplier so there is no need for an additional power supply. All software is resident on board-ROM, and has a zero-insertion socket.

VAK-5 2708 EPROM Programmer $269.00

VAK-6 EPROM BOARD

This board will hold 8K of 2708 or 2758, or 16K of 2716 or 2736 EPROMs. EPROMs not included.

VAK-6 EPROM Board $129.00

VAK-7 COMPLETE FLOPPY-DISK SYSTEM (May '79)

VAK-8 PROTOTYPING BOARD

This board allows you to create your own interfaces to plug into the motherboard. Etched circuitry is provided for regulators, address and data bus drivers; with a large area for either wire-wrapped or soldered IC circuitry.

VAK-8 Prototyping Board $49.00

POWER SUPPLIES

ALL POWER SUPPLIES are totally enclosed with grounded enclosures for safety, AC power cord, and carry a full 2-year warranty.

FULL SYSTEM POWER SUPPLY

This power supply will handle a microcomputer and up to 65K of our VAK-4 RAM. ADDITIONAL FEATURES ARE: Over voltage Protection on 5 volts, fused, AC on/off switch. Equivalent to units selling for $225.00 or more.

Provides +5 VDC @ 10 Amps & ±12 VDC @ 1 Amp

VAK-EPS Power Supply $125.00

*KIM is a product of MOS Technology

2967 W. Fairmount Avenue
Phoenix AZ. 85017
(602)265-7564

Prices in effect Nov. '78

BYTE March 1979 89
### Table 1, continued:

<table>
<thead>
<tr>
<th>Opcode</th>
<th>Addressing</th>
<th>Functions</th>
<th>Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>OUTI dst,src,R</td>
<td>Special output, increment and repeat</td>
<td>dst = src</td>
<td>IR</td>
</tr>
<tr>
<td>OTIR dst,src,R</td>
<td>Autoincrement dst</td>
<td>R = R - 1,</td>
<td>IR</td>
</tr>
<tr>
<td>SINB dst,src</td>
<td>Special input</td>
<td>R = src,</td>
<td>DA</td>
</tr>
<tr>
<td>SINDB dst,src,R</td>
<td>Special input and decrement</td>
<td>dst = src</td>
<td>IR</td>
</tr>
<tr>
<td>SINIRB dst,src,R</td>
<td>Special input, increment and repeat</td>
<td>dst = src</td>
<td>IR</td>
</tr>
<tr>
<td>SOUTB dst,src</td>
<td>Special output</td>
<td>dst = src</td>
<td>DA</td>
</tr>
<tr>
<td>SOUTDB dst,src,R</td>
<td>Special output and decrement</td>
<td>dst = src</td>
<td>IR</td>
</tr>
<tr>
<td>SOTIRB dst,src,R</td>
<td>Autoincrement dst</td>
<td>R = R - 1,</td>
<td>IR</td>
</tr>
<tr>
<td>SOTDRB dst,src,R</td>
<td>Special output, decrement and repeat</td>
<td>dst = src</td>
<td>IR</td>
</tr>
<tr>
<td>SOUTIB dst,src,R</td>
<td>Special output and increment</td>
<td>dst = src</td>
<td>IR</td>
</tr>
</tbody>
</table>

#### Z-8000 Peripheral Support Circuits

<table>
<thead>
<tr>
<th>Name</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z-MBU</td>
<td>Microprocessor buffer unit for high speed elastic buffering between processors, and processors and peripherals. Organized in a 256 by 8 bit FIFO (first in first out) configuration. Can be used to interface Z-Bus systems to most other microprocessors.</td>
</tr>
<tr>
<td>Z-FIFO</td>
<td>First in first out buffer memory provides expansion of the Z-MBU to 16 bit words and any depth.</td>
</tr>
<tr>
<td>Z-CIO</td>
<td>Counter/timer and parallel I/O circuit contains three counter/timers and three parallel ports. Two of the parallel ports are eight bits wide and provide four handshaking modes, including IEEE-488 instrument bus protocol. The third port is four bits wide. The counters are all 16 bits wide.</td>
</tr>
<tr>
<td>Z-SIO</td>
<td>Serial I/O circuit contains two independent full duplex synchronous/asynchronous receiver/transmitters (USARTs). Each data channel contains full modem controls, programmable clock generator, and parity or CRC error code generation and checking.</td>
</tr>
<tr>
<td>Z-UPC</td>
<td>Universal peripheral controller is a Z-Bus compatible version of Zilog's new Z-8 8 bit microcomputer on a chip. It includes 124 general purpose registers, 2 K of masked read only memory, an internal UART, and two counter/timers.</td>
</tr>
<tr>
<td>Z-Bus RAM</td>
<td>There are two versions of these programmable memory circuits which directly interface to the Z-Bus. Both are organized as byte-wide structures to reduce the complexity of small, local memory design.</td>
</tr>
<tr>
<td>Z-MBU</td>
<td>4 K by 8 pseudostatic programmable memory has internal and transparent refresh circuitry. Its access time is in the range of 200-300 ns.</td>
</tr>
<tr>
<td>Z-SIO</td>
<td>2 K by 8 fully static programmable memory has access times below 150 ns.</td>
</tr>
</tbody>
</table>
Table 2: Comparison of the Z-8000 to several popular processors in the performance of several simple tasks.

<table>
<thead>
<tr>
<th>Task</th>
<th>Z-8000&lt;sup&gt;1&lt;/sup&gt;</th>
<th>8080A-1&lt;sup&gt;2&lt;/sup&gt;</th>
<th>Z-80A&lt;sup&gt;3&lt;/sup&gt;</th>
<th>LSI-11&lt;sup&gt;4&lt;/sup&gt;</th>
<th>PDP 11/45&lt;sup&gt;5&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load Byte</td>
<td>0.75</td>
<td>1.6</td>
<td>1.0</td>
<td>2.95</td>
<td>0.90</td>
</tr>
<tr>
<td>(Register to Register)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(A register in Z-80, 8080)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load Word</td>
<td>2.25</td>
<td>5.12</td>
<td>4.0</td>
<td>5.6</td>
<td>2.86</td>
</tr>
<tr>
<td>(Memory to Register)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(to HL in Z-80, 8080)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Add (16 bit)</td>
<td>2.25</td>
<td>9.61&lt;sup&gt;6&lt;/sup&gt;</td>
<td>5.25&lt;sup&gt;7&lt;/sup&gt;</td>
<td>6.3</td>
<td>2.86</td>
</tr>
<tr>
<td>Multiply (16 bit)</td>
<td>17.50</td>
<td>-</td>
<td>-</td>
<td>27 – 64</td>
<td>5.64</td>
</tr>
</tbody>
</table>

Notes:
1. 4 MHz clock, no memory wait, no refresh; data from Zilog Z-8000 advance specification, April 1978.
2. 3.125 MHz clock, no memory wait, no refresh; data from Intel 8080 Microcomputer System Users Manual, 5/75.
3. 4 MHz clock, no memory wait, no refresh; data from Z-80 Reference Manual.
6. BC-(nn)               | LD BC, (MEM)       |
| HL+HL+BC               | ADD HL, BC.        |
7. HL<sup>b</sup>DE     | XCHG               |
| HL<sup>b</sup>(nn)     | LHLD (MEM)         |
| HL+HL+DE               | DAD D.             |

Text continued from page 84

APL machine which could run large application packages such as SPICE for circuit analysis or SPSS for statistics, and solve dynamics equations on line for real time graphics simulations like lunar lander, or very large chess playing programs.

According to sources at Zilog, the Z-8000 and its memory management device support chip will soon be available in large quantity. The Z-8000 is compatible with the already available Z-80 family of support chips such as the SIO (serial I/O), the CTC (timers), and the PIO (parallel I/O), etc. A new series of extended support chips for the Z-8000 is also in the works. So far five LSI peripheral devices and a new memory family have been announced. The text box on opposite page contains a brief description of these new devices. The usual line of microprocessor support products including single board computers, evaluation boards and development systems will also be available. Although details are not available as I write this, the system bus structure will probably be oriented toward high performance multiprocessor systems. As for software, Zilog has announced a disk based development system and the PLZ, BASIC, COBOL, FORTRAN languages. Also there is a Z-80-to-Z-8000 translator. I expect a real time, multitasking and multiprocessing operating system to be available soon in order to take advantage of this processor’s many resources.

Figure 4: Logical to physical address translation using the memory management device. The Z-8000 allows the programmer to make use of virtual memory addresses, which are simply the addresses of locations in a memory segment from hexadecimal 0000 to FFFF. Virtual addresses are relative only to the start of their segment and need not bear any relation to physical addresses in memory. The clever use of virtual memory techniques can yield high-powered programming results.
Inverse Trig Functions

All except the very smallest BASIC interpreters provide sine, cosine, tangent and inverse tangent functions. None, that I am aware of, have the inverse sine or inverse cosine functions. These two functions are very simple to generate using the inverse tangent function. Lines 10 and 20 of listing 1 contain the definition of the inverse sine and inverse cosine, respectively. Lines 30 to 80 contain a driver function for demonstration purposes.

Listing 1:
10 DEF FNSN (X) = ATN (1/SQR(1/(X*X)-1))
20 DEF FNCS (X) = ATN (SQR(1/(X*X)-1))
30 PRINT “A” ;”ARC SIN” ;”SIN” ;”ARC COS” ;”COS”
40 INPUT “ARC”; A
50 B=FNSN(A)
60 C=FNCS(A)
70 PRINT A; B, SIN(B),C,COS(C)
80 GOTO 40

Odd Tones

The following program is entered and run:

L3: MVI A, #$x
L2: MVI B, #$A8 (hex)
L1: DCR B
JNZ L1
DCR A
OUT 00
JNZ L2
JMP L3

By connecting a small speaker (in series with a 220 ohm resistor) between the least significant bit of port 0 and ground, we hear a tone. However, for X equal to an odd number, an audible blip is heard periodically, while for X equal to an even number, no blip is heard at any time. Why is a blip heard for odd Xs only? Try these programs or simply analyze the waveforms, then turn to page 178 for an answer.
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Designing with Double Sided
Printed Circuit Boards

David Lamkins
DBL Electronics
83 Morgan Cir
Amherst MA 01002

Materials Required for Layout Design
Pencils: Red, Blue and Black
Eraser and Pencil Sharpener
Tracing Vellum
Grid
Printed Circuit Design Template
Light Table
Large Scratch Paper Pad
Your Schematic, Integrated Circuit Pinout
Data, etc
Scotch Magic Transparent Tape

Table 1: Materials required for printed circuit board layout.

Figure 1: The author’s design for a homebrew light table used for drawing printed circuit board layouts. A sheet of Plexiglas or other clear plastic illuminated by a lamp is used as the drawing surface.

Magazines for electronic hobbyists sometimes run articles about do-it-yourself printed circuit layout and construction. Unfortunately I never saw an article which presented a unified printed circuit design strategy for large and very large systems (eg: a board with 20 or more integrated circuits).

Consequently, when the time came for me to design the printed circuit boards for a system involving more than 900 semiconductors, with greater than 60 percent of that count being integrated circuits, I didn’t know where to begin.

Determination is the prime motive force in a project that large, so I went ahead and started. Along the way I took notes about what I learned. Using the methods I developed, you should be able to design double sided printed circuits for your own behemoth kluge without undue anger or frustration.

To undertake a large printed circuit project, you should be properly equipped. Simple “pen and ink on grid paper” techniques may be adequate for small boards, but on a larger layout, even with only 20 integrated circuits, you will have an absolute minimum of almost 300 integrated circuit leads. Try drawing that many pads on 0.1 inch centers, not to mention interconnecting traces and associated components, and you will end up in a sobbing heap on your workshop floor.

Table 1 lists the materials necessary to the initial design of your printed circuit layout.

The black pencil will be used to delineate components and pads on your drawing. The red pencil is used to mark conductor runs for the solder side of the board, while the blue pencil marks runs on the component side. A necessary adjunct to the pencils is the eraser and pencil sharpener. Most likely, neither will see as much use as the pencils themselves, but both should be close at hand.

The tracing vellum should be good quality. You will not appreciate tears or holes as a result of the erasing you will be doing.

A grid is essential to good planning. Grids are precision printed on dimensionally stable Mylar and are available in a variety
of styles. Your selection will depend largely on the scale to which you draw your design. The most commonly used scales are 4x, 2x, and 1x. The 4x and 2x scales find wide use commercially, where use of automated manufacturing techniques requires extremely tight tolerances on component positioning. The other advantage of a larger scale is reduced eyestrain. For our purposes, the 1x scale is probably best since materials cost is lowest and the need for photoreduction facilities is alleviated. Therefore, your grid should have 20 lines per inch to allow component placement to the nearest 0.05 inch. You might find a grid with 10 lines per inch adequate, but many lead spacings do not fit exactly on a 0.1 inch grid, and you will quickly tire of trying to visually approximate the halfway mark.

The printed circuit design template helps you draw resistors, capacitors, diodes, transistors, integrated circuits, trimmers and edge fingers accurately and repetitively. Be sure you get the 1x size.

A light table is necessary to light your grid from the back and make the grid lines visible through the vellum. Commercial light tables are available, but they are not inexpensive. A homemade substitute can be as simple as a piece of Plexiglas leaning against a box on a table with an incandescent or fluorescent desk lamp providing the illumination (see figure 1). Should you use an incandescent lamp, a low wattage is recommended to minimize heating of the grid.

A pad of scratch paper should be kept handy for sketching of trial layouts, quick computations, doodles, etc.

I use Scotchbrand Magic transparent tape; it is the only readily available tape I have found that will hold the grid and artwork in place on the light table without oozing or creeping due to the heat of the light.

These materials along with your schematic and related pertinent data are all you need to lay out a printed circuit board.

Table 2 outlines the layout strategies I follow in order of execution by heading, and in order of relative importance by subheading.

Initially, you should study your schematic to identify functional groups of components. Carry this out to as detailed a level as you are able. The procedure will enhance your understanding of the circuit in general as well as the interrelations among subcircuits and the correspondence between circuits and components that influence your design. Additionally, you may be able to define critical areas at this time, such as the need for shielding, isolation, or heat removal. Be sure that all unused logic inputs and nonstandard supply pinouts are explicitly included in your schematic.

Your board interface is a definition of how signals connect to and from the printed circuit board. The interface may be configured as edge connections, solder pads for single leads or ribbon cable, a special connector, or any combination of these. Your system’s physical design may place constraints on the locations of the interface connections. If your system is so large that a single board implementation is impractical, or if your system is being constructed modularly, you should define macrofunctions or subsystems into which your overall system can be partitioned. First, define a system by which individual boards can be interconnected. Then, treating each partition as a complex component, define any requirements for shielding, isolation, or heat removal. You may want to consider using a printed circuit backplane or mother board to make system interconnections (see figure 2). The mother board is a good place to locate your power supply and front panel controls if you want a truly modular system.

Now calculate the board size. An ab-

Table 2: Some printed circuit board layout strategies.

- Divide circuit into functional groups.
- Define board interface.
- Calculate board size.
- Trial position integrated circuits.
  1. Locate analog circuitry close to interface.
  2. Group components by functional groups.
  3. Arrange circuits symmetrically around shared integrated circuits.
  4. Arrange functional groups to minimize number of interconnects.
- Position other Components.
  1. Keep analog traces short with inputs separated from outputs.
  2. Provide supply bypassing at each linear and TTL integrated circuit and at any other circuitry sensitive to supply noise or circuitry generating fast edges.
- Don’t crowd components.
- Route traces.
  1. Shortest runs first.
  2. Runs local to functional group.
  3. Inter-group runs.
  4. Runs to interface.
  5. Power runs last.
- Check spacings.

Avoid blocking power and ground pins.

About the Author

David Lamkins is a twenty-three year old consultant in the analog and digital electronics field, and has been working since 1974 on a digital electronic music system. David’s hobbies also include playing the guitar and reading science fiction.
solute minimum figure can be obtained by calculating the total area occupied by components (table 3). In practice, you will never achieve this minimum figure with a double sided board, but it is helpful to know how much component area you have. A more realistic figure to start with is 2 to 3 square inches per integrated circuit, tending toward the higher side if the board has many discrete components, large passive components, or a large number of edgeboard IO pins. If the board is constrained to be a certain size, you will have to try to make it all fit, although it could be very difficult if you have much less than 2 square inches per integrated circuit.

Now, take a sheet or two from your scratch pad and sketch a few trial arrangements for your integrated circuits. There are several things you should strive for. Most important is to locate any analog circuitry close to its associated board interface. This minimizes any adverse effects due to coupling or feedback that could be caused by long analog lines. Next is the arrangement of components by functional groups. If a multi-
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section integrated circuit is shared by two or more functional groups, try to arrange these groups close to the shared integrated circuit. It is often advantageous to make use of the symmetrical layout of many multisection integrated circuit pinouts. Functional groups should be arranged relative to each other to minimize the number and length of interconnections between groups. If a lot of lines go to an edgeboard connector, try to leave a clear route for them.

Tape the grid to the light table, then tape a sheet of vellum over the grid and proceed to lay out the board. Begin by defining the edges of the board in black pencil. Next, using black pencil and the template, locate the integrated circuits on the board using your best trial sketch as a guide. Leave plenty of space around the integrated circuits, because interconnections can consume a lot of board space.

Try to arrange the integrated circuits in a consistent XY grid to maximize the open paths a trace can follow from here to there. Leave plenty of room around the edges of the board; some of the longer traces are most easily routed there.

Still using template and black pencil, position the discrete components. In analog circuitry, maintain short signal leads and separation between input and output of high gain stages. Be sure to provide adequate bypassing: One bypass capacitor per integrated circuit is not too much. Don't crowd components. Keep in mind that you may need access to integrated circuit pins for servicing, and leave room to adjust trimpots. Also, keep important test points out in the open. Avoid locating small components out of sight below larger, overhanging components, and don't allow components or groups of components to block access to integrated circuit pins. During this process, you may find you'll have to move things around somewhat to fit everything where you want it. This may require some erasing.

Now comes the difficult part. Using red and blue pencils and eraser, draw the traces on the vellum. Red is used for solder-side runs and blue for component-side runs. Trying things out on scratch paper can save you much erasure.

The shortest traces will be those interconnecting the pins of a single integrated circuit to one another. Do these first. Use red whenever possible to minimize the number of component-side runs. You should be able to get this far without creating any connections that start on one side of the board and finish on the other (except via a hole used for a component lead). The next longest runs will be interconnections within a functional group: Do these next. If possible, avoid blocking access to integrated circuit power and ground pins.

Next should be runs connecting functional groups together, followed by runs to the edge-board interface, if used. Somewhere along the way you'll have to start using dedicated through-holes to run signals past areas that are blocked in completely (see figure 3). Depending on the complexity of your circuit, you shouldn't really need more than one or two through-holes per integrated circuit on the board.

As you proceed, you'll want to keep track of the connections made. I usually do this by numbering the integrated circuits on the layout, then marking them on the schematic to correspond. As I make a connection, I mark a slash through the lead on the schematic. For circuitry that uses identical sections repeatedly, I simply copy the first section as required.

The last connections are power and ground to the integrated circuits. The practice of saving these connections until last is uncommon, but it reduces drastically the number of dedicated through-holes on a larger board. It's easier to route two or three runs through a jungle of interconnections than it is to individually reroute each trace of that same jungle to go around two or three power runs. At any rate, the power runs should be heavy enough for the type and amount of logic being used. When working with TTL integrated circuits, be aware that some formidable current transients are coupled to ground; be sure to beef up that trace accordingly. CMOS at low speeds is relatively immune to power supply noise.

In routing some of the longer traces, you may think that access to some places is blocked by runs on both sides of the board. In such a case group all the interconnections in one area on one side of the board and move them in one direction; then move the interconnections on the opposite side of the board in that area in the other direction. You now have a clear space between the two
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groups for routing your connection via a dedicated through-hole (see figure 4a & 4b). At this point, you probably don't want to erase and move all those lines. I use a shorthand method to indicate this rearrangement (see figure 4c).

Once all the traces are drawn in place, make sure you have enough room to route traces through the crowded spots. Signal traces can be as narrow as 0.015 inch, in fact, you will find this width very easy to work with because tape in this width is extremely flexible. Spacings of 0.050 inch between conductors are easy to achieve. Avoid, if possible, running conductors closer than 0.1 inch to pads where no connection is intended. Leave at least 0.1 inch between a trace and the board edge. If you find you will have too little room for traces in a given area, calculate how much related components will need to move and mark the distance and direction on the vellum.

Congratulations! You now have a design that will be the basis of your tape-on-Mylar artwork master. Table 4 lists those materials necessary for the preparation of the artwork master.

Mylar drafting film comes in sheets and rolls. The price advantage of buying in roll form is slight and the curl of sheets cut from a roll is a nuisance at best.

Black donut pads come 500 to a pack. The 0.093 inch size will work for almost everything, but it's nice to have 0.075 inch pads on hand for the finer leads of transistors and diodes plus 0.111 inch pads to connect lead wires to the board.

I use three tape widths for most of my designs. The 0.015 inch width finds the greatest use. Power and ground runs usually use 0.040 inch or 0.062 inch widths.

Integrated circuit patterns are worth every penny for the time they save. If your requirements are modest, buy just one pack of 16 lead DIP patterns. These can be cut down to make 14 or 8 lead DIP patterns, and they can be split down the middle and arranged to make 24, 28, or 40 lead DIP patterns. Round 8, 10, or 12 lead TO-5 patterns can be accommodated by bending the device leads to fit DIP spacing. I find the 0.075 inch round pad style most suitable. Check the catalogs of the sources listed at the end of this article; many styles are available.

Targets come 250 per package, and, although expensive, are absolutely essential to assure accurate alignment of the three or four layers of artwork.

A drafting pen is used with the printed circuit design template to make an assembly drawing of your board. It will cost about $7.50 at an art supply store and is truly a joy to own.

Remove your vellum layout sheet from the light table and keep it nearby. Securely tape a Mylar sheet over the grid. Locate two targets in diagonally opposite corners of the Mylar and carefully align the centers with a grid intersection. The targets may be located inside or outside of the board area. If located within the board area, they can
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Figure 5: Two techniques for applying drafting tape around corners. Figure 5a shows the preferred method for narrow traces; figure 5b shows the technique for wide traces.

Table 5: Recommended drill sizes for drilling standard printed circuit board pad holes.

<table>
<thead>
<tr>
<th>Pad Size</th>
<th>Drill Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.075 inch pad</td>
<td>#71 drill</td>
</tr>
<tr>
<td>0.093 inch pad</td>
<td>#64 drill</td>
</tr>
<tr>
<td>0.111 inch pad</td>
<td>#55 drill</td>
</tr>
<tr>
<td>0.125 inch pad</td>
<td>1/16 inch drill</td>
</tr>
</tbody>
</table>

double later as mounting holes. Define the board edges with short pieces of tape at the board’s corners.

Now, working with a ruler marked in tenths of an inch and your vellum layout, transfer the component and through-hole locations to the Mylar using donut pads and stick-ons. Be sure to take into account the shifts notated as the last step of the layout preparation. Once all the components and through-holes appear as pad groups on the Mylar, align the vellum over the Mylar and check for missing or misplaced pads. This sheet now contains all the component pads that will appear on both sides of the board. Remove the vellum.

Tape a second sheet of Mylar directly over the first. Align targets with those on the first sheet. Using black tape, transfer all the lines appearing in red on the vellum to this sheet of Mylar. Take heed of any notes on the vellum to shift traces from their indicated positions. Narrow tapes are best routed directly with gentle corners where necessary. Wider tapes do not curve as easily and require cut corners for sharp bends (see figure 5). This sheet now contains all traces located on the solder side of the board. There are no pads on this sheet. The same procedure is followed using a third Mylar sheet and the blue lines for the component side traces.

For the sake of completeness, you should now make an assembly drawing on a fourth layer of Mylar sheet. This is done using the template by inking the component outlines aligned with their respective pads. The component designation or value should be included within or beside the outline using pen and ink or dry transfer lettering.

Your master artwork is now complete and should be rechecked for accuracy.

To make artwork is now complete and should be rechecked for accuracy.

To make negatives of solder-side and component-side artwork for use in photographically etching your board, simply align the Mylar sheet containing only pads with either of the sheets containing only traces before making a contact negative. The details of the negative-producing operation are well covered in the hobbyist magazines, and most local electronics stores sell printed circuit board etching kits.

You now have a negative for each side of your printed circuit board. Before coating your board with photoresist, pick two holes near diagonally opposite corners and accurately transfer their locations to the laminate. Use a very small drill to make these two holes. You now have reference points by which you can align the negative on each side of the board. The board is now photo etched on both sides.

All that remains is to drill the holes, mount the components, and solder the leads. Table 5 shows recommended drill sizes for various sizes of pads. When mounting components, crimp the leads flat against the solder side. Dedicated through-holes are stuffed with a short piece of wire crimped to the board on both sides. Solder leads on both sides of the board where necessary for through-board connections. As an alternative to soldering on both sides, you can crimp eyelets in the holes or get someone to process your board with plated through-holes.

Well, that’s all there is to it. Now you can put that very large project of yours on a printed circuit board. (The very first printed circuit board I ever designed had 26 integrated circuits, 144 resistors, 44 capacitors, 28 transistors, 30 diodes, and 23 indicators. I completed the master artwork using the techniques I have just described in less than 40 hours.) A homebrew double sided printed circuit board may be just the solution you’re looking for.!!

Sources of printed circuit board artwork supplies:

1. Bishop Graphics Inc.
   20450 Plummer St
   Chatsworth CA 91311
   (213) 993-1000

2. Chartpak Graphic Products
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- TARBECK VDM or ADM3A cassette version: interfaced to the APPLE monitor (8080A version of ZAPPLE) and VDM board or the Lear Siegler ADM3A terminal.
- CP/M 8" single density floppy disk VDM version or ADM3A version.
- CP/M 5½" MICROPOLIS floppy disk VDM version or ADM3A version.
- CP/M 5½" NORTH*STAR floppy disk VDM version or ADM3A version.

IMPORTANT NOTE:

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TOP Text Output Processor — Creates paginated, justified documents from source text files. Available only as part of A3 or A3+ package.

- SUPER BASIC — Sub-set of Xitan Disk BASIC with extensive arithmetic and string features but without random access data file support. Available optionally with features to support XDB Xitan video output board.

- A3 package includes Z-TEL, TOP, ASM and Super BASIC

- A3+ package includes Disk BASIC, Z-TEL, TOP, ASM, Z-BUG and LINKER

MICROPRO

- Super Sort I — Sort, merge, extract utility as absolute executable program or linkable module in Microsoft format. Sorts fixed or variable length files. Supports global and intra-line chaining. Can be saved on disk for re-use.

- Super Sort II — Available as absolute program only.

- Super Sort III — As II without SELECT/EXCLUDE.

- ISAM — Callable system with triple level index full ANSI level II COBOL capability. Utility included to convert existing sequential files to ISAM.

- Word Master Text Editor — In one mode has super-set of CP/M's ED commands including global searching and replacing, forward and backwards in file. In video mode, provides full screen editor for users with terminal addressable cursor terminal.

- Corresponder — Mail list system. Supporting form letter generation with personalized greetings, Reference fields permit sorting and extraction by name, address fields or reference data using Super Sort. Requires CBASIC.

- BASIC/S — Microsoft BASIC with Super Sort Capability

- FORTRAN/S — Microsoft FORTRAN with Super Sort Capability

- COBOL/S — Microsoft COBOL with Super Sort capability

SOFTWARE SYSTEMS

- CBASIC Disk Extended BASIC — Non-interactive BASIC with pseudo-code compiler and runtime interpreter. Supports full file control, chaining, integer and extended precision variables etc. Version 1 users can receive Version 2 and new manual for $45 with return of original diskette.

- Accounts Receivable — Open item system with output for internal aged reports and customer-oriented statement and billing purposes. On-Line Enquiry permits information for Customer Service and Credit departments. Interface to General Ledger provided if both systems used. Requires CBASIC.

- NAD Name and Address selection system — Interactive mail list creation and maintenance program with output as full reports with reference data or restricted information for mail labels. Transfer system for extraction and transfer of selected records to create new files. Requires CBASIC.

SOFTWARE SYSTEMS

- Structured Systems Group

- General Ledger — Interactive and flexible system providing proof and report outputs. Customization of COA created interactively. Multiple branch accounting centers. Extensive checking performed at data entry for proof, COA correctness etc. Journal entries may be batched prior to posting. Closing procedure automatically backs up input files. All reports can be tailored as necessary. Requires CBASIC.

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MORE COMPANIES JUMPING ON THE PASCAL BANDWAGON. The list of computer manufacturers committing themselves to support Pascal on their systems is growing rapidly. The list now includes American Microsystems (AMI) on their 6800 based system, Western Digital Corp on their 16 bit Pascal oriented microprocessor, National Semiconductor on their SC/MP-II, General Automation on their 16 bit microprocessor, Apple on their 8 bit microcomputer and, soon, Intel, on their 8080/8085 development system.

INTEL, TEXAS INSTRUMENTS AND IBM MAKE MEMORY NEWS. Intel has again beat its competitors to the marketplace with a new product. This time it is the 32 K byte programmable read only memory, called the 2732, following in the footsteps of the 2716 and the 2708. It is pin compatible with the 2716 16 K erasable byte read only memory, and is organized as 4 K by 8 bit words. It has a 450 ns access time and operates from a single 5 V power supply. Further, a separate chip-enable input reduces power dissipation by 80 percent (from 150 mA to 30 mA) when the device is not selected. The single unit price is $147.30 and drops to $91.65 in quantity. Intel claims the 2732 is now available in production quantities.

Texas Instruments has been sampling their new 64 K bit dynamic programmable memory (TMS 4164) since last fall to selected customers and expects to be in quantity production by the last quarter of this year. Motorola also recently began sampling their 64 K bit programmable memory and hopes to be in production by year-end (initial price is $130).

IBM, at a recent International Electron Devices meeting, disclosed that they had made an experimental MOS gate with channel lengths of 1.3 to 1.0 micrometers. This represents a significant breakthrough in very large scale integrated (VLSI) circuit technology. Using this technology it is now possible to build a 256 K bit memory part. Further, IBM reports that these devices have switching times of 230 picoseconds, which is three to four times faster than previous MOS circuits, and dissipate one tenth the power.

BUBBLE MEMORIES INCREASING IN AVAILABILITY. Texas Instruments and Rockwell are currently the only two manufacturers of bubble memories and their maximum size devices are only 256 K bits. National Semiconductor is expected to start sampling their 256 K device later this year. Also, look for Intel to enter the market before year-end. However, prices are still very high, compared to disk storage technology, and production is still very limited. Don't look for their use in microcomputers until the early 1980s, when bit capacity is up in the megabyte size and competition develops. Currently, bubble memories are being used in applications where the electro-mechanical disk systems are not rugged enough.

FLOPPY DISK IMPROVEMENTS COMING. Floppy disks are going to be with us for some time to come. It is expected that next year will see the introduction of 5 to 10 M byte floppy disks due to higher track density. This will be made possible by having the disk supply its own track positioning data and by improvements in media technology, allowing for narrower tracks. 5 inch floppies will be expanded to the 1 to 2 M byte range, per disk. Projections for 1980 are that bubble memory will drop to 0.1 cent per bit while disk will cost 0.0001 cent per bit. Further, projections are for bubble memory prices to drop to only 0.02 cent per bit by 1985.

In the meantime, floppy disks, first introduced in 1973, saw sales of close to 270,000 units last year with sales for this year expected to be over 350,000.

FLAT SCREEN TERMINALS ARE COMING. General Telephone and Electronics (GT&E) has announced that they are far along in development of a flat screen display using cathodoluminescence. They are working on it jointly with Lucitron Inc. GT&E predicts that the display will be in production by 1981 at the latest. A color display, using the same technique, is also being developed. The system will permit large displays, up to 50 inches (127 cm, measured diagonally) and approximately three inches thick. The Lucitron panels use a "self-scanning" system which does not require complex drive circuitry. The initial display panels will be used for computer terminals, with television type displays, providing good gray scale, following a year or two later.

APL ON A MICROCOMPUTER FOR $2000 AVAILABLE SOON. APL buffs waiting patiently for a home APL system will finally get their dream. Alan Rose, of Scientific Time-Sharing Corp, considered one of the APL authorities, reports that he and a small company called Quark will soon introduce a microcomputer system dedicated to APL. It will run the full APL language, as implemented by IBM and Scientific Time-Sharing Corp. It will be easily expandable in I/O and peripheral mass storage and will execute two to four times faster than the IBM 5100 APL machine. The unit, which will use the Intel 8086 16 bit processor, will contain its own keyboard and display and can be used in either a stand-alone mode or as an intelligent APL terminal to a host system. The best news is that the system price will start at only $2000. Look for availability this summer.
Although several "tiny APL" interpreters have been brought out for microcomputers, and IBM has a micro-APL in their 5100 desktop computer, these implementations have left a great deal to be desired. Vanguard Systems in Austin TX has available an excellent Z-80 APL interpreter which we understand will be licensed soon to one or more computer manufacturers. Microsoft had advertised their version of APL for some time, but as far as we know have not started delivery yet.

FCC TAKING ACTION ON RADIATING COMPUTERS AND GAMES. After severe interference problems that occurred with Citizen's Band radio interference on television sets, the FCC sought to regulate devices which employ radio frequency modulators. This is also the case with computers and electronic games that are connected to standard television sets via radio frequency modulators. Manufacturers are required to submit their units to the FCC for approval and licensing. Passing the standards appears quite difficult and so far only a few units have obtained approval. Several manufacturers have gotten around the problem by providing only video signal output, which means that the user must use a video monitor or TV set with special video input. Some manufacturers have ignored the FCC regulations and sold unlicensed units.

Recently the FCC served a cease-and-desist order on some personal computer system owners because of interference on neighbors sets. The FCC is also talking about imposing marketing sanctions on those companies who fail to meet interconnect qualifications.

PERSONAL COMPUTERS GOING GREAT IN EUROPE. Sales of personal computer systems are going great on the Continent. The Germans report that sales are soaring. An estimated 4000 PET's were sold in 1978, primarily to home users. Commodore is manufacturing the PET in England. Tandy also reports greater than expected sales, but has not disclosed figures. Tandy started selling the TRS-80 last summer through 340 stores. In Germany the TRS-80 (Level I) sells for $935 compared to $595 in the states. The Apple computer is being handled by ITT, who reports excellent sales. The TRS-80 and Apple are manufactured in the USA. Things will change this year as Siemens, one of the largest European electronics manufacturers, will soon announce their own personal computer system.

Interestingly, one of the major sales outlets for personal computer systems has become department stores. Several US department stores have tried selling personal computer systems but have withdrawn.

MICROPROCESSOR MAKERS MOVE INTO COMPUTER SYSTEMS BUSINESS. Integrated circuit manufacturers are going into competition with their customers, the computer systems manufacturers. Texas Instruments was one of the first. They have been selling complete minicomputer systems for several years now. Additionally, they have been selling 16 bit systems using their 9900 processor and now also will soon introduce a personal computer system using the 9900.

National Semiconductor is now selling a large system to replace IBM-370s and will soon offer for sale a microprocessor version of the DEC PDP-11 16 bit computer system. Also, Fairchild will soon sell a system that is compatible with the Data General NOVA computer system.

Zilog late last year introduced their system using the Z-80. It is a business-oriented system and has a full complement of computer languages, including BASIC, FORTRAN and COBOL; business application software packages are also offered. A Z-8000 based system is expected in the fall.

Intel is rumored to be working on a very powerful data base system using an associative processor to handle searching, inserting, deleting, etc, among an array of storage devices and host interfaces. The system will utilize a 16 bit processor and CCD memory that will represent a breakthrough in data base computer technology. Introduction is expected in 1980.

TANDY REVAMPS ITS COMPUTER MARKETING. Early last year Tandy opened a computer store in its Fort Worth TX building complex and also issued a computer catalog. The store and the catalog carried the Radio Shack TRS-80 and a wide variety of products ranging from the IMSAI 8080 to the Video Brain computers. Tandy considered it an experiment. The TRS-80 accounted for 80 percent of the sales. Now Tandy has decided on a new marketing approach. They have already opened five computer stores (Richardson, Dallas and Fort Worth TX, and New York City and Washington DC) and plans to open others soon in Tampa, Atlanta, San Francisco and Los Angeles. Each store will have a classroom and repair facilities.

Further, the stores will carry only three different computer systems. The TRS-80, Tandy-10 and Tandy-150 systems. The Tandy-10 is made for Tandy by Digital Data Systems (DDS) and will have a base price of $8995. Using an 8080, it will have a video display, keyboard, 48 K bytes of programmable memory, two 8 inch floppy disk drives, BASIC and a disk operating system similar to CP/M. The initial order placed by Tandy with DDS was reportedly for 250 systems. The Tandy-150 will be assembled by Tandy and use a Computer Automation 16 bit processor. Starting at $21,995, it will include a 10 M byte hard disk.

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THE BYTE BOOK OF COMPUTER MUSIC combines the best computer music articles from past issues of BYTE Magazine with exciting new material—all written for the computer experimenter interested in this fascinating field.

You will enjoy Hal Chamberlin's "A Sampling of Techniques for Computer Performance of Music", which shows how you can create four-part melodies on your computer. For the budget minded, "A $19 Music Interface" contains practical tutorial information—and organ fans will enjoy reading "Electronic Organ Chips For Use in Computer Music Synthesis".

New material includes "Polyphony Made Easy" and "A Terrain Reader". The first describes a handy circuit that allows you to enter more than one note at a time into your computer from a musical keyboard. The "Terrain Reader" is a remarkable program that creates random music based on land terrain maps.

Other articles range from flights of fancy about the reproductive systems of pianos to Fast Fourier transform programs written in BASIC and 6800 machine language, multi-computer music systems, Walsh Functions, and much more.

For the first time, material difficult to obtain has been collected into one convenient, easy to read book. An ardent do-it-yourselfer or armchair musicologist will find this book to be a useful addition to the library.

SUPERWUMPUS is an exciting computer game incorporating the original structure of the WUMPUS game along with added features to make it even more fascinating. The original game was described in the book What To Do After You Hit Return, published by the People's Computer Company. Programmed in both 6800 assembly language and BASIC, SUPERWUMPUS is not only addictive but also provides a splendid tutorial on setting up unusual data structures (the tunnel and cave system of SUPERWUMPUS forms a dodecahedron). This is a PAPERBYTE book.

TINY ASSEMBLER 6800, Version 3.1 is an enhancement of Jack Emmerichs' successful Tiny Assembler. The original version (3.0) was described first in the April and May 1977 issues of BYTE magazine, and later in the PAPERBYTE book TINY ASSEMBLER 6800 Version 3.0.

