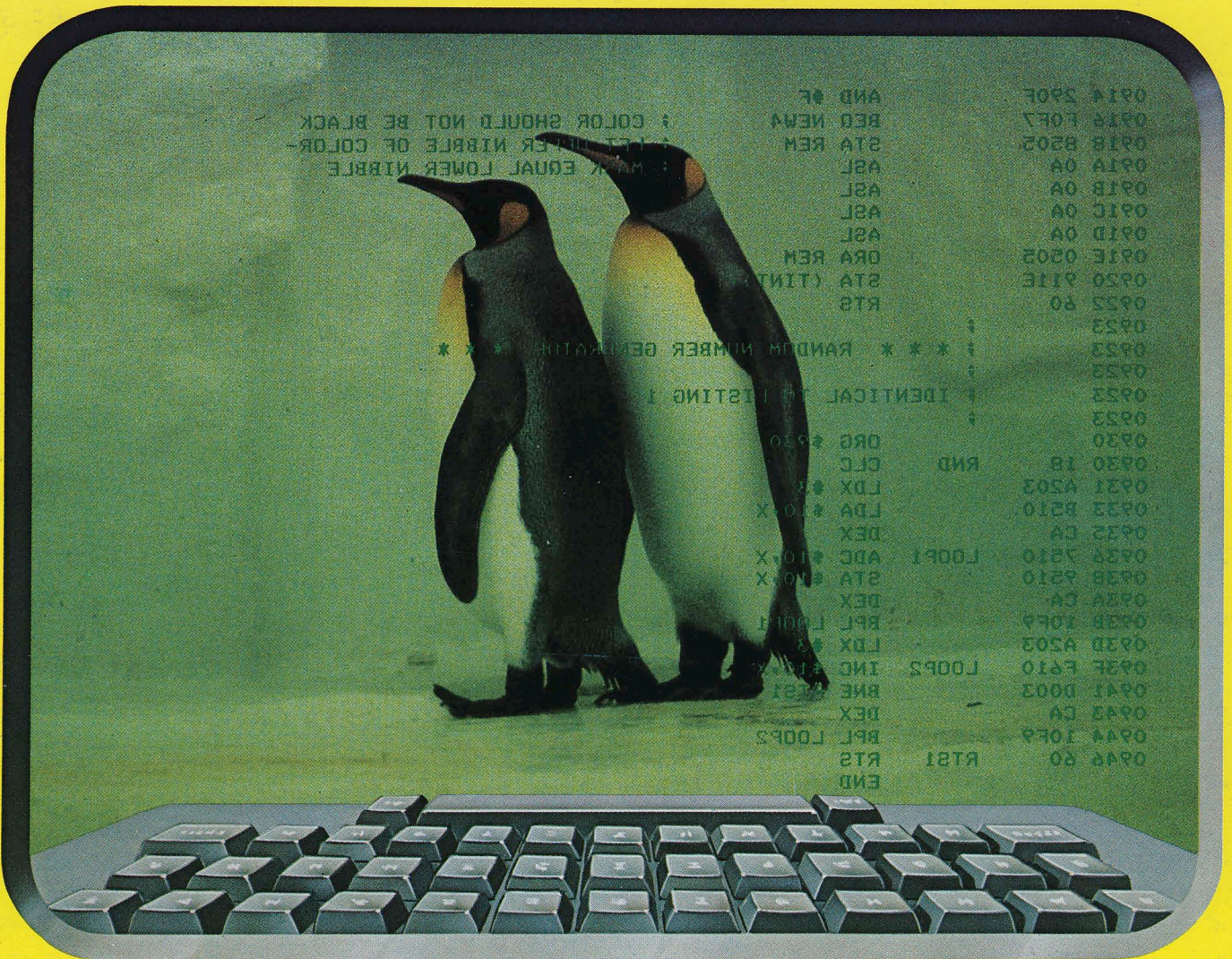


# MICRO™

## THE 6502/6809 JOURNAL



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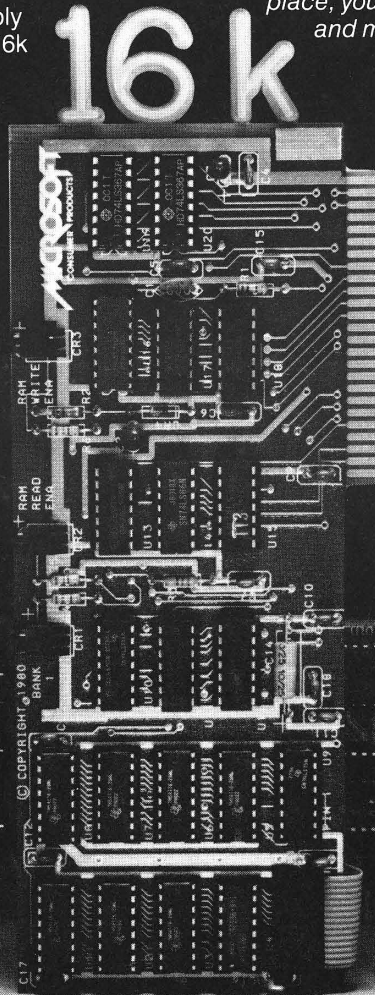
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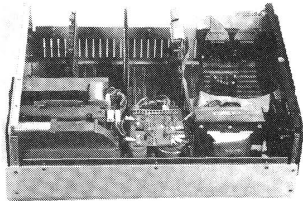
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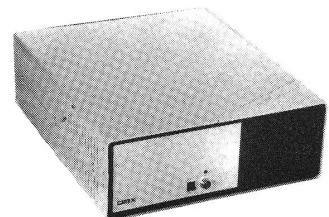
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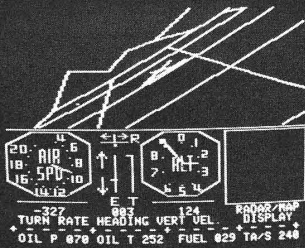
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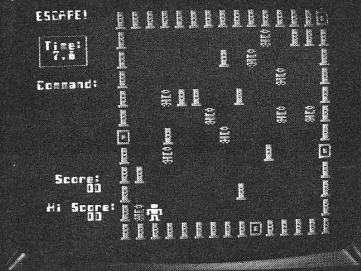
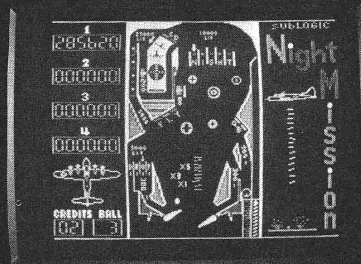


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THE 6502/6809 JOURNAL

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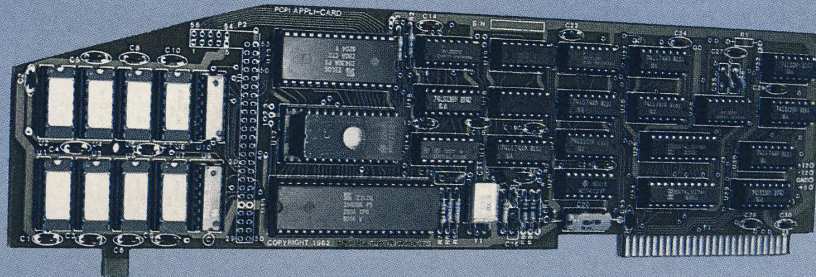
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The penguins on this month's cover happily reside in one of the country's larger, and more modern zoos. Computers help keep these penguins — and their fellow zoo-mates — content by monitoring care and feeding procedures and storing information on the animals' environmental needs.

Cover photo: Jack Smith  
Groton, Massachusetts

**MICRO** is published monthly by:  
MICRO INK, Chelmsford, MA 01824  
Second Class postage paid at:  
Chelmsford, MA 01824 and additional  
mailing offices  
USPS Publication Number: 483470  
ISSN: 0271-9002

Send subscriptions, change of address, USPS  
Form 3579, requests for back issues and all  
other fulfillment questions to

MICRO INK  
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Subscription Rates	Per Year
U.S.	\$24.00
Foreign surface mail	2 yr. / \$42.00
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Mexico, Central America, Middle East, North Africa, Central Africa	\$48.00
South America, South Africa, Far East, Australasia, New Zealand	\$72.00

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# MICRO™

## Editorial

### Higher than High-Level?

The Observation Level of Boston's John Hancock Tower was an appropriately lofty setting for the unveiling of Software Arts' latest product, TK!Solver (the "TK" stands for "Tool Kit"). The developers of VisiCalc have produced TK!Solver to settle the question, "Can they do it again?" As the lights dimmed, and company president Dan Bricklin sat down at the keyboard of an IBM Personal Computer, everyone knew that VisiCalc was going to be a tough act to follow.

Why have the creators of VisiCalc waited so long to launch a new product? Vice President Tracy Licklider explained that Software Arts has been developing "revolutionary" translation techniques. Using them, Software Arts can adapt a program to a new machine in a matter of days. The process transports an exact replica of a program into a new environment, neither introducing new bugs nor removing old ones. A user can therefore invest time in learning how to use a Software Arts product without worrying about whether those skills will be transportable. If a computer has a significant market share, Software Arts plans to make a compatible program version available.

When Dan Bricklin's large demonstration screen lit up, we saw a format suggestive of VisiCalc, but not organized according to rows and columns. TK!Solver allows the user to specify relationships between defined variables, give the computer data, and have it relate the data to the equations and print an answer. For example, in calculations dealing with real estate mortgages, the user would give the computer an equation that defines the relationship between principal, interest rate, monthly payment, and term of the loan. Given any three of the known values, TK!Solver can quickly calculate the unknown value. The program establishes on its own a sequence of problem-solving steps.

The grey eminence behind TK!Solver, Professor Milos Konopasek of North Carolina State University at Raleigh,

has spent more than 10 years developing the artificial intelligence techniques used in the TK!Solver program. These techniques, Konopasek says, enable people to interact with computers at a higher level than they can with "high-level" languages like BASIC and Pascal. While such languages relieve the user of having to give the microprocessor any instructions, they impose a sequential method of problem-solving that is not natural to the human mind. Professor Konopasek calls TK!Solver a "non-procedural programming language," in which the user can conceptualize a problem as a network of defined relationships instead of a rigid sequence of procedures. The result is a more natural, higher-than-high-level, problem-solving computer environment.

Software Arts plans to market TK!Solver in the fourth quarter of 1982, for \$299.00. It will first be available on the IBM Personal Computer and the Apple II. In addition to the TK!Solver program itself, Software Arts will produce a series of special application packages for use with the program. These will be available initially in the areas of mechanical engineering, financial analysis, high school science, and architectural design and construction. Each package will include the equations, tables, and values commonly used to solve typical problems in a given area.

MICRO supports the efforts Software Arts is making to bridge the compatibility gap between computers. The TK!Solver program, in combination with the application packages, may make it possible for non-specialists to tackle problems only a degreed professional could previously handle. If so, the computer revolution could be on the verge of realizing some of its enormous potential.

Laurence Kepple

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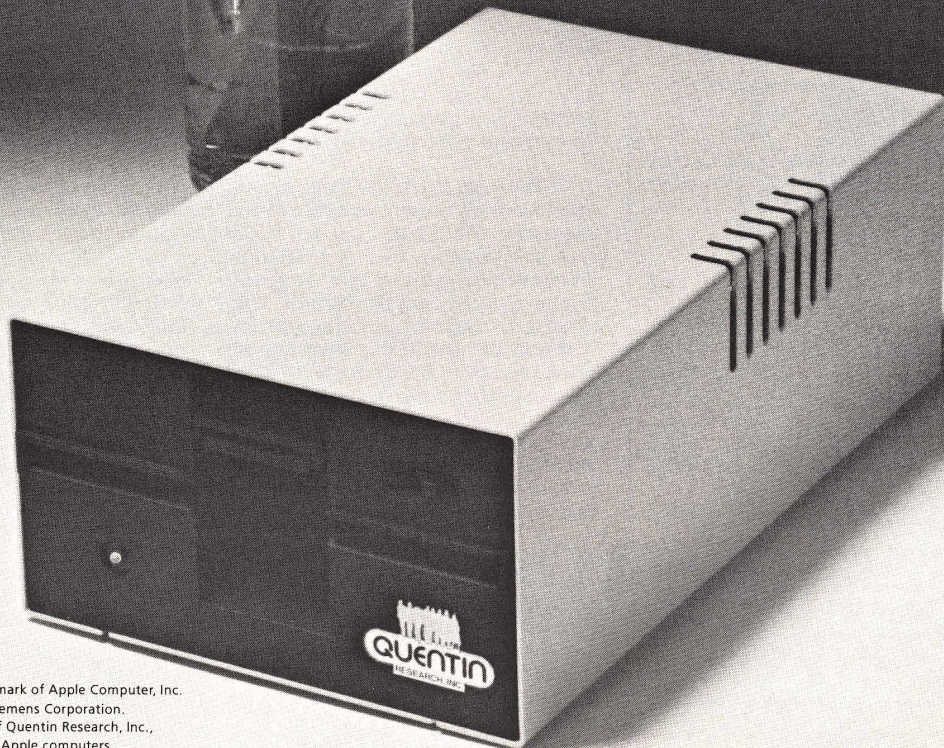
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### Steve Wozniak Creates Cultural Fall Festival

Three of the major cultural forces of the 80's — technology, music, and education — will meet in San Bernardino County over Labor Day weekend for an event called the "Us Festival." Steve Wozniak, co-founder and inventor of Apple Computer, predicts that the "Us Festival will be one of the most significant Labor Day weekend celebrations in the history of America." Wozniak has planned the festival to signal a shift from the "me decade" of the 70's to what he calls an "us decade" for the 80's. Festival promoters have signed top entertainers and expect to draw more than 300,000 people to the three-day event.

According to Wozniak, widespread popular understanding and acceptance of computers will be an important factor in helping us all work together to solve our problems. "The

value of people combining their efforts in families, the work force, and society can't be overemphasized," Wozniak said. "My hope is that the Us Festival will underscore the importance of those individual efforts and the role that computers can play in making interaction and cooperation both more effective and more fun."

A Technology Fair will feature exhibits of exciting new applications of computer technology as it relates to communications, education, small business, music, and ecology. For those unable to attend, a specially created Us Network will telecast the event live to theaters and millions of homes throughout America. No tickets may be purchased at the door. Contact The Us Festival at P.O. Box 95108-1157, San Jose, CA 95108, or at #TCW 314 on The Source.

### NewsNet: Newsletters for the Business Community

Up to 130 newsletters from 30 publishers are now available to the business community through NewsNet, an electronic information distribution and retrieval service.

Newsletters offered include *Communications Daily*, *Television Digest*, *Telecommunications Reports*, *Data Channels*, *Cablenews*, *Energy Daily*, *Coal Outlook*, *IRS Practices and Procedures*, *Education Funding News*, *Federal Grants and Contracts*, and *Hazardous Waste News*.

According to NewsNet president John H. Buhmer, many areas of industry will be represented, including farming and food, environment, investment, health, and general business.

Write to NewsNet at 945 Haverford Rd., Bryn Mawr, PA 19010.

### Low Cost Electronic Mail System

Small businessmen and computer hobbyists unable to afford expensive electronic mail accounts, can now enjoy this service by joining DCI.DEAFNET. Although primarily a nationwide electronic mail system for the deaf, DCI.DEAFNET now offers their service at considerably lower cost than other electronic mail accounts.

According to DCI.DEAFNET business manager Mary Robinson, anyone wishing to connect to the system pays a small monthly fee and a straight connect charge.

DCI.DEAFNET is offered by the Deaf Communications Institute. For more information contact Ms. Robinson at 95 Bethany Rd., Framingham, MA 01701, (617) 875-3617.

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If you have any questions on these, or any other SOURCE services, write to Source Telecomputing Corp., 1616 Anderson Rd., McLean, VA 22102, (703) 734-7500.

### Stock Market Information for Micro Users

Investors with personal computers now have free access to a computerized stock market bulletin board service, called Tickerscreen. Information provided on Tickerscreen includes closing New York Stock Exchange prices, closing market indexes, commission computation on any stock or option transaction, and a demonstration of Tickertec, the personal stock market monitor.

Tickerscreen is available from 5:00 p.m. to 9:00 a.m. weekdays, and 24 hours on weekends. To enter the system, dial (212) 986-1660, and connect your computer to your phone. For more information contact Max Ule and Co., 6 E. 43rd St., 27th Fl., New York, NY 10017, (212) 687-0705.

### Electronic Newspaper for Texas TRS-80 Owners

Radio Shack and the Fort Worth Star-Telegram now offer STAR-Text, an electronic newspaper home information service for the local Fort Worth, Texas, area.

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## Letters/Updates

### 6502 vs. 6809 Questions

Dear Editor:

I would like to discuss the article by Gregory Walker and Tom Whiteside, "Multiprecision Addition — A Comparison of 6809 and 6502 Programming" (MICRO 47:57). In their first example (figure 1), the time for 12 zero-page instructions for the 6502 was given as four cycles each instead of three. The corrected subroutine time should be 51 cycles for the 6502 as opposed to 50 for the 6809.