In September 1977, BYTE magazine published an article entitled, "Expanding The Tiny Assembler". This provided a detailed description of the enhancements incorporated into Version 3.1, such as the addition of a "begin" statement, a "virtual symbol table", and a larger subset of the Motorola 6800 assembly language. All the above articles, plus an updated version of the user's guide, the source, object and PAPERBYTE bar code formats of both Version 3.0 and 3.1 make this book the most complete documentation possible for Jack Emmerichs' Tiny Assembler.

A walk through this book brings you into Ciarcia's Circuit Cellar for a detailed look at the marvelous projects which let you do useful things with your microcomputer. A collection of more than a year's worth of the popular series in BYTE magazine, Ciarcia's Circuit Cellar includes the six winners of BYTE's Ongoing Monitor Box (BOMB) award, voted by the readers themselves as the best articles of the month: Control the World (September 1977), Memory Mapped IO (November 1977), Program Your Next EROM in BASIC (March 1978), Tune In and Turn On (April 1978), Talk To Me (June 1978), and Let Your Fingers Do the Talking (August 1978).

Each article is a complete tutorial giving all the details needed to construct each project. Using amusing anecdotes to introduce the articles and an easy-going style, Steve presents each project so that even a neophyte need not be afraid to try it.
BASEX, a new compact, compiled language for microcomputers, has many of the best features of BASIC and the 6800 assembly language—and it can be run on any of the 8080 style microprocessors: 8080, Z-80, or 8085. This is a PAPERBYTE™ book.

Subroutines in the BASEX operating system typically execute programs up to five times faster than equivalent programs in a BASIC interpreter—while requiring about half the memory space. In addition, BASEX has most of the powerful features of good BASIC interpreters including array variables, text strings, arithmetic operations on signed 16-bit integers, and versatile I/O communication functions. And since the two languages, BASEX and BASIC, are so similar, it is possible to easily translate programs using integer arithmetic data from BASIC into BASEX.

The author, Paul Warme, has also included a BASEX Loader program which is capable of relocating programs anywhere in memory.

PROGRAMMING TECHNIQUES is a series of BYTE BOOKS concerned with the art and science of computer programming. It is a collection of the best articles from BYTE magazine and new material collected just for this series. Each volume of the series provides the personal computer user with background information to write and maintain programs effectively.

The first volume in the Programming Techniques series is entitled PROGRAM DESIGN. It discusses in detail the theory of program design. The purpose of the book is to provide the personal computer user with the techniques needed to design efficient, effective, maintainable programs. Included is information concerning structured program design, modular programming techniques, program logic design, and examples of some of the more common traps the casual as well as the experienced programmer may fall into. In addition, details on various aspects of the actual program functions, such as hashed tables and binary tree processing, are included.

SIMULATION is the second volume in the Programming Techniques series. The chapters deal with various aspects of specific types of simulation. Both theoretical and practical applications are included. Particularly stressed is simulation of motion, including wave motion and flying objects. The realm of artificial intelligence is explored, along with simulating robot motion with the microcomputer. Finally, tips on how to simulate electronic circuits on the computer are detailed.

RA6800ML: AN M6800 RELOCATABLE MACRO ASSEMBLER is a two pass assembler for the Motorola 6800 microprocessor. It is designed to run on a minimum system of 16 K bytes of memory, a system console (such as a Teletype terminal), a system monitor (such as Motorola MIKBUG read only memory program or the ICOM Floppy Disk Operating System), and some form of mass file storage (dual cassette recorders or a floppy disk).

The Assembler can produce a program listing, a sorted Symbol Table listing and relocatable object code. The object code is loaded and linked with other assembled modules using the Linking Loader LINK68. (Refer to PAPERBYTE™ publication LINK68: AN M6800 LINKING LOADER for details.)

There is a complete description of the 6800 Assembly language and its components, including outlines of the instruction and address formats, pseudo instructions and macro facilities. Each major routine of the Assembler is described in detail, complete with flow charts and a cross reference showing all calling and called-by routines, pointers, flags, and temporary variables.

In addition, details on interfacing and using the Assembler, error messages generated by the Assembler, the Assembler and sample I/O driver source code listings, and PAPERBYTE™ bar code representation of the Assembler's relocatable object file are all included.

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LINK68: AN M68000 LINKING LOADER is a one pass linking loader which allows separately translated relocatable object modules to be loaded and linked together to form a single executable load module, and to relocate modules in memory. It produces a load map and a load module in Motorola MIKBUG loader format. The Linking Loader requires 2 K bytes of memory, a system console (such as a Teletype terminal), a system monitor (for instance, Motorola MIKBUG read only memory program or the ICOM Floppy Disk Operating System), and some form of mass file storage (dual cassette recorders or a floppy disk).

It was the express purpose of the authors of this book to provide everything necessary for the user to easily learn about the system. In addition to the source code and PAPERBYTE™ bar code listings, there is a detailed description of the major routines of the Linking Loader, including flow charts. While implementing the system, the user has an opportunity to learn about the nature of linking loader design as well as simply acquiring a useful software tool.

ISBN 0-931718-09-0
Authors: Robert D. Grappel & Jack E. Hemenway
Pages: 72
Price: $8.00
Winter 1979

TRACER: A 6800 DEBUGGING PROGRAM is for the programmer looking for good debugging software. TRACER features single step execution using dynamic break points, register examination and modification, and memory examination and modification. This book includes a reprint of “Jack and the Machine Debug” (from the December 1977 issue of BYTE magazine), TRACER program notes, complete assembly and source listing in 6800 assembly language, object program listing, and machine readable PAPERBYTE™ bar codes of the object code.

ISBN 0-931718-02-3
Authors: Robert D. Grappel & Jack E. Hemenway
Pages: 24
Price: $6.00

MONDEB: AN ADVANCED M68000 MONITOR-DEBUGGER has all the general features of Motorola’s MIKBUG monitor as well as numerous other capabilities. Ease of use was a prime design consideration. The other goal was to achieve minimum memory requirements while retaining maximum versatility. The result is an extremely versatile program. The size of the entire MONDEB is less than 3 K.

Some of the command capabilities of MONDEB include displaying and setting the contents of registers, changing the display and input base of numbers, displaying the contents of memory, searching for a specified string, copying a range of bytes from one location in memory to another, and defining the location to which control will transfer upon receipt of an interrupt. This is a PAPERBYTE™ book.

ISBN 0-931718-06-6
Author: Don Peters
Pages: 88
Price: $5.00

BAR CODE LOADER. The purpose of this pamphlet is to present the decoding algorithm which was designed by Ken Budnick of Micro-Scan Associates at the request of BYTE Publications, Inc., for the PAPERBYTE™ bar code representation of executable code. The text of this pamphlet was written by Ken, and contains the general algorithm description in flow chart form plus detailed assemblies of program code for 6800, 6502 and 8080 processors. Individuals with computers based on these processors can use the software directly. Individuals with other processors can use the provided functional specifications and detail examples to create equivalent programs.

Author: Ken Budnick
Pages: 32
Price: $2.00

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<td>Dig Group</td>
<td>4 MHz</td>
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<td>4 MHz</td>
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Designing a Robot from Nature

Part 2: Constructing the Eye

Andrew Filo
4621 Granger Rd
Akron OH 44313

1(a)

Photo 1: The author’s NELOC (neural logic cyberanimate). The manipulator arm (with five degrees of freedom) and the 8008 computer (at upper right) are shown. The object resembling a TV camera is actually a sustained contrast detector used to obtain a rough image of the object to be grasped (see photos 4a and 4b and figure 7). Just below and to the right of the sustained contrast detector is a small box called the net convexity detector (see photo 5), which detects the direction of motion of an LED mounted on the hand of the manipulator and feeds this information into the homebrew computer. Photos 1(b), 1(c), and 1(d) show the arm in action.

The first piece of hardware to be built in my system was the manipulator. From the start it was obvious that a tongue-manipulator concept would be impractical; I chose remote operator control over the manipulator arm because I wanted to program manipulator motion by “teaching,” and also to assist the system during its operation if necessary.

The manipulator I designed was roughly modeled after a human arm, with regard to its actions and dimensions. The manipulator is capable of five degrees of freedom, making it suitable for control by the motion of joints in a remote operator’s arm. The prototype arm was originally designed to be pneumatically operated, but electric motors were substituted for convenience during testing. The motors (which accurately simulate the actions of pneumatic pistons and their servo valves) are electro-optically controlled. To start a motor or open a valve, the optocoupler connecting the motor or valve to the circuit’s ground must be activated. Next, the forward or reverse coupler must be illuminated, connecting the motor or valve to a positive or negative voltage source, thereby causing the motor or air piston to extend or retract its portion of the manipulator. The only feedback devices located on the arm are two microswitches located just before the limit of travel of each joint. These microswitches provide either a full extension or full retraction signal for each joint. There is also a set of tactile sensor switches located in the fingertips of the device. Even though this manipulator may appear to have little in common with the frog, almost every facet of its design has been mentioned, in one form or another, in the previous (see February 1979 BYTE, page 12) analysis. The optoisolators, for instance, resemble the neuromuscular junctions in function, being the point where control signals leave the processing system and enter the motive system. The switches in the joints approximate the neuromuscular spindles. The tactile switches resemble the innervated capsules in the skin. And the entire manipulator itself is a folding, prehensile device, as is the frog’s tongue.
Net Convexity Detector

Other structures developed for the turret system more closely resemble their biological counterparts. To monitor the motion of the manipulator more closely, my system requires a device that can track the motion of the arm. A matrix of net convexity detectors proved more than adequate for the task. By monitoring a small bright spot of light either reflected from a retroreflector or emitted from a brilliant LED (light emitting diode) source located on the manipulator, the net convexity detectors can easily monitor the motion of the manipulator. The net convexity detectors built for the turret system utilize the concepts of receptor geometry, weighting (for processing), and output suppression for size discrimination.

Building a small matrix of net convexity detectors could involve the use of possibly hundreds of sensors and many processing devices, but since I was not concerned with building an accurate model of the net convexity detector in the frog's retina, I could trade off various design features. For example, I deduced that 20 is the minimum number of receptors required to define motion on at least four axes. The geometry of these receptors has to be in a matrix of four columns by five rows with the high sensitivity receptor occurring in the fifth row, third column (see figure 6 and boxed text at end of article). In the frog, a net convexity detector may have up to 100 receptors in its receptor field, allowing the frog to precisely monitor the angle of the insect's trajectory, but to duplicate this would require the use of a monolithic digital sensor of photodiodes if the system were to be portable. Even a 4 by 5 matrix would require a 1 inch square surface to contain all of the detectors. This means that four net convexity detectors would require a 2 by 2 inch imaging surface - impractical both in terms of size and optics. Another serious problem was scanning and processing the information from the photodetector devices.
Sources of Parts

A few items mentioned are available only from single sources:

National Semiconductor 650 calculator modules are available from Poly Packs, POB 942, South Lynnfield MA 01940.

The best sheet plastic and cement I have found for hobby use can be purchased from Plastruct Inc, 61 Monterey Pass Rd, Monterey Park CA 91754.

Photo 2: Close-up of the manipulator's hand.

Photo 3: Elbow of the manipulator.

Figure 6: Shown at (a) is a sectional view of the net convexity detector, used to determine the motion vector of the manipulator arm. Light entering the lens passes through one of 20 holes in a 4 by 5 array at any instant of time, and impinges on one of a corresponding set of phototransistors. 19 of these photo-darlington (the low sensitivity detectors) activate the 1 key of a calculator module. The remaining photo-darlington activates the 0 key; its off-center location is used to uniquely determine the arm's direction of travel. (The final version of the unit does not use fiber optics bundles, except inside the brass tube. See figure 9 and accompanying text box.) At (b) are some examples of typical vectors passing over the retina, along with the corresponding calculator outputs.
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Figure 7: Details of the sustained contrast detector. At (a) is a cross section of the unit, which resembles a television camera; (b) is a simplified block diagram of the system. The sustained contrast detector is used to obtain a rough image of the object to be grasped by the manipulator.

Photo 4: Interior of the sustained contrast detector. Shown at (a) is the lens (at left), the array of phototransistors (at right), and the associated electronics. 4b shows the 4 by 5 prototype array (compare with final version in figure 7).
I solved both problems by using a simple 6 digit, 4 function calculator integrated circuit, the National Semiconductor MM 50736. Before I began work on the neural logic cyberanimate, I had experimented with this device and found it to be compatible with photo-darlington transistors 2N5777 thru 2N5780. With the photo-darlington transistors as input devices, the calculator circuit could register pulsations of light from a diffused LED source more than two feet away. Clearly this device was capable of detecting bright objects at short distances. Additionally, it was possible to use the data processing nature of the calculator circuit to assign different values to the receptors and, based on these values, produce two distinct output signals. The weighted inputs were made simply by attaching one photo-darlington amplifier to the calculator circuit where the 1 switch of the keyboard would normally be connected, and a second photo-darlington to what would normally be the 0 position.

The two types of output signals are the results of the data which the photo-darluntons receive. Note that there are only two photo-darluntons connected to the calculator circuit in figure 6, yet I had previously stated that the minimum configuration for the net convexity detector was a matrix of 20. This is because I used fiber optic pipe for “receptors” and the photo-darlington devices as detectors. Figure 6b shows the arrangement of the optical fibers. 19 fibers have a value of 1 (they are equivalent to the low sensitivity receptors). All 19 of these fibers are fused to the photo-darlington that has a numerical value of 1. The remaining fiber is fused to the 0 value photo-darlington (to simulate the high sensitivity receptor). The completed device can detect and record the trajectory of a small moving penlight flashlight at a distance of 4 feet (well beyond the extended length of the manipulator); obviously, if the object’s path does not cross the high sensitivity detector, the data is invalid.

Sustained Contrast Detector

Another structure derived from my analysis is a sustained contract detector (figure 7). This device is a spinoff of a previous electro-optic project. But without the analysis of the frog’s eye I would never have considered this application. The sensor consists of a matrix of five rows by five columns of photo-darlington transistors (see photo 4). The columns of the sensor are scanned by TTL (transistor-transistor logic) devices controlled by the computer. The 5 row output is fed into a programmable read only memory that serves two functions. First, the logic voltage level on the address lines of the programmable read only memory sets the on/off contrast levels for the sensors, thus eliminating the gray scale conversion problem. Second, the programmable read only memory is encoded with a truth table that can vertically reduce

![Figure 8: Simplified system flowchart, showing parallel functions in the brain.](image-url)
a high contrast image line by line with the computer's assistance. The image reduction process will horizontally outline an image and vertically dimension it (see figure 7 and photos 4a and 4b), enabling the computer to gauge the dimensions of objects within reach of the manipulator.

Finally, there was the design of the processing system. By designing all of the most external appliances first, I hoped to further define some of the required characteristics of the neural logic cyberanimate. The purpose of my processing system (including the computer program, preprocessing, and post-processing elements) as stated before, is to locate, classify, and manipulate objects specified by control instructions. To accomplish this, the system first has to be able to recognize the command instructions that specify the location of the object to be manipulated and what is to be done with it. Next, the system has to use measurements of pressure and reflected light from the environment made by the sensory instruments. Once in the processing system, this information has to be recognized and labeled. Incorrect or unnecessary measurements will then be eliminated. The filtered measurements will then be combined according to their information content (i.e. optical and mechanical data relating to the position of the manipulator would be combined, etc). The combined data, whether optical, optical-mechanical, or mechanical, is then processed according to its type. Optical data is reduced to information pertaining to object size and location. Optical and mechanical information processing describes the location and position of the manipulator. Processed mechanical information relates manipulator position and contact with an object. Based on the results of this processing, the system then has to grasp and move the object as specified by the command instructions. Following this, the system notifies the command system.

The processing system uses an 8008 processor (not the best choice, but one which was chosen for expediency since I already owned one) interfaced to a series of 8223 programmable read only memories used to decode gray scale images, fire the LEDs in the optocouplers, and perform the various other tasks in the system.

The algorithm for the NELOC system is diagramed in figure 8. Notice in the algorithm that sections of the program perform functions similar to those discussed in the cyberanimetric analysis of the brain. For example, monitoring, filtration, and suppression of sensory data, which are reticular functions, are performed in the program. Also in the algorithm are routines that combine sensory data, process and coordinate it, and control the input and output of data-functions that simulate those of the frog's brain. Another routine placed in the algorithm accepts instructions from the I/O and converts them into a form that can be used by the rest of the program. This routine makes it possible to control the system by external command.

During its trial operation, the neural logic cyberanimate performed quite well. With electric motors driving the manipulator arm, it took the system about 60 seconds to find and manipulate a test object. The most impressive feature of the system's operation is its ability to resolve the position of the manipulator and the test object.

Conclusion

During the design and construction of the NELOC system I encountered no major design problems because, from the start, it was possible to determine what portions of the system would be difficult to design or construct, and, therefore, I could budget my time and money accordingly. The benefits of clearly defining the organization of the system before designing the hardware are obvious. I put about 120 hours into the research, design, and construction of the prototype neural logic cyberanimate. If I had tried to develop these structures without the cyberanimetric philosophy, it would probably have taken much longer to design a net convexity detector or a reticular system.

Of course the NELOC system itself represents the equivalent of only a very thin neurological slice through a simple organism. By no measure is the neural logic cyberanimate intelligent, but I believe this design philosophy could be useful for designing systems beyond the simple servo system.
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The great unknown.
Building the Net Convexity Detector

The net convexity detector used in my system is a good example of how a calculator circuit can be used for noncalculator application. As illustrated in figure 9, the net convexity detector is a very simple device. The whole idea behind the circuit's operation is that the sensory head can, in effect, push the right keys on the calculator in response to the motion of an image that is a certain size and brightness. As explained previously, the purpose of the net convexity detector is primarily to define angle and direction of a small bright object. In this design, a mask is used as a template to gauge the diameter of an image. If a bright, moving image is small enough to illuminate only one hole of the template at a time, the calculator will register its movement as a series of numbers. If the image is too large, and illuminates more than one hole at a time, the calculator will display only one number that, in terms of a trajectory, would mean nothing.

To build the net convexity detector it is first necessary to build the sensor head. Figure 9b is an exploded view of the sensor. In the construction of the sensor it is necessary to use a lens that forms a focal point at a distance no shorter than 25 mm. Next a case is constructed from sheet plastic. This case should be at least twice as long as the focal point of the lens and must be able to hold a mask containing a 4 by 5 matrix of holes. The simplest way to make the mask is to use a piece of unclad perforated circuit board with holes 2.5 mm on center. Just cut a corner of the board off so the piece will have four by five holes. The mask must then be secured in the case so it will be at the lens's focal point. The inside of the forward end of the case must now be painted flat black. Two end pieces are cut, one is drilled to accommodate the lens and is glued to the front of the case. Next, a 4 lead cable is brought through a hole drilled in the end of the case. A short piece of plastic tube is glued over this hole and filled with epoxy to block light. Two photo-darlingtons are
Some Books on obtained from cognitionists robot information about vector that If until a type the darlington the glued finished. photo -darlington tube carries the paint black. Before attaching the back of the case, make sure that the 1 value photo-darlington is in the center of the case.

After the sensor has been completed, it is a simple matter to complete the circuit. A National Semiconductor calculator module, the NS 650, has all of the solid state electronics for a calculator, including a 6 digit display. By adding a battery, switch, and the sensor head (see figure 10), the circuit is finished.

To test the circuit, use a small penlite type flashlight, moving it in board circles at a distance of 3 feet away from the sensor. Many 1s and a few 0s should fill the display until the calculator indicates an overflow. If you move the light source on a straight vector that crosses the hole to the isolated darlington you will get a certain readout. Figure 6b shows all of the possible fields of vectors, the direction that the object must be traveling, and the output that should be displayed by the calculator. All other combinations are illegal.

Although the net convexity detector is a very simple device, it must be built very precisely. All surfaces should be flush, parallel, or perpendicular. Optics should be carefully aligned and all seams should be checked for light leaks.

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**BIBLIOGRAPHY**

Listed are 15 books, some containing information about amphibians, others concerning robot and artificial intelligence systems built by cognitionists and neural cybernetists. The books range from elementary to very complex.

*Some of the data about the biological frog was obtained from the following sources:*


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Continued from page 13

along the entire back panel as well as the lower back corner of the mother board (5 VDC voltage regulators are on each circuit board). With two exceptions, everything went together easily, and exactly as presented in the assembly manual.

The first problem occurred when I attempted to install the self-retaining nuts in the side panels. For one thing, it can be very difficult to press these nuts into the very sturdy composition board unless they are gently tapped with a hammer. In addition, the part numbers for one of the nuts on the left side panel as illustrated in the assembly manual didn't correspond to the associated detail pictorial in the illustration booklet.

The only other problem I encountered during this stage of assembly was the installation of the side panels. Access to the side panel self-retaining nuts at the bottom rear corner of the chassis was obstructed by the previously installed screws and nuts that hold the rubber feet to the bottom of the chassis. My solution was to turn the chassis onto the side panel to be attached and insert and tighten the remaining screws to the appropriate panel.

The Mother Board

The mother board consists of two sections: a portion of the power supply, and ten rows of paired 25 pin plugs used later for connecting circuit boards and cables to the system bus. The installation of the plugs can be tedious. If you have not had much soldering experience, practice before you begin this board.

The most challenging part of the mother board assembly process is soldering some 500 pins which form the connectors for the individual boards of the system. The remainder of the board consists of a few capacitors, resistors, and diodes. There are, however, two instructions whose sequence should probably be reversed. Specifically, you are instructed to solder two electrolytic capacitors to the board and then secure each to the board with a self-locking cable tie. Reversing this sequence insures that no strain will be placed upon the soldered capacitor leads by the cable ties when they are tightened. The finished board is installed on the righthand side panel of the chassis after the twisted pair of 18 V leads from the power supply transformer are connected to the board. I had no trouble obtaining the proper resistance and power supply...
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test readings outlined in the manual, and proceeded to the next step of assembly.

Front Panel Circuit Board

The H8 front panel control system has many features which make using the H8 a pleasure. One of these is the multifunction console keypad that provides users with direct, easy-to-use commands to operate the H8 without a terminal (see figure 1). Another feature is the 7 segment LED (light emitting diode) display system that displays a variety of system status information in an easy to read format not found on many larger 8 bit systems. We'll take a closer look at this unique system later, but first let's consider its assembly.

The entire assembly procedure is very straightforward. However, it is during the assembly of this board that a second rather tedious subassembly construction activity is encountered. In particular, it is necessary to prepare the cables that run from the board to the first row of plugs on the mother board and between the front panel and processor boards. The instructions and illustrations for this stage of construction are excellent and, if they are followed exactly, you should have no problems. The work performed on the cables is rather delicate, requiring the same amount of care and patience needed while assembling the mother board. One construction hint: you are instructed to mount four single element LEDs on the upper left side of the board. Make sure that each LED is mounted at exactly the same height as the others (0.25 inches from the board to the base of each LED). This can be easily accomplished by cutting a piece of 0.25 inch wire and using this as a spacer placed underneath each LED between the pairs of LED leads prior to soldering each to the board.

The Processor Board

Another feature of the H8 is the processor board, which comes preassembled. This is a real advantage because many of the problems that computer kit builders encounter are caused by mistakes made during assembly or installation of the processor board (see photo 2).

With assembly of the circuit boards and chassis complete, all that remains is to install the components. Of course, the H8 does not come with other boards that are necessary to have a functioning computer, such as extra memory and an
Here's a very small sample!

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I/O (input/output) board. These are options the user purchases when buying an H8 (and most other computers, for that matter).

The Memory Board

If you want to use your H8 without external devices, the H8-1 memory board is the only other board you will need. The H8-1 is a 4 K byte programmable memory board which can be extended to a full 8 K by installing the optional H8-3 memory chip set. This board is easy to assemble, and not much more need be said about it — nothing, that is, except a short story about a mistake I made which also points to another nice feature of the H8.

Briefly, it happened like this: I was assembling the H8's circuit boards with extreme care, paying particular attention to the quality of the instructions and illustrations and making notes in my manuals I might want to use later. On the evening I started putting the memory board together, friends dropped over, and because the board looked so simple to put together, I decided to put part of it together while we relaxed and chatted. As a result of my divided attention, I installed a 14 pin IC socket in a 16 pin socket location.

One of my visitors was just beginning to get interested in computers (which was part of my reason for doing some of the assembly while company was around) and I showed her the partially completed board. She looked at it, asked a few questions, and then said, "What are those holes for by the end of that socket?"

I turned a bit red — I had blundered in the middle of a demonstration. Well, for the next 45 minutes we struggled to remove the socket, clean out the solder that was plugging the holes in the board and refit another socket. The H8 as well as its accessory kits come with sockets for all of the ICs including the 7 segment displays. If you ever need to replace an IC, you won't have to struggle with unsoldering it and cleaning off the board. And you won't have to pay extra for the socket sets when you buy the kits. The finished board is shown in photo 2.

The H8-5 SIO Board

If you want to connect your H8 to a console terminal or use the system software stored on cassette tape, you'll also want the H8-5 serial I/O and cassette interface board. It took quite a while to assemble because of its relatively high component density, but it presented no construction problems.
Testing and Alignment

After assembling the basic H8 system, you are instructed to perform three programmable test routines as well as an alignment of the cassette interface. The first test routine is a short program entered in machine code through the front panel keypad. The routine performs a general check of the H8 and at its end-of-run displays several messages on the front panel LEDs (i.e.: YOUR H8 . . . IS UP AND . . . RUNNING). If the test routine does not execute properly, the reader is directed to an extensive troubleshooting flowchart that is ten pages in length and very clearly written. I had no trouble at this point and proceeded to the next test routine.

The second of the two routines is a memory test routine. It is also entered in machine code through the front panel keypad. The program performs a thorough test of every memory location on any 4 K or 8 K byte memory board by storing and retrieving consecutive octal values from 000 through 377 in every memory location. If an incorrect value is detected during a compare operation, the program halts, sounds an audio alert, and displays the expected (rather than observed) contents of the location where the test failed. The address where the test fails and the actual (or observed) contents of memory at that location can both be displayed on the LEDs by displaying the contents of the HL register pair and the accumulator, respectively. If no problems are encountered during execution of this routine, it will continue to repeat the test cycle until stopped by the user. Everything worked fine for me as I watched the memory content values go sailing by in the display.

The last task to be performed is the alignment of the cassette interface on the cassette I/O board. The procedure consists of setting the two variable resistors on the board to the correct positions as indicated by the readout on an on board single element LED test lamp. This LED also comes in handy later for troubleshooting the H8's circuitry. The adjustments were quite tricky to make, but after two tries and a number of test loads of software cassette tapes, it worked very well. Had it not worked, I could have referred to another trouble-shooting flowchart to locate the problems.

But everything did work. I proceeded to play around with the keypad commands, becoming familiar with what made my H8 "tick." Finally it was time to install the front panel cover and the louvered metal chassis cover. I connected the serial I/O
With so many new names on the street, it’s good to know that one company has been producing and distributing top quality software for the TRS-80 for almost as long as there has been a TRS-80.

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cable to my H9 video terminal and was ready to do the final test routine for the serial I/O channel on the serial I/O board. It consists of setting up the USART (universal asynchronous/asynchronous receive/transmit device) assigned to this channel and transmitting and receiving characters to and from the terminal. I was amazed at how easy it was to do I/O routines from the front panel. The final test was completed, so I left my system for awhile to return to the H8 operating manual and software manual set.

The Benton Harbor Bus

The Benton Harbor Bus represents a departure from the S-100 bus, which has become one of the "standards" of the microcomputer industry. The H8 system bus uses only 50 lines, compared with the 100 lines of the S-100. Since the S-100 was designed early in the history of the microcomputer industry, it incorporates bus lines which are no longer needed or which have been replaced by more recent system control hardware.

Manufacturing costs are kept down by not having to machine an edge connector tongue, not using gold plated edge connectors, and replacing the expensive 100 pin socketing system of the S-100 with much less expensive plug and socket sets which are assembled by the user.

Another feature found on the H8 is its convection cooling system. This system has been designed so that power supply voltage decreases slightly every time a circuit board is added to the mainframe. As more boards are added, the proportional amount of heat dissipation from each circuit board regulator also decreases. It is for this reason that you are instructed to "locate circuit boards in alternating positions for improving ventilation." When the time comes to add boards to the unoccupied alternating rows of plugs on the mother board, the effective heat dissipation will be low enough to position boards adjacent to one another. To improve upon this scheme, all circuit boards are installed on a slant to facilitate the convection cooling process. The end result is a quiet running machine which does not require the added cost of a fan to keep component temperatures down.

Costs are also kept down by the size of the H8's power supply. I saved a lot of money by not buying an 8 bit machine with a large power supply. The fact is that you pay dearly for every extra and often unused ampere that a power supply delivers. In this regard, the H8 delivers a full 10A,
which is sufficient to operate all of the boards that the chassis can hold — up to seven in addition to the front panel and processor boards. It is also switch-selectable for operation on either 110 or 220 VAC, an advantage for European users. It also includes a switch for normal or low level line voltages, which may come in handy in case of a brownout — you'll need a separate generator for a blackout.

Split-Octal Notation

Before going on to discuss the firmware that coordinates many H8 operations, we should first describe the type of machine language code notation used by the H8. The H8 uses a number system called split octal, a modification of straight octal that is well suited to 8 bit computers like the H8. It is also well suited for the H8 display system, as you will see.

Split-octal notation is identical to octal notation except that the two most significant bits of each pair of data bytes are represented by one arabic numeral. In this scheme 377 is the highest value that can be represented by one 8 bit byte (ie: word) of data. Thus:

\[ 3 \text{77} = 11111111 \text{77} \]

And, the highest value that can be represented by two 8 bit bytes of data would be 377.377. The H8 defines 1 K bytes of memory as 003.377 bytes and 8 K bytes of memory as 037.377 bytes. The H8 is designed to reserve certain portions of memory for the system monitor and later system expansion as shown in the H8 memory map (see figure 2).

PAM-8, the Front Panel Monitor

The functions and features discussed above are tied together by another H8 feature – the front panel monitor – which resides in 1 K bytes of read only memory on the processor board. It also controls such activities as initializing the system during power-up, coordinating tape loads and dumps, communication with the Console Driver routine (part of every Heathkit software package), processing restart and clock interrupt vectors, and processing user defined interrupt requests.

H8 Software

Someone once said a computer system is no better than the software that comes with...
it. This is as true for large computers as it is for microcomputers. The H8 software packages are intended to function as an integrated system. They include TED-8, a line oriented text editor; HASL-8, a machine language assembler; BUG-8, a machine language debugger; and Benton Harbor BASIC, Heathkit's version of the popular interactive programming language created many years ago at Dartmouth College. Let's see what they're all about.

Common Elements

Each of these software packages contains a console driver routine that enables the H8 to communicate with a user's console terminal (Teletype, video display terminal, etc.) and a cassette or paper tape transport. It occupies 355 decimal bytes of programmable memory in each software product from locations 040.100 through 041.144. Thus, all of the console driver routines are available to users for special purpose modifications as well as for use in user-designed software which would benefit from using the same I/O routines, including I/O port assignment. It is responsible for processing console terminal interrupts, setting up and reading USART (universal synchronous-asynchronous receiver-transmitter) modes, commands and statuses, processing control characters (such as CTL-C, CTL-Q, and CTL-S), reading and writing single characters, and processing character strings in the 28 character type-ahead buffer. During interrupt processing, the console driver interacts with the PAM-8 system monitor. The entire listing of the console driver routine in assembly language is provided in an appendix to the software manuals. As in the case for the monitor, the console driver routine and all other software for the H8 were developed for Heath by Wintek. The Heath Company cannot (under contract with Wintek) provide any listings other than the partial listings presented in the software manuals, and "cannot provide consultation on user developed programs or modified versions of Heath software products." However, with a homebrew disassembler or memory dump routine and the partial listings provided, you might not have too much difficulty in generating your own unofficial versions of the source codes.

Another common element to all Heath software products is the software configuration procedure that must be performed before any software distribution tape is loaded into the H8. The procedure provides opportunities for the user to adapt each software package to his or her own needs. A list of program configuration parameters is presented to the user, who can then define items such as BKSP, which allows the user to define which key will be used to control the backspace function, HIGH MEMORY, which allows the user to specify that section of high memory that he or she does not want used by the system program, and LOWER CASE, which allows the user to select either upper and lower case or upper case only I/O to the terminal.

A third element common to all Heath software products is command completion. The feature allows the user to enter the first letter(s) of a program command, whereupon the software routine, in conjunction with the console driver, will print out the remainder of the command. For example, a text editor allows the PRINT command to be evoked by typing P, and the system responds with RINT, completing the command. The problem is that, if one is a fast

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**Figure 2: The H8 memory map.**
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typist or has used computer terminals before, one tends to enter too many beginning characters and thereby cause an error. For example, I still haven't gotten used to typing just `P` to evoke the print command. So what happens? I type out the entire command, PRINT, and the result is PRINT RINT. The problem is even more bothersome because the command completion for some of the same commands is different for different software. Using the text editor (the above example), typing just `P` evokes the RINT completion; using BASIC, a PR evokes the INT completion.

TED-8, the Heath Text Editor

A text editor turns the user's terminal into a typewriter of sorts with the added capability to store what is typed into memory, and to edit the contents once stored. It is essential for writing assembly language programs and for preparing various kinds of texts, such as newsletters and reports, for personal use.

TED-8 is a line oriented text editor that occupies approximately 4.3 K of user memory. It has commands for loading and dumping both files and individual records, searching for character strings, clearing the text buffer, replacing and deleting lines, specifying range statements which control the number of lines upon which commands will operate, creating new text, and editing existing text in the buffer. It also includes a TAB command to facilitate the writing of assembly language programs, a wide variety of range commands, and a USE command that provides the user with a current number-of-lines count and memory usage information.

In my opinion, TED-8 is a reasonably good small system text editor with considerable flexibility. It is, however, somewhat inconvenient to use, especially when one needs to edit a particular line but does not know the exact line number and must therefore either count the lines (an inconvenience if there's a lot of text to cover) or write and execute an often lengthy expression to specify the character string in the line that is to be edited. Some of this could have been avoided if a line numbering system had been included, which could be stripped off at the end of editing.

Another problem is that the text editor and assembler are interdependent in some situations but must each be loaded separately into memory. This makes repeated editing and execution for program testing a real chore. I would have liked to see these programs (TED-8 and HASL-8) put together as one package, or have been provided with a dedicated linking loader as part of the
PAM-8 monitor that would enable me to load both programs into memory. Aside from these two disappointments, I am pleased with the general capabilities of TED-8. For the small amount of memory it occupies, it is relatively powerful.

HASL-8, the Heath Assembly Language

HASL-8 is a 2 pass assembler which effectively means that you must load (playback) your source program (created by TED-8) twice before the assembly of the source program can be executed. (You can see how often you may have to load and unload, rewind and playback cassette tapes if you are editing and testing even a moderately sized assembly language program.) The output of HASL-8 is object code which is the machine language for the computer. In addition, a source listing of your program is generated, which includes not only the text of your original program but also the addresses which correspond to specific assembly language and machine language instructions (op codes). The Heath assembly language resides in slightly less than 8 K bytes of user memory and supports a complete set of operators, tokens, and pseudo opcodes (assembler directives), including in the latter a large set of pseudo ops for error detection and control of listings.

When a configured version of HASL-8 is started, the user must first answer a series of questions regarding the desired page size, interpage gap size, listing port, whether or not to produce a binary image of the source program in memory, and whether or not to save a binary image on tape. The program then requests input of the source program from tape, makes a second pass after the tape is rewound, assembles the object program, and dumps out a listing at the console terminal. The listing includes single character error codes in the far lefthand margin, and run summary data at the end of the listing (number of statements listed, remaining free bytes in user memory, and the number of errors detected). HASL-8 does not process macros or provide a cross-reference listing of user labels and associated addresses, both of which would be a nice improvement in a subsequent version. It is a fairly average assembler for its size, but should be adequate for most general purpose assembly language programming. Its documentation is very good, as is the documentation for all of the software products from Heath.

BUG-8, the Heath Console Debugger

BUG-8 is one of the best software packages that comes with the H8. Residing in any
3 K bytes of memory, it provides the user with powerful tools for writing, editing and debugging machine language programs from a console terminal in octal, decimal or ASCII format. It interacts with the PAM-8 monitor and uses many of the PAM-8 routines. With BUG-8 running as a full console monitor, you can do any of the following:

- examine the contents of any memory locations;
- change the contents of memory locations;
- examine the contents of any processor register;
- change the contents of any processor register;
- start program execution;
- perform single step execution of a program;
- set program breakpoints;
- clear program breakpoints;
- load and dump programs from OR to tape.

The command format used in BUG-8 is short, which makes using BUG-8 a real pleasure (the same kind of feature would be very desirable as a configuration option for TED-8).

Benton Harbor BASIC and Extended BASIC

When you purchase an H8 kit, you are supplied with Heath's 8 K byte, Benton Harbor BASIC. In addition, Heath has also marketed two versions of Extended BASIC (versions 10.01.02 and 10.02.01) which provide the user with functions for string manipulation and a number of other useful features. Version 10.02.01 of Extended BASIC also enables the user to load and dump variables, program text, and both text and variables. This latest version is a significant improvement over the earlier version of Extended BASIC in that it allows the user to pass variables from one program to the next.

There has been quite a bit of discussion about the relative execution speed of various versions and brands of BASIC that are on the market. However, the benchmark tests for Heath BASICs that have appeared in the small systems literature have been performed only under somewhat restricted circumstances. In particular, the H8 real time clock was not enabled when Extended BASIC benchmark tests were published, which by omission and implication exaggerates the speed of the 8 K byte version of BASIC. Now, speed isn't the only criterion in evaluating a higher level language's performance, but to provide you with a more balanced perspective on this issue, I give you the following benchmark comparisons between the two versions of Extended BASIC and the 8 K BASIC that comes with the kit.

A modified benchmark algorithm developed by J G Letwin (a software engineer for Heath) was used to conduct all of the tests. All timings were accomplished using the H8 real time clock via the POKE and PEEK commands. Table 1 presents the comparative data for execution time of various functions in milliseconds. The real time clock was enabled for all tests. The algorithm I used is as follows:

110 B=1.1:C=1.5 (numeric constants)
120 POKE B219,0:POKE B220,0 (set clock = 0)
130 FOR I=1 TO 2000 (2000 iterations)
140 (line for each test function)
150 NEXT I
160 Y=PEEK (B219)+PEEK (B220)*256 (read run time)
170 X=(correction factor for "A=B")
180 T=((Y/500-X))/2000 (time in ms)
190 PRINT "T=";T,"Y=";Y (output)
32767 END

The argument at line 180 computes the time for execution of one operation of the function supplied at line 140 by dividing total time in milliseconds (Y) by 500, subtracting the time for the identity statement A=B, and then dividing by the total number of iterations (2000). Line 140 contains the function being benchmarked across each version of BASIC (for example, 140 A=IN(B), 140 A=SQR(B)). The POKE and PEEK commands are placed immediately before and after the test routine to be timed, respectively, thus holding any time required to execute these commands constant and to a minimum.

<table>
<thead>
<tr>
<th>FUNCTION/OPERATOR/STATEMENT</th>
<th>8 K BASIC (Version 05.01.00)</th>
<th>Extended BASIC (Version 10.01.02)</th>
<th>Extended BASIC (Version 10.02.01)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A=B</td>
<td>14.9</td>
<td>15.7</td>
<td>15.8</td>
</tr>
<tr>
<td>ABS</td>
<td>1.2</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td>+</td>
<td>1.9</td>
<td>2.7</td>
<td>2.5</td>
</tr>
<tr>
<td>-</td>
<td>2.2</td>
<td>3.0</td>
<td>2.7</td>
</tr>
<tr>
<td>INT</td>
<td>2.3</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>RND</td>
<td>2.4</td>
<td>2.4</td>
<td>2.4</td>
</tr>
<tr>
<td>PEEK</td>
<td>3.5</td>
<td>3.3</td>
<td>3.2</td>
</tr>
<tr>
<td>+</td>
<td>4.3</td>
<td>3.3</td>
<td>3.1</td>
</tr>
<tr>
<td>/</td>
<td>5.2</td>
<td>5.9</td>
<td>5.7</td>
</tr>
<tr>
<td>FOR/NEXT</td>
<td>5.4</td>
<td>5.5</td>
<td>5.5</td>
</tr>
<tr>
<td>POKE</td>
<td>14.5</td>
<td>13.8</td>
<td>13.7</td>
</tr>
<tr>
<td>COS</td>
<td>18.3</td>
<td>15.0</td>
<td>14.6</td>
</tr>
<tr>
<td>SIN</td>
<td>19.3</td>
<td>15.7</td>
<td>15.3</td>
</tr>
<tr>
<td>EXP</td>
<td>22.1</td>
<td>17.3</td>
<td>17.0</td>
</tr>
<tr>
<td>LOG</td>
<td>27.2</td>
<td>21.8</td>
<td>22.0</td>
</tr>
<tr>
<td>ATN</td>
<td>29.2</td>
<td>24.9</td>
<td>24.3</td>
</tr>
<tr>
<td>SQR</td>
<td>47.8</td>
<td>15.7</td>
<td>15.3</td>
</tr>
</tbody>
</table>

Table 1: Comparison of execution times for three Heath BASICs for various common functions, operators, and the FOR/NEXT statement. All times are in milliseconds, with the real time clock enabled.
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What can we glean from all these timings? For one thing, the 8 K basic BASIC is generally slower than either of the Extended BASICS. The differences in execution times between the three versions is not really significant for the arithmetic functions. On the other hand, the transcendental functions run faster in Extended BASIC. The differences between the versions are most evident when the SQR function timings are compared. It appears that for arithmetic applications, such as those used in most financial accounting, the user can get by very well without using Extended versions. On the other hand, those who plan to do engineering or scientific applications software development should give serious consideration to using only the Extended versions. All of the versions will operate approximately 10 to 15 percent faster if the real time clock is disabled, which might be a further incentive for the scientific programmer to use only the latest version (10.02.01) of Extended BASIC.

Aside from timing benchmarks, there are many other criteria to consider when reviewing a higher level language like BASIC. Since I cannot possibly cover all of them in this article, I'll select the ones which are probably of most interest to many readers. Let's start with the command and function types of the three versions.

8 K Benton Harbor BASIC contains most of the commands and functions found in many commercial brands of BASIC for small systems. It has a set of editing facilities, immediate and program command modes, and a full set of relational operators. It also has additional commands, including PEEK, POKE, SEG (for controlling the H8 LED displays), PAD (for utilizing the H8 control keypad while running BASIC), and several commands for loading and dumping programs. Most 8 K BASIC functions can use variables in addition to constants within their arguments, which makes programming more flexible. This version of BASIC does not provide functions for manipulating string variables.

In contrast to 8 K BASIC, both versions of Extended BASIC have a variety of functions for handling string variables. In addition, such commands as BUILD, DELETE, LINE INPUT and CONTROL make program development easier. Each version makes use of the FREE commands, which prints out memory allocation data for the user. The latest version of Extended BASIC also includes commands for differentiated loading and dumping of program text and variable as well as LOCK/UNLOCK commands for file protection. Both versions display the type of data being loaded or dumped on the H8 front panel LED displays. As the data in
table 1 indicates, the latest version is quite fast. Additional refinements, such as incorporating PRINT USING, OCTS and DECS (for octal to decimal, and decimal to octal conversion), and file handling commands that could be executed in program mode (such as PUT and GET), would have been useful. In addition, a special INPUT command that suppresses the carriage return/line feed would also have been useful formatting the terminal display during INPUT, as would a more flexible RUN command to specify a file/program name for storing and executing one of several programs stored in user memory. This can be accomplished now using a combination of the GOTO and CONTINUE commands. However, this procedure prevents the use of identical variable names in different programs unless such variables are reinitialized before each execution, or the variable values of a previously executed program are to be used as global variables in subsequent programs in memory.

A Few Pointers

The following section includes some suggestions about using the real time clock for program run timing, displaying output using user defined patterns or character messages on the LEDs, and using the audio feedback system for any number of interesting projects. By combining and augmenting some of the following techniques, you can use your H8 as a daytime clock, alarm clock, device controller timer, and even a (rather crude) music synthesizer.

Among the applications software packages available from Heath for the H8 are a Space War program and a set of games programs. The Space War game, which requires 24 K bytes of memory is a sophisticated version of Star Trek. It has excellent displays, a full range of commands, and some surprises for those of you who dream of cruising the galaxy. Finally, the games set, which comes on one cassette tape, contains a variety of interesting games, including Craps, Nim, Hexapawn, Tic Tac Toe, Orbit, Hamrabi, and Derby, all stored in machine language and executable without first loading the BASIC interpreter into memory.

In addition to the above applications software, the Heath Company is also planning to market some business software in the not too distant future. This source of applications programs will be supplemented by the software that will become available from the Heath user’s group (HUG), which is presently reviewing and cataloging hundreds of programs that are being donated to HUG by users. Software from HUG will be available to HUG members at a nominal cost and will...
be announced in the HUG magazine REMark as contributed programs become available.

The H8 Real Time Clock

Every 2 ms the H8 generates a level 1 interrupt which is then used to service the front panel and update the real time clock. The clock or "tick counter" is located in two bytes of user memory at locations 040.034 and 040.033 and is called TICCNT. Both the high order byte (040.034) and low order byte (040.033) of the counter can be displayed on the H8 LEDs using the following short assembly language program which can be executed in memory with the assembler (HASL-8) resident:

```
074.000 ORG 074000A
074.000 041 033 040 LIX H,040033A
074.003 116 DISPLAY MOV C,M
074.004 054 LOAD LOW BYTE INR L
074.005 106 NEXT BYTE MOV B,M
074.006 055 LOAD HIGH BYTE DCR L
074.007 303 003 074 RETURN POINTER JMP DISPLAY
074.012 NEXT BYTES END 074000A
```

Be sure to set the front panel to display the BC register pair before running the program.

The BASIC timings described earlier accessed the TICCNT memory locations by using the PEEK function and POKE command. Using these commands, it is possible to create a program run timer for programs that run up to approximately two minutes. Unfortunately, after this time TICCNT will start all over again instead of continuing to increment third and fourth memory locations, which would have provided a very convenient built-in extended range timer. You will need to allocate additional bytes in memory for a higher order counter in order to extend the clock range.

H8 Display Control

As discussed earlier, the H8's front panel is an integral part of the entire system and can be used for many operations even while using a console terminal. One of the advantages of this design is that the LED display can be accessed and controlled by the user either through the front panel or through a program being run from a terminal. Much of this is made possible by accessing the monitor control cells and flags stored in memory.

As an example, the assembly language program in listing 1 provides you with complete control of the display updating. First the display update control bit in the user definable memory flag MFLAG is set to 002 to disable display update. The displays are then loaded with the desired bit pattern, in this case the pattern "XrunningX" (where X = blank). The user accessible memory cells for each LED bit pattern are in memory locations 040.013 through 040.023. The temporary bytes for storing the pattern for this display are in locations 071.000 through 071.010. Each byte in the temporary area is, in progression, loaded into the corresponding byte in the monitor LED memory bytes. To modify the display, change the bit patterns in the temporary area. Add additional temporary bit pattern tables and a table reference and transfer routine to display more than one front panel message.

The H8 Horn

The audio feedback system that is part of the H8 has other practical uses. The audio tone can be turned on from a running program that stores the octal value 160 in the front panel hardware control cell CTLFLG located at 040.011. If an attempt is made to do this from the front panel without going through a program, the front panel will be disabled before the operation is completed. The tone can be turned off by restoring CTLFLG to its normal octal value of 360.

Here is an interesting BASIC routine to generate an audio beep sequence with timing that follows a sine curve. Change the value of X to vary the timing curve. (Note: line number 3 is written in multiple statement form to structure the program to run as fast as possible.)

```
1 X=1
2 A=8201: B=120: C=208: D=20
3 J=J+X: POKE A,B: POKE A,C:
   FOR I=X TO SIN(J)*D+D: NEXTI: GOTO 3
4 END
```

Split-Octal to Decimal Conversion

It is often useful to be able to quickly convert split octal bytes to their decimal equivalents. The following routine does this. It can be located as a temporary program in BASIC while other programs are being developed or executed. Be sure to use line numbers that do not conflict with those in the program you are using. (Note: input N if done.)

```
010 REM OCTAL TO DECIMAL CONVERSION
020 PRINT: INPUT "A=?”: N
```
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Listing 1: An 8080 assembly language program to allow the user to control the LED (light emitting diode) readouts on the front panel of the H8 computer.

071.000 071.000 377
071.001 071.001 235
071.002 071.002 203
071.003 071.003 221
071.004 071.004 221
071.005 071.005 363
071.006 071.006 221
071.007 071.007 240
071.010 071.010 377

071.011 071.011 041 010 040
071.014 071.014 076 002
071.016 071.016 167
071.017 071.017 041 000 071 DISPLAY
071.022 071.022 021 013 040
071.025 071.025 176 LOADIT
071.026 071.026 353
071.027 071.027 167
071.030 071.030 353
071.031 071.031 043
071.032 071.032 023
071.033 071.033 067
071.034 071.034 077
071.035 071.035 076 024
071.037 071.037 273
071.040 071.040 322 025 071
071.043 071.043 303 011 071
071.046 071.046

ORG 071000A
DB 377A LED PATTERN 1
DB 235A LED PATTERN 2
DB 203A LED PATTERN 3
DB 221A LED PATTERN 4
DB 221A LED PATTERN 5
DB 363A LED PATTERN 6
DB 221A LED PATTERN 7
DB 240A LED PATTERN 8
DB 377A LED PATTERN 9

071.000 071.011 H,040010A POINTER TO _MFLAG
071.014 MVI A,002A (A)=OFF CONSTANT
071.017 MOV M,A DISABLE LED UPDATE
071.022 LXI H,071000A PATTERN TBL POINTER
071.025 LXI D,040013A LED TABLE POINTER
071.026 MOV A,M (A)=BIT PATTERN
071.027 XCHG DISPLAY IT
071.030 XCHG (H)=DISPT, (D)=DISPT
071.031 INX H NEXT PATTERN BYTE
071.032 INX D NEXT LED
071.033 STG SET CARRY=1
071.034 CMC SET CARRY=0
071.035 MVI A,024A (A)=COMPARE CONSTANT
071.036 CMP E (A)<(E)
071.037 JNC LOADIT NEXT PATTERN/LED
071.038 JMP DISPLAY REINITIALIZE
END 071011A

Heath Support Services

Regarding the servicing of digital systems like the H8, Heath's present approach is to do most repairs at regional centers or at the factory in Benton Harbor MI until such time as each local store can either provide additional service training for existing technicians or add on additional technical staff. Some stores that are not regional centers, such as the Heathkit Electronic Center in Peabody MA, have service technicians who are capable of performing most of the necessary digital equipment repair jobs. All Heath products are warranted for a 90 day period from date of delivery. If replacement parts are needed, some parts can be obtained through local stores; the remainder must be ordered from the factory. I have used the replacement parts service and found it to be most adequate.

Another area of support services is the Heath Users Group (HUG). Owners of Heath computers can pay a yearly membership fee to join HUG which is administered in St Joseph MI. HUG supplies users with a variety of services including contributed software, membership information, and newsletters. HUG is an important component of the overall services provided by Heath and is growing rapidly. HUG members who are interested in forming local or regional users groups should feel free to contact HUG manager Robert Furtaw for additional information and assistance.

A third area of support services is new system products. The design of the H8 lends itself to upgrading and expansion in many ways, which Heath is already taking advantage of. I have also heard they're considering a number of designs for interfacing the H8 to their excellent line of ham radio gear, which should be of considerable interest to ham operators who are also interested in RTTY (radio teletypewriter). Likewise, I wouldn't be surprised if Heath introduces sophisticated video game boards to interface to their television sets, and household controllers to interface with some of their home oriented equipment.

Final Thoughts

Aside from these items, the possibilities are many. Digital to analog/analog to digital converters, video drivers, speech recognition systems, EROM (erasable read only memory) boards, upgraded firmware monitors, firmware versions of existing and future software, printers, modems, intruder entry detection devices, graphics boards, and perhaps even bubble or CCD (charge coupled device) memory boards are just a few of the many possible products that Heath might market.
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A Stepping Motor Primer

Part 2: Interfacing and Other Considerations

Interface Circuitry

Part 1 of this article (“A Stepping Motor Primer,” February 1979 BYTE, page 90) described the theory of operation of the stepping motor. Part 2 concludes the discussion with a description of how to interface stepping motors to microcomputers. The interface can be accomplished in several different ways. The most common methods are to either decode the control sequence in software, outputting it to a parallel port with buffers and connecting the output of the buffers to the drive transistors, or use the output ports of the computer to feed into an external decoder that will sequence the drive. Since personal preference and individual application dictate how much or how little of this will be in the program, I will first describe a hardware version for a 4-phase, full-step drive, then describe how to transfer it to software.

Let us assume that two control lines from an input/output (IO) port are used to control the stepper. One line is for direction and the other is for a step command. The program can then control the speed of the motor by controlling the frequency of pulses on the control line. Figure 17 shows a simple interface circuit. The control lines coming from an output port are buffered and sent over a cable to this circuit, which is in close proximity to the motor. (Avoid high voltage and current spikes near the processor.) The first thing to be done is to clean up the signals and then feed them into an up-down counter. The counter determines in which of the four excitation stages the motor is to be. The outputs of the counter are fed into a decoder section that activates the drive transistors at the correct time.

There is a 16 pin integrated circuit available (SAA 1027) through North American Philips Corporation that can do all of this, as well as including the drive transistors, for under $10. The program needed for the system is now fairly simple. What must be done is to select the direction of travel and then pulse the step line the correct number of pulses at the desired stepping speed. Ramping the speed of the motor is discussed in the following section.

The software version of this system would use four lines of parallel port interfacing directly with the drive transistors, with the excitation sequence stored in the program. To advance the motor, the program either increments to the next sequence pattern and outputs it for forward, or decrements the pattern and outputs it for reverse. Again, the speed of the motor is determined by how fast the patterns are outputted.

Although not covered in this article, there are drives available that allow one to input to the drive the number of steps to travel and then activate the go line. The drive automatically ramps the motor up in speed and then stops at the number of steps set beforehand. These drives are known as preset indexers. Another type of drive uses a voltage level to control an oscillator for the stepping speed.

Behavior of Motors in Operation

Like any other motor, the stepper cannot instantly start and stop at full speed and maximum load and still be expected to end at the correct position.

When a motor takes a step, it behaves in a manner similar to that of a fiberglass pole with a weight on one end, as shown in
STEP

CW/CCW

RESET

IC1a 7414

ICb 7414

IC1c 7414

IC2 74191

IC3a 7486

IC3b 7486

IC3c 7486

+5V

RST EN

A B

A B

A B

NEW WEIGHT POSITION

NEW BASE POSITION

BASE

BASE MOVEMENT

WEIGHT SHAKE FOR AWHILE

WEIGHT (SHAFT AND LOAD)

FIBERGLAS ROD (MAGNETIC FORCE)

BASE (ELECTRICAL POSITION)

BASE POSITION (ELECTRICAL)

Figure 17: Hardware version of step sequence generation for a 4 phase full stepping motor.

Figure 18: Analogy to single step movement in a stepping motor. When the base (electrical position) is suddenly moved to a new position, the fiberglass rod (magnetic force) pulls the suspended weight (shaft and load) along with the base. Because the fiberglass rod is flexible, the weight causes it to shake for a while before stopping. The inertia of the shaft and load in the stepping motor's case is the mass that makes the weight oscillate for a time.
Figure 19: Step position versus time for a typical stepping motor. The actual frequency of oscillations and time to decay is different for every motor and load combination.

Figure 20: Simplified diagram of inertial damping used to reduce overshoot of a motor.

Figure 21: Example of a friction coupled inertia damper.

Figure 18. When the electrical position is advanced one step, the magnetic force tries to pull the shaft and load to the next mechanical position. Depending on the drive, inertia of the load, and friction on the load, the shaft will bounce back and forth (oscillate) around the next mechanical position (like the weight on the end of the fiberglass pole) until it has dissipated its energy. Figure 19 is a graph showing position versus time for one step of a motor. This overshoot of the shaft may not be a problem in a low inertia, high friction system, but can cause troubles in a high inertia system with low friction.

To reduce the overshoot some form of damping must be added, the easiest being friction damping. This consists of adding friction to the motor shaft, which opposes any kind of motion and provides energy dissipation during oscillation. Although this method is easy and inexpensive, it reduces the available torque from the motor. This also affects the performance and the final position accuracy of the system.

Another type of damping is known as inertial damping (sometimes referred to as Lanchester damping), which is the most commonly used method for mechanical damping. A simplified diagram of this type is shown in figure 20. This type of damper is constructed with a coupling that is somewhat loose and slips like an automobile clutch that is not fully engaged. The coupling will try to bring the damper inertia to the same speed as the motor shaft. When the speeds are equal, there is no friction between the damper and motor, so the damper is inactive. This type of damper does not affect the final position accuracy but reduces the acceleration and deceleration rate of the system. These dampers are much more expensive than the simple friction damper. The inertia of the damper (which is related to the size and weight) has the largest effect on the amount of damping, and must be selected for the particular application.

Two common ways that coupling can be made are by friction or by using a viscous fluid similar to oil. Figures 21 and 22 give examples of friction and viscous coupling dampers, respectively. The friction damper has a disk attached to the shaft and two other disks, or bearings, that are free to rotate on the shaft. By adjusting the springs, the amount of friction between the free disks and the mounted disk can be changed. The viscous damper consists of a cylindrical case attached to the motor shaft with another cylinder that is free to rotate inside the case. Fluid inserted between the two
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cylinders acts as the coupling. By changing the viscosity of the fluid, the amount of damping can be adjusted.

Another damping method uses the control circuit to electronically damp the mechanical oscillations. This is accomplished by giving the motor a quick reverse, then forward pulse, just as it were about to stop at the final position. Although inexpensive, it requires tuning of the pulses to the load, and the motor will be sensitive to fluctuations in load and friction. For this reason, this type of damping is not suggested for most personal computing applications.

Since the motor cannot normally start and stop at high speeds, some form of acceleration and deceleration must be used. This quickly becomes obvious if the inertia is too large for the initial speed attempted. The motor will make noise and the computer will sequence through the steps, but the motor will not run. Fortunately, this will not harm the motor. To correct this situation, provided that the motor and drive combination is capable of that speed, the motor must start at a speed low enough to turn the shaft and then gradually accelerate to the desired speed. If the acceleration is too fast, the motor will lose synchronism and stop running. To stop the motor, it should be decelerated or it will continue to turn even after the pulses have stopped. As a rule, the deceleration rate can be faster than the acceleration rate.

An operating parameter exhibited by all stepping motors that should be noted is resonance. Every motor has a particular speed at which it has difficulty running. This is called its primary resonance, and it is usually located somewhere between 50 and 150 steps per second. An unloaded motor, when run at its resonance, will have very little torque and may sputter, make noise, stop turning or run backwards. This will not hurt the motor, but it will make the system do a lot of strange things.

To lessen the effects of resonance, a number of things may be done. More friction could be provided by damping, or the drive could be made to deliver less power. The best solution, however, would simply be not to run at that particular speed. When ramping up or down in speed, acceleration through resonance is possible as long as it is only for a few pulses.

The characteristics mentioned above can be found for every motor by examining the motor's speed versus torque curve. Figure 23 shows a typical curve. One point to remember about the graphs is that the curve represents a particular motor with a particular drive, so it is only a rough approximation for a motor with a personally designed drive. The bottom of the graph usually represents the speed of the rotor in steps per second. The side scale shows the torque that the motor can produce. The curve usually shows the maximum torque that can be applied and still start and stop without error. Notice the sag in the curves at low speed. This is where the resonance is located. Under certain conditions, the sag can be very sharp, going down to almost no torque and then back up to several hundred ounce-inches of torque in only 20 to 30 steps per second.

It should be kept in mind that if there is less current in the main drive than what is

---

**Figure 22**: Example of a viscous fluid coupled inertia damper.

**Figure 23**: Typical speed versus torque curve for a medium power stepping motor. The solid line represents the maximum speed-torque combination that the particular motor and drive combination is capable of producing. The dotted curve shows the maximum speed-torque combinations that can be achieved and still start and stop without gradual acceleration or deceleration.
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The following list contains various sources from which stepping motors and pertinent literature may be obtained.

Manufacturers:
Superior Electric Co, Middle St, Bristol CT 06010.
Sigma Instruments Inc, Motion Control Div, 170 Pearl St, Braintree MA 02184.
North American Philips Control Corp, Cheshire Industrial Park, Cheshire CT 06410.
Warner Electric Brake, MCS Div, Beloit WI 53511.
Computer Devices of California, 11901 Burke St, Santa Fe Springs CA 90670.
Singer Co, Kearfott Div, 1150 McBride Av, Little Falls NJ 07424.
Berger-Lahr, Jaffrey NH 03452.

Surplus Stepping Motors and Equipment:
AST/Servo Systems Inc, 930 Broadway, Newark NJ 07104.

### Some Stepping Motor Calculations

The following formulas are commonly used in stepping motor calculations:

Distance \( s = \frac{1}{2}at^2 + v_0 t + c \) where
- \( s \) = distance (inches or cm)
- \( a \) = acceleration (inch per second\(^2\))
- \( t \) = time (seconds)
- \( v_0 \) = velocity, initial (feet per second or meter per second)
- \( c \) = constant.

Velocity (linear) \( v = v_0 + at \) where
- \( v \) = velocity (inch per second or meter per second)
- \( a \) = acceleration
- \( t \) = time
- \( v_0 \) = velocity, initial.

Velocity (angular) \( \omega = \frac{v}{r} \) where
- \( \omega \) = angular velocity (radians per second)
- \( v \) = linear velocity (inches per second or meter per second)
- \( r \) = radius (inches or meters)

\( \omega = \frac{RPM \times \pi}{30} \) where \( \omega \) = revolutions per minute
- \( RPM \) = number of steps per revolution
- \( N \) = angular velocity in steps per second.

(Torque = \( F \times d \), where
- \( F \) = force applied or restraining force, ie: friction, weight, load (ounces or newtons).

The relationship between torque and rotary motion is:

\( T = J \omega / t \) where
- \( T \) = torque (ounce-inches or newton-meters)
- \( J \) = moment of inertia (ounce-inches\(^2\) or newton-meter\(^2\))
- \( \omega \) = angular velocity (radians per second)
- \( t \) = time (seconds)

The moment of inertia for a rotating disk (pulley, gear, etc) is:

\( J = \frac{W r^2}{2} \) where
- \( J \) = moment of inertia
- \( r \) = radius of disk
- \( W \) = weight of disk

L/R Time Constant

The ratio of the inductance to resistance of a winding is used to determine the buildup or decay of current in a stepping motor. The basic equation which represents current flowing in a stepping motor is as follows:

\[ I = l_s \left( 1 - e^{-\frac{L}{R}} \right) \]
where
- \( I \) = instantaneous current (amps)
- \( l_s \) = steady state current in winding (amps)
- \( e \) = natural exponent = 2.718
- \( t \) = time (seconds)
- \( L \) = inductance in winding (henries)
- \( R \) = total resistance in the current path (ohms)

By examining the formula closely, it can be seen that the instantaneous current will reach its steady state value much sooner if the ratio of inductance to resistance is decreased. The result is that the motor will react faster to input signals, which will increase system performance.
shown for rated current, the curve will be shifted below the rated curve. A speed versus torque curve of the motor to be used will help to make the design much easier, and without unexpected disasters. By trying to operate safely below the curve, and observing the design rules, no unforeseen problems should be experienced with the system.

Once the motor has been selected and the drive fully completed, the next logical step is to make a speed versus torque curve of the motor and drive combination. This is important for a number of reasons. First, the speed versus torque curve obtained is the actual response of the motor and drive combination rather than a representative curve provided by the manufacturer. Second, it becomes a reference to compare against if any changes in the drive are made to alter its performance. Another reason for obtaining a curve is that it gives the experimenter a hands-on feel of the behavior of the stepping motor. (See text box for a detailed method of finding the torque of a stepping motor.)

I hope the information presented in these two articles will inspire you to use the versatile stepping motor for your own applications.

---

Obtaining the Torque Curve: A Practical Technique

A simple technique for obtaining the curve is through the use of a spring scale (small fishing scale will serve the purpose) and a thin nylon cord. In this system, a cord suspended from a spring scale is wrapped several times around the motor shaft (or a lightweight pulley on the shaft) and is used to apply a frictional torque on the motor (see figure 24). Changing the size of the pulley will provide several ranges of torque. To find the torque, the motor is run at a constant speed and the free end of the cord is pulled very slowly. As friction builds up, the scale will begin to move. At the point where the motor stops turning, the value on the scale times the radius of the shaft (pulley) gives the maximum torque for that speed. This should be repeated several times to get the correct reading. This is repeated for several different speeds. The typical speed points taken start at 50 steps per second and proceed in increments of 50 steps per second up to 250 steps and then every 200 steps per second thereafter. Other points to find are the maximum torque point, maximum speed no torque point and resonance points. When enough points are taken to get an idea of the curve (about 10 to 15), the points are plotted on regular graph paper and a "best fit" curve is drawn through the points.

Warning: Be careful at low speeds, because the motor can run backwards when it is "jerked" out of synchronism and wind the cord around the shaft in the reverse direction (your finger can get wrapped in there in larger motors). A thin nylon cord is preferable because of its strength. A point to remember is that this is a frictional load and that the shaft (pulley) and cord will heat up when trying to dissipate the energy.

---

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Build a Computer Controlled Security System for Your Home: Part 3

There are many security systems on the market. From the simple $10 door buzzers which signal forced entry to elaborate professionally installed Rollins and ADT systems, their purpose is singular: give the occupant advance warning of an emergency condition. Protection of property is a secondary benefit of the more sophisticated alarms. Ultimately it is the overall complexity of the security system that defines how much coverage is attained in each of these areas.

Forced entry, prowler, and fire detection are but three possible events for which people buy alarms. A $15 smoke alarm alerts the occupants, who rush out of the house in the nick of time but stand watching the house burn because they didn't have time to call the fire department. Similarly, a prowler breaks into a home when the family is out. He has grown accustomed to the regular pattern of timer controlled lights after observing the house for a few nights and immediately disables the alarm horn upon entry. Had the occupants been home they of course would have been alerted to the break-in, but that was not the thief's intention.

To provide full protection, the ultimate security system should discourage intrusion, monitor all potential emergency situations and have the intelligence to initiate a preset series of actions should the alarming event ever occur. Combining all these elements into a single computer controlled security system is the subject of this and the two preceding articles (January 1979 BYTE, page 56; February 1979 BYTE, page 162).

With the control system proposed and developed in this series, the user will have more of a process control computer than a burglar alarm. Except for the detection of the alarming event itself, a system designed to discourage intrusion and automatically respond to certain situations cannot be configured solely as a passive detection unit. The programs which this computer executes either in response to timed events or sensor inputs amount to a process control situation.

The computer controlled security system outlined in these three articles has the capability (presuming you have wired the same output controls as I have) to detect cars or people approaching a residence and track them by sequentially turning on flood lights aimed to cover the perimeter of the house, or give an audible warning in daylight situations. It can also control the power to AC appliances (TV, lights, stereo, etc) either to simulate occupancy or provide the luxury of remote control. This same software allows preset responses to water and temperature sensors for the control of wood heating, water circulating stoves or simply to turn on a pump in the basement. Should any perpetrator be ignorant enough to break in even after sufficient warning, the system has all the usual bells and whistles, an automatic telephone...
dialer, a hidden video tape recorder to obtain evidence, and, finally, a separate communications link to your neighbor.

The first article presented a general outline of the control system, the types of inputs available, and proposed responses. The second article described the hardware modifications to the SDK-85 computer used as the controller and provided an extensive description of the control and data acquisition software. With these three articles, more advanced readers should have enough information to configure a similar control computer using any microprocessor.

The final installment in the series presents examples of discrete input sensors to monitor temperature, moisture, motion, fire, and smoke. To allow the computer to make the proper response to such inputs, designs for flashing lights, strobes, siren, and AC remote control interfaces are also detailed. Finally, just to alleviate any lingering apprehensions over what appears to be a complex software algorithm, we will trace the flow of an alarm input as it is processed by the security system and demonstrate the versatility of table-driven software in this application.

The Alarm System Is Only as Good as Its Input Sensors

The SDK-85 has 38 bits of parallel I/O (input/output). In this application 18 of these bits have been set aside to control outputs, while the remaining 20 are used solely for input. Because the computer is composed of TTL (transistor-transistor logic) circuitry, any input to it must also be TTL compatible. It is a further requirement that all signals be discrete in nature. That is, they change state from a 1 to a 0 or a 0 to a 1 level when the set point is attained. Analog inputs are not beyond the capabilities of the software, but no analog to digital interface has been built into the system.

Analog Input Sensors

Temperature and voltage are important analog parameters which any sophisticated alarm system requires if it is to monitor freezer or furnace room temperature and brownout conditions. The circuit of figure 1 can be used to read temperature setpoints. IC1 is a special integrated circuit having an output voltage proportional to temperature.

![Figure 1: Temperature setpoint indicator circuit. IC1 is a special integrated circuit whose output voltage is proportional to temperature. The circuit feeds into an Intel SDK-85 single board computer, which accepts only TTL (transistor-transistor logic) level inputs. Op amp IC2 is used as a computer to convert the output accordingly.]

AC TO DC CONVERTER TO MONITOR POWER FAILURE OR BROWN OUT CONDITION

![Figure 2: Circuit which can be used to monitor any DC voltage between 0 and 24 V. A latching relay is used to latch on when a voltage transient occurs.]

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Since the SDK-85 can respond only to TTL inputs, op amp IC2, configured as a comparator, changes logic levels when the output of IC1 equals the setting of the temperature trigger pot. IC2 is powered by a 5 V power supply so that the output is TTL compatible. If a multiple array of temperature transducers is to be constructed, use an LM339 quad comparator instead of four LM301s to reduce wiring complexity. Another analog circuit, shown in figure 2, can be used to monitor any DC voltage between 0 and 24 V. It could be used to monitor the battery back-up supply to the computer or some other important parameter. Since voltage fluctuations are often significant and desirable to catch, the circuit uses a latching relay to keep it in the set condition once triggered. If that is not a desirable feature, then replace RLY1 (relay 1) with a nonlatching type. A relay should continue to be used, however, because it isolates the computer from the monitored voltage sources.

**Discrete Input Sensors**

Actually, all inputs to the computer are discrete, and this need not be a separate category. The outputs from the sensors are primarily contact closures for a reason I'll explain later. Some of the important ones worth considering are liquid level or moisture, smoke and fire, and ultrasonic and infrared interrupted beam motion detectors.

A liquid level sensor suitable for detecting basement flooding so that a sump pump can be turned on is illustrated in figures 3a and 3b. This circuit uses a new integrated circuit from National Semiconductor specifically...
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Figure 5: Intrusion alarm infrared transmitter and detector. Shown in (a) is a low voltage pulsed LED (light emitting diode) transmitter; the light beam receiver with optional focusing lens is shown in (b). The lens extends the range of the unit from approximately 10 to 50 feet. Anyone or anything breaking the beam will alert the security system.

designed for this purpose. As configured, the relay contacts will close in the presence of water or condensing moisture. The circuit is extremely sensitive and can be used with practically any conductive liquid.

Probably the most important sensors on the security system are the ones that detect fire and smoke. A commercially available ionization type smoke detector, shown in figure 4, has been configured to interface to the computer. The AC powered TC49A by Honeywell is ideally suited for this purpose, since it is designed for parallel attachment to other sensors. In this instance any number of normally open temperature sensors can be attached between the blue and yellow output leads of the device. Should any of these sensors or the smoke detector itself detect an alarm condition, the 35 V normally present on these wires will drop 2 V. The relay which had previously been in an energized state will open, signaling the event to the computer. Protection must be provided during power failures, however, so that the computer (which has an emergency supply) does not detect a false alarm. If the program which scans the smoke alarm also checks the power failure sensor, positive results should be obtained. In any case it is always a good idea to have a battery powered smoke detector also within the residence.

Note that the majority of sensor designs presented in this article can be used independently. The device normally activated when the sensor signals an alarm condition can be attached and directly controlled through another parallel set of relay contacts. An example would be the water detector that automatically turns on the sump pump. Requiring the computer to receive the signal, process the control record, and turn on an AC powered pump would be a waste of wire. The computer need know only that the high water mark has been reached to notify the residents on the display panel: it does not have to control it as well. Before you string a mile of wire through the house, consider what functions really need "computer" rather than "local" control.

The two remaining special input sensors are related in purpose. Both are used to detect an object or person passing between two points, and both use interrupted beam sensing techniques. One is an infrared light beam and the other is ultrasonic. The light beam circuit is shown in figure 5 and the ultrasonic circuits are illustrated in figure 6. The range of the infrared unit is about 10 feet without a lens and as much as 50 feet with proper ambient light shielding and a focusing lens. No focusing was tried on the ultrasonic unit, but 25 feet was easily achieved.

Testing and alignment of the ultrasonic transmitter can be tricky, while the infrared is simply a mechanical alignment consideration. First, the transmitter must be tuned to resonance. The nominal frequency of the ultrasonic transducers can be 34 to 42 kHz; they should be bought in pairs. An oscillo-
scope should be put across the transducer in the transmitter circuit when power is applied. Coils T1 and T2 should then be adjusted to produce the greatest amplitude across the transducer. The usual value is about 30 V peak-to-peak and the frequency should be the nominal $F_0$ listed for the part.

Once the transmitter is tuned, place it about 2 feet in front of the receiver. Adjusting the center frequency adjustment pot should cause the relay to pull in and the LED (light emitting diode) to light. The transmitter and receiver can now be placed across a driveway or large room.

**Wireless Inputs**

So far we have only discussed input sensors which are directly wired to the connectors of the SDK-85 computer. If a reed switch were attached to the garage door a wire must be run from it to the computer. In a larger house this can amount to a lot of wire and can extend system construction time. One possible solution is to use a wireless transmitter and receiver between the computer and remote points within the house.

Homebrew wireless transmitters, while cheap, suffer from a lack of reliability. They are not being considered for this application because there is a commercial unit available which is both cost effective and reliable. The particular device is the Norelco Home Patrol wireless burglar alarm system available in most discount stores for about $200. It consists of a receiver, four contact-closure-activated transmitters, and a smoke

---

**Figure 6: Medium power ultrasonic transmitter (a) and receiver (b).** As with the infrared system in figure 5, interruption of the ultrasonic path will alert the security system.

**NOTE:** THE ULTRASONIC TRANSDUCER USED THE TRANSMITTER AND RECEIVER MUST HAVE IDENTICAL $F_0$. 

**Diagram:**

- **(a)** Ultrasonic Transmitter circuit
- **(b)** Ultrasonic Receiver circuit

**Circuit Details:**

- **(a)**
  - $f_0 = 40$ KHz
  - Transistor: 2N2222
  - Resistors: 22K, 180pF, 47K, 330pF, T1, T2
  - Capacitors: 100µF, 10µF, 0.01µF, ±100µF
  - Switch: Adjustable 1-3 mH

- **(b)**
  - $f_0 = 40$ KHz
  - Transistor: 2N3904
  - Resistors: 220K, 2.2K, 47K, 1K
  - Capacitors: 0.0047µF, 0.02µF, 0.01µF
  - Switch: 10k Center Frequency Adjust
  - Tone Decoder: NE567
  - LED
  - RLY
  - 2.7K
  - 10µF
  - 2.2K
  - 1µF

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detector with built-in transmitter. Photo 1 shows the components of the system and figure 7 details how each of these separate transmitters can be expanded to cover a wider area.

The Norelco receiver has four separate output channels designated as fire, intrusion, car, and miscellaneous. Transmitters are supplied for intrusion and fire only—transmitters for the other two channels must be purchased separately. Photo 2 shows one of these devices.

Photo 3 shows the output connections of the receiver and figure 8 illustrates the type of interface which must be constructed to convert the 0 and -15 V Norelco receiver outputs to be TTL compatible. Only then can the security system be aware of these remote alarm inputs.

Security System Outputs

Once an alarm condition has been detected or the event processor activated, the security system responds accordingly. Whatever the cause, the output will be a TTL change of state which can be used to drive a mechanical or solid-state relay. Typical output interfaces are warble alarms, high intensity flashers, and strobe lights. They are shown in figures 9, 10 and 11, respectively.

AC output control can be handled in either of two ways: solid-state or mechanical relays. While solid-state relays are definitely the more modern approach, it is very difficult to find control panels incorporating them which are understandable to electricians or which meet local electrical codes. Rather than fight the system it was easier to install a readily available relay control panel as shown in photo 4. The two cabinets on the right are relay cabinets, and the one on the left is the regular breaker box. Each relay enclosure contains six relays. The left relay enclosure controls the six outside light circuits and the righthand enclosure remotely controls six wall outlets around the house. The relays are DC input and can either be controlled directly from the computer or manually from scattered points around the house. Each of the 12 relay outputs requires a separate cable to the outlet or light to be controlled. This is not an inexpensive control method, but it does meet the code and is a convenience once installed.