In their second example, "the restriction that these subroutines must leave all processor registers unchanged" (except flags), was not adhered to for the 6809's index registers. If we eliminate the same restriction for the 6502's index registers and correct the branch-not-taken timing, the total time becomes 100 cycles as opposed to 101 for the 6809. The correct byte count for the 6502 is 16 as opposed to 17 for the 6809.

If the 6809 has any clear advantage over the 6502 in terms of execution time or memory usage, it certainly can't be proved by these examples.

George Wells  
1620 Victoria Place  
La Verne, CA 91750

*Mr. Wells is correct that the 6502 LDA and STA instructions in figure 1 use three cycles instead of four cycles. Thanks for pointing out our goof! Including the setup time, the 6502 needs 75 cycles versus 70 for the MC6809.*

*His comment that we did not preserve the index registers in the second example is not true. The only registers changed were the "A" and "B", which were saved with the PSHS D instruction. He is correct that we missed the "1" cycle for the 6502 branch-not-taken. If we include the setup time, the 6502 needs  $111 + 36 = 147$  cycles versus  $101 + 24 = 125$  cycles for the MC6809. The MC6809 program is faster despite the added overhead for using position-independent code (a penalty we did not require of the 6502).*

*The MC6809 was more byte efficient and faster than the 6502 examples, but we trust that perceptive readers will not limit the comparison to these factors. Consider also that the MC6809 offers extra registers, many of which are 16-bit indexes. It offers the ease of writing position-independent code, extra addressing modes and extra instructions, a reduced dependence on "zero page" RAM, and a stack that may range anywhere in memory.*

Greg Walker and Tom Whiteside

### COPCOP Updated for OS65D 3.3

Charles H. Ellis, Jr., of Lynn, MA, sent in this update:

Peter Kleijnan's disk copy program ("COPCOP Single Drive Copier," MICRO 47:21) is a brilliant example of OSI C4P programming. After three years of compulsively programming my C4P, I thought that I had explored every corner of the operating system. What a pleasant surprise to find that a DOS command file can be executed

#### Listing 1: Corrections to run on OS65D 3.3.

```
5 POKE 133,79
110 DIMD$(39,8):CR$ = CHR$(13):MA = INT( (PEEK(8960)
- 36)/8)
998 DATA 2,10,18,26,64,72,88,96,104,112,120,128,136,144
1080 DISK!"ME F000,5000":PRINT#5,"EXIT";CR$;PRINT#9
1164 PRINT#5,"CA 0200 = 06,4";CR$;CR$;"Insert
MASTER disk";CR$;
1280 DISK!"ME 5000,F000":DISK!"IO 10,02":RETURN
```

#### Listing 2: Directory Cleanup Modifications

```
90 DB = 11897:DEFFNA(X) = 10*INT(X/16) + X - 16
*INT(X/16)
1091 PRINT:INPUT"Directory Cleanup";DC$
1093 IF DC$ = "Y" THEN DISK!"CA 2E79 = 12,1"
2010 IF D$(1,1) = "ORD$(1,1) = "N" THEN GOSUB 8000:
I = I + 1:GOTO 2005
5035 IF DC$ = "Y" AND J = 12 THEN D$(12,1) = "2E79/1"
8000 TT = I:IF DC$ < > "Y" THEN 8090 : REM — Directory
Entry Delete
8010 FOR II = DB + 6 TO DB + 254 STEP 8
8020 IF TT < FNA(PEEK(II)) OR TT > FNA(PEEK(II + 1))
THEN 8060
8040 FOR JJ = II - 1 TO II - 6 STEP - 1:POKEJJ,ASC("#"):
NEXTJJ
8050 POKE II,0:POKE II + 1,0
8060 NEXT II
8090 RETURN
```

## Letters/Updates *(continued)*

directly from memory (another example of the power of OSI's system architecture).

I wish to offer some corrections to this excellent program so that it will run on the new OS65D 3.3, and present a directory clean-up subroutine to enhance the disk copier.

### *Corrections*

Under the new V3.3 of OS65D, "COPCOP" will not run without the revisions shown in listing 1. Since V3.3 BASIC and the keyboard enhancement occupy 2K of memory not used in OS65D 3.2, the published program produces an 'OM' error when it tries to dimension the 39 x 8 array. Also, the track 0 copy utility has been relocated on the V3.3 system disk from track 13 to track 6.

These problems are simple to solve. Moving up the top of the BASIC workspace by 2K leaves ample room for the

array. Changing the address in lines 1080 and 1280 from \$4800 to \$5000 moves the memory output and input, and replacing 80 with 72 in the DATA statement (line 998) protects the command file block during copying. Changing the call in line 1164 from 13,1 to 06,4 correctly locates the track 0 utility.

The added 2K of DOS permits copying of one less track in each pass, and requires the change in line 110 (from PEEK(8960) - 29 to PEEK(8960) - 36). This still allows copying of 19 tracks per pass on a 48K machine, and 7 tracks on my 24K system.

### *Update — Directory Cleanup Subroutine*

I have always been frustrated that most disk copiers simply copy the original disk directory to the copy disk, even when some tracks have not been copied to the new disk. COPCOP inspired me finally to deal with this problem. If the new lines of listing 2 are added to the program, the new disk

can, optionally, be provided with a directory which includes only those files which were fully copied.

When a track is not to be copied, or has a missing header, the subroutine searches the directory buffer (\$2E79-\$2F78) for an entry including that track number. If the search succeeds, the buffer is edited to delete the entry. If this option has been selected, the edited directory buffer will be saved to disk during copying, rather than a copy of the original track 12,1.

A warning: this routine works only for a directory complete in the first page of track 12. I have never yet had a disk with more than one page needed for its directory. Only on a data disk might you have more than 32 one-track, named files. If this large a directory exists, the disk should be copied without the cleanup option. Then the directory can be cleaned up in the old way, by hand, file-by-file, using a delete program. I don't expect to have to do this.

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# Data Transfer from AIM to PET

by Alan K. Christensen

---

**Software is provided to transfer data, such as machine-language programs, from the AIM to the PET.**

---

**AIM to PET  
requires:**

**PET  
AIM 65 or SYM  
AIM Assembler ROM  
Cable (see page 12)**

---

The owner of any popular computer soon realizes that it is easy to get locked into using only the programs and peripherals offered by that manufacturer. This article grows from a belief that almost any computer can be expanded by adding a different computer in a network. This allows the user to choose between peripherals, tape formats, and programs offered for either machine. This article explains how to make a logical connection between a Commodore PET and a Rockwell AIM 65.

I purchased my AIM after a lengthy search for a fast PET assembler that would run in my 8K PET. Throughout this search, I kept admiring the small ROM-based editor assemblers found on the SYM and AIM. I decided that if I waited long enough a similar product would be available for the PET. After waiting, and adding up the cost of commercial software and the required memory expansion and additional peripherals, the cost of an AIM no longer seemed too high, so I bought one.

*(Editor's note: ASM-TED is a cassette-based assembler written in machine language for the 16K PET and other 6502 computers. It is available for \$49.95 from Eastern House Software, 3239 Linda Drive, Winston-Salem, NC. Two small, ROM-based*

assemblers have recently become available: Mikro from Skyles Electric Works, 231E South Whisman Road, Mountain View, CA 94041, and EZ-ASM from Data Cap, 73 Rue du Village, 4545 Feneur, Belgium.)

The AIM editor and assembler are not the fanciest programs, but they do have features that I required most. The assembler accepts standard 6502 mnemonics with symbolic names. It is not, however, a macro assembler. The editor is line-oriented with search and replace capabilities as well as insert and delete. With the code in ROM, they leave most of the RAM available for text or symbol tables. The combination makes it reasonable to develop serious programs in assembly language. My only problem was to get the programs from the AIM to the PET.

There appeared to be three ways to transfer information between the two computers: manually, through a storage medium, or with a direct connection. The direct connection approach turned out to be the easiest. For details on how to construct a cable, see page

Once the two machines are connected, there are many ways to use them in tandem. For example, I use the PET to buffer large amounts of output and send it to a Commodore printer at its leisure. I also use the AIM keyboard as an input device to the PET (my PET has the old, tiny keyboard). All of these applications work best in assembly language, so the first goal is to transfer assembly-language programs from the AIM to the PET. The AIM monitor supports user-defined devices. Listing 1 shows a simple software interface to get the assembly object out of the machine by sending it to the user (U) device. There is more information on the data transfer in the AIM manuals.

The interface as described supports only half-duplex transmissions. This means that the PET has to be ready to accept the information when the AIM sends it. The program for the PET is written in BASIC because it is easier to enter and debug a BASIC program on the machine. This program (listing 2) will pick apart the AIM format object code and POKE it into the PET memory. With this program, the parity of the data is not checked, and the PET relies entirely on the checksums in the object format for data integrity.

The program has been optimized for speed. I will briefly describe it from back to front. Lines 800-830 are a trap location and are only entered when an error is detected. The program variables and the 6522 registers are initialized in lines 600-735. This module is written as a subroutine because I occasionally add short, special-purpose routines on the back of the program and they need initialization too. Lines 500-550 process the last line of object format; all other lines are processed in lines 400-480. The bytes are read into an array; if no checksum errors occur, they are POKEd into memory. Subroutine 300-310 returns a 16-bit value based on four hex characters. Subroutine 200-220 returns an 8-bit value based on two hex characters. Subroutine 100-120 gets one character from the interface. The PET user port does not provide a complete A port, so this subroutine has to handshake the values using the CB2 line. The program uses no string variables and will not be affected if another program is loaded into high memory.

By typing GOSUB 600 : GOTO 800 the cable and interface subroutine can be tested. To test the entire routine, dump the contents of \$8000-\$83FF from the AIM with U as the output device (after assembling the AIM user interface). The PET screen should fill

entirely with various characters, and the PET should not crash. If this operation is successful, the interface has a good chance of being correct.

When the BASIC program is working, the program from listing 3 can be entered into the AIM, assembled, and transferred to the PET. This program is virtually the same as the BASIC program, but written in assembly language. There are two addresses which are valid only for the early versions of the PET. The value of ADDR must be a zero-page location that will not interfere with the operation of the PET. I used \$58 at the end of the input buffer in old ROMs. (*Editor's note:* These addresses should work most of the time for upgrade and 4.0 ROMs.) This program places a jump to INIT in memory location 1 and 2 so that the program can be started by typing SYS 0. These locations could be used as the value of ADDR for any PET.

The label CKSTOP is set to the address of a routine which will check to see if the stop key has been pressed and thereby exit the program. This should be changed to the appropriate routine for later ROMs (as indicated in the comments). Any PET can use the get routine address of 65508 for CKSTOP by changing the BEQ EXITI after the label FLAGCK to a BNE EXITI. This will cause the program to halt if any key is pressed on the PET keyboard.

There are additional comments in the listings. The assembler listing has as comments the line numbers that correspond to the BASIC program. These can be used as a guide to the conversion of the program from BASIC. Note that the two programs use different methods to convert hex characters into binary values. To fit the entire assembly-language source into a 4K AIM, it should be entered without comments. The AIM can be expanded to have more memory and additional 6522 ports, so that one AIM could be connected to several PETs.

This program, with some modification, could be used to send object code from an AIM into nearly any 6502-based computer that has I/O lines accessible to the programmer. Once that is accomplished, the way is open for several network programs on the machines. One of the simplest multiprocessing configurations is to have one machine process data while the other controls input or output, including formatting or real-time control. Another possibility: one machine can serve as a memory extension of the other, perhaps maintaining sorted lists or multi-dimensional

## Making a Cable

PET		AIM (SYM)		
Pin	Signal	Signal	AIM Application Connector Pin	SYM AA Connector Pin
A	ground	ground	1	1
B	CA1	CA2	21	4
C	PA0	PA0	14	D
D	PA1	PA1	4	3
E	PA2	PA2	3	C
F	PA3	PA3	2	12
H	PA4	PA4	5	N
J	PA5	PA5	6	11
K	PA6	PA6	7	M
L	PA7	PA7	8	10
M	CB2	CA1	20	E

Because the PET's CB2 line is used here, other uses, such as sound, will not be possible when transferring data.

### Connectors

The connector for the AIM or SYM is a standard 44-pin edge card connector available from Radio Shack and other electronics parts stores. The PET's parallel user port connector may be more difficult to obtain. The following manufacturer's part numbers can be used:

Cinch	251-12-90-160
Sylvania	6AG01-12-1A1-01
Amp	530657-3
Amp	530658-3
Amp	530654-3

### SYM VIA Addresses

For the SYM, the following addresses apply for its VIA #2:

Output register A	\$A801
Data direction register A	\$A803
Peripheral control register	\$A80C
Interrupt flag register	\$A80D

arrays, and provide data at the command of the master device. In many of these cases, a network approach will provide great improvements in speed and flexibility. The largest pitfall occurs when one machine is running while the other waits, only to have the other machine begin processing while the first waits. As a final caution, if the communications protocol becomes too complex, both machines may spend more time handshaking than working.

---

Alan Christensen received a BSEE from the University of Texas and has programmed both large and small computers for five years. His systems include a PET with a graphics screen display from Micro Technologys Inc., and an AIM with MTU graphics and floppy disks. Mr. Christensen may be contacted at 1303 Suffolk, Austin, Texas 78723.

---

### Listing 1

```

;AIM/PET OUTPUT OCT 12, 1981 AKC
; THIS PROGRAM CONNECTS THE PET AND AIM
; WITH THE PET BEING DEFINED AS THE
; USER DEVICE OF THE AIM.
ENTRY = $2000 ;ENTRY AND LOWEST ADDRESS
;
* = $010A ;OUTPUT VECTOR FOR AIM (SYM - $A663)
UOUT .WORD OUTPUT
;
* = ENTRY
;
OUTPUT = * ;OUTPUT FUNCTION
BCS OUTCHR
LDA #$FF ;OUTPUT STATUS FOR A PORT
STA DDRA
;
;
INITA = * ; 6522 INITIALIZATION
; THIS INITIALIZATION ASSUMES THAT THE A PORT
; HAS NOT BEEN PREVIOUSLY SET TO GENERATE
; INTERRUPTS.
ORAR = $A001 ;PORT A DATA REGISTER (WITH HANDSHAKE)
DDRA = $A003 ;PORT A DATA DIRECTION REG
PCR = $A00C ;PERIPHERAL CONTROL REG
IFR = $A00D ;INTERRUPT FLAG REG
;
LDA PCR ;SAVE PORT B SETTINGS ON PCR
AND #$F0
ORA #9 ;SET HANDSHAKE FOR PORT A
STA PCR
;
RTS
;
OUTCHR = * ;OUTPUT THE CHARACTER ON STACK
LOOP LDA IFR ;WAIT UNTIL PET IS READY
AND #2 ;THIS ROUTINE WILL HANG THE AIM UNLESS
BEQ LOOP ;THE PET RESPONDS
;
PLA ;AFTER PET RESPONSE SEND THE CHARACTER
STA ORAR
RTS
;
.END

```

### Listing 2

```

10 GOSUB 600 :GOTO 400
100 POKE PCR,P0%:POKE PCR,P1%
105 IF N0 = (PEEK(ITFR) AND CA1) THEN 105
110 A=PEEK(ORAR)
115 POKE ITR,CA1
120 RETURN
200 GOSUB 100:C1=C(A-C0)
205 GOSUB 100:C2=C(A-C0)
210 A=C1*16 + C2
215 KK=KK+A
220 RETURN
300 GOSUB 200:AA=A
305 GOSUB 200:AA=256*AA + A
310 RETURN
400 GOSUB 100:IF A<>SEMI THEN 400
405 KK=N0:NR=NR+N1
410 GOSUB 200:CNT=A
415 IF CNT=N0 THEN 500
420 GOSUB 300 :AD=AA
425 FOR I=N1 TO CNT
430 GOSUB 200 :A(I)=A
435 NEXT
440 CK=KK
445 GOSUB 300
450 IF AA<>CK THEN PRINT"CHECK SUM ERROR":STOP:GOTO 800
455 FOR I=1 TO CNT
460 POKE AD,A(I)
465 AD=AD+N1
470 NEXT
480 GOTO 400
500 GOSUB 300
505 IF AA<>NR THEN PRINT"RECORD COUNT MISMATCH"
:STOP:GOTO 800
510 CK=KK
520 GOSUB 300
525 IF AA<>CK THEN PRINT"CHECKSUM ERROR":STOP:GOTO 800
530 GOSUB 100
535 GOSUB 100
545 PRINT"DONE":STOP
550 GOTO 800