Two other details left to be considered are the emergency power supply to the com-

Photo 2: Single wireless transmitter with one read switch attached to it. Multiple reed switches can be attached in parallel to cover a wider area, as described in the text.
Photo 3: Output connections of the Norelco receiver. Using the circuit described in figure 8, the outputs of the Norelco receiver can be easily interfaced to the computer. There are four distinct output channels of the Norelco unit. As purchased in its basic form it comes with transmitters for fire and intrusion only.

Figure 8: Details of the Norelco Home Patrol receiver showing how it is connected to the central computer.
Figure 9: CMOS warble alarm.

Figure 10: 115 VAC incandescent lamp flasher.

Figure 11: 115 VAC Xenon strobe light. Parts for this circuit are available from Chaney Electronics, 2010 W Dartmouth Unit # 8, Englewood CO 80110.
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Circle 45 on inquiry card.

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Circle 46 on inquiry card.
Figure 12: Bedside annunciator panel used to display the status of the home security system.

puter and the display panel located in the bedroom.

The Alarm Status Display Panel

The purpose of the alarm status display panel is to provide the resident with a graphic representation of the status of the security system. Figure 12 is a sketch of a simple annunciator (the picture was omitted because the control panel I finally built bears no resemblance to the purpose we are discussing, and might be confusing since it contains numerous additions to the basic concept).

The circuit (see figure 13) is simply a BCD (binary coded decimal) to decimal decoder driver which is multiplexed by a 3 bit output from the SDK-85. The computer sequentially sends out the codes for the particular lights to be lit. This is done repeatedly and with sufficient speed so that they appear constant. If the annunciator panel is more than 50 feet from the computer, the user may want to consider the addition of the line drivers also described.

Emergency Power Supply

Should power ever be lost in the residence, it is important to maintain the security system in an active mode. To do this a 12 V automobile battery is used to power the computer all the time. The SDK-85 5 V power is derived from the 12 V through a regulator. The EROM (erasable read only memory) can be either a single +5 V unit such as a 2716; or, if using a 2708, the −12 V can be derived using one of the circuits outlined in my article "No Power for Your Interfaces? Build a 5 V DC to DC Converter" (October 1978 BYTE, page 22). The requirements of such a power supply are maintenance of the 12 V on the battery, recharging the battery as it needs it, and also providing standby power to critical sensors and alarms.

Tracing an Activated Alarm Condition: An Example

Part 2 of this series (February 1979 BYTE, page 162) emphasized the software of our computerized home security system. To adequately complete the description of this design, it is necessary to include an example which illustrates the use of table driven software. Included is a listing of the digital scan module and various response modules which should aid in understanding.

Suppose one of the functions of the system is to respond to a smoke and fire detector. First, assume that the sensor in question is wired into the least significant bit (bit 0)
on port 0. Response to this sensor is on a reset-to-set (0 to 1) transition, and that on a set-to-reset (1 to 0) transition no action is to be taken. As detailed in part 2 of this series, the initial state change is detected by DIGSCN (the digital scan module) which uses the information contained in XFVE (the sensor state transfer table) to initiate the processing of a digital event. If you recall, the sensor state transfer table is comprised of four byte records, with one record being required for each digital input:

Sensor State Transfer Record

Bytes 0 and 1: event record address for reset-to-set transition plus active/inactive flag (bit 7);
Bytes 2 and 3: event record address for set-to-reset transition plus active/inactive flag (bit 7).

The smoke and fire detector connected to bit 0 input uses the first record in the sensor state transfer table to initiate the required responses. Since no action is required for a set-to-reset transition, bytes 0 and 1 are set equal to hexadecimal FF. This makes such a transition inactive (active/inactive flag = 1). We do, however, want to process a smoke and fire alarm. Therefore, bytes 2 and 3 must contain the address of the event record associated with the alarm. For this example let us assume that the address of the event record used to process this alarm is at hexadecimal 4214 (therefore byte 2 of the transfer record will equal hexadecimal 14 with byte 3 being equal to 42):

Sensor State Transfer Record for Smoke and Fire Alarm

Byte 0 = FF;
Byte 1 = FF;
Byte 2 = 14;
Byte 3 = 42.

To summarize, the digital scan module detects the transition of the smoke and fire sensor from a reset to a set state. Using the information contained in the sensor state transfer table, the system processes the event by first extracting the address of the event record associated with this alarm and then activating EVPRO (the event processor module).

EVRREC (the event record), which is used by the event record processor, contains the indices to the various response records associated with this alarm. As you may recall, one of the features of this system is its ability to associate several responses to

---

**Figure 13:** Driving circuitry for the annunciator panel (see figure 12). A BCD (binary coded decimal) code from the computer is converted to decimal by IC7445 to drive the LEDs on the panel, which are driven sequentially with sufficient speed so they appear to be lit constantly. An optional RS-232 interface for driving the circuit at some distance from the computer plus a 5 V power supply are also shown.
a single event. The event record is the mechanism which accomplishes this as follows:

**Event Record Format**

- Byte 0: number of responses associated with record;
- Byte 1: relative index of response record i;
- Byte 2: relative index of response record j;
- Byte n: relative index of response record z.

Initially the response might be to activate the autodialer notifying the police and fire departments of the predicament. But before doing that, let us take a few seconds to check for a false alarm and, if possible, verify the situation. This can be accomplished with the following responses to the alarm. First we do want to initiate the autodialer. So, our first response will be the initiation of a 60 second delay of the autodialer. Next, since we may be in the bedroom and unable to hear the alarm itself, we will initiate an audible alarm — and, so that we can tell the location of the alarm, we will display the location of the alarm on the annunciator panel.

These functions will require an event record containing the indices of the following responses:

- Delay timer activation for the 60 second delay.
- Application task response for driving the annunciator.
- Digital output response for activating the audible alarm.

In this example it is assumed that the response indices are 0, 1, and 2, respectively. The event record for this event will therefore be four bytes in length as follows:

---

**Figure 14**: Automatic charger circuit for the 12 VDC car battery computer backup power supply.
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Circle 203 on inquiry card.
**Listing 1: Selected 8080/8085 subroutines for the home security system.**

| ZERO | EQU | 0 |
| ONE | EQU | 1 |
| Pl | EQU | 0  |  * PORT 1 *
| P2 | EQU | 1  |  * PORT 2 *
| P3 | EQU | 2  |  * PORT 3 *

* THE FOLLOWING ARE TO BE LOCATED IN RAM *

| TEMP | DB | 0 |
| TEMP | DB | 0 |
| TEMP | DB | 0 |
| PORT1 DB | 0  |  CURRENT INPUT DATA FOR PORT 1 *
| PORT2 DB | 0  |  CURRENT INPUT DATA FOR PORT 2 *
| PORT3 DB | 0  |  CURRENT INPUT DATA FOR PORT 3 *
| PORT1H DB | 0  |  PREVIOUS INPUT STATE FOR PORT 1 *
| PORT2H DB | 0  |  PREVIOUS INPUT STATE FOR PORT 2 *
| PORT3H DB | 0  |  PREVIOUS INPUT STATE FOR PORT 3 *
| POUT DB | 3  |  OUT PUT PORT STATUS *
| DIGIN DB | 6  |  DIGITAL INPUT HIT PROCESSING INDEX *
| XFE DB | 4H  |  SENSE STATE TRANSFER TABLE *
| EVHKREC DB | 10H  |  EVENT RECORD FILE *
| TOHKREC DB | 10H  |  TIME OF DAY RECORD FILE *
| TIMREC DB | 15H  |  DELAY TIMER RECORD FILE *
| RESREC DB | 15H  |  RESPONSE RECORD FILE *
| DIUREC DB | 16H  |  DIGITAL OUTPUT RECORD FILE *

* THE FOLLOWING MODULES REPRESENT THE MODULES *

* REQUIRED FOR PROCESSING THE OCCURRENCE OF *

* A DIGITAL EVENT. THESE MODULES WOULD RESIDE IN RAM *

* *

* THE DIGITAL SCAN MODULE READS THE DIGITAL *

* INPUTS, COMPARES THE CURRENT STATE WITH THE PREVIOUS *

* STATE AND IF DIFFERENT INITIALIZES THE PROCESSING *

* OF THE STATE CHANGE, UPON COMPLETION OF THE DIGITAL *

* INPUT PROCESSING THE CURRENT STATE *

* OF THE DIGITAL INPUTS IS UPDATED AND THE *

* NEXT SCAN INITIATED *

| DIGSCN | IN | P1  | * INPUT PORT 1 *
| STA | POUT1 |
| IN | P2  | * INPUT PORT 2 *
| STA | POUT2 |
| IN | P3  | * INPUT PORT 3 *
| STA | POUT3 |
| MV | A-Y | * RESET DIGITAL PROCESSING INDEX *
| STA | .N15H |

* ISOLATE BIT FROM HISTORY AND CURRENT DIGITAL STATE *

| DIG1 | LDA | DIG1  | * READ PROCESSING INDEX *
| CPI | HO  | * INDEX GT.8 *
| JC | D164 | * JUMP IF INDEX gt 7 *
| CPI | H8  | * INDEX.LT.16 *
| JC | D133 | * JUMP IF INDEX EO 15 *

* PROCESS THRU PORT *

| LXI | H.M00T3 | * MP:PORT3 DATA ADDRESS *
| LXI | H.M00T3H | * DE:PORT3 HISTORY ADDRESS *
| N102 | CALL | CP.01IT | * MP COMPARE DJT *
| JNZ | D180 | * IF EZO NO CHANGE *
| DI022 | LDA | D100H | * INCREMENT PROCESS INDEX *
| CPI | 256 | * ALL INPUTS PROCESSED *
| JNZ | D111 | * JUMP IF NOT *
| JMP | D15CN | * GUT RESTART SCAN *

* PROCESS SECOND PORT *

| LXI | H.M00T2 | * MP:PORT 2 DATA ADDRESS *
| LXI | H.M00T2H | * DE:PORT2 HISTORY ADDRESS *

* PROCESS FIRST PORT *

| N104 | LXI | H.M00T1 | * MP:PORT 1 DATA ADDRESS *
| LXI | H.M00T1H | * DE:PORT1 HISTORY ADDRESS *
| JMP | N107 |

* IF A = 1 PROCESS A SET STATE *

* IF A32 PROCESS A RESET STATE *

* DIGIN CONTAINS THE-relative INDEX INTO *

* THE SENSE STATE TRANSFER VECTOR TABLE *

| DIGPRO | STA | TEMP |
| LDA | D1FE | * BASE ADDRESS *
| D10D | RCL | 4 |

**Event Record for Smoke and Fire Alarm**

<table>
<thead>
<tr>
<th>Hexadecimal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
</tr>
<tr>
<td>4214 = 3</td>
</tr>
<tr>
<td>4215 = 0</td>
</tr>
<tr>
<td>4216 = 1</td>
</tr>
</tbody>
</table>

* The event processor will process the entries in the event record sequentially, extracting the response record index and activating RESPRO (the response record processor). Using this index the response processor will obtain RESREC (the indicated record from the response file) and direct the activation of the appropriate subprocessors, which contain the following information:

**Byte 0 = response type**

- 0 = digital output;
- 1 = application module;
- 2 = delay activation;
- 3 = delay deactivation;
- 4 = time-of-day activation;
- 5 = time-of-day deactivation.

**Bytes 1 and 2 = module address of record index.**

For our example the records will be as follows:

**Response File**

| Record 0 | Byte 0 = 2 |
| Byte 1 = 0 | second delay |
| Byte 2 = 1 | timer record; |
| Byte 3 = 1 |

| Record 1 | Byte 4 = 0F |
| Address of annunciator | Byte 5 = 2C | application module; |
| Byte 6 = 0 |

| Record 2 | Byte 7 = 0 |
| first digital output | Byte 8 = 0 | record. |

The first record processed causes DE-LINT (the delay module) to activate the second record in TIMREC (the delay timer file). These records contain the delay time (in seconds) and address of the event record to be activated when the directed delay has timed out:

**Delay Time Record**

* Bytes 0 and 1: active flag plus remaining time; *
* Bytes 2 and 3: number of seconds to delay; *
* Bytes 4 and 5: address of event record. *

In our example this record (prior to activation) will appear as follows:

**Bytes 0 and 1: 80, 0 = record inactive;**

**Bytes 2 and 3: 0, 3C = 60 second delay;**

**Bytes 4 and 5: 18, 42 = event record at hexadecimal 4218.**

After the delay has been initiated, the event processor will notify the response processor to initiate the second response.
Listing 1, continued:

```
PLC
MOV C, A
MVI 897E140
DAD HL.BC
LOA TEUPI
CPI 2
J7 OIRV1
INX H
INX I
*JUMP IF SET TO
RESET
DIGP1 LOAx
OE
TRANSFER VECTOR
CPI 80H
IS HIGH ORDER
BIT SET
JNC Dir, 2e
*JUMP IF RECORD INACTIVE
LD4x DE
MOV L.A
INx nE
LOAX OE
MOV H.A
CALL EVPRO
*PROCESS
EVENT RECORD
JMP DIP;
COMBIT ISOLATES
ANU
COMPARES
THE
DATUM
BIT
IN
THE
CURRENT
AND
HISTORICAL
DIGITAL
INPUT
HL=
CURRENT DATA ADDRESS
DE=
HISTORY DATA
ADDRESS
COMBIT
LOAX
D
*HISTORY DATA
CMP H
JZ COSAS
NO
COMPARE
ISOLATE BIT
MVI 4, 1
COI?
COM1
CPI 0
JZ COh: 4
RLC A
COM2 STA TEUO2
*GET
CU=JOeLa
SLAY
NET
*COMPARE HISTORY
TO
CURRENT
JUMP
IF
CURRENT=HISTORY
*SET
MASK
SHIFT
COUNTED
*SHIFT
MASK
BIT
SAVEm
MASK
*OCCURRENT
DATA
A_CuRRENT
BIT
TEMPJ_CURRENT
BIT
STATUS
W
HISTORY
WIT
A_CURRENT
BIT
*COMPARE
BITS
RFTURN
TF
EQUAL
CPI C
*15 HIT
RESET
JNZ
CO!i
JUMP IF
BIT SET
MISTPOY
STA TEMPI
uFT
MASK
CMA
COMPLIMENT
XCHG
ANA M
MOV H.A
*STURE HISTORY
INP A
STA DIGIND
MVI A.1
PET
COM3 STA DIGIND
MVI A +? 
*SET HISTORY
STATE
COM4 LDA DIGIND
ADD nD
STA DIGIND
MVI A +0
*AEU
COM5 LDA DIGIND
ADD nD
STA DIGIND
MVI A +0
*AEU
COM6 LDA DIGIND
ADD nD
STA DIGIND
MVI A +0
```

---

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Listing 1, continued:

LOA TEMP2  
JMP COM1  
  
* THE EVENT RECORD PROCESSOR OBTAINS THE INDEX  
* OF THE RESPONSE RECORD FROM THE EVENT RECORD  
* CALCULATES ITS ADDRESS  
* AND CALLS THE RESPONSE RECORD PROCESSOR  
* EVENT RECORD ADDRESS IS IN ML  
EVPRO MVI B x  
* SET INITIAL INDEX  
  
EVPR1 INX  
PUSH ML  
  
MOV A \#ML  
  
CALL EREC  
PUSH ML  
  
GET EVENT RECORD ADDRESS  
PUSH OE  
  
GET INITIAL RECORD ADDRESS  
PUSH PSH  
  
* SET INDEX  
INX A  
  * INCREMENT INDEX  
XCHG  
  
* ML=INITIAL ADDRESS  
MOV B,\#ML  
  
* NUMBER OF RECORDS TO PROCESS  
XCHG  
  
* HL=RESPONSE RECORD ADDRESS  
PUSH OE  
  
* SAVE INITIAL RECORD ADDRESS  
CMP \#0  
  
* MOVE ALL RESPONSE RECORDS BEEN PROCESSED  
JA EVPR2  
  
* JUMP IF MORE TO PROCESS  
PUSH \#ML  
  
* MOVE BASE ADDRESS OF RECORD FROM STACK  
RET  
  
EVPR2 POP DE  
PUSH PSH  
PUSH OE  
  
* POP PROCESS NEXT ENTRY IN RECORD  
  
* THE RESPONSE RECORD PROCESSOR OBTAINS THE  
* RESPONSE TYPE FROM THE RECORD AND TRANSFERS CONTROL  
* TO THE APPROPRIATE RESPONSE MODULE  
* ON ENTRY ML=RESPONSE RECORD ADDRESS  
  
RESPRO MOV L,\#x7E90  
  
* HL=RESPONSE INDEX  
MOV A,\#\#  
MOV F,=  
DAO DE  
DAO DE  
NAU OE  
  
* HL=RESPONSE INDEX\#3  
XCHG  
  
* HL=RESPONSE INDEX\#3  
LXI \#M\#RESREC  
ADD DE  
  
* HL=RESPONSE RECORD ADDRESS  
MOV \#1\#  
ADD A  
  
* HL=ADDRESS OF NEXT DATA ITEM IN RECORD  
XCHG  
  
* HL=ADDRESS OF NEXT DATA ITEM IN RECORD  
MOV C,=  
MVI A,=\#RHRU  
LXI \#ML\#RESTAR  
DAO BC  
  
* HL=ADDRESS  
XCHG  
  
* HL=ADDRESS OF RESPONSE MODULE  
MOV H,=  
PUSH BC  
XCHG  
  
* HL=ADDRESS  
TXA  
  
MOV F,=  
RET  
  
* GO TO RESPONSE SUBPROCESSOR  
  
RESTAR DW DOUT  
DW APL  
DW \#ELINT  
DW \#DLWAC  
DW \#TONAC  
  
* THE DIGITAL OUTPUT SUBPROCESSOR EXTRACTS  
* THE PORT/MASK AND DIRECTIVE INFORMATION FROM  
* THE INDICATED RECORD AND OUTPUTS THE NEW VALUE  
* DE CONTAINS THE RECORD INDEX  
  
DOUT LXI ML,\#DIGREC  
  
* SET DIGITAL OUTPUT RECORD ADDRESS  
DAO DE  
DAO DE  
DAO DE  
  
* HL=OUTPUT RECORD ADDRESS  
PUSH ML  
  
* SAVE OUTPUT RECORD ADDRESS  
MOV A,=  
MVI A,=\#RFDH  
LXI \#ML\#PORT  
  
* HL=OUTPUT PORT BASE ADDRESS  
DAO HC  
  
* HL=ADDRESS OF PORT DATA  
MOV A,=  
  
* AEOUTPUT PORT CURRENT STATE  
PUSH ML  
  
* HL=OUTPUT PORT ADDRESS  
TXA  
  
* HL=THE MASK ADDRESS  

This time it determines that the response required from record 1 is to call the application module located at hexadecimal address 2COF. This information is transmitted to APL (the application task initiator subprocessor) by the response processor, which transfers control. In our particular example this application module will cause the display panel to flush the location of the sensor giving the alarm. Upon completion of this function the application module returns control to the event record processor.

Next, the event record processor transfers the index of response record 2 to the response processor. Recognizing that a digital output is to be initiated, the processor extracts the index of DIRREC (the digital output record), 0 in this example, and initiates DIGOUT (the digital output subprocessor).

The function of this subprocessor is to activate the audible alarm. A 3 byte record is used to effect the actual output:

**Digital Output Record**

Byte 0 = output port;  
Byte 1 = bit isolation mask;  
Byte 2 = 0 for reset (off);  
Byte 2 = 1 for set (on).

In our case let's assume that the audible alarm has been connected to bit 5 on output port 3 and must be set to a logic 1 to sound the alarm. This requires a digital output record as follows:

**Audible Alarm Output Record**

Byte 0 = 3;  
Byte 1 = 20;  
Byte 2 = 1.

Using this information bit 5 on output port 3 is set and the alarm horn is turned on. Processing this final response causes the event processor to return to the digital scan module, which will continue monitoring the state of all the digital inputs.

The intent of this example is to show how the system works when attached to the real world. While this example does not cover all the functions one might associate with a smoke or fire alarm, it does serve to illustrate how the various tables are structured. What you can do with such a system is limited only by your imagination. As stated earlier in this series, the system can be structured to perform many of the discrete tasks associated with the control and monitoring of the home or office, as well as protecting your property against intruders. So let your imagination take command and have fun. Next month: musical toys.
Listing 1, continued:

ANA
PSW
IN
ML
MOV A,
ML
DCX
ML
CP1
GPF
J2
DINT
POP RC
MOV A,
ML
PORT
STA
DINOUT2+1
MOV A,
Port
DINOUT
DINOUT2
MOV C,
C
MOV A,
DPL
IN
ML
OUT
ML
POP
RC
DAD
OUT
ML
MOV A,

*SAVE MASKED STATE
*GET SET/RESET DIRECTIVE
*SAVE PORT NUMBER IN OUTPUT INSTRUCTION

DIGOUT
DCX
ML
MOV A,
ML
ADOUTPUT PORT
STA
DINOUT2+1
MOV A,
ADOUTPUT DATA

DIGOUT2
OUT
ML
MOV C
PW
LXI
ML
DPL
DAD
OUT
ML
MOV A,

*SAVE NEW STATE IN MEMORY

DIGSET
MOV A,
AM
*EMASK
C4A
POP
RC
POP A
*SAVE MASKED VALUE
MOV A,
*NEW OUTPUT STATE

*VECTORS TO APPLICATION TASK
*DE CONTAINS MODULE ADDRESS
*APPL
PUSH
DE
*SAVE ADDRESS ON STACK
RET
*EXIT TO APPLICATION MODULE

*DELINT ACTIVATES THE DELAY RECORD WHOSE
*RECORD INDEX IS IN DE

DELINT
L-1
ML+DELREC
*SET BASE ADDRESS
DAU
DE
DAD
DE
DAD
DE
DAD
DE
MOV A,
ML
DELREC
MOV A,
*MLEDELAY RECORD ADDRESS
MOV A,
*GET ACTIVE FLAG
ANT
MOV A,
*IS ACTIVE FLAG RESET *ACTIVE
C
IN
ML
IN
ML
*GET TIMER ACTIVATION VALUE
MOV A,
*GETIMER VALUE
DCX
ML
DCX
ML
MOV A,

*SET VALUE IN RECORD

*DELDAC REACTIVATES THE DELAY RECORD
*WHOSE INDEX IS IN DE

DELDAC
LXI
ML+DELKES
*SET BASE ADDRESS
DAU
DE
DAD
DE
DAD
DE
DAD
DE
DAD
DE
DAD
DE
MI
A2FM
MOV A,

*RESET ACTIVE FLAG
RET

*TONAC ACTIVATES THE TOP RECORD
*WHOSE RECORD INDEX IS IN DE

TONAC
LXI
ML+TONREC
*SET BASE ADDRESS
DAU
DE
DAD
DE
DAD
DE
DAD
DE
DAD
DE
MI
A2FM
MOV A,

*ACTIVATION MASK
AH
A
*SET RECORD ACTIVE
MOV A,

*SET RECORD INACTIVE

*SET MASK ADDRESS

TONDAC
LXI
ML+TONREC
*SET BASE ADDRESS
DAU
DE
DAD
DE
DAD
DE
MI
A2FM
MOV A,

*UACTIVATION MASK
AH
A
*SET RECORD INACTIVE
MOV A,

*RETURN
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Common Mistakes
Using Warnier-Orr Diagrams

Editorial Note...

Since publishing David Higgins' first two articles on Warnier-Orr diagramming techniques, we have received a number of letters from people expressing the message (paraphrased) "If I have this or that self-documenting structured programming language, why should I use Warnier-Orr techniques? After all, if a program in my language is logically equivalent to the Warnier-Orr structure, and it is directly executable, I see no need for an extra layer of documentation."

A very real answer to this objection is that it is correct. There is no point to using Warnier-Orr techniques if you properly use a language such as PASCAL which, having structured programming constructs built in, allows long descriptive names for variables and procedures, and as a result can support self-documenting code.

But most currently used languages in personal computing do not easily support self-documenting code and modern concepts of structured programming. The usefulness of the Warnier-Orr methodology is that it provides a disciplined way of imposing such structure on a language such as BASIC, FORTRAN or assembly language. In effect, the Warnier-Orr discipline is a programming language which is intended for hand translation into one of the existing unstructured languages... CH

In my opinion, one of the best program and system design methods is the Warnier-Orr structured systems design approach, which I described previously ("Structured Program Design," page 146, October 1977 BYTE; "Structured Programming with Warnier-Orr Diagrams," page 104, December 1977 and page 122, January 1978 BYTE). This article is being presented because of the interest expressed in this subject, and because a lot of people will be trying these techniques for the first time. Newcomers to this methodology often have many questions about their work, and want to know whether or not what they are doing is correct. The purpose of this article is to outline a few of the more common mistakes that beginners make when using this technique.

Philosophical Errors

Many first time users of the Warnier-Orr diagrams tend to make mistakes which are so similar that they are worth examining. The biggest and most common mistakes tend to be a direct result of what we can call philosophical errors; not really a misuse of the techniques so much as a misunderstanding of the techniques. The most common error stems from the fact that many computer programmers tend to be obsessed with the desire to write some kind of code at the very beginning of the design process. This problem usually manifests itself in any or all of the following three ways:

- Trying to code the program while designing it (called the design-a-little, code-a-little approach).
- Relying too heavily on language restrictions and considerations while doing logical design.
- Skipping the design phase altogether because:
  a) the program is "too easy" or
  b) the program is "too smart."

Any of the above practices will destroy most if not all of the effectiveness of the Warnier-Orr methodology [or any other structured programming methodology for that matter... CH]. It will certainly cause you to waste a great deal of time.

If you try to use the first technique, the design-a-little, code-a-little approach, you will probably be in for quite a bit of erasing or retyping when you have to change the design because you coded yourself into a corner that you can't design your way out of. Your program will tend to be twice as long as it should have been and half as efficient. You will probably be in for a lot of debugging runs while trying to put back into the code everything that you left out when you changed the design. As you can see, this technique just naturally generates problems.

The second technique described above is a common mistake that veteran programmers almost always seem to make: relying too heavily on the program language they will be using while doing the program design. Consider the two examples of program...
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designs shown in figure 1. Both figures 1a and 1b are diagrams of the same process: computation of overtime wages. The diagram in figure 1a however seems to be the type that veteran programmers will almost always try to draw. Note its heavy stress on the language aspect of the function. It almost looks like part of a BASIC program cut out and pasted on a diagram. Contrast that diagram with the one of figure 1b which correctly details the logical process being performed. You can see that if figure 1a was the only documentation for this particular procedure, you would probably not be able to tell what that piece of code was supposed to be doing. You might have some idea because this program seems to have semimeaningful field names from which you might deduce some purpose. All we can tell for sure from figure 1a is that some part of the program is going to crunch a couple of numbers. What numbers it is going to crunch and just what for are anyone’s guess. On the other hand, it is impossible to misunderstand what the process diagrammed in figure 1b is doing. It is very easy to read and comprehend because it shows the logical side of the procedure.

This stress of the logical over the physical while designing with the Warnier-Orr diagrams is essential to their correct usage. Designing as in figure 1a serves absolutely no purpose as far as understanding the process that is being described and is essentially worthless as far as documentation is concerned. Even though you might be able to tell what that diagram does the day you draw it, you probably won’t be able to understand it in six months. Someone else who wants to use your documentation might never understand it.

As long as we’re on the subject of documentation, I might mention that through the development period of this technique, many people were concerned that the diagrams might become too far removed from the actual code, which would render them useless as effective documentation. They worried that since the diagrams depicted the logical side of the problem, they had little or no relevance to the physical (real world) side. Those fears were easily put aside with two diagramming and coding conventions, as follows:

- Physical mileposts on the Warnier-Orr diagrams.
- Logical symbol tables in the programs.

Thus, when we actually wrote code that looked like that of figure 1a, we would tie it to the logical figure 1b by adding the following to the diagram.

```
COMPUTE OVERTIME PAY
```

Figure 1: DOs and DON’Ts of Warnier-Orr diagramming. Figure 1a looks like actual program code and should not be used when trying to logically design a program. Figure 1b shows the correct method. The entire diagram contains only logical statements which could be coded into any computer language.

![Diagram of pay calculation](image)

**Figure 2:** Typical productivity curve of programmer being introduced to Warnier-Orr diagram methodology.
This would be included in the program itself by using comment statements:

```
1000 REM COMPUTE OVERTIME PAY
1001 REM HFLD = HOURS WORKED
1002 REM OVTFLD = OVERTIME PAY
1003 REM SALFLD = SALARY
```

This allows us to have a very clear and concise, one to one mapping between the logical diagram and the physical code. References between the two diagrams are quite easy. If, for instance, you want to know what a particular section of code is supposed to be doing, you need only to look it up on the logical diagram. Similarly, if you want to find out which part of the program is carrying out a particular logical function, you have the location information at your fingertips. This is excellent documentation in the event that you or someone else might someday want to make a modification to your code.

The third common philosophical error, that of skipping the design phase altogether, is a real problem to most newcomers. In fact, if you look at a typical productivity curve for a programmer who is introduced to the Warnier-Orr diagrams, it generally looks something like the curve in figure 2.

A currently productive programmer producing work at a constant rate up until the time the Warnier-Orr techniques are introduced (point A), will typically show an initial burst of very high productivity (point B). This is usually followed by a slump (point C) where the programmer sinks back to or just above his previous level of work. Eventually, he will climb back up to a new, higher level of work (point D), where he will usually stay. This peculiar slump at point C seems to be primarily due to the fact that since the programmer has begun to feel comfortable with the new technique and has had some initial success with it, he begins to feel confident enough to try to do the work without doing the diagrams first. He soon realizes that the quality of his work has dropped off and starts to do the diagrams once again, this time for good, and his work level rises up to a new, higher level that will remain fairly constant.

Apparently, the only way to get new people to avoid this temptation is to forewarn them that it does tend to happen, so that if and when they find themselves on the downhill side of the productivity curve, they can recognize the trap in time to escape the worst of it.

```
PRODUCT CODE = A
(0,1) +
```

```
PRODUCT CODE = B
(0,1) +
```

```
PRODUCT CODE = C
(0,1) +
```

```
COMPUTE MARKET PRICE

GO TO COMPUTE MARKET PRICE

GO TO END PRICE
```

Figure 3: Example case statements making use of logically illegal GOTO statements. When a set of statements is finished the diagram will logically fall through all of the other exclusive ORs, +, and arrive at the END PRICE section. Thus no GOTO need be shown.

So much for the philosophical errors. There are also a few common technical errors that people make, and we'll look at those next.

Technical Errors

For a lot of people who are just starting to program and may be unfamiliar with structured programming techniques, some of the diagramming methods may seem to be a bit uncomfortable. One of the most often seen technical errors is the attempted use of a GOTO statement on the diagram. The case statement shown in figure 3 illustrates this problem.

Two of the occurrences of the GOTOs in figure 3 are incorrect and the other is ambiguous. The GOTOs in "PRODUCT CODE = A" and in "PRODUCT CODE = B" are unnecessary and incorrect. The default logical linkages will see to it that the appropriate steps are executed. The GOTO at "PRODUCT CODE = C" is unclear. If it is supposed to mean that we are to cease execution of this process and jump to the procedure "COMPUTE MARKET PRICE" to begin processing, then its usage is incorrect. If on the other hand it means that "COMPUTE MARKET PRICE" is a common utility routine and is described elsewhere in the system, then the GOTO is misleading. Instead, we should have written:

```
PRODUCT CODE = C
(0,1) +
```

```
COMPUTE MARKET PRICE

...SEE PAGE #3,
```

if the process was expanded on a different page of the diagram; or something like the words "...SEE ABOVE" or "...SEE BELOW" if that process appears elsewhere on the same page. The GOTO is a physical entity to be used at execution and is not a logical relationship, so it does not belong on
exclusive statements, are out

**Figure 5:** These processes are mutually independent.

**Figure 4:** Example of a case statement with mutually exclusive and mutually independent statements.

**Figure 5:** When a case statement has mutually independent and mutually exclusive statements, the statements may be rearranged into any order without changing the logic of the diagram.

**Listing 1:** Typical if-then-else structure for Warnier-Orr diagram of Figure 6.

| IF 'player has no body' THEN... |
| ELSE IF 'player has no neck' THEN... |
| ELSE IF 'player has no head' THEN... |
| ELSE IF 'player has two antennae' THEN... |
| ELSE 'give player one antenna'

Although Figure 6 is a typical Warnier-Orr diagram of the game of BUG, the game was outlined in a program design article called "Structured Program Design" (Oct 77 BYTE). In the game, a die is rolled for each player, and the number of the die corresponds to a part of the bug's body; the player finishing his bug first wins the game. If a player rolls a 4 for instance, he is entitled to one antenna. But he must have already acquired a body, a neck and a head in that order before he can receive an antenna. He needs a total of two antennae if he is to complete a bug.

Many people would try to code that process as a case statement as in Figure 6. The process in Figure 6 certainly looks correct, and indeed, if you code it as a case statement, as in Listing 1, it will even run correctly.

However, this process is not a case statement. It is more properly called a pseudo-case statement, because each of its cases is mutually dependent. The cases cannot be reordered within the statement without destroying its logic. Notice that reordering the case statement as shown in Figure 7 does not work at all. This arrangement will give the player an antenna anytime a four is rolled, until he has two antennae, regardless of whether or not he already has a body, a neck or a head. A more correct logical interpretation of the case structure we want is shown in Figure 8.

You might also notice that since the bug must have a body before it can have a neck (and a neck before it can have a head) if we...
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merely check for the presence of the head, we will be indirectly checking for the neck and the body, so that figure 9 is an equivalent structure.

Another common technical error is the misuse or lack of use of the (0,1) notation in conjunction with the exclusive OR, ©. Many times, people will simply write:

\[
\text{TEST} \begin{cases} 
\text{CONDITION A} \\
\text{CONDITION B} \end{cases}
\]

By this they often imply the (0,1) notation with the use of the symbol © alone. Actually, this is not incorrect; in fact, for most people familiar with the diagrams, this notation seems to be just as clear. But for users not quite familiar with the Warnier-Orr diagrams it is probably best to go ahead and include the (0,1).

To conclude, I'll reiterate a point made in an earlier article: Understanding a Warnier-Orr diagram is very easy; creating one from scratch is much harder than it looks.

---

Figure 7: When the statements in figure 6 are rearranged as shown, it can be seen that the program fails to work as desired.

Figure 8: This method of approaching the stated "bug" problem is more logically correct than that of figure 6. All of the statements at each level of the diagram are mutually exclusive and mutually independent.

Figure 9: Since a bug must have a head in order to have an antenna, and a body and neck to have a head, the search process can be shortened by just checking for the presence of a head.
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Solution to Machine Language Puzzler  (See page 92)

The waveforms shown in figure 1 depict the voltage waveform being applied to the speaker from the least significant bit of port 0 for each case.

When the outer loop constant (in A) is decremented to 00, the accumulator is reinitialized with #X. If X is even, only an imperceptible discontinuity in the waveform results owing to the execution time of 2 more instructions. If #X is odd, however, the waveform contains one extra half cycle, and a blip is heard. Every time A is reinitialized with an odd X, the waveform phase is changed by 180°.

Figure 1: Voltage waveform appearing at the least significant bit (LSB) of port 0 for each case in the problem.
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This is a 4K Z-80 machine language program utilizing every byte of available memory on the TRS-80. It displays a graphic chessboard and even flashes the piece on which the computer narrows its attention prior to making its move. Based on earlier chess programs for the 8080 and 6502 microprocessors, Microchess incorporates the improvements suggested by hundreds of users, and offers three levels of play to challenge all players from beginners to real chess enthusiasts.

Microchess can be fun on any TRS-80 and is easily loaded from cassette with the CLOAD command. Standard algebraic notation is used to describe the moves, and a simple command lets you temporarily number the squares to assist in move entry. Every move is checked for legality, and the program even handles castling and en passant captures. You can play white or black, set up special board situations and play them out against the computer, or even watch the computer play against itself.

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In 6502 machine language, this version of Microchess offers eight levels of play to suit everyone from beginner to the serious player. It examines positions as many as six moves ahead, and includes a chess clock for tournament play. $19.95 each.

TRS-80 (4K) □ PET (8K) □ Apple (16K) □

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TRS-80 (16K Level III) □ PET (8K) □ Apple (16K) □

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TRS-80 □

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You enter the date, time, and place of your birth. The program computes the sidereal time on the equator of your birth and your ascendant or rising sign, midheaven, and vertex angles in degrees / sign of zodiac / minutes of arc format. The helio and geocentric planetary positions are also given, and the program will optionally calculate and display the Local Space positions of the planets, the Local Space chart for a locality shift, give the position and direction in azimuth along the horizon of any city in the world, or display the equatorial coordinates for your natal planets. You can even input the right ascension and declination of any celestial object, and the program will compute its position on the horizon or Local Space chart. This program is loaded with celestial mechanics equations, and will save you or your astrologer hours of calculating time. $14.95 each.

PET □

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PET □

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A Search for Vector Graphics

I am a subscriber and avid reader of BYTE, and I have a problem I hope you can help me solve. I am trying to find some information on a particular type of video graphic display and whether it is currently available on any personal computers. Unfortunately, I don't know a technical name, so I'll have to attempt a cumbersome non-technical description. What I want is to be able to draw one dimensional lines between defined endpoints, and to move the lines continuously across the screen.

Let me give you an example. Suppose an application I want to display is an aircraft instrument panel. The altimeter might look something as shown in figure 1. With the relatively common raster scan grid the altimeter would look as shown in figure 2.

One problem here is that in order to have enough detail to read the instruments, they would have to be too big to get an entire instrument panel on the screen. Another is that "lines" are not continuous. They are approximations that frequently lose their original shape when rotated between horizontal and vertical. Also, small displacements are lost if they aren't large enough to cause a quantum jump between plot grid points.

With high density noncolor graphics, you gain the ability to create a more detailed drawing, but motion becomes impractical. To show increasing altitude on the altimeter above, you must calculate a new location for each point on the rotating indicator and set and reset the corresponding bits in memory. That might represent several hundred calculations for each degree of rotation. Also, the indicator will not move as a unit. That is, it "warps" point by point, as shown in figure 3.

In the past, I have used a Tektronix 4010 storage tube. This particular device allows plotting graphics as lines between endpoints. That is, your program specifies a starting and ending point for a line segment, and you can then "draw" a line between the points. So, for rotation of the altimeter, you need only calculate the positions of three points, and connect them with line segments. The line segments are always continuous, never warped. However, the Tektronix stores the line until the entire screen is erased, so you can draw detailed diagrams although true motion is impossible. You must erase the entire screen and redraw it at the new position—a process which takes several seconds for complex diagrams.

Let me now try to describe what I need. The display must be able to define lines as the Tektronix does, so that line movements are done by simply recalculating the endpoint locations. But, it must also allow for moving the line without having to recreate the entire drawing— or, if it must recreate the entire drawing, it must recreate it fast enough so that you don't see an erase and redraw action. (I have seen this type of display in only two places, both of which were in 25 cent video arcade games, and both of which were a Space War game. The games were similar in that they both showed spaceships which moved continuously through space, able to turn through any angle.)

If you or any of your readers can tell me who makes this type of display, or how it works, or if it's even feasible to do with personal computers that are available today, I would certainly appreciate it.

We cannot help specifically in this reply, but can point you in the right direction: you are looking for a vector display, where an XY oscilloscope with blanking is driven from a list of XYZ coordinate triples. (The Z axis simply indicates an intensity for the line of 0 or 1.) An example of this was found in Steve Ciarcia's article, "Make Your Next Peripheral a Real Eye Opener," (November 1976 BYTE, page 78). Steve's design is not, to our knowledge, currently being manufactured, so you will have to build it yourself... CH
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Filling 6800 Op Code Holes

When looking at a reference chart for the Motorola 6800 processor, one may notice many nonimplemented op codes. It is possible that these codes, when properly explored, can lead to interesting operations of the processor. I could not resist the challenge to do this and have spent many frustrating hours trying to understand the strange results obtained. By dint of perseverance, I eventually worked my way through every one, producing table 1. I have not yet made a study of the complete effect of each operation on the condition code register, although some were obvious along the way.

It is interesting to note that four of the op codes (hexadecimal 87, 8F, C7 and CF) actually modify the program, conveniently skipping one program step in the process. This jumped over step could contain a branch or jump instruction, so that if the modified part of the program is immediately followed by a branch back to the skipped over instruction we would have the possibility of an approximately 65,536-way branch, depending on the result of some calculation in either of the accumulators or the index register. Of course, any program using this self-modifying feature can only be implemented in programmable memory. Committing it to read only memory would automatically render it unchangeable.

Three codes (hexadecimal 3D, 9D and DD) cause the 6800 to continuously increment the address bus with both the valid memory address (VMA) and read write (RW) lines held high, but the microprocessor does not act on the instructions it reads along its route. Perhaps they can be used in the form of some direct memory access instruction with a hardware halt to the process by activating RESET.

It would be interesting to find out if all 6800s follow the patterns in my table, or if the results are specific to my individual unit. Remember, these instructions worked in my processor but may not necessarily work in yours. The best course of action is to use my table as a base and then double check your own processor.

REFERENCES

### Table 1, continued:

<table>
<thead>
<tr>
<th>Hex</th>
<th>Dec</th>
<th>Instruction</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>38</td>
<td>56</td>
<td>RTS</td>
<td>Same as 39 followed by 34; ie: RTS followed by reset of stack pointer to original setting plus 1.</td>
</tr>
<tr>
<td>3A</td>
<td>58</td>
<td>RTI</td>
<td>Same as 3B followed by 34; ie: RTI followed by reset of stack pointer to original setting plus 1.</td>
</tr>
<tr>
<td>3D</td>
<td>61</td>
<td>DMA</td>
<td>Program counter continuously increments address bus. VMA and RW lines go high.</td>
</tr>
<tr>
<td>41</td>
<td>65</td>
<td>CPZ A</td>
<td>Compare register A with zero. Leaves register A unchanged, but sets NZVC according to result of the compare with zero.</td>
</tr>
<tr>
<td>42</td>
<td>66</td>
<td>COM A</td>
<td>Copies least significant bit of register A into carry bit. Leaves register A unchanged. Sets overflow bit (V) according to V=NC + NC. Sets zero bit (Z) if either register A or B is zero. Could be used (by following with BCS) to branch on register A equal to an odd number.</td>
</tr>
<tr>
<td>45</td>
<td>69</td>
<td>CPY A</td>
<td>Copies least significant bit of register B into carry bit. Leaves register B unchanged. Remarks similar to 45 above.</td>
</tr>
<tr>
<td>4A</td>
<td>6A</td>
<td>DEC A</td>
<td>Same as 4A.</td>
</tr>
<tr>
<td>4E</td>
<td>6E</td>
<td>NOP</td>
<td>Same as 60.</td>
</tr>
<tr>
<td>51</td>
<td>81</td>
<td>CPZ B</td>
<td>Compare register B with zero. Similar to 41 above.</td>
</tr>
<tr>
<td>52</td>
<td>82</td>
<td>COM B</td>
<td>Same as 53.</td>
</tr>
<tr>
<td>55</td>
<td>85</td>
<td>CPY B</td>
<td>Copies least significant bit of register B into carry bit. Leaves register B unchanged. Remarks similar to 45 above.</td>
</tr>
<tr>
<td>5B</td>
<td>86</td>
<td>DEC B</td>
<td>Same as 5A.</td>
</tr>
<tr>
<td>5E</td>
<td>8E</td>
<td>NOP</td>
<td>Same as 64.</td>
</tr>
<tr>
<td>61</td>
<td>97</td>
<td>NEG X</td>
<td>Same as 6A.</td>
</tr>
<tr>
<td>62</td>
<td>98</td>
<td>COM X</td>
<td>Same as 63.</td>
</tr>
<tr>
<td>66</td>
<td>9C</td>
<td>LSR X</td>
<td>Same as 64.</td>
</tr>
<tr>
<td>68</td>
<td>9E</td>
<td>DEC X</td>
<td>Same as 7A.</td>
</tr>
<tr>
<td>71</td>
<td>A9</td>
<td>NEG e</td>
<td>Same as 70.</td>
</tr>
<tr>
<td>72</td>
<td>AA</td>
<td>COM e</td>
<td>Same as 73.</td>
</tr>
<tr>
<td>75</td>
<td>AB</td>
<td>LSR e</td>
<td>Same as 74.</td>
</tr>
<tr>
<td>7B</td>
<td>AD</td>
<td>DEC e</td>
<td>Same as 7A.</td>
</tr>
<tr>
<td>83</td>
<td>B2</td>
<td>SB1 A#</td>
<td>A (immediate+1).</td>
</tr>
<tr>
<td>87</td>
<td>B6</td>
<td>ST2 A</td>
<td>PC+2+(A). Stores contents of register A at current program counter plus two and advances to program counter plus 3.</td>
</tr>
<tr>
<td>8F</td>
<td>B8</td>
<td>ST2 S</td>
<td>PC+2, PC+3=SP. Stores current value of stack pointer at program counter plus two and three and advances to program counter plus four.</td>
</tr>
<tr>
<td>93</td>
<td>C4</td>
<td>SB1 A d</td>
<td>A (memory direct)+1. Adds one to contents of referenced memory, subtracts result from register A and stores result of subtraction in register A. Leaves memory contents unchanged.</td>
</tr>
<tr>
<td>9D</td>
<td>C8</td>
<td>DMA</td>
<td>Same as 3D above.</td>
</tr>
<tr>
<td>A3</td>
<td>D2</td>
<td>SB1 A X</td>
<td>A (memory indexed)+1. Similar to 93 above.</td>
</tr>
<tr>
<td>B3</td>
<td>E2</td>
<td>SB1 A e</td>
<td>A (memory extended)+1. Similar to 93 above.</td>
</tr>
<tr>
<td>C3</td>
<td>F0</td>
<td>SB1 B#</td>
<td>B (immediate+1).</td>
</tr>
<tr>
<td>C7</td>
<td>F4</td>
<td>ST2 B</td>
<td>PC+2-(B). Similar to 87 above.</td>
</tr>
<tr>
<td>CC</td>
<td>F8</td>
<td>CPX #</td>
<td>Same as 8C.</td>
</tr>
<tr>
<td>CD</td>
<td>FA</td>
<td>BSR r</td>
<td>Same as 8D.</td>
</tr>
<tr>
<td>CF</td>
<td>100</td>
<td>ST2 X</td>
<td>PC+2, PC+3=IX. Stores current value of index at program counter plus two and three and advances to program counter plus four.</td>
</tr>
<tr>
<td>D3</td>
<td>106</td>
<td>SB1 B d</td>
<td>B (memory direct)+1. Similar to 93 above.</td>
</tr>
<tr>
<td>DC</td>
<td>10E</td>
<td>CPX d</td>
<td>Same as 9C.</td>
</tr>
<tr>
<td>DD</td>
<td>110</td>
<td>DMA</td>
<td>Same as 3D above.</td>
</tr>
<tr>
<td>E3</td>
<td>116</td>
<td>SB1 B X</td>
<td>B (memory indexed)+1. Similar to 93 above.</td>
</tr>
<tr>
<td>EC</td>
<td>120</td>
<td>CPX X</td>
<td>Same as AC.</td>
</tr>
<tr>
<td>ED</td>
<td>124</td>
<td>JSR X</td>
<td>Same as AD.</td>
</tr>
<tr>
<td>F3</td>
<td>130</td>
<td>SB1 B e</td>
<td>B (memory extended)+1. Similar to 93 above.</td>
</tr>
<tr>
<td>FC</td>
<td>134</td>
<td>CPX e</td>
<td>Same as BC.</td>
</tr>
<tr>
<td>FD</td>
<td>138</td>
<td>JSR e</td>
<td>Same as BD.</td>
</tr>
</tbody>
</table>

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Some Comments on

BBC Teletext

E John Dehaven (April 1978 BYTE, page 152) is a little out of date regarding British TV standards. In 1936 the world's first high definition television station started regular broadcasts from Alexandra Palace, London ENGLAND. The transmission used 405 lines with AM sound and synchronized to the 50 Hz power lines. After the war the system was extended to cover the whole country on VHF.

With the introduction of color, a new UHF network was set up which now has around 1000 transmitters. The color system uses a 625 line phase alternation line (PAL) system with FM sound. In the PAL color system, the subcarrier derived from the color burst is phase inverted from one line to the next to minimize possible transmission hue errors. ...CM/ No new 405 sets have been available for many years. Official policy has been to delete the 405 line system as soon as practical since all channels are duplicated on UHF. The problem is that many small communities in hilly areas find UHF reception very poor and a local UHF transmitter is not always economic.

In Britain the whole 50 Hz power system is synchronized by high voltage links, but transmitters are no longer tied to it. This change is perhaps unfortunate since some sets show a moving band, at the difference frequency, up or down the screen. This is usually faint but noticeable to the critical.

There is no need to modify the latest British color sets. They include high quality video display unit facilities to receive the new Teletext transmissions. All 625 channels now transmit digital data on unused picture lines giving up to 800 pages on each channel (more with special arrangements as below).

A standard format of 24 lines, each with 40 characters, is used, with odd parity 8 bit bytes for each character. Each page is numbered (100 to 899) and the whole series is transmitted in sequence each 15 seconds or so. Some pages (eg: page 100) give general or special indexes to other pages which carry all kinds of information from news to recipes, sports to weather maps, etc. A digital...
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 as well as word hyphenation is not required since lines of text are formatted automatically.

When text is printed, The Electric Pencil II automatically inserts carriage returns where they are needed. Numerous combinations of line length, page length, line spacing and page spacing allow for any form to be handled. Character spacing, BOLD FACE, multicolumn as well as bidirectional printing are included in the Diablo versions. Right justification gives right-hand margins that are even. Pages may be numbered as well as titled. This entire page (excepting the large titles and logo) was printed by the Diablo version of The Electric Pencil II in one pass.

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<table>
<thead>
<tr>
<th>Vers</th>
<th>Video</th>
<th>Printer</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>SS-II</td>
<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>
<td>SV-II</td>
<td>VDM</td>
<td>TTY or similar</td>
<td>$225.</td>
</tr>
<tr>
<td>SR-II</td>
<td>REX</td>
<td>TTY or similar</td>
<td>$250.</td>
</tr>
<tr>
<td>SI-II</td>
<td>VIO</td>
<td>TTY or similar</td>
<td>$250.</td>
</tr>
<tr>
<td>DS-II</td>
<td>SOL</td>
<td>Diablo 1610/20</td>
<td>$275.</td>
</tr>
<tr>
<td>DP-II</td>
<td>VTI</td>
<td>Diablo 1610/20</td>
<td>$275.</td>
</tr>
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<td>DV-II</td>
<td>VDM</td>
<td>Diablo 1610/20</td>
<td>$275.</td>
</tr>
<tr>
<td>DR-II</td>
<td>REX</td>
<td>Diablo 1610/20</td>
<td>$300.</td>
</tr>
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<td>DI-II</td>
<td>VIO</td>
<td>Diablo 1610/20</td>
<td>$300.</td>
</tr>
<tr>
<td>NS-II</td>
<td>SOL</td>
<td>NEC Spinwriter</td>
<td>$275.</td>
</tr>
<tr>
<td>NP-II</td>
<td>VTI</td>
<td>NEC Spinwriter</td>
<td>$275.</td>
</tr>
<tr>
<td>NV-II</td>
<td>VDM</td>
<td>NEC Spinwriter</td>
<td>$275.</td>
</tr>
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<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>

**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 $15.00 to MSS. Accept only original media at time of purchase.

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clock is given on the top line of each page, exact to the second.

A small key pad is provided. Keying a page number selects that page from the stream and stores it in the set for display as required. Normally only one page is stored but this is limited by economics alone. Storage may be for seconds or weeks if necessary. Extra pages above the basic 800 are obtained by using sets of pages with the same page number, and cycling them over several minutes, or even once per day. The keypad has extra buttons that permit normal picture display, Teletext display and combined display. It also has clock time setting switches that allow a page to be selected at a given time and stored to be displayed at leisure.

To use the set as a personal video display unit, one merely needs to input serial bytes in the published standard Teletext format via a spare channel. Superb facilities are available, all controlled by the data. Characters are of a high standard since they are generated as video signals by the Teletext unit with an equivalent bandwidth of about 14 MHz. The whole ISO-7 ASCII set is available with upper and lower case. Additionally, there are 64 graphics characters (permitting maps and other displays). These are in a 3 by 2 rectangle using one of six bits to give all possible on or off combinations. A duplicate upper case permits legends within the graphics.

The Teletext unit has direct control of the three color guns, permitting all characters to be displayed as black, white, red, green, yellow, blue, magenta or cyan in almost any combination, against a background of a chosen color. Any or all of the characters may be flashed on and off to attract attention.

A special control character may be used to open and close a box in the normal picture. The box may be of any size or shape and in any position on the screen. This facility is normally used for subtitles and news flashes, but could allow part of the screen access to the personal computer while the family watches a normal program on the rest of it. The store is continually updated by incoming new or repeat data but, if required, the whole page may be erased before a new page is started.

Overall, this set seems to have a high potential of usefulness. This may increase in the future since several control characters are still spare. In Britain this video display unit is also being standardized for telephone data so that all possible digital information services may use the household television, giving a minimum total cost. One wonders what the limit is going to be.
<table>
<thead>
<tr>
<th>Package #</th>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>1036 (II)</td>
<td>COMPLETE SMALL BUSINESS</td>
<td>$495.00</td>
</tr>
<tr>
<td>1038 (II)</td>
<td>ACCOUNTS RECEIVABLE</td>
<td>$99.95</td>
</tr>
<tr>
<td>1039 (II)</td>
<td>ACCOUNTS PAYABLE</td>
<td>$99.95</td>
</tr>
<tr>
<td>1044 (II)</td>
<td>INVENTORY CONTROL</td>
<td>$125.00</td>
</tr>
<tr>
<td>1045 (II)</td>
<td>INVOICING</td>
<td>$99.95</td>
</tr>
<tr>
<td>1046 (II)</td>
<td>PAYROLL</td>
<td>$99.95</td>
</tr>
<tr>
<td>1047 (II)</td>
<td>MAILING LIST</td>
<td>$99.95</td>
</tr>
<tr>
<td>1024 (II)</td>
<td>SPACEWAR I - BANNER - UFO ATTACK - PILE UP - BIORHYTHM - AUTO RACE and WORDS.</td>
<td>$24.95</td>
</tr>
<tr>
<td>1026 (II)</td>
<td>SPACEWAR II - CIVIL WAR - TRAP THE TRIBBLE - LIFE - KNIGHT - CONCENTRATION and LUNAR LANDER.</td>
<td>$24.95</td>
</tr>
</tbody>
</table>

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Adding

Lowercase Display
to the ADM-3A

The scenario: you wanted a good quality, versatile video display, so you stretched the budget to the limit to buy a "dumb" terminal kit. After it's all together, you're showing off the result of your assembly skills when someone innocently asks "Does it have lowercase?" Well no, it doesn't, actually. You ask around, and find there is a way, but at $89, the kit from Lear Siegler doesn't quite fit the constraints. So a short expedition into the innards of the ADM-3A should be helpful; after all, one should only need a bit more of a character generator read only memory to do the trick. Lo and behold, the designers at Lear Siegler have even provided the socket, so let's see what fits into it.

ADM-3A maintenance manual explains nicely on page 6-11 that "the lowercase read only memory is a custom masked part" whose distinguishing attribute is that "all of the address lines ... are inverted." Well, just how unusual is that custom read only memory? After some experimentation and further delving into the mysteries of the schematics, it appears that all one has to do is turn over the six character address bits, use a readily available lowercase 2513 for about $9.95 and be on the air. An easy way to invert six bits might be with a 74LS04 transistor-transistor logic (TTL) integrated circuit.

To avoid any modifications to the
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Acct. No ___________________________ Exp. Date ____________

Signature ______________________________________
Figure 1: Modifications that must be made to the existing ADM-3A to produce lower case characters.

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ADM-3A, I built my lowercase adapter on a 24 pin dual-in-line plug that inserts into the existing lowercase read only memory socket (location L14) in the terminal. On top of the plug I mounted a small piece of 0.1 by 0.1 inch (0.254 by 0.254 cm) perforated board with sockets for the added lowercase 2513 and the 74LS04 inverter. Using this assembly method requires fairly careful consideration to avoid interference with the cabinet top or other components. For more compact assembly, the perforated board and sockets might be omitted with the new read only memory mounted directly on the plug and the inverter glued in place upside down on top. Since all but six of the read only memory’s pins are connected directly to those of the plug, adequate support is available. The remaining six pins needing inversion can be bent out for appropriate connection to the 74LS04.

Regardless of the final mounting and installation method chosen, the required wiring is given in figure 1. Note that two additional 2102-1 memories are required, which plug into locations J11 and H11 to store the uppercase/lowercase data bit on characters stored in the display memory. The total cost of materials for my unit is $14.25, and it can be built for less depending upon your junkbox, where you shop for parts, and the method of construction.

Once installed in the ADM-3A, and assuming the UC DISP-U/L DISP at the inside rear of the unit is set to U/L DISP with the LC EN-UC switch at the left of the key-board set at LC EN, the result is a full 95 character terminal display including the 26 lowercase letters and five additional symbols as shown in table 1. Note that, since the characters are still only generated with a 5 by 7 dot matrix, the lowercase letters with descenders, such as g, j, p, q and y, do not actually display the descenders below the writing line, but instead are elevated so as to allow the characters, including descenders, to be displayed within the 5 by 7 matrix. This technique results in a very acceptable low cost upper and lowercase display. My customized ADM-3A has been in service quite satisfactorily for more than eight months.

<table>
<thead>
<tr>
<th>Bits</th>
<th>765</th>
<th>110</th>
<th>111</th>
</tr>
</thead>
<tbody>
<tr>
<td>0000</td>
<td></td>
<td></td>
<td>p</td>
</tr>
<tr>
<td>0001</td>
<td>a</td>
<td></td>
<td>q</td>
</tr>
<tr>
<td>0010</td>
<td>b</td>
<td>r</td>
<td></td>
</tr>
<tr>
<td>0011</td>
<td>c</td>
<td>s</td>
<td></td>
</tr>
<tr>
<td>0100</td>
<td>d</td>
<td>t</td>
<td></td>
</tr>
<tr>
<td>0101</td>
<td>e</td>
<td>u</td>
<td></td>
</tr>
<tr>
<td>0110</td>
<td>f</td>
<td>v</td>
<td></td>
</tr>
<tr>
<td>0111</td>
<td>g</td>
<td>w</td>
<td></td>
</tr>
<tr>
<td>1000</td>
<td>h</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>1001</td>
<td>i</td>
<td>y</td>
<td></td>
</tr>
<tr>
<td>1010</td>
<td>j</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1011</td>
<td>k</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1100</td>
<td>l</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1101</td>
<td>m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1110</td>
<td>n</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1111</td>
<td>o</td>
<td>DEL</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Additional characters added to the ADM-3A by the modification shown in figure 1.

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If the answer to any of the above questions is "yes," this article should interest you.

A Simple Password Procedure

One way to restrict system access is by

Table 1: Possible password combinations using upper case letters and digits.

<table>
<thead>
<tr>
<th>Number of characters in password</th>
<th>Number of possible passwords</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>46,656</td>
</tr>
<tr>
<td>4</td>
<td>1,679,616</td>
</tr>
<tr>
<td>5</td>
<td>60,466,176</td>
</tr>
<tr>
<td>6</td>
<td>2,176,782,336</td>
</tr>
</tbody>
</table>

Figure 1: A simple password approach.

Figure 2: An improved password approach.
Assume that the 26 upper case letters and the 10 digits will be used to establish a password. For the algorithm in figure 1, a user could try, in order, all 36 characters to find the correct first character. After the first character is identified, the user could follow the same procedure to find the second character. Once the second character is found, the procedure could be repeated to find the third.

With this system, there are \( 36 \times 36 \times 36 = 108 \) different possible passwords. This is too few combinations for adequate security.

An Improved Password Procedure

A better procedure is shown in figure 2. Here, a 3 character password is also used. However, in this method all characters are entered before the password is checked. Thus, a failing password yields little information. The user can't tell which of the characters is incorrect. All that is known is that the combination tried was incorrect.

With this procedure, there are \( 36 \times 36 \times 36 = 36,666 \) possible passwords. This should be an acceptable level of security. If additional security is desired, the password can be expanded beyond three characters. Table 1 shows the number of different possible passwords in these situations. This table was developed with the assumption that only upper case letters and digits would be used in a password.

The program in Listing 1 is an 8080/Z-80 coding of the algorithm in figure 2. The program as shown uses the password YES. It has been implemented on a North Star Horizon Computer. The following comments should allow this program to be modified for other systems (all numbers shown in hexadecimals; DOS stands for disk operating system):

<table>
<thead>
<tr>
<th>Statement</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>CALL 200D</td>
<td>Calls the DOS output routine. Outputs the character in the B register.</td>
</tr>
<tr>
<td>CALL 2900</td>
<td>Calls the DOS character input subroutine.</td>
</tr>
<tr>
<td>JMP 270F</td>
<td>Jumps to the DOS to allow normal system access.</td>
</tr>
<tr>
<td>MVI E, 53</td>
<td>Establishes the password as &quot;YES.&quot; These three statements are where you establish your own password.</td>
</tr>
</tbody>
</table>

A password subroutine is easy to implement and requires little computer memory. However, it increases the security of your system.

Listing 1: An 8080/Z-80 assembler listing of the improved algorithm for a 3 character password. This program is written for the password YES.

```assembly
2969 ;**************************************************
2969 /*
2969 */ PROGRAM NAME: ID
2969 */ PROGRAMMER: R. J. KREINDLER
2969 */ DESCRIPTION: THIS PROGRAM
2969 */ ALLOWS THE USER TO ESTABLISH
2969 */ A THREE CHARACTER ID(PASSWORD)
2969 */ TO CONTROL SYSTEM ACCESS
2969 */
2969 ***************************************************

2969 ;DEFINE STORAGE LOCATIONS FOR INPUT CHAR
2969 LOC1: EQU 29CCH
2969 LOC2: EQU 29CDH
2969
2969 ;ESTABLISH NUMBER OF TRIYS
2969 ;
2969 16 02 ID: MVI D, 02H ;SET ATTEMPTS TO TWO
2967 06 00 IDETR: MVI B, 0DH ;PLACE "CR" IN B
2967 CD 00 20 CALL 200DH ;PRINT "CR"
2967 0E 0A MVI B, 0AH ;PLACE "LF" IN B
2967 CD 00 20 CALL 200DH ;PRINT "LF"
2967 0E 49 MVI B, 49H ;PLACE "I" IN B
2967 CD 00 20 CALL 200DH ;PRINT "I"
2967 0E 44 MVI B, 44H ;PLACE "D" IN B
2967 CD 00 20 CALL 200DH ;PRINT "D"
2967 0E 3F MVI B, 3FH ;PLACE "?" IN B
2967 CD 00 20 CALL 200DH ;PRINT "?
2967 0E 20 MVI B, 20H ;PLACE " " IN B
2967 CD 00 20 CALL 200DH ;PRINT " - "
2967
2969 ;OBTAIN THE THREE INPUT CHARACTERS
2969 ;
2967 CD 00 29 CALL 200H ;GET INPUT CHAR
2967 32 CC 29 STA LOC1 ;STORE CHAR AT ADDRESS LOC1
2967 CD 00 29 CALL 200H ;GET NEXT INPUT CHAR
2967 32 CD 29 STA LOC2 ;STORE CH AT LOC2
2967 CD 00 29 CALL 200H ;GET LAST INPUT CHAR
2967 18 7A ;LEAVE IT IN A
2969
2969 ;COMPARE INPUT TO VALID ID IN REVERSE ORDER
2969 ;
2969 ID1: MVI B, 53H ;PLACE "S" IN E
2969 32 BB CMP E ;COMPARE WITH LAST CHAR IN
2969 C2 BD 29 JNZ TRYS ;NO MATCH GO TO TRYS
2969 32 CC 29 STA LOC1 ;STORE CHAR AT ADDRESS LOC1
2969 CD 00 29 CALL 200H ;GET NEXT CHAR
2969 32 CD 29 STA LOC2 ;STORE CHAR AT LOC2
2969 CD 00 29 CALL 200H ;GET LAST CHAR
2969 18 7A ;LEAVE IT IN A
2969
2969 ;VALID CHAR IN
2969 ;
2969 1E 53 MVI E, 53H ;PLACE "S" IN E
2969 32 BB CMP E ;COMPARE WITH FIRST CHAR IN
2969 1E 59 MVI E, 59H ;PLACE "Y" IN E
2969 32 BD 29 CMP E ;COMPARE WITH 1ST INPUT CHAR
2969 C2 BB JNZ TRYS ;NO MATCH GO TO TRYS
2969 32 BD 29 CMP E ;COMPARE WITH 2ND INPUT CHAR
2969 C2 BB JNZ TRYS ;NO MATCH GO TO TRYS
2969
2969 ;IF ID VALID PRINT "OK" & GIVE SYSTEM ACCESS
2969 06 4F OK: MVI B, 4FH ;PLACE "O" IN B
2969 CD 00 20 CALL 200DH ;PRINT "O"
2969 0E 4B MVI B, 4BH ;PLACE "K" IN B
2969 CD 00 20 CALL 200DH ;PRINT "K"
2969 0E 3F MVI B, 3FH ;PLACE "?" IN B
2969 CD 00 20 CALL 200DH ;PRINT "?
2969 0E 20 MVI B, 20H ;PLACE " " IN B
2969 CD 00 20 CALL 200DH ;PRINT " - "
2969
2969 ;IF INPUT INVALID PRINT "NO"
2969 06 4F TRYS: MVI B, 4EH ;PLACE "N" IN B
2969 CD 00 20 CALL 200DH ;PRINT "N"
2969 0E 4F MVI B, 4FH ;PLACE "O" IN B
2969 CD 00 20 CALL 200DH ;PRINT "O"
2969
297C ;TEST NUMBER OF INPUT TRIYS
297C
297C 15 DCR D ;REDUCE D BY 1
297C 26 6B 29 MVI B, 6BH ;THIS PROCESS 0TRYS
297C 29CB CALL 2900H ;IF 0 D NOT 0 TRY AGAIN
297C 29CB ;IF ALL ALLOWED TRIYS FAIL THEN HALT
297C 29CB 76 HALT: HLT
```
The Power of the
HP-67 Programmable Calculator, Part 1

Introduction

This article is not a simple product review. Rather, it is the presentation of a complex programming example designed to illustrate the exploitation of a computing system composed of the HP-67 and its accessories, and worksheets that reduce the task of programming the calculator to a systematic exercise. The HP-67 is a pocket-sized version of the HP-97. The built-in thermal printer of the HP-97 is the major difference between the calculators. The HP-67 is shown in photo 1.

In addition to the HP-67, there are other sophisticated programmable calculators available at price levels which attracted consumers to the first scientific calculators in 1972 and the years following. I purchased my HP-35 early, and until the introduction of the HP-67 I considered it to be the finest calculator ever manufactured.

I must admit that I was intrigued by the features of the SR-52 when it was introduced. However, three of the Hewlett-Packard features force me to vote for the HP-67: choice of display format (fixed decimal, scientific and engineering; all with number of digits control), reverse Polish notation (RPN), and my previous experience with Hewlett-Packard. (Since 1972 I have experienced zero down time with the HP-35. Therefore, I am properly impressed with HP quality.)

Although I expect to see calculators with more memory capacity and some increase in programming capability in the future, I think the HP-67 represents a plateau of sophistication that will satisfy the needs of a large percentage of users. The HP-67 has 26 data storage registers, 224 steps of program memory (each step can hold as many as three keystrokes), unconditional and conditional branching, three levels of subroutines, four flags, 20 labels, indirect addressing, and, if that isn’t enough, it accepts magnetic cards that record data or programs. In addition, each of the 35 keys control up to four separate operations, and, of course, it is completely portable with the rechargeable battery pack.

Photo 1: The HP-67, one of the sophisticated pocket calculator products which represent the small end of the personal computing hardware range.
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Learning to Use the HP-67

Table 1 is a list of cautions which should be memorized before using the HP-67. These simple rules will allow maximum utility with minimum misery. After memorizing these rules, read Appendix B of the HP-67 handbook before attempting to use the calculator.

The HP-67 is a very powerful computer. One should not expect to memorize the Owner's Handbook and Programming Guide with a cursory reading. (The handbook is almost 3/4 inch thick.) Its contents should be digested in two stages: After acquiring your HP-67, read the handbook leisurely for two or three days, performing calculations when necessary. Next, design programs that require as many functions as possible, referring to the handbook often.

In addition to the Owner’s Handbook and Programming Guide, the HP-67 is accompanied by a "Standard Pac" of programs which includes:

* 15 prerecorded magnetic cards containing programs for problems common to business, science and engineering, a diagnostic program and an abrasive cleaning card.
* 24 blank magnetic cards.
* Standard Pac Handbook.

The Standard Pac Handbook contains a description of each of the standard programs, instructions for running the programs, example problems, program listings and explanations of important programming techniques. As part of learning to use the HP-67, an owner should be sure to read this handbook. Pay particular attention to any programming techniques you might be able to utilize.

Application packs (which include business decisions, statistics, mathematics, electrical engineering, clinical lab, nuclear medicine, mechanical engineering, and surveying) contain about 20 prerecorded program cards apiece and a handbook containing a description of the programs with relevant equations, instructions for running the programs, example problems and program listings.

All prerecorded cards in the packs have printed mnemonics which substitute for the instructions after a few familiarization runs. The mnemonics include input variables, keys to be pressed and outputs to be expected. A full explanation of the mnemonic symbols for the magnetic cards may be found on page vi of the Standard Pac Handbook and in each Application Pac Handbook.

Key Functions

All of the HP-67 Key Functions are discussed briefly on pages 8 thru 13 of the Owner's Handbook and Programming Guide. The mathematical key functions are discussed in detail in the first 120 pages of the guide. Following this is a complete description of the programming key functions. Card reader operations and the appendices take up the rest of the guide.

Many of the mathematical and programming functions are self-explanatory by their designations. Examples of these, which would be familiar even to those people unfamiliar with Hewlett-Packard calculators, are ÷, ×, +, −, π and √x. Experienced users should recognize ENTER, CHS, EEX and CLX. After brief explanations, it is easy to remember the function of most unfamiliar keys by their abbreviations: STK = stack review, ABS = absolute value, INT = integer portion, FRAC = fractional portion, RND = round off, STO = store, and RCL = recall.

32 of the keys may be used as a single stroke function, or they may be preceded by one of three prefix keys (two stroke function) and, occasionally, they may be followed by another function key (three stroke function). These 32 keys are used to provide 116 functions (five are redundant), but because the key designations closely describe the functions performed, they are easily memorized. I also found the mathematical functions listed in table 2 to be especially useful.

Functions I Would have Appreciated

The programming functions of the HP-67

<table>
<thead>
<tr>
<th>1. Always have a battery pack installed in calculator.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Connect the calculator to the charger using the following steps:</td>
</tr>
<tr>
<td>a. Turn HP-67 off.</td>
</tr>
<tr>
<td>b. Connect charger to calculator.</td>
</tr>
<tr>
<td>c. Plug charger into power outlet.</td>
</tr>
<tr>
<td>d. Turn HP-67 on.</td>
</tr>
<tr>
<td>3. Disconnect the charger from the calculator using the following steps:</td>
</tr>
<tr>
<td>a. Turn HP-67 off.</td>
</tr>
<tr>
<td>b. Unplug charger from power outlet.</td>
</tr>
<tr>
<td>c. Disconnect charger from calculator.</td>
</tr>
<tr>
<td>4. Leave the W/P RM RUN switch in the RUN position except when programming or recording a program.</td>
</tr>
<tr>
<td>5. Check each program of the Standard Pac and your Application Pacs as soon as you receive the Pacs. Don't wait until the need occurs to discover an error.</td>
</tr>
<tr>
<td>6. Store partially completed programs on two blank cards. Don't trust yourself with only one copy.</td>
</tr>
<tr>
<td>7. If any difficulty is experienced when removing a program card from the window slot, press down on the card with a pencil's eraser and slide the card out of the slot.</td>
</tr>
<tr>
<td>8. If the motor begins to sound as if it is laboring, a pass or two of the abrasive cleaning card may clear up the problem. Remember, also, that a fully discharged battery pack must be charged for five minutes before a card can be read.</td>
</tr>
</tbody>
</table>
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A hypothetical assembly language called MIX has been developed by the author to illustrate programming examples throughout the series. MIX is easily convertible to other assembly languages.
certainly allow the writing of complex programs. Yet, I would ask for the following additional features:

- I would like to be able to clear registers R0 thru R9 with one or two keystrokes, without clearing registers A thru E and I. (Pressing f CL REC clears primary storage registers R0 thru R9 plus A thru E and I.)
- I would like to be able to perform direct storage register arithmetic upon the contents of all registers. (Storage register arithmetic can be performed directly upon the contents of registers R0 thru R9 only. *Indirect* storage register arithmetic can be performed upon the contents of any storage register.)
- I would like to be able to directly address all storage registers. (Registers R0 thru R9 and registers A thru E and I can be addressed directly, while registers R50 thru R59 can be addressed indirectly or by pressing f P⇒S.)

Most Appreciated Features

Personally, I think the most powerful HP-67 functions are the five program editing and manipulation functions. These five functions are nonrecordable operations that assist you in altering and correcting your programs.

The SST (single step) function may be used while either programming or running a program. When SST is pressed (with the W/PRGM-RUN switch set to W/PRGM) the calculator moves to and displays the next step of program memory. This allows you to view each step of the program without execution. If SST is pressed while the W/PRGM-RUN switch is set to RUN, the calculator displays the next step of program memory, and, when you release the SST key, the calculator executes the instruction loaded in that step. This operation is especially useful when debugging a program.

When the W/PRGM-RUN switch is set to W/PRGM, the h BST operation causes the calculator to move to and display the previous step of program memory. If the W/PRGM-RUN switch is set to RUN, pressing BST, after h has been pressed and released, causes the calculator to display the contents of the previous step of program memory. When BST is released, the original contents of the X register are displayed, the calculator having executed no instructions.

The GTO.nn operation permits you to jump to any location in program memory for editing, additions or corrections to a program. When GTO. is pressed, followed by a three digit step number, the calculator transfers execution so that the next operation or instruction will begin at that step number (this happens whether the W/PRGM-RUN switch is set to W/PRGM or to RUN). No instructions are executed.

When the W/PRGM-RUN switch is set to W/PRGM, a press of h DEL will erase the instruction at the current step of program memory, and all subsequent instructions in program memory move upward one step. (Note: Any time an instruction is inserted between existing instructions in a program, all subsequent instructions in program memory move downward one step. Thus the HP-67 has a true insertion capability.)

**Programming the HP-67**

A program for the HP-67 is nothing more than a listing of the keystrokes necessary to perform the desired calculations manually, plus the labels to define the beginning and ending of the program, loops and subroutines. The listing may be prepared using a worksheet such as that shown in figure 1. The form shown is page 1 of a set of five with preprinted program steps from 1 thru 224.

When creating programs, remember that any solution that gives the correct outputs may be a suitable program. There is no one correct program for any problem. Emphasis, when programming, must only be placed on time. The *time* spent in programming must be compared to the *time* involved in running the program and the number of *times* the program will be used. It would be silly to spend days modifying a program with a running time of 30 minutes so that it could be run in 20 minutes if the program is to be used only two or three times.

In addition, programming is a personal art. Spend enough time creating your programs to satisfy your own artistic fastidiousness. Of course, you are limited to the available memory. However, the example to be discussed illustrates that very complex

---

**Table 2: Some useful mathematical functions available on the HP-67 and HP-97 programmable calculators**

<table>
<thead>
<tr>
<th>Function Name</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>PR</td>
<td>Rectangular to polar coordinates conversion</td>
</tr>
<tr>
<td>LSTx</td>
<td>Polar to rectangular coordinates conversion</td>
</tr>
<tr>
<td>R</td>
<td>Recalls number displayed before the previous operation</td>
</tr>
<tr>
<td>D</td>
<td>Converts degrees to radians</td>
</tr>
<tr>
<td>DEG</td>
<td>Converts radians to degrees</td>
</tr>
<tr>
<td>RAD</td>
<td>Sets decimal degree mode for trigonometric functions</td>
</tr>
<tr>
<td>GRD</td>
<td>Sets radians mode for trigonometric functions</td>
</tr>
<tr>
<td>H.MS</td>
<td>Converts decimal hours or degrees to hours, minutes and seconds, or degrees, minutes and seconds</td>
</tr>
<tr>
<td>H.MS+</td>
<td>Adds hours, minutes and seconds (or degrees, minutes and seconds) in the Y register to those in the X register</td>
</tr>
</tbody>
</table>
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problems can be handled with 224 steps of program memory. Furthermore, don't forget that data may be stored on the magnetic cards, and this memory is limited only by the number of blank cards you purchase.