```

### Listing 2 (Continued)

```

600 A=0:AA=0:I=0
605 AD=0:REM MEMORY ADDRESS
610 CNT=0:REM BYTE COUNT
615 N0=0:N1=1:REM CONSTANTS
620 CK=0:REM CHECK SUM
625 KK=0:REM BYTE VALUE COUNT
630 C1=0:REM HIGH NIBBLE
635 C2=0:REM LOW NIBBLE
640 NR=0:REM RECORD COUNT
645 SEMI=ASC(" ; ")
650 C0=ASC("0")
655 PCR=59468:REM PERIFERAL CONTROL REGISTER
660 REGA=59471:REM A DATA (WITHOUT HANDSHAKE)
665 ITR=59469:REM INTERRUPT FLAG REGISTER
670 CA1=2:REM CA1 INTERRUPT FLAG
675 I=PEEK(PCR) AND (16+8+4+2):REM SYSTEM BITS
680 P0%=I OR ((8+4)*16):REM CB2 LOW
685 P1%=I OR ((8+4+2)*16):REM CB2 HIGH
690 DIM C(15+7):REM CHARACTERS "0"- "F"
695 DIM A(24):REM UP TO 24 BYTES/RECORD
700 DATA 0,1,2,3,4,5,6,7,8,9
705 DATA -1,-1,-1,-1,-1,-1,-1
710 DATA 10,11,12,13,14,15
715 FOR I=0 TO 15+7
720 READ C(I)
725 NEXT
730 POKE 59459,0:REM DATA DIRECTION REGISTER
735 RETURN
800 GOSUB 100
805 PRINT CHR$(A);
810 GOTO 800
820 REM PET AIM CONNECTION
825 REM ALAN K. CHRISTENSEN
830 REM JULY 20, 1981

```

### Listing 3

```

;PET#AIM#ASM.C
;AIM TO PET LOADER INTERFACE
;BY ALAN K. CHRISTENSEN
;AUSTIN, TEXAS
;JULY 20, 1981
;
;PET DEPENDANT ADDRESSES
;PET 1.0 ADDRESSES GIVEN
ADDR = $58 ;USE END OF BASIC INPUT BUFFER
;TO STORE ADDRESS. THE BYTES
;WILL BE RESTORED AT EXIT
CKSTOP = 62250 ;ROUTINE TO CHECK FOR STOP KEY
(Upgrade - 62209, 4.0 - 62261)
;
JMP INIT ;USR(0) ENTRY
;
*=$2200
MSG = *
FCHMSG .BYTE 13,'FINAL '
CHKMSG .BYTE 'CHECK SUM '
.BYTE 'ERROR',13
CHKLEN = *-CHKMSG
FCHLEN = *-FCHMSG
;
RECMG .BYTE 13,'RECORD NUMBER '
.BYTE 'MISMATCH ERROR',13
RECLEN = *-RECMG
;
DONE .BYTE 13,'DONE',13
DONEL = *-DONE
;
;LINE 100
GETAIM = * ;GET 1 BYTE FROM THE AIM
LDA P0 ;PULSE CB2
STA PCR ;FIRST LOW
LDA P1 ;THEN HIGH
STA PCR ;TO MAKE HANDSHAKE
;
FLAGCK JSR CKSTOP ;CHECK FOR STOP KEY
BEQ EXITI ;TO LEAVE LOOP
;
;LINE 105
LDA ITR ;CHECK THE INTERRUPT FLAG
AND #CA1 ;REGISTER FOR READY
BEQ FLAGCK ;SIGNAL FROM AIM

```

(Continued)

Listing 3 (Continued)

```

;LINE 110
LDA REGA ;GET 1 BYTE FROM INTERFACE
PHA

;LINE 115
LDA #CA1 ;CLEAR THE INTERRUPT FLAG
STA ITRF

;LINE 120
;
PLA ;RETURN
RTS

;LINE 300-310
G2BYTES JSR GETBYT ;GET 2 ASCII BYTES
TAX ;THE 1ST IN X
; ;AND THE SECOND IN A
;LINE 200
GETBYT JSR GETAIM ;GET 1 ASCII BYTE FROM AIM
SEC ;AND CONVERT THE ASCII
SBC #'0' ;HEX INTO BINARY
CMP #10 ;
BCC HEX1 ;RETURN BYTE IN A
SBC #7
HEX1 ASL A
ASL A ;MULTIPLY 1ST DIGIT
ASL A ;BY 16
ASL A
STA DIGIT1

;LINE 205
;
JSR GETAIM ;GO FOR THE
SEC ;SECOND DIGIT
SBC #'0'
CMP #10
BCC HEX2
SBC #7
HEX2 = *

;LINE 210
;
ORA DIGIT1 ;COMBINE THE 1ST AND 2ND DIGIT
;LINE 215
;
PHA ;ADD THIS BYTE TO THE
CLC ;CHARACTER COUNT
ADC KKSUM+1
BCC ADD1
INC KKSUM
ADD1 STA KKSUM+1
PLA

;LINE 220
;
RTS ;RETURN

EXITI LDX SAVSTK ;RESET STACK POINTER
TXS ;TO ALLOW EXIT FROM
JMP EXITT ;WITHIN SUBROUTINE

;LINE 400
;
LOADER = * ;LOAD A RECORD IN AIM FORMAT
JSR GETAIM ;LOOK FOR THE SEMI-
CMP #';' ;COLON THAT STARTS
BNE LOADER ;THE RECORD

;LINE 405
;
LDY #0 ;RESET THE CHARACTER COUNTER
STY KKSUM ;TO COUNT ALL CHARACTERS
STY KKSUM+1 ;AFTER THE ''
INC NREC+1
BNE ADD2 ;ADD 1 TO NUMBER OF RECORDS
INC NREC
ADD2 = *

```

Listing 3 (Continued)

```

;LINE 410
;
JSR GETBYT ;FIRST BYTE OF RECORD IS
AND #$1F ;THE DATA BYTE COUNT
STA COUNT ;AND SHOULD BE <= 24

;LINE 415
;
BEQ LAST ;CHECK FOR LAST RECORD

;LINE 420
;
JSR G2BYTES ;GET THE BASE ADDRESS
STX ADDR+1 ;FOR THE DATA BYTES
STA ADDR ;AND SAVE IN ZERO PAGE

;LINE 425
;
FLOOP1 = * ;Y=0 FROM LINE 405

;LINE 430
;
JSR GETBYT ;GET THE DATA BYTES
STA ARRAY,Y ;AND SAVE THEM IN ARRAY

;LINE 435
;
INY ;LOOP BACK FOR ALL BYTES
CPY COUNT ;
BNE FLOOP1 ;

;LINE 440
;
LDA KKSUM ;THE ACCUMULATED SUM
STA CHKSUM ;OF THE BYTES SO FAR
LDA KKSUM+1 ;ARE EQUIVALENT TO
STA CHKSUM+1 ;THE CHECK SUM

;LINE 445
;
JSR G2BYTES ;GET THE CHECKSUM
; ;FROM THE RECORD

;LINE 450
;
CMP CHKSUM+1 ;CHECK CALCULATED
BNE CHKERR ;CHECKSUM WITH
CPX CHKSUM ;RECORD CHECK
BNE CHKERR ;SUM

;LINE 455
;
LDY #0 ;SET UP DATA-
FLOOP2 = * ;BYTE STORE LOOP

;LINE 460
;
LDA ARRAY,Y ;STORE ALL DATA BYTES
STA (ADDR),Y

;LINE 465
;
INY ;INCREASE ADDRESS OF STORE

;LINE 470
;
CPY COUNT ;CHECK FOR FINISHED
BNE FLOOP2

;LINE 480
;
JMP LOADER ;GO BACK FOR NEXT RECORD

;LINE 500
;
LAST JSR G2BYTES ;GET NUMBER OF RECORDS SENT

;LINE 505
;
CMP NREC+1 ;COMPARE TO NUMBER OF
BNE RECERR ;RECORDS RECEIVED
CPX NREC ;A MISMATCH INDICATES
BNE RECERR ;THAT DATA WAS LOST