The guide (and probably every other publication which discusses programming) suggests that a flowchart be drawn for each program. A flowchart breaks down a program into small groups of instructions which can be handled more easily than the entire program. In addition, flowcharts can be used as documentation for the program. I cannot argue with this reasoning because it seems logical. I can only say that I personally find flowcharts worthless when they are drawn, and I can, within the limits of my capabilities, write a program while another programmer is fooling around with the flowchart.

I certainly do suggest, however, that you try the flowchart approach to programming, but don't be surprised if you find it easier to tackle the program directly. For documentation, I believe that comments with the program and the run instructions are more valuable than any flowchart, especially a year or two after the program is written.

While creating a program, a review of the "Function Key Index" every now and then will keep the full repertoire of the HP-67 fresh in your mind. This is important if you want to take advantage of the many mathematical, branching and looping functions available. Also, since there are usually many ways to accomplish a desired series of steps, spend a moment or two thinking of the various possibilities. For example, if a conditional test must be executed, would \( g = Y \), \( f = 0 \), \( f = DSZ \), \( f = ISZ \), g DSZ(i) or g ISZ(i) fit best in your program? Each of these functions is designed to be used in slightly different ways, yet all of them may be used to test for zero.

When \( g = Y \) and \( f = 0 \) are used, the calculator branches around the next instruction if the question asked by the conditional is not true; \( f = DSZ \) and \( f = ISZ \) decrement or increment the contents of the I register unless its contents are zero, and, if the number in the I register has become zero, program execution skips the next step just like a false conditional instruction; \( g = DSZ(i) \) and \( g = ISZ(i) \) decrement or increment the contents of the storage register addressed by the current number in the I register unless the contents of the addressed register are zero, and, if the number in the addressed register has become zero, one program step is skipped.

These functions, as well as the many other programming functions, are fully explained in the guide. Since it is not my desire to reprint the guide, I will not dwell upon these explanations. I would, however, like to mention two other types of choices that must often be made.

One of these choices is whether to branch forward or to branch backward. A backward branch, which is usually executed faster, becomes necessary when all labels have been used for other purposes. But any correction to the program after the backward branch has been added may necessitate a correction to the number stored in the I register. (It is the number stored in the I register which causes the jump.)

The other choice is whether or not a subroutine should be used to accomplish the functions performed by a group of keystrokes used more than once during program

---

**Figure 1:** An example of the author's calculator program sheet used to write a program for the HP-67 which solves up to nine equations in nine unknowns.
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YOU BOUGHT
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execution. Because of the run time needed to search for the subroutine and the discontinuity in the program which results, I recommend not using subroutines unless it is absolutely necessary to save space in memory to accommodate a program which would otherwise have more than 224 steps.

I have seen commercial programs so riddled with subroutines that the programs had to be completely rewritten at enormous expense after the programmers were replaced. Of course, you would not want to punish yourself this way. When you own the calculator, you don't pay for computer time or memory. It costs you the same to run a 224 step program as it does a five step program.

As I have stated above, the guide covers all programming operations thoroughly. There is one operation I found difficult to implement. I am referring to the g MERGE function, but now that I have performed the function successfully, I can't imagine the cause of the difficulty I experienced.

The g MERGE function allows data or programs from magnetic cards to be merged with data or programs in the calculator. When a program from a card is merged with one in the calculator, steps 000 thru nnn of the original program are preserved. This function permits you to add to or alter a program that is already loaded in the calculator.

In fact it is possible to include the g MERGE instruction immediately preceding the h PAUSE instruction in a program and to load a program or data from a magnetic card into the calculator while a program is running. Not mentioned in the guide is the fact that when a program is loaded during a pause in a running program an h RTN immediately following the h PAUSE will be overwritten by the first step of the merging program and execution of the new program will begin immediately after it is loaded.

Card Reader Operations

One of the primary reasons the HP-67 is such a versatile calculator is its ability to store information on magnetic cards and to retrieve this information at a later time. Therefore, I would like to stress the following points concerning this operation:

- When storing the contents of the registers on a data card, always pass side 1 of the card through the card reader first, then side 2, if necessary. This insures that any nonzero data in the secondary registers will always be stored on side 2 of the card.
- When it is necessary to restore data from only one side of a magnetic card into the calculator, pass the side of the card which contains the data through the card reader. Then, when crd is displayed, press CLX.
- Accidents may occur that will destroy the program or data on a card, therefore, if the information to be stored is important or extensive, do yourself a favor and store it on two cards.
- Identify the information on your magnetic cards with a #2 pencil. When necessary, the cards can be easily erased.
- When inserting the leading edge of a card to be read into the card reader automatically during a pause, remember that the program must actually be running when you insert the leading edge. Be sure to insert the tip of the card far enough into the card reader.

Next month's concluding installment of this article features an example program showing how the HP-67 can be used to solve simultaneous network equations for an electrical network.
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<table>
<thead>
<tr>
<th>DISPLAY</th>
<th>SPECIFICATIONS</th>
<th>INTERFACE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCREEN CAPACITY, CHARACTERS</td>
<td>2000</td>
<td>DATA FORMAT</td>
</tr>
<tr>
<td>CHARACTERS PER LINE</td>
<td>80</td>
<td>DATA BIT 7</td>
</tr>
<tr>
<td>NUMBER OF LINES</td>
<td>25</td>
<td>PARITY</td>
</tr>
<tr>
<td>SCREEN</td>
<td>P4 phosphor (white)</td>
<td>STOP BITS</td>
</tr>
<tr>
<td>TUBE SIZE (DIAGONAL)</td>
<td>12 inches (30.4 cm)</td>
<td>DATA TRANSFER RATE</td>
</tr>
<tr>
<td>VIEWING AREA</td>
<td>54 square inches (137.1 cm)</td>
<td>CHARACTER SIZE</td>
</tr>
<tr>
<td>REFRESH RATE</td>
<td>60 Hz (50 Hz available)</td>
<td>CHARACTER GENERATION</td>
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<td>Raster</td>
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<td>POWER ON/Off Switch</td>
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<td>POWER REQUIREMENTS</td>
<td></td>
<td>BRIGHTNESS CONTROL</td>
</tr>
<tr>
<td>MODEL 501</td>
<td>115 volts, 60 Hz, 100 watts nominal</td>
<td></td>
</tr>
<tr>
<td>MODEL 502</td>
<td>230 volts, 50 Hz, 100 watts nominal</td>
<td></td>
</tr>
</tbody>
</table>

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The production of flight plans is a task that lends itself well to computer solution. It is a time-consuming and repetitious job involving numeric manipulation and output formatting, just the sort of thing that computers do accurately and quickly. The drawback has been, of course, that computer facilities have not been made available to pilots in a way that allows timely production of flight plans. To be useful, flight plans must reflect accurate route and weather data, and so cannot be produced too far in advance. The solution, of course, is that the increased availability of computing facilities made possible by the microprocessor makes automated flight planning practical even for private pilots.

The heart of any flight planning system consists of three calculations. Indeed, anything else the system may provide is really the option of the system’s designer. The first necessity is a true air speed calculation. Without going into too much detail, airplanes fly with “indicated” air speeds, but flight plans need “true” air speeds for their calculations. The formula used in my program is:

true air speed = indicated air speed
x (.971 + temp x ((.017 + INT (altitude / 50.1 x .002)/10)
+ altitude / 10 x .02 + INT (altitude / 50.1 x .00035)).

This formula provides accuracy within 1 knot up to altitudes of 15,000 feet. The error is somewhat greater than that above 15,000 feet, but might be considered acceptable up to 20,000 feet. For private sector flying this formula should provide excellent accuracy and reasonable simplicity. Another simpler formula is usable up to altitudes of 8,000 feet:

true air speed = indicated air speed x (temp x .002
+ altitude / 10 x .018 + .971).

There are formulae which purport to give absolute accuracy at all altitudes, but those that I am familiar with are extremely cumbersome and time-consuming.
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The second necessary calculation is drift. Drift is the measure of how many degrees off your intended course the wind will blow you if you let it. My program uses a one pass wind solution that gives the drift and ground speed after going through the formula just once. This particular solution has the disadvantage of requiring the use of an inverse sine (sin^-1) in the calculation. The one pass drift formula is:

\[
\text{drift} = \sin^{-1} \left( \frac{\text{wind velocity} \times \sin(\text{course} - \text{wind direction} - 180)}{\text{true air speed}} \right)
\]

It is possible to substitute an inverse tangent calculation for the inverse sine. This substitution is:

\[
\sin^{-1} (Y) = \tan^{-1} \left( \frac{Y}{\sqrt{1 - Y^2}} \right)
\]

The one pass ground speed formula is the third of the three necessary calculations. This formula will not work for direct head winds or tail winds. These conditions must be handled separately. In this program, I detected these situations prior to the drift calculation to save the extra step. The one pass ground speed formula is:

\[
\text{ground speed} = \sin \left( 180 - \text{course} + \left( \frac{\text{wind direction} + 180}{\text{drift}} \right) \times \text{true air speed} \right)
\]

\[
= \sin \left( \text{course} - \left( \frac{\text{wind direction} + 180}{\text{drift}} \right) \right)
\]

The special cases of direct head or tail winds are easy to handle. In either case the drift is 0. For head winds (\text{course} - \text{wind direction} = 0), the ground speed will be equal to true air speed minus wind velocity. For tail winds, ground speed will be equal to true air speed plus wind velocity.

An alternative to the one pass system is a two pass system. In this case the course is applied to the formula initially to obtain an estimate of the drift. This in turn is applied to the course to get a heading. The heading is then used in the formula to obtain the actual drift and ground speed. This routine is equally accurate and has the advantage that it requires no functions more sophisticated than sine and cosine. In an extreme case the sine and cosine functions could be obtained by reading a table.

As I said earlier, any output beyond these three basic pieces of information is at the discretion of the system's designer. I use a similar system to produce flight plans for low altitude and high-speed routes, which I fly as a C-130 instructor navigator. That system uses fixed route data stored on disk and produces precise ETAs (estimated times of arrival) and includes a lot of ancillary output information concerning altitudes,
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A CURRENT LINE NUMBER is internally maintained by the editor for displaying when prompting for input and with certain other commands. Line numbers are dynamically adjusted as the result of line inserts and deletes, and may be used for positioning within the file. They are not stored or associated with the text in any manner.

C/PM is thoroughly documented with a User's Manual describing each command and feature, and includes numerous examples. It is 9.5k bytes in size, and a minimum C/PM operating system of 20K is recommended. A User's Manual and standard size single density diskette are $69.00. A User's Manual is $7.50, refundable with purchase. COD and money orders shipped next day. COD orders require 10% deposit. Personal checks must clear before shipment. Include $2.00 shipping/handling per order.

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high obstructions along each leg, and detailed descriptions of each turn point.
This program, however, is intended to fit the most general case; readers can tailor it to their own needs more easily if what they start with is not too cluttered. The program accepts basic header data and then information concerning each leg of the flight plan.

Listing 1: Sample program of the flight program. The typical output from the program is also shown.

```
DATE (YY,MM,DD): 78,06,20
THIS FLIGHT PLAN GOES FROM: LITTLE HOCK
TO: NEW ORLEANS
PILOT'S NAME: TITUS PUNDB
ACFT TYPE:
PROPOSED TAKE-OFF TIME: 1200

LEG # 1
THIS LEG GOES FROM LITTLE HOCK TO (MEMPHIS )

MAG COURSE: 072
LEG DIST: 111
ALTITUDE (X100): 50
TEMP AT ALT (C): 22
IND AIR SPEED: 120
WIND (DDD,VV): 210,15
DO YOU HAVE ANOTHER LEG TO ENTER? YES

LEG # 2
THIS LEG GOES FROM MEMPHIS TO (GRNWOD )

MAG COURSE: 186
LEG DIST: 97
ALTITUDE (X100): 50
TEMP AT ALT (C): 22
IND AIR SPEED: 120
WIND (DDD,VV): 230,10
DO YOU HAVE ANOTHER LEG TO ENTER? YES

LEG # 3
THIS LEG GOES FROM GRNWOD TO (JACKSON )

MAG COURSE: 177
LEG DIST: 50
ALTITUDE (X100): 50
TEMP AT ALT (C): 22
IND AIR SPEED: 120
WIND (DDD,VV): 230,10
DO YOU HAVE ANOTHER LEG TO ENTER? YES

LEG # 4
THIS LEG GOES FROM JACKSON TO (MCCOMB )

MAG COURSE: 177
LEG DIST: 79
ALTITUDE (X100): 50
TEMP AT ALT (C): 22
IND AIR SPEED: 120
WIND (DDD,VV): 230,10
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Continued from page 6

paste, until the document is finished or the author is exhausted. To me, that is inefficiency! Of course, many computer text editors are not well suited to creative composition, being little more than teletype writer editors. Even with many display editors one still has to resort to hard copy for effective editing. That is the nub of our problem: most display editors are line oriented and run on “glass teletypewriters.” The latter were derived from hard copy terminals, which were in turn derivatives of keypunches—certainly an old way of thinking about text production. If the display media are truly utilized, however, a quantum improvement in editing facilities can result: information can be presented as in a “video book,” complete with rapid random access paging and on screen cutting and pasting.

Given such a tool, creative composition becomes a joy. Freedom of expression is improved; the ideas flow freely from mind to screen. A phenomenon of egoless composition results; the author does not have to measure the content of a passage against the agony involved in its creation. As a result, the author is more willing to modify and polish the document, even experimenting with major revisions in order to present the topic in its best light. What is truly exciting is that the technology for such editing systems is now of modest cost; one need only break with the past ways of thinking about editors.

What does this have to do with our subject? There is a strong analogy between the editing task and the programming task. We must examine the programming task the same way we looked at editors. Alas, most of us still program on “virtual keypunches.” We may even use one of these excellent display editors to create our card deck, but we create a linear string of characters and throw the completed program at a compiler; given that there are no syntax errors, we try to run the program, probably debugging with dumps, print statements, or debuggers which give us information in terms of the compiled code. If an error is found, we return to the editor to modify the source, recompile, and try again. Given these conditions, sloppy work habits are inevitable. In fact, the conditions are sloppy.

Editing Programs

Now we are at a critical point in programming: do we build a better “programming keypunch,” or do we look for a programmer’s tool analogous to the display editor? I would opt for the latter, and would
claim that the paradigm of LISP programming is the appropriate model from which we should begin.

First, let's examine the conservative "key-punch" approach. The traditional edit-compile-debug cycle is improved by a display editor, operating with a compiler that can return the user to the editor upon indication of a syntax error, pointing at the source statement that caused the error. A quick edit, and the syntax check cycle begins again. However, once the program is compiled, we are still at the mercy of primitive debugging techniques. One solution is to require that the user specify more information about the program, indicating expected behavior of program modules with the assumption that the compiling phase can be made more knowledgeable, and check the consistency of the expectations against the realities present in the user's encoded algorithms. This reassures us that the code which gets to the debug portion of the cycle does operate as expected. In general these user expectations are difficult to express, and checking their consistency is even more problematic. Syntactic consistency checks based on simple properties of the programmer's variables can be checked in a reasonably straightforward manner. Such properties are called
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AI and Programming Expectations

What about programs whose expectations are not easily formulated? The primary example is artificial intelligence programming: often it is only the final algorithm itself which expresses the expectation. The creative programming process is driven by a partially understood phenomenon; the programming effort is to capture as much of that phenomenon as possible. We program in a world of great uncertainty, much like driving a car. We may have a reasonably detailed roadmap, but the path may involve traffic lights, accidents, and detours. We do not return home and restart every time we encounter an unexpected situation; we correct on the fly and continue. I feel that much of modern computation has this exploratory character of artificial intelligence.

What about programs which contain issues involving more than correctness? For example, it would be difficult to express the specifications of a text editor in terms of static conditions. To be sure, certain aspects of editors involve correctness, but usability is equally important. An experimental process is involved which requires modification and iteration. In fact the editor
exists for modification. If we made no typing errors we would not need an editor. For example, when we discover an error in a text file, we don’t erase the whole file and retype it—we edit the error and keep the result. However, in the traditional debugging paradigm, when we discover a runtime error, we throw away all the computation, edit the file, and restart. If that computation has taken several hours (or even minutes) to elicit the bug, it will be most painful to restart.

Most programming involves a deeper issue than debugging: it involves modifiability. Programs are always being modified because we change our expectations. Debugging is only a very minor component of the problem of program modification. Therefore, as we progress to more and more complex programming tasks, programming modification will take on a more fundamental role. Don’t try to stamp out program modification as a manifestation of human frailty and error; it is a fundamental ingredient of our field. Cater to modification at the innermost levels of our programming systems. Assembly language continues to dominate systems design not because of innate masochism, but because of modifiability. There is a close (but low level) match between the language, the debugger, and the execution device. Any language that expects to dethrone machine language must offer an equally compelling environment.

“Modifying a Blank Screen”

One artificial intelligence researcher has characterized programming as “debugging a blank piece of paper.” To that I would add: programming is modifying a blank screen. Get the machine into the programming process as soon as possible, but it must be done right. In that context we will see a rise in productivity comparable to that experienced in the editing task when a true display editor is used. We can expect egless programming and good work habits to evolve naturally. With such tools the promise of structured programming can become a reality. That is, it is the activity of programming that involves the structuring. One should not expect to find structure in a program anymore than one can look at the final board positions of a chess game and tell whether that game was played by Masters or amateurs. Imagine programming systems whose “moves” involve stepwise refinement of partially elaborated programs; imagine the transcript of those keystrokes as comparable to the recording of moves in the chess game. The transcript of the program development would be available for analysis by programming students.
and teachers. Such a system would truly support structured programming. Current practice does not support such activity. We are forced to submit character strings to our language systems, even though our methodology tells us to compose in terms of structure. Until that disparity is resolved we should expect little improvement in the software problem.

Most programming languages do very little to reinforce the creative process of algorithm discovery and creation. They are more concerned with the execution of already constructed algorithms. This is a natural outgrowth of their ancestry: a numerical computation era in which the emphasis was placed on minimizing computer time at the expense of programmer time. Also, the programming problems of that day involved the transcription of well-specified numerical algorithms into an equally precise programming language. Times and economics have changed. The problems are more complex and no longer as well-specified as those of numerical analysis. Now computers are cheap and programmers are expensive; we need techniques to speed the development of correct programs. Certainly the verification efforts are aimed in this direction, but verification typically is an after-the-fact reconciliation of a completed algorithm with some descriptive specification of its behavior. We need languages that support the creative and exploratory phases of program development. Of course, one may question this. In the Computing Surveys, Wirth writes:

... It is therefore entirely possible that in the future a more interactive mode of operation between compiler and programmer will emerge, at least for the very sophisticated professional. The purpose of this interaction would not, however, be the development of an algorithm or the debugging of a program, but rather its improvement under invariance of correctness. [Wirth’s emphasis].

I most definitely agree with the emphatic phrase; we must develop such program transformation systems. However, it is equally important to improve the program development phase.

Exploratory programming, which is the hallmark of artificial intelligence and which, to a very large extent, occurs in the creative stages of any programming task, is best done with an untyped interactive language like LISP. Strong typed languages like Pascal only confuse and obfuscate the formulative stages.

LISP’s basic unit is an expression, meaning
that every LISP construct computes a value. LISP tends to emphasize the applicative nature of algorithms, using "function application" as its basic computational notation and using recursion to express the control aspects of the process; recent research has indicated that many common recursive schemes can be executed in an iterative fashion. That is, the evaluation mechanism need not involve the usual stack oriented overhead. One should not confuse the recursive notation with the evaluation mechanism.

The basic unit of Pascal is a statement, rather than an expression. That is, Pascal's units tend to be executed for effect rather than value. It is interesting that John Backus, the "father" of FORTRAN, has spent considerable time in recent years studying and advocating applicative languages, turning from the more traditional imperative, statement oriented languages like FORTRAN, ALGOL, and Pascal. In his Turing lecture, Backus writes:

This world of statements is a disorderly one, with few useful mathematical properties. Structured programming can be seen as a modest effort to introduce some order into this chaotic world, but it accomplishes little in attacking the fundamental problems created by the word-at-a-time von Neumann style of programming, with its primitive use of loops, subscripts, and branching flow of control.

Of course things are not all that black and white. Pascal has applicative aspects and LISP has imperative aspects. The difference is again one of emphasis and philosophy: the expression versus the statement. The difference has a mighty influence on the language design: expressions lead to calculator-like interactions; statements lead to computer-like programs. Wirth, in the Computing Surveys, writes:

We must recognize the strong and undeniable influence that our language exerts on our way of thinking, and in fact defines and delimits the abstract space in which we can formulate—give form to—our thoughts.

Computing Attitudes

That is a critical point, true in natural language as well as in programming languages. In fact, the problem goes deeper than programming language. One's attitude about computation is deeply connected with the human interface problem. Those who

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The Controller Board Kit is an intelligent switching system that listens to the world through 8 opto-isolator inputs, confers with the computer, and then issues open/close instructions to 8 reed relays. If you get tired of low power applications, high power AC modules are available, each kit includes applications notes and an onboard self-tester, $95 per kit.

For some people, the fun stops once you've put a board in your computer. With a Mullen board, the fun's just beginning.

**MULLEN Computer Products**

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Mullen boards are available at computer stores nation-wide or by direct mail (Californians add sales tax).

---

Circle 72 on inquiry card.
If your system needs on/off control of lights, motors, appliances, etc., our PC3200 System components are for you. Control boards allow one I/O port to control 32 (PC3232) or 16 (PC3216) external Power Control Units, such as the PC3202 which controls 120 VAC loads to 400 Watts. Optically isolated, low voltage, current-limited control lines are standard in this growing product line.

P.O. Box 516
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(formerly comptek)

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YOUR
**NORTH STAR ** COMPUTERS
PROGRAMMING SPECIALISTS!
You can look to us for innovative and imaginative programs
** Interac Intertubes now available **

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<tr>
<th>DOSCHG</th>
<th>CSUB</th>
<th>TIMESHARE</th>
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<td>Patches to connect Thinner Toys 8&quot; Disk Drives to North Star DOS &amp; Basic. Fully supports all North Star Functions on 8&quot; disk.</td>
<td>A set of Functions defined in North Star Basic that handle all disc accesing (Sequential, Random, &amp; Keyed Access) and all CRT display, formatting &amp; input.</td>
<td>Patches to North Star DOS &amp; BASIC that take advantage of the versatility of the Horizon computer to implement an interrupt driven bank-switching time sharing system. Requires additional memory &amp; terminals.</td>
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Mike Mike's
905 Buchanan, Amarillo, Texas 79101
806-372-3633
computer language; it is BASIC's interactive nature, allowing quick experimentation with programming ideas, that accounts for its longevity. This interactive flavor can be grafted onto a Pascal-like language, but it is much more difficult to do this successfully. In the process one either compromises the tenets of the language (extensions) or compromises the resulting system.

"Wild West" Computing

The essence of personalized computing has been sort of the "wild west" attitude: open, undisciplined, but creative and lusty as hell. You are a very healthy sign; today, a modest personal computer has more power and flexibility than that available in a professional installation 20 years ago. Each of you has molded your system according to your desires and economic constraints. But freedom is expensive; systems and programs become one of a kind. Enter compatibility and, unless you are careful, exit individuality. Clearly these problems are not solely the province of personal computing; the manufacturers feel the same pressures. So the real question is: can we bring discipline and order to programming without curtailing the creativity?

Personal computer users need not give up the interactiveness of BASIC to gain the structure and portability which Pascal is advertising; LISP offers both. BASIC's longevity, indeed strength, lies in its "friendliness." That is a critical ingredient of an interactive programming language. I guarantee that if BASIC were available only in the traditional batch oriented environment, its popularity as a personal computer language would not have occurred. Similarly with LISP or Pascal. That is, it is the total environment in which a language is situated that is important. The UCSD experience with Pascal illustrates this point well. The real question then is: can we do better?

LISP is not a special purpose list processing language. A modern LISP system has more flexible data handling facilities than other more recent languages. For example, MACLISP's data types include arbitrary precision numbers, very flexible record structures (called property lists), strings, arrays, list structure, and even procedures. One attribute which leads to LISP's elegance and economy of expression is that all of these data types are available as values of programming constructs. Thus LISP procedures may take procedures as values, return procedures as values, or create arrays which are returned as value.
PET™ EXPANDOR PRINTER
FROM PETSHACK Software House
P.O. Box 966
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PRINTER PRICE WITH PET INTERFACE $525
- Small size of 4.5"H x 12.5"W x 9"D
- Impact printing: 3 copies
- Prints 80 columns wide
- Print Cylinder - not a matrix
- User 8" x paper, pressure or pin feed
- Easy to maintain yourself, or return to us
- Regular Paper - Coated paper not required
- Lightweight, 11 lbs. with cover
- Prints 10 characters per second
- 64 Character ASCII Character Set
- Full Documentation Included

This is the ideal, low cost, reliable, self maintained printer with which to complete your PET system.

PET-ROM LISTINGS
PET SCHEMATICS
PET TO PARALLEL INTERFACE with 8V.BA power supply
PET TO 2nd CASSETTE INTERFACE
BUDGET - NEW - Keep track of Bills and Checks. Update as needed
NUMBERAMA - Number Guessing Game based on 'MASTERMIND'
STATES - Help the kids with their geography. March States & Capitals
MATH TUTOR - Help youngsters learn math in an enjoyable way
6502 DISASSEMBLER
MACLIBS: PARTY FAVORITE! Hilarious stories created
WORLD CONQUEST - Advanced game of Strategy
STARTREK - All-time favorite written for the PET's special Graphics
MORTAR - Advanced game with X-Y coordinates & angles
PSYCHO ANNE - Tell your problems to Psycho Annie
COMPUTER DERBY - Up to 4 people can play the horses
MAILING LIST - For personal or business applications
HOME UTILITIES - Loans, Savings, Electricity, & miles per gallon
MACHINE LANGUAGE MONITOR - Write Machine Code, Save on tape

PET is a trademark of Commodore Business Machines

Lest you suspect that such generality implies inefficiency, note that LISP has been used as the systems programming language for the MIT LISP machine. All system software is written in LISP even to the level of the algorithms that place the characters on the screen. Even the microcode is written in LISP. LISP compilers can be as good as those of any other language. In one experiment, the MACLISP compiler was tested against a FORTRAN compiler on some purely numerical examples. The LISP compiler's code was better both in terms of space and time.

Might not such generality lead to sloppy programming techniques? Note again that a language is a tool, and is only as effective as its user. I would rather sharpen the user than dull the tool. In terms of user aids, LISP excels. A modern LISP system is an integrated programming environment incorporating editors, debuggers, and compilers. Some LISP packages include sophisticated error recovery modules, allowing the user to undo computations or explore alternative computations. The integration of these "programmer's assistants" with modern display techniques has begun. The results are quite impressive. The flexibility of these systems is due in large part to LISP'S unique representation of programs as data structures. As a result, it is easy to write programs which manipulate programs. Note that language editors, debuggers, compilers, and program transformations systems like those advocated by Wirth (above) all fall into this category.

One also hears dreadful rumors about LISP's syntax (Lots of Irritating Single Parentheses). First, the regularity of the notation and the simple syntax more than make up for any initial inconvenience. However, these syntactic difficulties can also be stifled directly. It is quite simple to supply LISP with an ALGOL like sugared input and output. Such parsers and unparsers are simple LISP programs.

The above discussion has hinted at a very important aspect of LISP: LISP is a machine language. In the traditional machine, instructions reside in memory locations just as data does. It is the access path of the processor that determines how the contents of a location are to be interpreted. Access by the program counter implies an instruction fetch; other access implies a data fetch--so too in LISP. Data and program are stored identically; both are presented to the machine in a simple syntax of lists. The LISP CPU (central processing unit), called eval, accesses LISP memory either to fetch code or data. Instead of the linear sequential representation of traditional ma-
machines, LISP has a tree-like storage scheme. One very exciting area of investigation involves architectures for LISP-like machines.

Finally, it is often assumed that LISP demands large expensive computers for its implementation. That, too, is not true: there are versions of LISP for the Z-80, 8080, 6800, F8, LSI-11, and even a version in BASIC. Certainly the machine size will limit the range of feasible applications; but that is true of any language. The new class of microcomputers is particularly exciting. They will open up many new areas—including artificial intelligence study—for the personal machine. The new machines will support very substantial implementations of LISP.

It is particularly important to influence the personal computer advocate now, given the growth in computing power and the cries for compatibility, discipline, and standardization. The DOD-1 language effort is but the latest manifestation of this attitude. I do not believe that this legislative approach is healthy. I believe that LISP offers a healthy alternative to the current choices of programming languages for personal computation.

REFERENCES


Southeastern Michigan Computer Organization Sponsors TRS-80 Group

SEMCO (the Southeastern Michigan Computer Organization) sponsors a TRS-80 special interest group for Radio Shack TRS-80 enthusiasts. Meetings are for the beginning hobbyist and computer expert alike. The main objective is to share ideas on programming, troubleshooting, and new or compatible TRS-80 products. This group meets the first Saturday of every month from 6 to 9 PM. The location is the Bryant Branch Library, Michigan Av and Mason St, Dearborn MI 48124.

Northwest Computer Society

The Seattle chapter of the Northwest Computer Society meets at the Pacific Science Center on the first and third Thursday of each month at 7:30 PM. The first meeting of the month is normally held in room 200 on the east side of Science Center Court. This meeting usually features a formal presentation by a speaker or speakers. The second meeting of the month is normally held in the main room at the southeast corner of Science Center Court. This meeting is usually more informal with freewheeling discussion and problem solving. Call the recorded information line at (206) 284-6109 or write to POB 4193, Seattle WA 98104.

South Florida Computer Group

The South Florida Computer Group has two chapters, one in Miami and the other in Ft Lauderdale. Members can attend meetings at both chapters and tour visitors are welcome. The Miami chapter meets the first Monday of every month at the Papanicolaou Cancer Research Institute, 1155 NW 14 St, Miami. The Ft Lauderdale chapter meets the second Tuesday of every month at the Social Annex Building, Holiday Park (behind the Parker Playhouse). Both chapters have a $5 a year membership fee which includes their monthly newsletter, I/O. For more information about this group, write to Robert Lief, Papanicolaou Cancer Research Institute, 1155 NW 14 St, Miami FL 33136.

Australian 9900 Users Group

The Australian 9900 Users Group is a relatively new club concerned with the 9900 family of devices and applications for process control and business data processing. They have both Texas Instruments and Technico equipped members and welcome contact with overseas correspondents. Presently, they do not have meetings but operate by direct contact or by correspondence between members. Contact Barry Day, 43a Osborne Rd, Lane Cv, NSW 2066, AUSTRALIA.

Melbourne Australia Computer Club

We have heard from Andrew Stewart, correspondence secretary of MICOM (the Microcomputer Club of Melbourne). The club meets the second Saturday of every month at Railway Modellers' Hall, Wills St, Glen Iris, Victoria. The dues are $7.50 per year, which includes a monthly newsletter and quarterly magazine. MICOM can be contacted at POB 60, Canterbury, Victoria 3126, AUSTRALIA.

North London Hobby Computer Club

A press release has come our way informing us of a recent meeting of the North London Hobby Computer Club. At this particular meeting, held at the Polytechnic of North London, over 200 members and guests listened to a talk given on the present situation in personal computing. After the talk, three user groups were formed: a PET user group; a business user group; and another group of individuals interested in homebrew activities. The club is planning a series of lectures, and hopes to publish a regular monthly newsletter. For more information, contact Robin Bradbeer, Dept of Electronics and Communications Engineering, Polytechnic of North London, Holloway Rd, London N7 8DB, ENGLAND.
Attention: TDL Users

An exchange of information among users of TDL (Technical Design Labs) equipment and software is being started by Dr. John R. Cameron, POB 1517, Palo Alto CA 94301. If you would like to correspond with others who have similar interests, send descriptions of any and all Z-80/TDL related hardware and software to Dr. Cameron. He asks that you enclose a brief summary (typed, single spaced) of your offerings and wishes, with your return address. Whatever material you wish to disseminate may be enclosed, or give prices and availability for commercial offerings. A users survey is also being compiled, so you may wish to describe your system and its applications. For copies of other users' summaries and information of general interest, send $3 to Dr. Cameron at the above address.

New Computer Group in Battle Creek MI Area

Called the Battle Creek Area Microcomputer Club, this group consists largely, but not exclusively, of TRS-80 owners. Meetings are on alternate Thursdays at 7 PM and include software swapping, hardware topics, tutorials, etc. Both professionals and beginners are welcome. For detailed information, contact Jeff Stanton, 8587 Q Dr N, Battle Creek MI 49017.

Pittsburgh Area Computer Club Members Compete for Monthly Babbage Award

PACC (the Pittsburgh Area Computer Club) is currently meeting every third Sunday at 11 AM in the community room of the Northway Mall. They normally have a 2-hour general session, followed by a formal meeting with a speaker. This in turn is followed by another general session in which the various user groups meet. During the formal meeting the monthly Babbage is awarded to the "best in its class." Members and guests are invited to bring their systems, share their ideas and vie for the Babbage prize. Contact PACC, 400 Smithfield St, Pittsburgh PA 15222.

Space Coast Microcomputer Club Celebrates Second Birthday

Ray Lockwood, president of the Space Coast Microcomputer Club, called us with information about his computer group. The club recently celebrated its second birthday and boasts a membership of approximately 100. They meet every fourth Thursday at 7:30 PM at the Merritt Island Public Library, 315 Inlet Av, Merritt Island FL. The membership fee of $5 includes the club’s newsletter. Ray tells us there is club interest, but not exclusively, in 8080 and Z-80 systems. If you wish further information, he can be reached at (305) 452-2159.

Get a head start with computers the easy, inexpensive way with Rockwell's AIM 65.

For learning, designing, work or just fun, the R6500 Advanced Interactive Microcomputer (AIM 65) offers features you won’t find on other comparably priced systems.

• Alphanumeric 20-Column Thermal Printer for Hard Copy Listing
• Alphanumeric 20-Character Display
• Dual Cassette, TTY and General-Purpose I/Os
• R6502 NMOS Microprocessor
• Read/Write 1K Byte RAM Memory
• System Expansion Bus Connector
• PROM/ROM and RAM Expansion Sockets
• Advanced Interactive Monitor Firmware
• Big, Terminal-Style Keyboard
• Optional Two-Pass, Symbolic Assembler and BASIC Interpreter

AIM 65 is available from your local Hamilton/Awens distributor or send the coupon below to:
Microelectronic Devices, Rockwell International, P.O. Box 3669, Anaheim, CA 92803 or phone (714) 632-3729.

GET ME STARTED!
☐ Send me more information on AIM 65.
☐ Have someone phone me at ____________

Name __________________________
Address ________________________

Rockwell International
...where science gets down to business

Circle 318 on inquiry card.

March 1979 © BYTE Publications Inc 223
Add-In Associative Memory for the S-100 bus

Discussed and dreamed about by computer scientists for years, Content-Addressable Memory (CAM) is now here at an affordable price. CAMs have been so costly to build that few have actually been produced. Now Semionics has developed a simplified design, lowering the cost by two orders of magnitude. This new memory is called Recognition Memory (REM), since (like the human brain) it can recognize words, patterns, etc.

Adding a REM board to an ordinary microcomputer converts it into a very powerful machine known as a Content-Addressable Parallel Processor (CAPP).

Features:
- 4K bytes per board
- Static—no refresh needed
- Can be used as ordinary RAM or as CAM
- RAM access time: 200 ns
- CAM access time: 4 ns
- Multiwrite—writing into multiple locations with one instruction
- Masking—for individual bit access
- Multiple REM boards accessed in parallel

Adds 17 associative memory functions to instruction set of Z-80 or 8080.

Applications:
- Pattern Recognition
- Information Retrieval
- Compiling & Interpreting
- Natural Language Processing
- Code Compression
- Artificial Intelligence

Price: $325

4K firmware package of REM routines: $90

Semionics
41 Tunnel Road • Berkeley • CA 94705
(415) 548-2400

Sondheimer, Sperry Univac, POB 500, M S 2G3, Blue Bell PA 19424, (215) 542-5896.

Boston is Having a Huge Small Computer Show

Hynes Auditorium in Boston is the site of the Northeast Computer Show. The show originally scheduled to be held April 6, 7 and 8, 1979 has been changed to September 28, 29 and 30, 1979. The Northeast Computer Show will be a total spectrum presentation for the trade and public. There will be two separate sections to the show: a small business system section and a personal computing section.

The personal computing section will feature microcomputers, small computer systems, business opportunities, electronic and video games, career and employment opportunities, education exhibits, free seminars and lectures. Exhibitors will display the latest in personal computing hardware and software, computerized music synthesizers, computer amusements, computer generated art, graphics, and animation. Dozens of free lectures and seminars will be given by internationally recognized speakers for all categories and levels of enthusiasts including introductory classes.

Tektronix Microprocessor Design and Development Lab Workshops

Tektronix Inc is offering a series of microprocessor design and development lab workshops. Two different types of workshops are available: one lasts five days for those who want exposure to basic microprocessor design and organization, as well as experience in designing and building a lab workshop. The other is a 3 day workshop for those already experienced in microprocessor design who wish more intensive training in developing and testing a design using the Tektronix 8000 Microprocessor Development Lab. Both workshops provide a practical, hands-on, results oriented learning experience. The purpose of the workshop is to help the attendee grow as a professional designer. For a complete listing of dates and locations, write to Tektronix Inc, POB 500, Beaverton OR 97077.

International Date Standard

Software system writers may be interested in the international standard for writing numeric dates. In 1971 the International Organization for Standardization adopted Recommendations 1974, which provides for a system of descending order when writing numeric dates on any letter or document. If numbers only are used, the first day of July in the year 1979 should be written 1979-07-01. The hyphen is preferred as a separator, rather than the period, slant, or space.

If the month is given in alphabetic form, one can write the date in any order (eg: 1 July 1979, July 1 1979, or 1979 July 1). No ambiguity results when a 4 character year field is used.

Sargon Reproduced

We have been informed by Matt Mihovich of the Hayden Book Company
that the Sargon chess program described in recent issues of BYTE is no longer directly available from the authors. It is now marketed by the Hayden Book Company in book and tape (TRS-80, Level II) formats. The book retails for $14.95 and the tape for $19.95. Contact Hayden at 50 Essex St, Rochelle Park NJ 07662.

New Computer Chess Champion

At the Computer Chess Championship held at the 1978 ACM (Association for Computing Machinery) meeting this past December, a new champion emerged from the Swiss system tournament. The program, Belle, developed at Bell Laboratories, edged out defender Chess 4.7, the program developed by Slate and Atkin at Northwestern University. The Belle program runs on a Digital Equipment Corp PDP-11 with special hardware to generate moves, and a new device to evaluate positions using high speed hardware.

Of Interest to microcomputer users is the relatively good performance of the Sargon program, written by Dan and Kathe Spracklen. It managed a good enough performance for a tie for third place, although the Swiss system leaves controversy concerning its exact ability.

Still waiting in the wings is Slate and Atkin's newest effort, Chess 5.0. At this writing, this version is not ready for competition. The rewritten program uses the venerable FORTRAN language.

Association for Women in Computing

It has been announced that the AWC (Association for Women in Computing) was founded on December 5, 1978 in Washington DC. The purposes of AWC are:

- to promote communication among women in computing;
- to further the professional development and advancement of women in computing;
- to promote the education of women and girls in computing.

Membership in AWC is open to all persons interested in the purposes of the association regardless of sex, race, religion, or national origin. To obtain further information and/or a membership application, contact Anita Cochran, SA137 Bell Laboratories, Murray Hill NJ 07974.

Automated Shopping List

During the past Christmas season, an interesting computer application was demonstrated at the Mall of New Hampshire in Manchester. The Digital Equipment Corp retail store there set up three DECstation 78 computer systems for use by shoppers. Each system executed a program for an automated shopping list. Each user answered four questions about a gift recipient, and the computer selected appropriate gifts from a database containing 10,000 items. The selections were printed out in the form of a list of 20 suggestions. The data base was created from gift lists submitted by various stores in the mall in each of the several categories. An exemplar of a gift suggestion list is reproduced here. The list is specified as being appropriate for a female, 18 years of age or older, in the price range of $20 to $50, in the category of general presents.

It is estimated that over 1000 people per day used the system. The DEC store has received many inquiries about the system, and no doubt many such systems will appear in other locations. The program used in the system was written in the DIBOL language. The processor unit in the DECstation 78 is a microcomputer version of the venerable PDP-5.

MERRY CHRISTMAS FROM THE DIGITAL STORE!

OUR COMPUTER HAS PROCESSED YOUR DATA AND SUGGESTS THE FOLLOWING GIFTS:

<table>
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<tr>
<th>STORE</th>
<th>DESCRIPTION OF GIFT</th>
<th>PRICE</th>
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<tr>
<td>WEATHERVANE</td>
<td>PLAYOUTSHOULD BAG</td>
<td>23.00</td>
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<tr>
<td>FILELINE'S</td>
<td>E LAUHER PVT COLLECTION 1/2 OZ</td>
<td>45.00</td>
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<tr>
<td>KARTEN'S</td>
<td>PERCOLA TOUCH</td>
<td>50.00</td>
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<td>BRAZIL CONTEMPO</td>
<td>LIMPED PRINTS</td>
<td>50.00</td>
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<tr>
<td>GREAT EXPECTATIONS</td>
<td>GIFT CERTIFICATE FOR PERMANENT</td>
<td>25.00</td>
</tr>
<tr>
<td>LONDON HARNESS COMPANY</td>
<td>AUTHENTIC SCRIMSHAW</td>
<td>25.00</td>
</tr>
<tr>
<td>THE GREY SET</td>
<td>SCANDINAVIAN DESIGN</td>
<td>25.50</td>
</tr>
<tr>
<td>SEARS ROEBUCK AND CO.</td>
<td>TRADITIONAL BASKET</td>
<td>26.50</td>
</tr>
<tr>
<td>PHOTO CORRAL</td>
<td>800G SLIK TRIPOD</td>
<td>22.50</td>
</tr>
<tr>
<td>JOY OF COOKING</td>
<td>COPO COOKWARE</td>
<td>15.00</td>
</tr>
<tr>
<td>TARRANT'S CUTLERY</td>
<td>KING'S ARMS 2PC CARVE SET</td>
<td>37.50</td>
</tr>
<tr>
<td>SEARS ROEBUCK AND CO.</td>
<td>CRAFTSMAN TOOLS</td>
<td>35.00</td>
</tr>
<tr>
<td>LAMP AND SHADE WORLD</td>
<td>STUFFED CHILDREN TOYS</td>
<td>25.00</td>
</tr>
<tr>
<td>C.B. PERKINS &amp; CO.</td>
<td>BRASS FIRST MATE'S LAMP</td>
<td>57.50</td>
</tr>
<tr>
<td>ABUNDANT LIFE WOODSTOVES</td>
<td>CAST IRON TEA KETTLE</td>
<td>29.95</td>
</tr>
<tr>
<td>LECHMERES SALES</td>
<td>GE DIGITAL SCALE</td>
<td>39.88</td>
</tr>
<tr>
<td>BREWSTER GLASSMITH</td>
<td>HANDMADE GLASS WASHING MACHINE</td>
<td>22.50</td>
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THANK YOU FOR SHOPPING AT THE MALL OF NEW HAMPSHIRE
I am just reaching the point where I can remember that TH is a search mode and ZA is the number of characters in a word. This is particularly regrettable in a program with avowedly pedagogical purposes. I shall refrain from belaboring the similar confusion caused by the program’s use of GOTOs.

Finally, I am sorry that the authors did not comment generally on the memory requirements for the program, its performance, and the question of high versus low level languages for competitive chess programs. Still, it is an exciting series and I look forward to adapting the program when my Western Digital Microengine arrives.

David A Mundie
104-B Oakhurst Cir
Charlottesville VA 22903

ATTENTION ATARI EXPERTS

I am getting started in home computing. I have an Atari video computer with interchangeable game cartridges and controls. Is it possible to modify this so that I can write small programs on it? If anyone has done this, I would appreciate being sent some directions on how to do it. (I have some experience in putting electronic kits together.)

If these modifications are not feasible, does there exist a plug-in cartridge for playing chess? It seems to me that the 12 key keyboard or the 10 pin connector could be made to handle chess functions. I would appreciate help and advice from your readers.

Paul Rensink
POB 247
Ashton IA 51232

DIGICAST: A CORRECTION AND AN OPINION

I would like to make a couple of corrections to the otherwise fine article by A I Halsema regarding “The Digicast System” in January 1979 BYTE, page 100.

- The explanation offered for the functioning of the standard FM Multiplex transmission and reception system needs clarification. What is normally referred to as the stereo pilot signal is a signal sent to the FM tuner at 19 kHz from center frequency, which acts as an on-off switch for the tuner’s demultiplexing section. In the presence of the 19 kHz pilot, the tuner will attempt to combine the difference signal being sent in the 38 kHz band with the summary monaural signal to derive two channels [algebraically, (L + R) x (L - R) = (L² - R²)]; in the absence of the pilot, the monaural signal is fed to both preamplifier channels.

- I highly doubt that, in practice, one could realize a full 6 M bit data rate on a UHF television channel whose full channel bandwidth is only 6 MHz total. The realities of broadcast transmission and reception would probably yield a service operating at less than half this frequency (I would guess 2.0–2.5 M bps tops).

Neil D Weiser
81 Horton St
Stamford CT 06902

CAN OUR READERS HELP?

I would appreciate information concerning any suppliers of an IBM compatible Magnetic Cassette which may be interfaced to a microcomputer which uses the S-100 bus.

Ray Menzies
3/545 St Kilda Rd
Melbourne 3004
AUSTRALIA

Any BYTE reader with appropriate information is requested to correspond with Mr Menzies.

TEXT EDITOR

Your editorial “On the Virtues of Writing Editors” (November 1978 BYTE, page 6) prompted this letter to the editor. It seems that we have been reinventing the same wheel. I began writing my text editor about nine months ago—after becoming sufficiently frustrated with the Teletype-oriented editor purchased when I first got my system running. I have actually intended to write this letter since I read your earlier editorial asking for a better text processing system. However, I have been busy completing my doctorate during the period when the program was being developed so other things have also occupied my time. Many of your ideas were incorporated into my program. Here is a description of my editor.

VideoWriter is a video display-oriented text editor. I wrote it for the most common hobbyist systems (16 lines of 64 characters) but it is easily modified for other page lengths, and can be modified for other page widths (It is very easily modified for the Sorcerer size screen). It is an expandable program designed to have extra features added on as desired by the user. A complex split screen video driver for a memory mapped video display and a keyboard input routine using three flashing cursors are incorporated into VideoWriter so that support software external to the program is not needed.

The screen is divided into a text display area and a command and message

6800 PERFORMANCE PRODUCTS FROM MICROWARE

A/BASIC COMPILER
Unmatched for speed, versatility and efficiency, generates pure 6800 machine language from BASIC source. Fast integer math, strings, logical and array operations. Output is ROMable and requires no runtime package. Cassette version requires RT/68 and 8K RAM. Disk versions require 12K and have the complete disk I/O statements plus other extensive changes.

Cassette Version — A/Basic V1.0C $ 65.00
SWTPC Miniflex — A/BASIC V2.1F $150.00
SSB DOS-68 — A/BASIC V2.15 $150.00

RT/68 OPERATING SYSTEM
Compatible MIKBUG replacement ROM with expanded, improved monitor plus real-time multiprocessing executive. 1000's in use since 1976.

RT/68 MX on 6830 ROM (Mikbug pin compatible) $ 55.00
RT/68 MXP on 2708 ROM (EPROM pin compatible) $ 55.00

6800 CHESS
challenging chess program, two difficulty levels. Runs in 8K RAM. Mikbug-compatible object plus A/BASIC source. Specify cassette, SSB or SWTPC minidisk.

CHESS V1.0 $ 50.00

DR. ELIZA
6800 version of famous MIT artificial intelligence program. Computer as psychoanalyst communicates in plain English dialog. MIKBUG compatible object plus A/BASIC source. Specify cassette, SSB or SWTPC minidisk.

ELIZA 1.0 $ 30.00

AS-1 A/D INTERFACE
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display area. The text area is the bottom 13 lines of the screen. A flashing cursor indicates the position at which the next operation in the text buffer will occur. This cursor changes to different figures for either the text input mode or the command mode so the operator can tell at a glance which mode is in effect. The cursor can always be moved within the area. To illustrate the use of the cursor, imagine that you are entering text and notice a misspelled word several lines up on the page. Without changing operating modes, move the cursor up to the line containing the error and then over to the wrong letter, positioning the flashing cursor over the error. Touching the delete key (or any other key so defined at assembly) removes the letter and the line below the cursor moves back one place. Now simply type in the letter or letters desired. The line moves to the right to make room. If the line becomes too long for the screen width it is split into two parts at the cursor position, and you continue entering on the same line. If you come to the end of the screen line an automatic carriage return and line feed is executed. If you were part way through a word at the end of the line the entire word will be entered on the next text line, and you simply keep typing. When a letter is entered in the last position on the screen line the cursor wraps around to the start of the next line. The cursor always indicates where the next insertion or deletion will occur. The operator does not need to enter a carriage return at the end of the line—this is done automatically.

Text lines in the text buffer are terminated by a single carriage return character. Actual line length varies from the single carriage return up to 64 text characters, and a carriage return. The text buffer arrangement is the most memory conservative arrangement that I could easily implement. Any byte (hexadecimal 00 to FF) can be entered into the text buffer.

Videowriter features user set, variable tab stops that work exactly like tab stops on a typewriter. 16 tab stops are allowed—and they can be set at any line position.

The top line of the screen is used for messages from the editor to the operator. If more tabs are entered into a line than there are tab stops set in the tab stop buffer the message TAB STOP NOT SET appears in the upper left corner of the screen and the system's bell is sounded. Similar messages announce other user errors and undefined conditions.

The command mode of operation allows the operator to manipulate the text through the execution of command strings. Commands are all single letter entries (upper or lower case) made on the third line of the screen. Command characters do not have to be separated by a delimiter, but a delimiter $ is used to separate groups of commands. Each group delimited by a $ will be repeated as a loop according to the number preceding the group on the command line. For example:

```
$9999adft23ERT5h$121K$$
```

will be interpreted in the following way.

1. Execute the commands A, S, D, and F; and repeat 9999 times.
2. Do E, R, T 23 times.
3. Do one H; execute L and K commands.
4. Stop.

After the command string is entered on line 3, the two dollar signs $$ signal the start of execution. The line is first moved up to line 2, and then the commands are actually read from the video memory and executed. If the operator makes an error another command string can be entered on line 3 with the previous string still visible on line 2. Existing line 2 command strings can be repeated, and line 3 command entries can be deleted singly or the entire line can be erased. The command line cursor indicates where the next command line entry will go. A text cursor indicates where the next command will have effect in the text buffer. For example, the delete command will delete characters starting at the current text cursor position.

There are two types of commands. The 26 single letter commands are reserved for use on the command line as described above. These commands are decoded in sequence and a vector is found in a table which then place any vector in this table and the editor will then call the user's routine. A number of immediate commands are implemented using the set of ASCII control characters. A control E initiates the text enter mode. A control C halts execution of any command mode string (if the user has written it into the routine!) and returns to the command mode with a *BREAK* message and a bell. Control R deletes the entire line 3 command string entry. A control X returns to the monitor or operating system. The control Z command causes the next character
entered from the keyboard to be entered into the text buffer, regardless of any assigned function of the character.

Videowriter is constructed in two parts. The core program does the housekeeping for the original described above (except for the delete command). None of the 26 single letter commands is used by the core program. (Control T initiates the tab set or clear routine.) All of the immediate commands are processed by the core program. Text buffer entry or delete, cursor control, screen scrolling, and keyboard entry are managed by the core. Decoding of the 26 single letter commands, command line execution and loop control is done by the core, and control is passed to the vector in the command vector lookup table. Underlined commands return control to the command processing routine.

The other half of Videowriter is a user expandable set of extension routines vectored to by the core program. The user’s routine does not need to save any registers or the stack pointer position, but the address on the stack when their routine is called must be saved. This is the return address to the command processor. Input and output routines are obvious candidates for the extension routines, since these routines must be tailored to the user’s individual disk or tape system. The normal editor functions to search for strings, substitute strings, delete text blocks, copy blocks, move blocks, etc, are implemented in the extension routines.

The character delete routine is a good example. The single letter D or d causes one character to be deleted from the text buffer. D100 will delete a block of 100 characters. D10D will delete 100 characters one at a time, with the results displayed on the screen after each deletion. 3D0100 will delete 30 blocks of 100 characters each. The \ command simply searches from the current pointer position toward the end of the text buffer looking for the first occurrence of the character in the text buffer. Text is then deleted from the cursor to the stop flag, or to the end of text if no flag is set. The \ command outputs from the buffer from the cursor to the stop flag or end of text, and the 0 command saves the entire buffer. The move command moves a block, from the cursor to the stop flag, to a position marked in the buffer by a special flag. The function requires only one byte more than the original buffer size, regardless of the size of the block moved. Copy works similarly to the delete. All original blocks are not destroyed. It appears that there will be about ten unused command vector positions left in the command vector table for the addition of user functions. These could be used to implement text output processing extensions.

Videowriter is not meant to be used by simply pointing the cursor and then performing the function doing it without having to count lines or places, etc. All changes to the text buffer are displayed. It has always seemed obvious to me that this is an absolute requirement for a text editor, but I have never seen another program that does as much for the operator as Videowriter. Since no one else had what I considered to be a “decent” editor, I wrote it myself.

Of course, the current implementation of Videowriter doesn’t satisfy me completely. It has one major drawback which must be fixed—the more text between the cursor position and the end of text the slower it runs (block transfers are slow). The text is being edited with 16 K bytes of text following the cursor, a fast typist can enter characters faster than Videowriter can put them into the buffer. This will be fixed by using a line input buffer so that no more than 64 characters will be moved at each entry until the line is full. Nested command loops will be added, probably before you receive this letter. This will allow true macrocommand loops to be entered and executed.

Only two simple routines are needed to allow nested command loops, with no changes to the current command processing system. The one is 999999; the other is a string of iterations of each loop are allowed, but this will be changed to allow 65535 passes. That should be enough to satisfy anyone! I want to add a display at the upper right corner of the screen to show the workspace remaining. The tab set and clear routine must be modified to display the position number of each tab stop. And, finally, I would want to add a separate command buffer so that huge macrooperation can be executed. The command buffer contents will be saved and loaded just like the text buffer. These are all changes to the core program, and should take another month or two at the most.

Do you like it? Do you have any suggestions for further additions or modifications? If you do I would certainly appreciate your opinions. Of course it isn’t complete (as I would like it) now, but it works—and, of course, I am using Videowriter to write this letter! Virtually all of the extensions need rewriting to speed them up. I forgot to mention one point: Videowriter was assembled in TDL’s pseudo-8080-lik...
What Is an Interrupt?

Busy work! It's a terrible thing to inflict on people or computers. Wait loops in input or output operations are busy work for computers, and unless you learn how to tap your computer on the shoulder when you need it, it will probably spend most of its time doing busy work.

As hobbyists, we are always concerned about squeezing the greatest value out of our investments. We want our computers to run as efficiently as possible. Since it is likely that we will be involved in designing and building some of our own IO devices, we should develop an understanding of the concept of interrupts. To efficiently program peripherals for IO purposes it is often necessary to use interrupts.

This article introduces the basic concepts of interrupts, defines the terminology that applies to interrupt mechanisms, and describes the processing events that must occur during the time from the receipt of an interrupt to the return from that interrupt.

Concepts

An excellent example of interrupt processing is the system used in telephones. Let's see why.

We know when someone is trying to call us because the telephone rings. But consider how much time would be wasted if we had to periodically pick up the receiver to see if anyone was on the telephone if the phone had no bell. This periodic method is called polling; it works well for telethons and radio talk shows. However, it's not the best method for normal home telephone installations. Assume you receive an average of one or two phone calls a day at home. Imagine yourself as a processor and the callers as the IO requests from a keyboard. The order of magnitude differences in this example are about the same as with your processor and its IO. The bell on your telephone is, of course, an interrupt. It is an
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excellent way to resolve the asynchronism and speed differentials of the telephone communications system. Interrupts can resolve the same fundamental mismatches for computers as well.

Terminology

Let's carry this analogy a little further to introduce the terminology that refers to variations of the basic interrupt concept.

If your phone is ringing, and you are about to process an interrupt, what are your reactions? How does your interrupt processing work?

More than likely, you will perform a sequence of actions precisely analogous to those your microprocessor performs when it receives an interrupt. Figure 1 is a flowchart of the typical procedure we would run through for a telephone interruption. It consists of both the housekeeping chores of switching from the background task you were doing, reading, to the interrupt task, answering the phone, and back again in an orderly and complete fashion, as well as the interrupt handler itself.

In the computer an interrupt is a special control signal that is sent to your microprocessor when a given asynchronous event, such as a switch closure, or an IO ready signal, is detected by your system. It is the mechanism by which your processor is forced to take note of that exceptional event.

The interrupt causes your processor to transfer control to a set of instructions known as the interrupt handler. The interrupt handler is nothing more than a pre-coded contingency plan in the form of a subroutine that may be called at any time in response to an interrupt signal. What you do in this subroutine is limited only by the software capabilities of your processor.

In microprocessors, interrupt processing is basically a software technique with varying degrees of hardware support depending on your particular processor and system. The term vectored interrupt refers to a simple method of reacting to an interrupt. The processor is sent to the interrupt handler which will lead the processor through steps to determine the source of the interrupt, initiate appropriate actions and return to the point of interruption. The vector is simply the starting address of the interrupt handler, and is supplied either externally or internally, depending upon your particular processor's hardware.

Microprocessor integrated circuit designers who seek to minimize the hardware requirements in their processors often
assign a fixed location or set of locations in the processor's address space to hold the vector(s). The 6800 processor uses this approach, as does the Texas Instruments TMS-9900. Other processors such as the 8080 receive their vectors directly from external sources, a method which usually involves more system hardware.

The built-in process that occurs in your microprocessor chip is usually limited to saving the program counter and the processor's status register, masking subsequent interrupts, and then transferring control to your interrupt handler (loading the program counter with the interrupt handler's starting address). The task of determining where the interrupt came from is left to the interrupt handler itself. In the simplest case, where you have only one device tied to an interrupt line, the origin of the interrupt is implied. Since we may at some time have more devices than we have separate interrupt lines, we should also know how to make a more sophisticated system capable of handling many devices.

To see how multiple interrupts are handled, consider another analogy. Assume you had just settled back into your easy chair after finishing with the telephone interruption, when suddenly a pair of hands covers your eyes and a voice says, "Guess who?" You've been interrupted again, and you don't know which of your 12 children it is, so you will have to save your place again, and begin by saying, "Is that Olen?" "No." "Isn't it Travis?" "No." "Is it Mary Ellen?" etc., until you get a positive response. In much the same way, several devices can use a single common interrupt line to your processor so that, once the interrupt handler is initiated, it can interrogate all the devices to see which one sent the interrupt signal. To accomplish this, it is customary to have a device status register in the microprocessor's address space for each individual device. The data in this location indicates the device's current status: busy or ready.

Now suppose this game of guess-who is very popular with your children, and they are all playing it on you, some much more often than others. Your best strategy would probably be to adopt an ordering scheme to optimize the handling of these many interruptions. This simply means that you would guess the names of the children who were the most frequent players first, and check the least likely ones last. Similarly, in interrupt processing you should arrange the order of checking the device status registers of your IO units from the most frequent source of interrupts to the least

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frequent. By ordering your interrupt servicing this way, you can add significantly to the efficiency of your system.

By now you've probably realized that the idea of letting multiple devices share one interrupt line is problematical: two devices may want to interrupt the processor at the same time. In terms of our analogy, all 12 of your children may want to play the guess-who game with you at the same time. The way to handle this situation is to say, "Hold it! I will play the game with each of you...but only one at a time." By doing this you act on one interrupt while you mask out the rest.

The concept of maskable interrupts is incorporated in many of today's processors. There is usually a mask bit or bits used to block or mask the interrupt signal from the processor. This masking is frequently part of the built-in process on your microprocessor chip to protect the function of saving critical information, such as the program counter and status register, from subsequent interrupts. Once masked out, your system's design will determine if a subsequent interrupt will be held pending or lost. Interrupts that are kept pending are often referred to as queued interrupts. Sometimes circuitry external to the processor chip itself is used to give the pending interrupts an order of priority in much the same way as you might tell your children to line up in the order of youngest to oldest to play the guess-who game. The N level priority interrupt capabilities that are mentioned as features of microprocessor systems refer to this type of interrupt queuing. A higher priority interrupt that arrives after several low priority ones will usually bump the lower priority interrupts down in the queue.

For those cases where an interrupt must get the processor's attention right away, a nonmaskable interrupt is usually also provided in the chip's structure. This control line is for a very high priority function of your choice, which can override the maskable interrupts even if they are in progress. This is valuable for very high speed IO, such as a floppy disk unit, and for hardware emergencies such as fire or power loss routines. Your system reset is usually a nonmaskable interrupt.

**Mechanisms**

Now that you have a feel for the terminology, let's take a look at the mechanisms and processing that are common to all interrupt routines. Figure 2 is a typical flowchart of the functions necessary to accomplish the transfer of control from the background processing to the interrupt handler and return. You may think of this as putting the background process "on hold" while the interrupt is processed and recommencing the background process when it returns. The background process is not affected by what has happened; thus the interrupt processing is completely transparent to the background process and may be executed at any time without fear of disturbing it. The only definite change is

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**Figure 2:** Analogous to the human interrupt processing of figure 1, the typical computer's interrupt processing activities are shown by this chart. The differences between the two figures (1 and 2) are largely in the activities described in each box; the form of the processing logic in this particular set of examples is nearly identical.
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Table 1: The following list of responsibilities must be jointly met by both the programmer and the system being programmed, if interrupts are to be properly handled. The key item to remember is that when the interrupt occurs, the critical data values which determine the state of the machine must be saved so that at the end of the interrupt process, the original process can be resumed "as if the interrupt never happened."

- Sensing an interrupt signal and determining appropriate response.
- Setting the mask to protect the processor from subsequent interrupts.
- Note where you are by saving the program counter and status register.
- Transferring processor control by loading the program counter with the interrupt vector address.
- Executing the interrupt handler which may:
  - save accumulator(s).
  - save index register(s).
  - save pointers(s).
  - search for interrupt source.
  - satisfy device request.
  - restore pointer(s).
  - restore index register(s).
  - restore accumulator(s).
  - clear the interrupt mask.
- Resume normal processing by restoring the program counter and the processor status register.

That the background processing will slow down somewhat because the processor has to take extra time to service the interrupt(s). As a result, any real time clocking in the system will be offset by that interrupt processing time.

The joint responsibility of the processor and you, the interrupt routine programmer, is to ensure that the background process is not disturbed. These responsibilities are simply stated in Table 1.

Within the interrupt handler it is not always necessary to save all of the working registers for every interrupt, but you must at least save and restore every register used in your routine.

Deciding when to remove the interrupt protection (clear the mask) is your responsibility. The key is to pick a point which comes after the saving of the critical registers. The mask shouldn't be removed in the middle of your interrupt routine unless the routine is reenterable. Reenterancy is a term that refers to software routines that find new memory locations to store their working data each time that they are reentered before they have been exited. The significance of this is that if you clear the mask and a subsequent interrupt arrives, stops your current interrupt processing, and begins to use the same interrupt routine you were just using, you must ensure that it doesn't destroy your current working data. The safest procedure is to stay masked throughout the interrupt processing until you become experienced with the reentry software techniques. Figure 3 shows the division of these interrupt processing duties for a typical microcomputer system.

If your processor's monitor was supplied by the manufacturer, there is much to be learned from studying its interrupt handler section. Look for the methods used to accomplish the basic steps we have outlined above, then write your own simple interrupt handler, modify the interrupt vector to point to your routine instead of theirs, and execute your interrupt handler.

Once you have done this successfully, you will have developed an appreciation of how the modern digital computer, large or small, services the requests of so many peripheral devices seemingly simultaneously. Understanding interrupt driven processing, which is the central concept of computer operating systems, will help you to grasp the awesome power that lies within your own personal computing system.

Figure 3: A division of the functions at an interrupt between hardware and software is detailed in this diagram. The exact boundaries are often set by the system's hardware and software design details.
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The 650 was the most popular IBM computer during the 1950s until it was supplanted by the 1401 at the end of the decade. The machine was used widely by small banking, accounting and insurance companies which did not require the capabilities of the relatively powerful 705, and it is safe to say that IBM's current share of the commercial data processing market got its initial impetus from the successful marketing of the 650. However, the sophisticated personal computer user of today wouldn't give a passing glance to a machine of its capabilities.

The original 650 consisted of three units: the power supply, console and card reader/punch. Later modifications allowed for the addition of an on line printer and magnetic tape units, but the original 650 was strictly cards in and cards out. A tabulating machine such as the 407 was therefore required to produce printout, but this system was not satisfactory from financial and ecological points of view, since punching cards as an intermediate step to a printed page is very wasteful. The really bad news, however, was storage. Either 1000 or 2000 10 digit decimal words could be stored on a magnetic drum in bands of 50 words, each band having its own read head. Since the drum rotated at 12,500 revolutions per minute, average access time (half a revolution) was a little less than one hundredth of a second, or in modern terms 9,600,000 ns.

The problem of rotational delay could have been a serious detriment to processing speed except for a very clever assembly program. Modern computers using random access memory are programmed on the assumption that, in the normal course of execution, instructions are stored in consecutive locations. Had this been the case on the 650 it would have reduced processing speed to roughly one instruction per drum revolution, or 12,500 program steps per minute, because the processor was not fast enough to process an instruction in less time than it took for the next instruction to pass under the drum's read heads. However, instructions consisted of an operation code and two addresses; a data address and a next instruction address. Theoretically, the programmer could organize an optimum way to store the finished program so that the completion of each instruction coincided with the arrival of the next instruction under a read head. Since execution times varied from one instruction type to another, it was very difficult to optimize a program by hand.

Photo 1: The basic IBM 650, consisting of power unit, processor and card reader/punch.
The IBM 650

Fortunately, the SOAP assembler (SHARE optimum assembly program) did a pretty good job of optimizing the object programs it produced.

The instruction execution process was accomplished through a minimal number of registers (see figure 1). An instruction was brought from the drum to the program register, where the operation code and data addresses were passed on to the 2 digit operation register and 4 digit address register. If necessary, the data word specified by the address register was brought to the distributor, where it may have been used in conjunction with the lower or upper accumulators (the accumulators were logically considered as a 20 digit number separated into upper and lower halves). Then the instruction address was moved from the program register to the address register in order to process the following instruction.

Validity checking of numbers took place whenever they were transferred among registers or to the drum. Digits were stored in quinary form, requiring seven binary bits per digit, in which one of two bits represented either 0 or 5 and one of the remaining five bits represented 0, 1, 2, 3 or 4. The sum of the two "on" bits could therefore represent the digits 0 thru 9 and the validity check ensured that exactly one bit of the pair and one of the group of five was "on."

Given the other constraints of the 650, the instruction set was reasonably complete, including read and punch, branching, add, subtract, multiply and divide, shifting and even a table lookup instruction. Routines

![Figure 1: The instruction execution cycle of the IBM 650.](image-url)
to simulate floating point were available through the SHARE user group, but they were slow in operation. In most cases it was preferable to assume decimal point positions and to use shift instructions to align them before adding.

Input and output were restrictive and clumsy due to reliance on punched cards. Even in the later days of the 650 when magnetic tapes were available, flexibility was not greatly increased. Since tape was faster than the drum, a core memory buffer of 120 words was used, and all tape records were of this length.

The biggest problem of all was the small memory. 2000 10 digit words cannot be equated exactly with, say, 8 K bytes. While five alphabetic characters could be stored in one 650 word, each number and each instruction took up a full word. In a personal computer having a 16 bit word, a program of 2000 instructions takes less than 4 K bytes.

It would have completely filled the memory of the 650.

Given all these failings, why was the 650 so popular? Because it was the only minicomputer that IBM made at that time. Although Burroughs built the 205 at about the same time, no company except IBM had established itself as a viable computer manufacturer (in 1959 IBM had about 90% of the computer market). Furthermore, the 650 was seen as a natural replacement for punched card calculators like the 602, which were used in conjunction with the so-called electric accounting machines, sorters, collators and tabulators, to handle payroll and accounting problems. Clearly, at a rate of $600 per hour, the 704 or 705 could not be used by smaller businesses. The 650 cost about $50 per hour, which nowadays is a preposterous rate for such low computing power, but in the 1950s was the only answer to the computing needs of small businesses.
Intelligent Programmer for Intersil Ultraviolet Memory Chips

Intersil has introduced its new Model 660 programmer. This new product is priced at $645. Contact Pacific Cyber/Metrix Inc., 3120 Crow Canyon Rd, San Ramon, CA 94583.

4 MHz Single Card Computer

Cromemco's Single Card computer features the Z-80 processor and 5100 bus architecture. The card offers a 4 MHz operation, 8 K bytes of on board 2716 programmable read only memory and 1 K bytes of static programmable memory. It also provides an RS-232 [or 20 mA current loop] serial interface with programmable transmission rates up to 76,800 bps, 24 bits of bidirectional parallel input and output (I/O), five programmable timers and vectored interrupts. Only a power supply and programmable read only memory software are required for operation. The Single Card computer can also be the core of an expandable S-100 bus system that can include additional memory, I/O, or even floppy disk drives as required.

Cromemco's Z-80 Monitor and 3 K byte Control BASIC are available in 2716 read only memory for use with the Single Card computer. With these two memories, the computer can be used immediately without any additional memory or I/O. The Monitor has 12 comments to aid in program development. The 3 K byte Control BASIC has 36 commands and functions and can directly access I/O ports and memory locations, and call machine language subroutines.

The Single Card computer is available in kit form for $395 and assembled and tested for $450. The Monitor and Control BASIC are available in two read only memories for $90. For additional information contact Cromemco Inc., 280 Bernado Av, Mountain View, CA 94040.

Custom Built Computer Desk

This custom built, all wood desk for your computer system features a split level 35 by 26 inch top with walnut grain Formica. Upper level is 26 by 26 inches (66.04 by 66.04 cm) and is a perfect surface for a printer. The lower level is 30 by 26 inches (76.2 by 66.04 cm) which places the keyboard at elbow height for maximum fatigue. Under the printer area is a 23 by 23 by 24 inch (58.42 by 58.42 by 60.96 cm) compartment with two fully adjustable shelves. There is room for a processor and disk memory. The door opening is 21 by 23 inches (53.34 by 58.42 cm). The standard finish is walnut. Options available are righthand or lefthand design, other finishes and top and minor variations in dimension sizes. Desks are built to customers' requirements and a 50 percent deposit should accompany the order. The price is $295 from Stephen Moe Company, POB 595, Springfield, OR 97477.

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The information printed in the new products pages of BYTE is obtained from "new product" or "press release" copy sent by the promoters of new products. If in our judgment the information might be of interest to the personal computing experimenters and homebrewers who read BYTE, we print it in some form. We openly solicit releases and photos from manufacturers and suppliers to this marketplace. The information is printed more or less as a first in first out queue, subject to occasional priority modifications. While we would not knowingly print untrue or inaccurate data, or data from unreliable companies, our capacity to evaluate the products and companies appearing in the "What's New?" feature is necessarily limited. We therefore cannot be responsible for product quality or company performance.
SOFTWARE

New Book Explores Varied Facets of Personal Computing

**BASIC and the Personal Computer** by Dwyer and Critchfield describes the uses of personal computers, then explains how to make these ideas become a reality by using the power of interactive computer programming. It features examples that cover a wide range of applications possible with personal computers.

Topics include microcomputer hardware, programming in BASIC and extended BASIC, computer graphics, word processing, data structures, sorting algorithms, computer games, computer art, simulations, business applications, color graphics and the use of special interface devices.

The book requires no previous experience with computing. The text is integrated with a large number of original illustrations that clarify both beginning and advanced concepts.

This 438 page softbound book is published by Addison-Wesley Publishing Co Inc, Reading MA 01867 for $12.95.

Circle 630 on inquiry card.

**Software Package for the North Star Disk System**

The Program Utility Package (PUP) includes assembler and BASIC programs to enhance the usability of the North Star BASIC language. These programs use the input and output routines provided by the North Star disk operating system and the user. The package includes: CREF which is an assembler program producing a sorted cross-reference of variable and function usage by line number; SWAP is an assembler program which produces a sorted map of line reference by GOSUB and GOTO; LIST is an assembler program to produce a formatted BASIC program listing; MEMTEST is an assembler program which performs multiple memory diagnostics on user specified memory ranges; HEXMON is a BASIC program to load or list memory in hexadecimal. Each displayed line of 16 bytes of hexadecimal data also has the ASCII equivalents printed.

This package consists of six programs on a library diskette, 16 pages of documentation, and a diskette folder. The price of PUP is $25, with program listing available for an additional $7.

For further information, contact Business Computer Systems, 216 Collier Dr, Springfield IL 62704.

Circle 631 on inquiry card.

**The Complete Star Ship: A Simulation Project**

**Star Ship Simulation** by Roger Garrett explains the methods used in approaching the design of a software simulation. Readers become familiar with the techniques by which any large programming task can be implemented and learn how to attack a program in a straightforward, structured manner.

The first half of the book gives the reader a working knowledge of system design and program structure, and the last half deals with the actual development and implementation of the Star Ship simulation project. Details are given for every major function aboard a star ship as well as the intelligence of enemy and friendly space craft.

The 122 page book is priced at $6.95 and is available from Dilithium Press, 30 NW 23rd Pl, Portland OR 97210.

Circle 632 on inquiry card.

**Assembly Language Development System For 8800 or Z-80**

PDS is an assembly language development system for 8800 microcomputers with at least one disk drive.

PDS includes a unified assembler and editor, a macro-assembler combining the features of a relocating linking loader, a string-oriented text editor, and a trace debugger and disassembler.

The assembler favors the Intel instruction mnemonics, treating the Z-80 superset as a logical and syntactical extension. The debug module features breakpoint or single step execution of programs with trace display of all register contents, flag status, a memory window, and the mnemonics of the instruction just executed and the next instruction to be executed.

Source modules are available for floating point arithmetic, floating point I/O, trigonometric functions, numerical and alphabetic sorting, matrix inversion, fast Fourier transform and a full function expression evaluator.

The price is $99. For further information, contact Allen Ashley, 395 Sierra Madre Villa, Pasadena CA 91107.

Circle 633 on inquiry card.

**Micropolis CP/M System Upgrade**

The Micropolis CP/M System Upgrade gives the Micropolis disk owner the full capabilities of the CP/M disk operating system while retaining full access to Micropolis' operating system.

The CP/M System Upgrade allows the Micropolis disk owner to directly load and start CP/M and automatically execute a program at system startup. Other features include dynamic disk space allocation and reclamation, random access on all files, high speed disk read and write and full compatibility with all other CP/M systems and software.

For further details, contact the Computer Mart of New Jersey, 501 Rt 27, Iselin NJ 08830.

Circle 634 on inquiry card.

**Word Processor for the Commodore PET**

Connecticut microComputer has announced a word processor program for the Commodore PET. This program permits composing and printing of letters, flyers, advertisements, manuscripts, articles, etc., using the PET and an RS-232 printer.

Script directives include line length, left margin, centering and skip. Edit commands allow the user to insert lines, delete lines, move lines, change strings, save onto cassette, load from cassette, move up, move down, print and type.

The word program addresses an RS-232 printer through a Connecticut microComputer printer adapter. The program can be purchased for $29.50 from Connecticut microComputer, 150 Pocono Rd, Brookfield CT 06804.

Circle 635 on inquiry card.
DA Expands S-100 Line

**Video Display Board**

Featuring a full 128 upper/lower case ASCII character set stored in a 1K buffer memory. Easy to read 16 line x 64 character format can be displayed on an inexpensive video monitor or a modified TV set. Includes a TTY software driver. Add our powerful K 2 FDOS to create a versatile operator console.

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Speech Synthesis Integrated Circuit from TI

A significant new speech synthesis monolithic integrated circuit has been developed by Texas Instruments Inc, POB 5012, Dallas TX 75222. The circuit, along with two 128 K byte dynamic read only memories, each with the capacity to store over 100 seconds of speech, and a special version of the TMS1000 microcomputer, serve as the main electronics for a new talking learning aid called Speak and Spell, for ages seven and up.

Speech encoding is achieved through pitch excited linear predictive coding (LPC). LPC is a technique of analyzing and synthesizing human speech by determining from original speech a description of a time varying digital filter modeling the vocal tract. This filter is then excited by other periodic or random inputs. An 8-bit digital to analog converter on the chip transforms digital information processed through the filter into synthetic speech.

Codes for 12 synthesis parameters (ten filter coefficients, pitch, and energy) serve as inputs to the synthesizer chip. These codes are stored in read only memory and, once decoded by on-chip circuitry, represent the time varying description of the LPC synthesis model. The LPC speech synthesizer is an advanced design 10 stage lattice filter which has an integrated array multiplier, an adder coupler to the multiplier output and various delay circuits coupled to the adder output.

Circle 568 on inquiry card.

Dual Tone Separation Filter Integrated Circuit

The Model AF-100 dual tone separation filter integrated circuit provides channel isolation between the low frequency group tone (DTMF) frequencies 697 Hz thru 941 Hz and the high frequency group tones frequencies 1209 Hz thru 1633 Hz. It is intended for applications in which dual tone separation is required, eg: touch tone decoders, transceivers, modem interfaces, etc.

Contained in a 16 pin dual-in-line package, the dual resistance capacitance active filter chip features 30 dB minimum separation between high and low group tones, 1.5 dB maximum in-band deviation, dual and single power supply operation ±12 VDC at 2.5 mA each.

The Model AF-100 is priced at $32. For further information write to Data Signal Corp, 40-44 Hunt St, Watertown MA 02172.

Circle 569 on inquiry card.
The EW-2001 A “Smart” VIDEO BOARD KIT At A “Dumb” Price! A VIDEO BOARD + A MEMORY BOARD + AN I/O BOARD – ALL IN ONE!

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JADE Computer Products

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- **"KANSAS CITY STANDARD" TAPE INTERFACE**
  - Part No. 111 Board $7.60; with parts $27.50

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  - Part No. 232 Converts TTL to RS-232
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**EXPANDER'S BLACK BOX PRINTER**

This 64-character ASCII impact printer with 80-column capability is portable and uses standard 8" paper and regular typewriter ribbon. Base, cover and parallel interface are included. Assembled and complete with manual and documentation, only $470.00 (90 day manufacturer's warranty)

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  - Complete with test bits & hardware, 5½" x 11½" $49.00

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- **8802-3 M.D. Line Plug Board for Wire Wrap Power & Ground Bus, Emitter Glass 176/44 pin, socketed" $10.97

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Circle 195 on inquiry card.
Ohio Scientific is offering the video display interface from its Challenger IIP as a fully assembled accessory for any OSI system. The 540 video display features a 32 row by 64 column display of the standard 64 character ASCII font in 5 by 7 dot matrix form. Standard features include programmable formatting of the display for 32 by 32 or 32 by 64. The 32 by 32 mode is useful for video animation since it provides square character cells. The video board also features a keyboard port which can be used with a standard ASCII keyboard of OSI’s new programmable keyboard. The 540 optionally supports a graphics character generator which features lower case and about 170 special characters for plotting and gaming.