```



Listing 3 (Continued)

```

;
;LINE 510
;
;   LDA KKSUM+1 ;MOVE THE CHARACTER
;   STA CHKSUM+1 ;COUNT INTO CHECKSUM
;   LDX KKSUM   ;
;   STX CHKSUM  ;
;
;LINE 520
;
;   JSR G2BYTES ;GET FINAL CHECKSUM
;
;LINE 525
;
;   CMP CHKSUM+1 ;CHECKSUM SHOULD BE
;   BNE FCHERR  ;A GUARD FOR THE
;   CPX CHKSUM  ;RECORD COUNT
;   BNE FCHERR
;
;LINE 530
;
;   JSR GETAIM ;CLEAR REMAINING CARRIAGE
;
;LINE 535
;
;   JSR GETAIM ;RETURNS TO FREE AIM
;
;LINE 540
;
;EXIT  LDX #DONE-MSG ;PRINT 'DONE'
;      LDY #DONEL
;      JSR PRMSG
;
;EXITT LDA SAVEZP ;RESTORE ZERO PAGE
;      STA ADDR  ;USED BY ADDRESS
;      LDA SAVEZP+1
;      STA ADDR+1
;      RTS      ;RETURN TO CALLING PROGRAM
;
CHKERR LDX #CHKMSG-MSG ;CHECKSUM ERROR
;      LDY #CHKLEN ;PRINT MESSAGE
MSGXIT JSR PRMSG      ;AND RETURN
;      JMP EXITT
;
FCHERR LDX #FCHMSG-MSG ;FINAL CHECK-
;      LDY #FCHLEN ;SUM ERROR
;      BNE MSGXIT
;
RECERR LDX #RECMSG-MSG ;RECORD COUNT
;      LDY #RECLEN ;ERROR
;      BNE MSGXIT
;
;LINES 600-650
;
ARRAY  ***+24 ;VARIABLE STORAGE
DIGIT1 ***+1
CHKSUM ***+2
KKSUM  ***+2
NREC   ***+2
;
COUNT ***+1
P0      ***+1
P1      ***+1
SAVEZP  ***+2
SAVSTK  ***+1
;
;LINES 655-670
;
PCR = 59468 ;PERIFERAL CONTROL REGISTER
REGA = 59471 ;A PORT DATA REGISTER
ITFR = 59469 ;INTERRUPT FLAG REGISTER
DDRA = 59459 ;A PORT DATA DIRECTION REGISTER
CA1  = 2 ;MASK FOR CA1 INTERRUPT FLAG
;
INIT  LDA ADDR ;INITIALIZATION
;      STA SAVEZP
;      LDA ADDR+1 ;SAVE ZERO PAGE LOCATION
;      STA SAVEZP+1 ;USED BY ADDR
;
;      TSX ;SAVE THE STACK POINTER
;      STX SAVSTK ;SO STOP KEY CAN EXIT
;
;LINE 675
;
;      LDA PCR ;SAVE THE BITS FROM PCR
;      AND #$1E ;THAT ARE NOT USED IN INTERFACE

```

Listing 3 (Continued)

```

;
;LINE 680
;
;      ORA ##C0 ;CB2 LOW
;      STA P0
;
;LINE 685
;
;      ORA ##E0 ;CB2 HIGH
;      STA P1
;
;LINE 730
;
;      LDA #0 ;ZEROS MAKE DATA DIRECTION
;      STA DDRA ;INTO INPUTS
;
;      STA NREC ;INITIALIZE RECORD
;      STA NREC+1 ;COUNTER
;
;LINE 735
;
;      JMP LOADER
;
;
; SUBROUTINE TO PRINT A MESSAGE TO THE PET SCREEN
; X POINTS TO MESSAGE WITHIN PAGE LENGTH OF MSG
; Y IS THE LENGTH OF THE MESSAGE
; PRINT=##FD2 ;PET 2001 PRINT CHARACTER
;
;PRMSG = *
;
;
;      LDA MSG,X
;      JSR PRINT
;      INX
;      DEY
;      BNE PRMSG
;      RTS
;
;END

```

MICRO

# RPL



RPL is a fast, space-efficient language, designed for the PET/CBM user who wants to develop high-speed, high-quality software with a minimum of effort. While ideal for programming games and other personal applications, it is primarily oriented toward real-time process control, utility programming, and similar demanding business and industrial uses.

R. Vanderbilt Foster, of Video Research Corporation, says he thinks that "RPL is one HELL of a system!" (capitals his). Ralph Bressler, reviewing the package in The Paper, says "I know of few language systems this complete, this well documented, for this kind of price." For more information, see the following:

**MICRO, Dec. '81, p. 35**  
**MICROCOMPUTING, Feb. '82, p. 10**  
**MICRO, Mar. '82, p. 29**  
**BYTE, Mar. '82, p. 476**  
**COMPUTE!, Mar. '82, pp. 45, 120.**

See also the article "Basic, Forth and RPL" in the June '82 issue of MICRO, and Mr. Bressler's review in the Jan./Feb. '82 issue of The Paper. Don't let our prices deceive you: RPL is a first-class, high performance language in every respect. We are keeping its price so low in order to make it accessible to the widest possible number of users. Only **\$80.91**, postpaid, for both the RPL compiler and its associated symbolic debugger, complete with full documentation (overseas purchasers please add \$5.00 for air mail shipping). Versions available for PET-2001 (Original, Upgrade or V4.0 ROM's), CBM 4032, and CBM 8032/8096, on cassette, 2040/4040, and 8050 disk.

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MX80 (serial no. to 359999)	EPG80 (EPG82, 3 ROM Version)
MX80 (serial no. after 360000)	EPG81 (EPG83, 3 ROM Version)
MX80FT	EPG8F
MX80 Graftrax	Not Available
MX80 Graftrax Plus	EPG8G+
MX80FT Graftrax Plus	EPG8G+
MX100	Not Available
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# PET to AIM Download

by George Watson

A fast, reliable method is presented for transfer of programs from the PET microcomputer to the AIM 65 (or other micro with an accessible 6522). Macroassemblers available for the PET may thus be easily used for developing AIM, SYM, and KIM programs.

**PET to AIM**  
requires:

PET  
AIM 65 or SYM  
Interface cable (see page 12)

During the past several years, a wide range of computers has been developed based on the 6502 microprocessor. With such a wide spectrum it is possible to choose a system tailored specifically for a given job. A microcomputer with high-level languages, disk storage, and a plethora of peripheral equipment can be chosen for an application requiring extensive data analysis or file management. For simply controlling a piece of equipment though, a more reasonable and economical choice may be a single board computer. When both types of systems are present the thought naturally occurs that any type of program development for the bare bones system should be implemented using the full-blown system. Assembler source files and object code may be easily created with powerful macroassemblers or compilers. Then the object code needs only to be transferred to the less-expanded computer. Specifically, I would like to consider the downloading of machine code from the PET/CBM to the AIM 65.

The hardware requirements for transfer of data between two computers are: 1) an output port, 2) an input port, and 3) wires connecting the two ports. Many 6502 computers make available to the user a parallel port consisting of a 6522, the Versatile Interface Adapter. The AIM 65 has two 8-bit ports with

Listing 1: AIM Initialization Routine. Runs in AIM.

```

*****
0010 ;*****
0020 ;* AIM-FROM-PET DOWNLOAD *
0030 ;* GEORGE WATSON *
0040 ;* FEB. 9, 1982 *
0050 ;*****
0060 ;
0070 ;*****
0080 ;* ASSEMBLY DIRECTIVES *
0090 ;*****
0100 ;
0110 ;.BA $0200
0120 ;.CE
0130 ;.LS
0140 ;
0150 ;*****
0160 ;* AIM J1 CONNECTION PORT *
0170 ;*****
0180 ;
0190 VIA ;.DE $A000 ;BASE ADDRESS OF AIM 6522
;SYM VIA #2: $A800
0200 ORAH ;.DE VIA+$01 ;PORT A WITH HANDSHAKING
0210 DDRA ;.DE VIA+$03 ;DATA DIRECTION REGISTER A
0220 PCR ;.DE VIA+$0C ;PERIPHERAL CONTROL REG.
0230 IFR ;.DE VIA+$0D ;INTERRUPT FLAG REGISTER
0240 ;
0250 ;*****
0260 ;* PROGRAM VARIABLES *
0270 ;*****
0280 ;
0290 START ;.DE $00 ;START ADDRESS OF PROGRAM
0300 LENGTH ;.DE $02 ;LENGTH OF PROGRAM
0310 ;
0320 ;*****
0330 ;* INITIALIZE PORT *
0340 ;*****
0350 ;
0200- A9 00 0360 PORTINIT LDA #0 ;SET PORT A AS INPUT
0202- 80 03 A0 0370 STA DDRA
0205- A9 09 0380 LDA #9 ;SET CA2 OUTPUT HANDSHAKE
0207- 80 0C A0 0390 STA PCR ;MODE WITH CA1 INT FLAG
;SET ON RISING EDGE
020A- AD 01 A0 0410 LDA ORAH ;CLEAR PORT
0420 ;
0430 ;*****
0440 ;* GET START ADDRESS AND LENGTH *
0450 ;*****
0460 ;
020D- 20 39 02 0470 ADDRESS JSR PORTGET ;LOAD LOW THEN HIGH BYTE
0210- 85 00 0480 STA *START
0212- 20 39 02 0490 JSR PORTGET
0215- 85 01 0500 STA *START+1
0217- 20 39 02 0510 JSR PORTGET
021A- 85 02 0520 STA *LENGTH
021C- 20 39 02 0530 JSR PORTGET
021F- 85 03 0540 STA *LENGTH+1
0550 ;
0560 ;*****
0570 ;* DOWNLOAD PROGRAM *
0580 ;*****
0590 ;
0221- A2 00 0600 DOWNLOAD LDX #0 ;TRANSFER PROGRAM
0223- A0 00 0610 LDY #0
0225- 20 39 02 0620 NEXTBYTE JSR PORTGET ;LOAD BYTE
0228- 91 00 0630 STA (*START),Y
022A- C8 0640 INV
022B- D0 03 0650 BNE SKIP1
022D- E8 0660 INX ;GOTO NEXT PAGE
022E- E6 01 0670 INC *START+1
0230- E4 03 0680 SKIP1 CPX *LENGTH+1 ;END OF PROGRAM?
0232- D0 F1 0690 BNE NEXTBYTE
0234- C4 02 0700 CPY *LENGTH
0236- D0 ED 0710 BNE NEXTBYTE
0238- 00 0720 EXIT BRK

```

complete handshaking signals available. PET/CBM has one 8-bit port with partial support for handshaking. Pin-outs for construction of the cable are given on page 12.

The program required in the AIM (listing 1) is very short and consists of four sections: initialization, start and length parameters, downloading, and the port input subroutine. With the VIA address substitutions given, the program should run on the SYM, using its VIA #2. As assembled, the program resides in the second page of memory and may be entered via the AIM monitor. This program is run by setting the program counter < \* > 0200, and entering < G >. The AIM should always be initialized before the PET begins the transfer.

The PET program requests that input of the AIM start address, and the PET start and end address of the program, be transferred. (See listing 2.) All addresses should be given as 4-digit hex numbers. These addresses are input using a routine present in the PET monitor. If an error is made in entry, the user will be returned to the monitor with a "." prompt; exit with X and start again. The program has been preceded with a single line of BASIC (10 SYS1037) so that RUN causes execution of the download. Any editing or variable use at this point will destroy the program.

I usually download code to the AIM immediately after assembling it with Carl Moser's MAE macroassembler. After assembly, the end address (+ 1) of the stored object code is stored at \$7651,\$7652. Unfortunately it seems that the start address and offset address are not stored (although they are present in the source file). By replacing the section entitled \* GET PET END ADDRESS \* as follows we need only enter the PET and AIM start address and not be concerned with the program length.

```
MAEEND > DE $7651
HEXOUT  DE $D722
;
PETEND  LDY #H,STR3
        LDA #L,STR3
        JSR STROUT
        LDA MAEEND + 1
        STA END + 1
        JSR HEXOUT
        LDA MAEEND
        STA END
        JSR HEXOUT
```

Transferring programs between microcomputers equipped with 6522

#### Listing 1 (Continued)

```
0730 ;
0740 ;*****
0750 ;* VIA PORT GET *
0760 ;*****
0770 ;
0239- AD 0D A0 0780 PORTGET LDA IFR ;WAIT FOR DATA READY
023C- 29 02 0790 AND #2 ; SIGNAL
023E- F0 F9 0800 BEQ PORTGET
0240- AD 01 A0 0810 LDA ORAH ;RECEIVE BYTE
0243- 60 0820 RTS
0830 ;
0840 ;.EN
```

#### Listing 2: PET to AIM Download. Runs in PET.

```
0010 ;*****
0020 ;* PET-TO-AIM DOWNLOAD *
0030 ;* GEORGE WATSON *
0040 ;* FEB. 4, 1982 *
0050 ;*****
0060 ;
0070 ;*****
0080 ;* ASSEMBLY DIRECTIVES *
0090 ;*****
0100 ;
0110 ;.BA $0400 ;NORMAL START OF BASIC
0120 ;.CE
0130 ;.OS
0140 ;.LS
0150 ;
0160 ;*****
0170 ;* USER PORT VARIABLES *
0180 ;*****
0190 ;
0200 VIA ;.DE $E840 ;BASE ADDRESS OF PET 6522
0210 ORAH ;.DE VIA+$01 ;PORT A WITH HANDSHAKING
0220 DORA ;.DE VIA+$03 ;DATA DIRECTION REGISTER A
0230 PCR ;.DE VIA+$0C ;PERIPHERAL CONTROL REG.
0240 IFR ;.DE VIA+$0D ;INTERRUPT FLAG REGISTER
0250 ;
0260 ;*****
0270 ;* SYSTEM VARIABLES *
0280 ;*****
0290 ;
0300 ;ROM VERSION 4.0 ;UPGRADE
0310 ;
0320 KEYBUF ;.DE $9E ; # OF KEYSTROKES
0330 HEXIN ;.DE $FB ; LOW BYTE OF ADDRESS
0340 HEXINPUT ;.DE $D754 ;$E7A7 HEX ADDRESS INPUT
0350 STROUT ;.DE $BB1D ;ASCII PRINT STRING
0360 RDT ;.DE $FFCF ; INPUT CHARACTER
0370 ;
0380 ;*****
0390 ;* PROGRAM VARIABLES *
0400 ;*****
0410 ;
0420 PET ;.DE $00 ;PET START ADDRESS
0430 END ;.DE HEXIN ;PET END ADDRESS
0440 LEN ;.DE HEXIN ;PROGRAM LENGTH
0450 PCRWAS ;.DE STORE ;ORIGINAL PET PCR VALUE
0460 ;
0470 SENT ;.DE $00100000 ;ORA WITH PCR
0480 TAKEN ;.DE $11011111 ;AND WITH PCR
0490 SETUP ;.DE $11000000 ;CB2 HANDSHAKE
0500 ;
0510 ;*****
0520 ;* BASIC RUN START *
0530 ;*****
0540 ;
0490- 00 0550 BASIC ;.BY $0 ;START OF BASIC
0401- 0B 04 0560 ;.BY $B $4 ; LINE LINK
0403- 0A 00 0570 ;.BY $A $0 ; LINE NUMBER 10
0405- 9E 0580 ;.BY $9E ;SYS
0406- 31 30 33 0590 ;.BY '1037' ;DECIMAL ADDRESS
0409- 37
040A- 00 00 00 0600 ;.BY $0 $0 $0 ; END OF BASIC
0610 ;
0620 ;*****
0630 ;* INITIALIZE PET USER PORT *
0640 ;*****
0650 ;
0660 START
0670 ;
0400- A9 FF 0680 PORTINIT LDA #$FF ;SET PORT A AS OUTPUT
040F- 8D 43 E8 0690 STA DORA
0412- AD 4C E8 0700 LDA PCR ;SAVE CONTENTS OF PCR
0415- 3D 09 05 0710 STA PCRWAS
0418- 29 DF 0720 AND #TAKEN
041A- 09 C0 0730 ORA #SETUP ;USE CB2 AS MANUAL HANDSHAKE
041C- 8D 4C E8 0740 STA PCR
0750 ;
0760 ;*****
0770 ;* SETUP AIM *
0780 ;*****
0790 ;
041F- A0 04 0800 AIMSETUP LDY #H,STR0 ;MAKE SURE THAT AIM IS
```

**Listing 2**

```

0421- A9 AB 0810 LDA #L,STR0 ; WAITING FOR TRANSFER
0423- 20 1D BB 0820 JSR STROUT
0426- A9 00 0830 LDA #0
0428- 85 9E 0840 STA *KEYBUF
042A- 20 CF FF 0850 JSR RDT
0860 ;
0870 ;*****
0880 ;* GET & SEND AIM START ADDRESS *
0890 ;*****
0900 ;
042D- A0 04 0910 AIMSTART LDY #H,STR1 ; INPUT 4 DIGIT ADDRESS
042F- A9 CB 0920 LDA #L,STR1 ; AT WHICH PROGRAM SHOULD
0431- 20 A0 04 0930 JSR INPUT ; BE STORED IN AIM
0434- A5 FB 0940 LDA *HEXIN
0436- 20 85 04 0950 JSR PORTSEND
0439- A5 FC 0960 LDA *HEXIN+1
043B- 20 85 04 0970 JSR PORTSEND
0980 ;
0990 ;*****
1000 ;* GET PET START ADDRESS *
1010 ;*****
1020 ;
043E- A0 04 1030 PETSTART LDY #H,STR2 ; INPUT ADDRESS AT WHICH
0440- A9 EF 1040 LDA #L,STR2 ; PROGRAM STARTS IN PET
0442- 20 A0 04 1050 JSR INPUT
0445- A5 FB 1060 LDA *HEXIN
0447- 85 00 1070 STA *PET
0449- A5 FC 1080 LDA *HEXIN+1
044B- 85 01 1090 STA *PET+1
1100 ;
1110 ;*****
1120 ;* GET PET END ADDRESS *
1130 ;*****
1140 ;
044D- A0 04 1150 PETEND LDY #H,STR3 ; INPUT ADDRESS OF FIRST
044F- A9 FC 1160 LDA #L,STR3 ; BYTE AFTER END OF
0451- 20 A0 04 1170 JSR INPUT ; PROGRAM IN PET