All systems using the 540 incorporate OSI’s new 542 programmable keyboard. This fully programmable keyboard system is capable of upper and lower case and auto repeat on all characters. The keyboard also features up to five levels of shifting to allow many special single keystroke commands and direct single keystroke graphics. The keyboard has provisions for character editing and supports special formats for video games.

The Model 540 video board is available as an add-on option for any OSI system as a CA-11 for $495. The graphics character generator option retails for $29. Contact Ohio Scientific, 1333 S Chillicothe Rd, Aurora OH 44202.

Circle 559 on inquiry card.

Interface This Electronic Voice System to Your Computer

The Votrax VS-6.4 is an improved model of the VS-6 which produces electronically synthesized human speech from digital data. In the VS-6.4 two circuit boards have been changed to obtain improved voice quality. For those who wish to convert their VS-6 equipment, retrofit boards are available. Software is unaffected by the change.

The Votrax VS-6.4 electronic voice system is flexible and operationally simple. A complete range of interface types and options make it compatible with most conventional computer and communications equipment, and it can be used over telephone lines or paging systems.

For further information contact Votrax, 500 Stephenson Hwy, Troy MI 48084.

Circle 561 on inquiry card.

This low cost tape punch, which handles paper or Mylar tape, has been introduced by GNT Automatic Inc, 440 Totten Pond Rd, Waltham MA 02154. The GNT 36 tape punch is designed to handle oiled and dry paper tape and all types of Mylar and Mylar foil tapes without adjustment. Easily integrated into a wide variety of equipment, the unit measures 2.4 by 4.7 by 3 inches (6.10 by 11.94 by 7.62 cm).

Providing a die block life of 150 million characters, the GNT 36 punches up to 50 characters per second. With an allowable back tension of about 5 ounces, the bidirectional unit accommodates 5, 6, or 8 hole tape widths, selectable by the user. A second version of the GNT 36 punches up to 75 characters per second.

The GNT 36 tape punch is priced at $495. Contact GNT Automatic Inc, 440 Totten Pond Rd, Waltham MA 02154.

Circle 560 on inquiry card.
Thousands of personal and business systems around the world use this board with complete satisfaction. Puts 16K of software on line all times! Kit features a top quality solder-masked 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 EPROM CARD-S 100 BUSS**

**OUR BEST SELLING KIT!**

USES 2708's!

**$59.95 KIT**

**Our 450NS 2708's ARE $8.95 EA. WITH PURCHASE OF KIT**

**ASSEMBLED AND FULLY TESTED ADD $25**

**8K LOW POWER RAM KIT-S 100 BUSS**

250 NS SALE!

**$129 KIT**

Use 21L02 450 NS RAMS!

Thousands of computer systems rely on this rugged, workhorse, 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 on RAMs.
2. All sockets included.
3. Fully buffered on all address and data lines.
4. Phantom is jumper selectable to pin 67.
5. FOUR 7405 regulators are provided on card.

**16K STATIC RAM KIT-S 100 BUSS**

FULLY STATIC. AT DYNAMIC PRICES.

$295 KIT

WHY THE 2114 RAM CHIP?

We feel the 2114 is the future industry standard RAM chip (like the 2102 was). This means price, availability, and quality will all be good! Next, the 2114 is FULLY STATIC! We feel this is the ONLY way to go on the S-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 problems? And finally, Static RAM's the 2114 stands out! Not all 4K static RAMs are created equal! Some of the other 4K's have closed chip enable lines and various timing windows just as critical as Dynamic RAM's. None of our competitor's 16K boards use these tricky devices. But not us! The 2114 is the ONLY logical choice for a trouble-free, straightforward assembly.

**KIT FEATURES:**
1. Addressable as four separate 4K Blocks.
2. ON BOARD BANK SELECT circuitry (Dynamic Standard). Allows up to $524 on line!
3. Uses 2114 (450NS) 4K Static RAMs.
4. ON BOARD SELECTABLE WAIT STATES.
5. Double sided PC Board; with solder mask and silk screen layout. Gold plated contact fingers on RAMs.
6. All address and data lines fully buffered.
7. All includes ALL parts and sockets.
8. PHANTOM is jumpered to pin 67.
9. LOW POWER: under $2. ALL TYPICAL from the 2114 Bus.
10. Blank PC Board can be populated as any multiple of 4K.

**BLANK PC BOARD W/DATA-$33**

**LOW PROFILE SOCKET SET-$12**

**ASSEMBLED & TESTED-ADD $30**

**100 NS RAMS-$8 FOR $69.95**

**16K DYNAMIC RAM CHIP**

16K X 1 Bit. 16 Pin Package. Same as most 2114-4. 250 NS access. $10 NS cycle time. Our best price yet for this state of the art RAM. 32K and 64K RAM boards using this chip are readily available. These are new, fully guaranteed devices by a major mfg. VERY LIMITED STOCK!

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**WESTERN DIGITAL UART TR1602A, PIN FOR PIN SUB FOR AY5-1013 AND TMS6011.**

FOR SERIAL I/O

**$9.95 4 FOR $60.00**

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**FND 843 Common Anode**

**FND 850 Common Cathode**

$1.49 ea (6 for $6.95)

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HEX ENCODED KEYBOARD
This HEX keyboard has 19 keys, 15 encoded with 3 user definable. The encoded TTL outputs, B-4-2-1 and STROBE are debounced and available in true and complement form. Four onboard LEDs indicate the HEX code generated for each key depression. The board requires a single +5 volt supply. Board only $15.00 Part No. HEX-3, with parts $49.95 Part No. HEX-3A, 44 pin edge connector $4.00 Part No. 44P.

ES TRS-80 SERIAL I/O
- RS-232 compatible
- Can be used with or without the expansion bus
- On board mix switch selectable baud rates of 110, 150, 300, 600, 1200, 2400, 4800, or no parity odd or even, 5, 6 data bits, and 7 or 2 stop bits. 3 T/R line, Board only $19.95 Part No. 80110, with parts $59.95 Part No. 8010A, assembled $79.95 Part No. 8010C. No connectors provided, see below.

4K EPROM
This board is designed to operate with any speed or power 1708A or addressable in 4K increments and can be configured to occupy either 2K or 4K segments. It can be populated one memory chip at a time. Bare board $100, board with parts $200, assembled $250 Part No. EPM-1

16K OR 32K EPROM
Designed to operate with any speed or power 2708 or simple voltage-5V1716L. Addressable in 4K increments and can occupy multiples of 4K. It can be populated one memory chip at a time. Has bank addressing and Phantom Disable. The board comes with an exclusive software program that can be placed in 2730 or 2715 that will, when used in conjunction with a RAM memory board, check out every line on the EPROM-2. Bare board $100, with parts $200, assembled $355. Board with parts 2718 $1,225, assembled $1,255 Part No. EPM-2

8080A CPU (With Eight Level Vector Interrupt Capability)
Uses the 8080A and the 8224 clock chip. The crystal frequency used is 18 MHz and the vector interrupt chip is the 8214. The board will function normally without the interrupt circuitry. When the interrupt circuitry is built up, the board will respond to one of the interrupt levels of 8080A. Designed to be a plug-in replacement for the IMSAI CPU board and will work in other computers with the appropriate modifications made to the ribbon cable connectors. No. 8214. The board will work in systems without a front panel if the system has a PROM board that simulates the functions of the front panel. Bare board $30, with parts $195, assembled $220 Part No. CPU-1

16K STATIC RAM
Operates with any speed or power 2114. All input and output lines are fully buffered. Addressable in 4K. On commands board. If the system has a front panel, the board will allow itself to be protected. If there is no front panel, the board will not work. The board has Bank Addressability, Phantom Disable, MWRITE, and selectable wait states. Bare board $30, board with parts $685 Part No. MEMA

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Board only $14.95 Part No. 900, with parts $24.95 Part No. 900A

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To Order:
Mention part number, description, and price. In USA, shipping paid for orders accompanied by check, money order, or Master Charge, Bank America Card, or VISA number, expiration date and signature. Shipping charges added to C.O.D. orders. California residents add 6.5% for tax. Outside USA add 10% for air mail postage and handling, no C.O.D.'s. Checks and money orders must be payable in US dollars. Parts kits include sockets for all ICs, components, and circuit board. Documentation is included with all products. Prices are in US dollars. No open accounts. To eliminate tariff in Canada please mark 'Computer Parts.' Dealer inquiries invited. 24 Hour Order Line: 408 226-4064

For free catalog including parts lists and schematics, send a self-addressed stamped envelope.

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- Converts video to AM modulated RF, Channels 2 or 3. So powerful almost no tuning is required. On board regulated power supply makes this extremely stable. Rated very highly in Doctor Dobbs' Journal. Recommended by Apple. Power required is 12 volts AC C.T., or +5 volts DC. Board only $7.60 Part No. 107, with parts $13.50 Part No. 107A

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MICRO-COMPUTER
POWER SUPPLIES
FOR S-100 BUS, FLOPPY DISCS, ETC.

POWER TRANSFORMERS (WITH MOUNTING BRACKETS)

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>USED IN KIT NO.</th>
<th>PRI. WINDING TAPS</th>
<th>SECONDARY WINDING OUTPUTS</th>
<th>SIZE W x D x H</th>
<th>UNIT PRICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>1</td>
<td>0V, 110V, 120V</td>
<td>2x9A 2x2.5A</td>
<td>3/4&quot;x4&quot;x2 3/16&quot;</td>
<td>19.95</td>
</tr>
<tr>
<td>T2</td>
<td>2</td>
<td>0V, 110V, 120V</td>
<td>2x13.5A 2x3.5A</td>
<td>3/4&quot;x4&quot;x3 3/4&quot;</td>
<td>25.95</td>
</tr>
<tr>
<td>T3</td>
<td>3</td>
<td>0V, 110V, 120V</td>
<td>2x10A 2x2.5A</td>
<td>3/4&quot;x4&quot;x3 3/4&quot;</td>
<td>27.95</td>
</tr>
<tr>
<td>T4</td>
<td>4</td>
<td>0V, 110V, 120V</td>
<td>2x4.5A</td>
<td>3/4&quot;x4&quot;x2 3/16&quot;</td>
<td>19.95</td>
</tr>
</tbody>
</table>

POWER SUPPLY KITS (OPEN FRAME WITH BASE PLATE, 3 HRS. ASSY. TIME)

<table>
<thead>
<tr>
<th>ITEM</th>
<th>USED FOR</th>
<th>@+8 Vdc</th>
<th>@-8 Vdc</th>
<th>@+16 Vdc</th>
<th>@-16 Vdc</th>
<th>@+28 Vdc</th>
<th>SIZE W x D x H</th>
<th>UNIT PRICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>KIT 1</td>
<td>18 CARDS SOURCE</td>
<td>18A</td>
<td></td>
<td>2.5A</td>
<td>2.5A</td>
<td></td>
<td>12&quot;x6&quot;x4 3/4&quot;</td>
<td>46.95</td>
</tr>
<tr>
<td>KIT 2</td>
<td>SYSTEM SOURCE</td>
<td>25A</td>
<td>3A</td>
<td>3A</td>
<td></td>
<td></td>
<td>12&quot;x6&quot;x4 3/4&quot;</td>
<td>54.95</td>
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<tr>
<td>KIT 3</td>
<td>DISC SYSTEM</td>
<td>20A</td>
<td>2A</td>
<td>2A</td>
<td>4A</td>
<td></td>
<td>14&quot;x8&quot;x4 3/4&quot;</td>
<td>62.95</td>
</tr>
<tr>
<td>KIT 4</td>
<td>DISC SOURCE</td>
<td>6A</td>
<td>1A</td>
<td></td>
<td></td>
<td>8A</td>
<td>10&quot;x6&quot;x4 3/4&quot;</td>
<td>44.95</td>
</tr>
</tbody>
</table>

EACH KIT INCLUDES: TRANSFORMER, CAPACITORS, RESIS., BRIDGE RECTIFIERS, FUSE & HOLDER, TERMINAL BLOCK, ALUM.
CHASSIS PLATE, ALL NECE. MTG. PARTS AND INSTRUCTIONS.

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ETY March 1979
QUEST Super Elf Computer $106.95

Compare features before you decide to buy any other computer. There is no other computer on the market today that has all the desirable features of the Super Elf for so little money. The Super Elf is a small single board computer that does many big things. It is an excellent computer for training and learning programming with its micro chip language and it is easily expanded with additional memory. Tiny Basic, Ascii Keyboard, video game options, etc. are included.

The Super Elf includes a ROM monitor for program loading, editing and execution with SINGLE STEP program debugging which is not included in others at the same price. SINGLE STEP allows you to view the microprocessor chip operating with the unit address and data bus displays before, during and after executing instructions. Also, CPU mode and intrinsic cycle are shown on several LED indicators.

An RCA 1961 video graphics chip allows you to connect to your own TV set for video graphics. A speaker amplifier may also be used to drive stereo systems. A 24 key keyboard includes 16 HEX keys plus, reset, run, input, output, memory protect.

Super Expansion Board with Cassette Interface $39.95

This is truly an astonishing value! This board has been designed to allow you to decide how you want it to operate. The Super Expansion Board comes with 4K of low power RAM fully addressable anywhere in 64K with built-in memory protection and a cassette interface. The board includes slots for all 8080 options on the same expansion board and fits neatly into the hardwired cabinet alongside the Super Elf. The board includes slots for 64K or 128K RAM (and with our optional 64K RAM pre-programmed in) and to use your own IV video board. EPROMs can be used for the monitor and Tiny Basic or other purposes.

A K Super ROM Monitor $19.95 is available as an on board option in 7208 EPROM which has been pre-programmed in the same chip, loader editor and error checking in firmware. A 40 pin header allows you to use your own IV video board or TEA2160 board. The Super Monitor is written with subroutines allowing you to take advantage of monitor functions simply by calling them up. Improvements and revisions are easily made with the monitor. If you have the Super Expansion Board and Super Monitor on board and you decide you want to have more memory there are two 64K 100 pin sockets or 20 pin sockets or video boards. A Goodell 8K RAM board is available for $35.00. Parallel I/O ports $9.95, RS-232C $4.95, TTL 20mA $1.95, TTL 100 mA $1.95, 38-80 pin connector set with ribbon cable available for $25.00 for easy connection between the Super Elf and the Super Expansion Board.

The Power Supply for the Super Expansion Board is a 5 amp supply with +5 V, 18 V, 5V, 12V, 12 V regulated voltages. It includes a 12 volt optional. Deluxe version includes the case at $39.95.

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Small Computer Systems Handbook by Sol Libes

Small Computer Systems Handbook by Sol Libes is written for those new to the field of personal computers. The emphasis throughout is on important practical knowledge that the small computer user should have to be able to intelligently purchase, assemble and interconnect components, and to program the microcomputer.

This guide provides background in digital logic fundamentals, number systems, and computer hardware and software basics. Only a minimal amount of electronics is required. The book offers an introduction to programming on the machine level, and with higher level languages such as BASIC.

The various applications of small computers are described, such as maintaining financial records, storing records, controlling appliances, typewriting, sales analysis and inventory control.

This 197 page book is priced at $8.45 and is published by Hayden Book Company Inc, Rochelle Park NJ 07662.

PET Magazine on Cassette

Program is a new monthly magazine recorded on cassette and intended for use by 8 K byte Commodore PET computer owners. Subscribers will receive a standard magazine format for video display on side 1 of the cassette, with pages of articles, applications, sources of hardware and software, availability of peripherals, programming hints, etc. The reverse side contains three or more games, household and business programs, etc. The subscription rate is $27 per year. For further information contact Program, POB 461, Philipsburg PA 16866.

For Newcomers to the Computer Field

BASIC From the Ground Up by David E Simon assumes the reader knows nothing about computers. All the statements of BASIC are detailed as well as what goes on inside the computer when programming. The book covers at least one version of each of the BASIC statements along with some of their variations. BASIC From the Ground Up is 232 pages long and is priced at $8.95. Contact Hayden Book Company Inc, 50 Essex St, Rochelle Park NJ 07662.

Free Information on Commodore PET

Are you having difficulty locating information on the Commodore PET computer? New England Electronics Company, 248 Bridge St, Springfield MA 01103, has available free of charge a PET information package as well as a software and hardware products directory. The information package includes specifications on the PET 2020 printer, PET service and warranty information and other pertinent data concerning the PET.

Catalog Features Personal Computing

Introduction to Personal Computing is a composite of companies providing personal computing hardware and software to the marketplace. Included are profiles of 69 companies and an overview of their product offerings. It also includes the names and addresses of various computer related publications. This 72 page catalog is available for $25 ($5 handling charge if payment does not accompany the order). New Jersey residents should include 5% sales tax. For further information contact Alltech Publishing Company, 212 Cooper Center, N Park Dr and Browning Rd, Pennsauken NJ 08109.
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<table>
<thead>
<tr>
<th>Type</th>
<th>Code</th>
<th>Roll</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 AWG Blue Wire</td>
<td>50' Roll</td>
<td>R308 0050</td>
<td>$1.98</td>
</tr>
<tr>
<td>10 AWG Yellow Wire</td>
<td>50' Roll</td>
<td>R309 0050</td>
<td>$1.98</td>
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<tr>
<td>10 AWG White Wire</td>
<td>50' Roll</td>
<td>R310 0050</td>
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<tr>
<td>10 AWG Red Wire</td>
<td>50' Roll</td>
<td>R311 0050</td>
<td>$1.98</td>
</tr>
</tbody>
</table>

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R - 30 - TRI 3 color refill

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16 pin* 43 42 39 35 32 30
18 pin* 63 58 54 47 42 36
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24 pin 90 84 78 68 63 58
28 pin 110 100 90 84 76 71
30 pin 150 140 130 120 104 89

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Good Thru March 1979

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MB-7A 16KX8 Static RAM uses 1410 Protection, fully buffered over $25.00 in USA $72.95.

MB-A 2708 EROM Board. S-100, 8KX8 or 16KX8 kit without PROMS $75.00 PCBD $28.95.

MB-A 4KX8 RAM PROM Board uses 2122 RAMs or 25129 PROM kit without RAMS or PROMS $72.00.

IO-2 S-100 8 bit parallel I/O port. 1/2 of boards is for kludging Kit $46.00 PCBD $26.95.

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SP-1 Synthesizer Board S-100

PCBD $42.95 Kit $315.95.

WAMECO INC.

FDC-1 FLOPPY CONTROLLER BOARD will drive up to 8 drives, board on ROM with power boot up, will operate with PROM (not included). PCBD $24.95.

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CPU-1008A Processor board with PROMS $25.95.

RTC-1 Realtime clock board. Two independent interrupts. Software programmable PCBD $25.95.

EPROM-1 1024A 4KX8 EPROM card. PCBD $25.95.


QM-9 MOTHER BOARD Short Parallel port 9-steps PCBD $30.95.

MEM-2 16K x 8 Fully Buffered 2114 Board PCBD $25.95.

16K RAM BOARD by HWE fully buffered, bank select standard to 16E bus gold fingers. Input mask, plated thru holes, silk screened PCBD $325.95.

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280 PRIME $14.50 ea. $90.00 10.

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MEM-2 with MIKOS #13 16K ram with L1214 32K PROMS $265.95.

MEM-3 with MIKOS #1 450 NSEC 8K RAM $125.95.

CPU-1 with MIKOS #2 8080A CPU $89.95.

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EMP-1 with MIKOS #10 4K 1702 EPROMS $49.95.

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VIII

jumpers to create otherboard), and dual-disk provision for floppy disk power supply. Also available: Model CM4900—with 18 amp power supply and STREAKER-12* (12-slot motherboard)

$549.00 * $495.00

CM4800 COMPUTER MAINFRAME

Includes cabinet, 30 amp power supply, and the S-100 compatible STREAKER-22* (22-slot motherboard). The CM4800 is fan-cooled, has AC line filter to eliminate EMI, and is fully-assembled and factory-tested. Power and reset switches are located on front panel.

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- In 7, 12, and 22-slot versions • S-100 compatible
- Connectors have bifurcated, gold-plated contacts
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- Addressable in 8K steps
- Memory protection in 1K increments, from bottom board address up or down
- Memory protection activated / deactivated by large, easily accessible switch
- May deactivate up to six 1K segments of board by use of jumpers to create "holes" for other devices
- DIP switch selectable watt states
- Phantom line DIP switch
- Bank select for expansion beyond 65K of memory
- Schmitt trigger-buffered I/O lines
- All IC's mounted in low-profile sockets
- Assembled, tested, burned-in at factory

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- Memory protection in 1K increments, from bottom board address up or down
- Memory protection activated / deactivated by large, easily accessible switch
- May deactivate up to six 1K segments of board by use of jumpers to create "holes" for other devices
- DIP switch selectable watt states
- Phantom line DIP switch
- Bank select for expansion beyond 65K of memory
- Schmitt trigger-buffered I/O lines
- All IC's mounted in low-profile sockets
- Assembled, tested, burned-in at factory

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- Memory protection in 1K increments, from bottom board address up or down
- Memory protection activated / deactivated by large, easily accessible switch
- May deactivate up to six 1K segments of board by use of jumpers to create "holes" for other devices
- DIP switch selectable watt states
- Phantom line DIP switch
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RAM

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CALCULATORS

This new desktop, 10 digit business calculator featuring an item counter and grand total key has been introduced by Sharp Electronics Corp, 10 Keystone Pl, Paramus NJ 07652.

The new 4½ pound QS-1702 offers calculating and printing on standard roll paper. A 1 touch grand total key accumulates individual calculations. Specially designed minus equal and plus equal keys make the QS-1072 ideal for applications that require fast calculation. A constant add mode selector facilitates dollars and cents calculations. A 1 touch percent key, non-add and subtract total key for printing dates and codes, an item counter switch with a plus and minus and plus/only calculation and a fixed and floating decimal point selector are other major features of the QS-1702 calculator.

Circle 512 on inquiry card.

Handheld Printer and Display Calculator

This rechargeable handheld printer and display calculator has been introduced by Texas Instruments Inc, POB 53, Lubbock TX 79408. The TI-5025 features a thermal printer and a large vacuum fluorescent display that can be used without the printer to conserve paper. The unit provides four basic functions as well as percent and 4 key memory. The TI-5025 operates with the same number entry system used in other TI handheld calculators. The thermal printer has fewer parts than impact printers, providing reliable, quiet, ribbonless operation.

The unit is priced at $80 and comes with a charger and adapter, thermal paper and carrying case. Thermal paper rolls are available in packages of three for $0.99.

Circle 513 on inquiry card.

North Star Utilities Package

With these programs the user can:

Read a basic program directly from a disc and list all variables appearing in the program. (Listings can be made of variables versus line numbers or line numbers versus variables.)

Selectively print out any statement, function or command versus the line numbers that it appears in.

Print out a "flow chart" of the basic program.

This package is essential for examining and modifying basic programs. It is provided on a North Star Diskette for $15.00.

Potter's Programs
22444 Lakeland
St. Clair Shores, MI 48081
(313) 573-8000

Circle 308 on inquiry card.

Operator's Manual for Texas Instruments Programmable 58 and 59 Calculators

Personal Programming is written for owners of the Texas Instruments programmable 58 and 59 calculators. This manual gives a guided tour of keyboard basics, display control, algebraic functions, conversions, and statistical functions on keys; a step by step discussion of programming as well as advanced programming; and a detailed analysis of all calculator keys showing the full operating limits of the machines in various calculating situations.

The price of this manual is $12.95 plus tax and $1 for shipping. For further information contact Texas Instruments Inc, POB 2500, Lubbock TX 79408.

Circle 534 on inquiry card.

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**PRECUT WIRE**

**#30 WIRE KITS**

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**#3** $24.95

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Choose One Color or Random Assortment: Red, Blue, Green, Yellow, White, Orange, Black.

*#26 Prices on Request*

**EDGE CARD CONNECTORS**

44 pin Solder Tall $1.95 $17.50/100 All are Gold

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100 pin Wire Wrap $3.95 $35.00/100 spacing

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SK 10 $16.50

22" x 6.5"

FREE

#22 Precut wire over 100 pieces

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BT 30 Extra Bit 2.95

BT 2628 #26 Bit 7.95

Batteries & Charger 11.00

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**INDUSTRIAL WIRE WRAP TOOL**

BW 928 $49.95*

FREE Wire Kit #1 ($7.95 Value)

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Ribbon cable connectors for connecting boards to front panels, or board to board.

*Suitable for Level Sockets Available

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R-30-TRI Refill for TRI Color 3.75

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MOS 40 40 pin Insertion Tool 7.50

EX-1 IC Extractor Tool 1.49

H-PCB-1 Hobby PCB Board 4.99

WSU 30 Hand Wrap/Unwrap/Strip Tool 6.25

WSU 30M Same as WSU30 with Modified Wrap 7.50

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* MEM-2 16K BYTE 2114 RAM Board .......... $30.00
* CPU-1 8080A CPU Board
  With Vector Interrupt ..................... $30.00
* EPM-1 4K BYTE 1702A EPROM .............. $30.00

** EPM-2 16K or 32K BYTE EPROM
  2708 or 2176 interchangeable ................. $30.00
* QMB-9 9 SLOT MOTHER BOARD
  Terminated .................................. $35.00
* QMB-12 12 SLOT MOTHER BOARD
  Terminated .................................. $40.00
* RTC REALTIME CLOCK
  Programmable Interrupts ................... $30.00

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The Hazeitline 1400 Video Display Terminal is designed to optimize interactive real-time operation. The interface is capable of either local or remote connection through an EIA RS339-C interface at baud rates that are switch selectable up to 9600 baud.

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- Fully expandable Characters
- 12 Lines x 40 Characters
- Self Diagnostics Test

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100 PIN

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16k memory (8) 4116's

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DIGICAST

A/V-100

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LAWYERS, BUSINESSMEN... This terminal, when properly interfaced to your computer, allows you the flexibility of generating computerized error-free correspondence. Gives your clients the impression that you're the person who is personally typed for the recipient. Compose your correspondence and "Fill-in" forms on your computer, edit on your screen and when your letter is perfect, print out your computer to print an error-free copy on your terminal.

The heart of this terminal is the reliable Diaclec Typeiffer. If maintenance is ever required, the World Wide network of Diaclec service centers is at your disposal. The terminal is functional as a regular office typewriter when not performing computerized work.

Over the next several months 150 of these terminals will be removed from service, returned to the manufacturer, inspected and brought into perfect condition. Last Spring we offered for sale two hundred Diaclec printers. Within three weeks every unit was sold. Don't pass this opportunity to purchase a word processing terminal at an excellent price.

Selektor Terminal SG1000, $295.95. Shipped to the East coast $15. Combined TRS-80 interface and power supply available. Documentation will be supplied to those individuals who want to do their own custom interfacing.

Sorry, but credit cards will not be accepted on this purchase.

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Circle 39 on inquiry card.
What's New?

Ham Interface for the PET Microcomputer

The M-65 is a complete Morse code and radioteletypewriter (RTTY) system for the PET microcomputer. The hardware consists of a printed circuit board which plugs into a jack on the radio equipment and the PET user port. No external power is required. Both input and output circuits are optically isolated from the PET, minimizing radio frequency interference and spurious voltages. The board has a built-in side tone oscillator which connects to the speaker or headphone.

The software consists of two computer programs: Morse and RTTY, which are supplied on one audio cassette. Both programs are written in BASIC with machine language subprograms, and each requires 8K bytes of programmable memory.

The M-65 is available in kit form for $69.95 or fully assembled and tested for $99.95. Contact Microtronics, 5943 Pioneer Rd., Hughson CA 95326.

Circle 653 on inquiry card.

S-100 Bus Compatible 4 Channel Digital to Analog Converter

This 4 channel digital to analog converter is available for use with Z-80 or 8080/8085 processors. The S-100 bus compatible digital to analog board has 12 bit resolution and uses plug-in hybrid digital to analog converters with ±0.5 least significant bit accuracy. Power requirements are compatible with S-100 bus voltages: +8 V at 338 mA, +18 V at 122 mA, and -18 V at 156 mA.

The output is 10 V or 20 V full scale (strap selectable). The output range may be ±5 V, ±10 V, 0 to +10 V, or 0 to -10 V. An inversion strap is also provided for decreasing output with increasing input. Output current is 10 mA. Independent gain and offset adjustments are provided. Input coding may be in either binary or 2's complement. Conversion speed is 3 μs typical, and the converter slew rate is 20 V μs typical.

The price is $495. Contact California Data Corp., 3475 Old Conejo Rd, Suite C10, Newbury Park CA 91320.

Circle 654 on inquiry card.

New Terminal Outputs Composite Video

The OE 1000 terminal is designed to interface to any microcomputer that has a 300 bps serial data output port. It operates in the full duplex mode with either 20 mA current loop or RS-232 voltage swing. The OE 1000 outputs composite video for use with a modified television or video monitor. The screen format is 16 lines by 64 characters. It has an upper and lower case mode and teletype mode keyboard and will display 96 ASCII characters and 32 special characters. The OE 1000 has full cursor control, automatic scroll, erase to end of line, erase to end of screen, and clear screen.

The terminal is available as a kit for $275 or assembled for $350. Contact Otto Electronics, POB 3066, Princeton NJ 08540.

Circle 655 on inquiry card.

Digitizer for Small Computer Systems

Summagraphics has announced a new version of its Bit Pad, the digitizer for small computer systems. The new Bit Pad configuration is Intel Multibus compatible. The Bit Pad can now be plugged into the Multibus along with single board computers (SBC), memory and input/output (I/O) boards, peripherals and controllers.

All electronics are located on one SBC card. Operational control and status indication is provided from a small handheld console. The system also includes an 11 by 11 inch (27.94 by 27.94 cm) Bit Pad tablet and a date input stylus.

The basic Multibus Bit Pad configuration is priced at $625. For further information contact Summagraphics, 32 Brentwood Av, POB 781, Fairfield CT 06430.

Circle 656 on inquiry card.

PerSci’s New 4 Headed Voice Coil Floppy

A 4 headed flexible disk drive has been introduced by PerSci Inc, 12210 Nebraska Av, W. Los Angeles CA 90025. The Model 299 diskette drive interfaces to 8080, 6800 and Z-80 systems, as well as minicomputers.

The Model 299 is a dual-headed, dual diskette drive, reading and writing both sides of two 8 inch diskettes. Data can be encoded in single or double density in IBM compatible soft sectored formats or expanded hard and soft sectored formats on IBM Diskette I, II, IIID or equivalent media. The drive will store up to 1 M byte of data in IBM type format, 1.6 M bytes unformatted single density and up to 3.2 M bytes in unformatted double density encoding.

The operational tolerances required to achieve dual head, dual drive double density data handling are provided by PerSci’s voice coil positioning system for an average seek time of 33 ms (including 0 settle time), five to seven times faster than stepper motor positioned drives. A full stroke 76 track seek is performed in 100 ms. The speed and the capacity of the drive are achieved while maintaining industry standard data reliability figures of 1 in 10^16 soft errors and 1 in 10^12 hard errors.

The Model 299 features electric unloading and can be unloaded by remote software control. Optical write protect secures the file.

The price is $1595 in single unit quantities.

Circle 657 on inquiry card.
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THE INTERFACE KIT MAY BE USED SEPARATELY AS A 128 x 128 16 LEVEL GRAPHICS DISPLAY

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- VP-1 COMPUTER/VIDEO INTERFACE KIT (3 BOARDS) $999.00
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THIS VIDEO COMPUTER KIT CAN WORK WITH THE GE, REDICON, OR ANY OTHER 128 x 128 SENSOR CAMERA

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d) $600.00**

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**DIABLO HYTYPE I Model 1200 Printer Mechanism: used, complete and operational. Requires power supply, case & MUP interface. 15 day return privilege - no other warranties. LIMITED QUANTITY! $750.00**

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**NEW TAPE DRIVE CONTROL for Microcomputer: POS Version II tape drive controller is now available, rendering the POS Model II fully compatible with the now shipped Intermec Model TMX tape drive described below. Controller is sold only with tape drive, comes complete with connector cables to MPU and software listing in BBS assembly language (specific 2MHz or 4MHz system).**

---

**AMPX MODEL TMX TAPE DRIVE: ideal for microcomputer users who want backup magnetic storage or access to IBM-compatible drives. Drive is new & comes complete with 3$-15 mag tape. Specifications: 9-track, NRZI standard, 800 BPI, 12'-sec., 1000 Mbyte capacity. Drive is drive only; no need for controller. Sizes: Drive & Documentation $750.00**

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**PET 2001 PERSONAL COMPUTER**

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  - **PET-X Scope**
  - **KIM-1 MICROCOMPUTER**

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**PREMIER**

- **HYBRID AUDIO**
  - **Power Amplifiers**

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**ASYNC TERMINAL**

- **MICROPOWER**

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**SYM-1**

- **PORTABLE MINI-SCOPES**

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**The Complete MICROCOMPUTER System**

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**The Instructor 50**

- **from SIGNETICS**

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would like to use it as a character generator for our
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synchronized externally. Can anyone send plans
or ideas to do this by either stripping the present
sync and adding the new, or by rebuilding portions
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FOR SALE: September 1975 thru September 1976
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(S-100), $60. First money order or cashier's check
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offer. Andy Thornburg, RR2,
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FOR SALE: 64 22 pin 3 level tin wire wrap
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4238.

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money order over $750 takes a factory assembled
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<table>
<thead>
<tr>
<th>Inquiry No.</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>24</td>
</tr>
<tr>
<td>10</td>
<td>85</td>
</tr>
<tr>
<td>11</td>
<td>272</td>
</tr>
<tr>
<td>12</td>
<td>96</td>
</tr>
<tr>
<td>13</td>
<td>25</td>
</tr>
<tr>
<td>14</td>
<td>26</td>
</tr>
<tr>
<td>15</td>
<td>194</td>
</tr>
<tr>
<td>16</td>
<td>250</td>
</tr>
</tbody>
</table>

---

**BOMB—**

**BYTE's Ongoing Monitor Box**

<table>
<thead>
<tr>
<th>Article No.</th>
<th>ARTICLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Poduska: Building the Heath H8 Computer</td>
</tr>
<tr>
<td>2</td>
<td>Melton: A Map of the TMS-9900 Instruction Space</td>
</tr>
<tr>
<td>3</td>
<td>Klein: Files on Parade</td>
</tr>
<tr>
<td>4</td>
<td>Ritter, Boney: A Microprocessor for the Revolution</td>
</tr>
<tr>
<td>5</td>
<td>Costas: Cryptography in the Field</td>
</tr>
<tr>
<td>6</td>
<td>Maushaw: The Standard Data Encryption Algorithm</td>
</tr>
<tr>
<td>7</td>
<td>Rampill: Preview of the Z-8000</td>
</tr>
<tr>
<td>8</td>
<td>Laminke: Designing with Double-Sided Printed Circuit Boards</td>
</tr>
<tr>
<td>9</td>
<td>Filo: Designing a Robot from Nature</td>
</tr>
<tr>
<td>10</td>
<td>Giacom: A Stepping Motor Primer</td>
</tr>
<tr>
<td>11</td>
<td>Ciarcia: Build a Computer Controlled Security System for Your Home</td>
</tr>
<tr>
<td>12</td>
<td>Higgins: Common Mistakes Using VLSI Or-Diagramm</td>
</tr>
<tr>
<td>13</td>
<td>Kreindler: Password Protection for Your Computer</td>
</tr>
<tr>
<td>14</td>
<td>Arp: The Power of the HP-67 Programmable Calculator</td>
</tr>
<tr>
<td>15</td>
<td>Atkins: What Is an Interrupt?</td>
</tr>
<tr>
<td>16</td>
<td>Reid-Green: History of Computers</td>
</tr>
</tbody>
</table>

---

**A Lively Bomb Response**

The first and second place winners of the December 1978 BOMB were "Some Facts of Life" by David J. Buckingham (page 54) and "Life With Your Computer" by Justin Millian, Judy Reardon, and Peter Smart (page 45). These articles placed 2.17 and 1.21 standard deviations above the mean. First and second prices of $100 and $50 will be sent to the authors.

Third place went to "Fast Fourier Transforms on Your Home Computer" by William D. Stanley and Steven J. Peterson (page 14), followed by "Chess 4.7 versus David Levy" by J. R. Douglas (page 84).
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