```

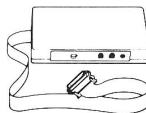
(Continued on next page)

Versatile Interface Adapters is not a difficult task. Better, more efficient program development will result by using the most powerful system available, even though the program will reside in a different computer. A small revision in a program no longer requires time spent with simple assemblers and tape files, or in entering object code repeatedly by hand. I would like to acknowledge the previous efforts and gains made on the PET/AIM system by Dr. John H. Miller, III and Dr. Michael Ryschkeiwisch.

George Watson is a graduate student in physics at the University of Delaware. His research involves light-scattering studies of condensed matter. Microcomputers are used heavily to control a Raman spectrometer and to collect and display spectra. He may be contacted at the Physics Department, University of Delaware, Newark, DE 19711.

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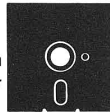


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### Listing 2 (Continued)

```

1190 ;*****
1200 ;* CALCULATE & SEND LENGTH *
1210 ;*****
1220 ;
0454- 38      1230 LENGTH      SEC      ;SUBTRACT END ADDRESS
0455- A5 FB   1240      LDA #END      ; FROM START ADDRESS
0457- E5 00   1250      SBC #PET      ; TO FIND PROGRAM LENGTH
0459- 85 FB   1260      STA #LEN
045B- 20 85 04 1270      JSR PORTSEND
045E- A5 FC   1280      LDA #END+1
0460- E5 01   1290      SBC #PET+1
0462- 85 FC   1300      STA #LEN+1
0464- 20 85 04 1310      JSR PORTSEND
1320 ;
1330 ;*****
1340 ;* DOWNLOAD PROGRAM *
1350 ;*****
1360 ;
0467- A2 00   1370 DOWNLOAD  LDX #0      ;TRANSFER PROGRAM
0469- A0 00   1380      LDY #0
046B- E1 00   1390 NEXTBYTE  LDA (PET),Y  ;SEND BYTE
046D- 20 85 04 1400      JSR PORTSEND
0470- C8     1410      INY
0471- D0 03   1420      BNE SKIP1
0473- E8     1430      INX      ;GOTO NEXT PAGE
0474- E6 01   1440      INC #PET+1
0476- E4 FC   1450 SKIP1    CPX #LEN+1  ;END OF PROGRAM?
0478- D0 F1   1460      BNE NEXTBYTE
047A- C4 FB   1470      CPY #LEN
047C- D0 ED   1480      BNE NEXTBYTE
1490 ;
047E- AD 09 05 1500 EXIT    LDA PCRWAS ;RESTORE PET
0481- 8D 4C E8 1510      STA PCR
0484- 60     1520      RTS
1530 ;
1540 ;*****
1550 ;* VIA PORT SEND *
1560 ;*****
1570 ;
0485- 8D 41 E8 1580 PORTSEND  STA ORAH   ;PLACE BYTE AT PORT A
048B- AD 4C E8 1590      LDA PCR
048D- 09 20   1600      ORA #SENT ;SET DATA SENT SIGNAL
048D- 8D 4C E8 1610      STA PCR
0490- AD 4D E8 1620 WAIT    LDA IFR   ;WAIT FOR DATA RECEIVED
0493- 29 02   1630      AND #2    ; SIGNAL
0495- F0 F9   1640      BEQ WAIT
0497- AD 4C E8 1650      LDA PCR  ;RESET DATA SENT SIGNAL
049A- 29 DF   1660      AND #TAKEN
049C- 8D 4C E8 1670      STA PCR
049F- 60     1680      RTS
1690 ;
1700 ;*****
1710 ;* INPUT ROUTINE *
1720 ;*****
1730 ;
04A0- 20 1D B8 1740 INPUT    JSR STROUT ;PRINT INPUT PROMPT
04A3- A9 00   1750      LDA #0   ;EMPTY KEYBOARD BUFFER
04A5- 85 9E   1760      STA #KEYBUF
04A7- 20 54 D7 1770      JSR HEXINPUT ;INPUT HEX ADDRESS
04AA- 60     1780      RTS
1790 ;
1800 ;*****
1810 ;* INPUT PROMPT MESSAGES *
1820 ;*****
1830 ;
04AB- 0D 50 52 1840 STR0    .BY $D 'PREPARE AIM, THEN HIT RETURN.' 0
04AE- 45 50 41
04B1- 52 45 20
04B4- 41 49 4D
04B7- 2C 20 54
04BA- 48 45 4E
04BD- 20 48 49
04C0- 54 20 52
04C3- 45 54 55
04C6- 52 4E 2E
04C9- 20 00
04CB- 0D 0D 45 1850 STR1    .BY $D $D 'ENTER HEX ADDRESSES:' $D
04CE- 4E 54 45
04D1- 52 20 48
04D4- 45 58 20
04D7- 41 44 44
04DA- 52 45 53
04DD- 53 45 53
04E0- 3A 0D
04E2- 0D 41 49 1860      .BY $D 'AIM START?' 0
04E5- 4D 20 53
04E8- 54 41 52
04EB- 54 3F 20
04EE- 00
04EF- 0D 50 45 1870 STR2    .BY $D 'PET START?' 0
04F2- 54 20 53
04F5- 54 41 52
04F8- 54 3F 20
04FB- 00
04FC- 0D 50 45 1880 STR3    .BY $D 'PET END?' 0
04FF- 54 20 45
0502- 4E 44 3F
0505- 20 20 20
0508- 00
0509- 00      1890 STORE    .BY 0
1900 ;
1910      .EN

```

MICRO

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compilation.

```
*** commodore basic 4.0 ***
31743 bytes free
ready.
directory d1
1 "petspeed" ps 2c
31 "your program" prg
1961 blocks free.
ready.
```

Simply type in  
your program  
name.

```
PETSPPEED
PROGRAM NAME : YOUR PROGRAM
ISSUE 2.0 (C) O.C.S.S. 1982
```

Directory  
AFTER  
compilation

```
*** commodore basic 4.0 ***
31743 bytes free
ready.
ready.
1 "petspeed" ps 2c
31 "your program" prg
35 "your program.gt" prg
18 "your program.w" prg
1779 blocks free.
ready.
```

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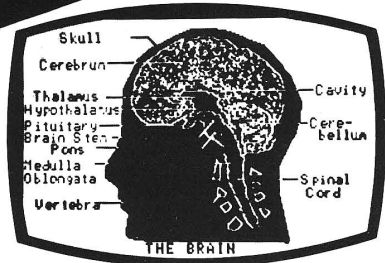
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# Expanding File Cabinet for the Apple

by David P. Allen

**The public domain "File Cabinet" is still in use by many Apple owners. Techniques to access "File Cabinet" data for use in other programs are presented.**

**File Cabinet**  
requires:

Apple II or Apple II Plus  
48K  
Applesoft in ROM

An axiom of executive efficiency experts is "Never handle a piece of paper more than once." When you get a paper, finish with it completely before you set it down.

There is a parallel to this idea when it comes to managing data with a computer: "Never enter the same data more than once through the keyboard." Once entered, we should be able to do just about anything we want with it — sort it, select items, make labels, edit, etc.

Several programs for sale do exactly that. They're called data managers, and most of them are very good. They are also among the most expensive software items being sold today.

One data manager has been around for almost as long as the Apple II itself. One of its best features is that it is almost free. I am talking about the reliable but often-sneered-at FILE CABINET program that originally appeared on one of the first Apple-supplied "Contributed Programs" disks. This program and its progeny have been used for many tasks by Apple users. In spite of its shortcomings (and there are a few), it continues to have a life undiminished.

One reason for this is the great volume of data that has been translated into FILE CABINET index files. Before you know it, you have spent so much

time entering information into this electronic cabinet that the thought of entering all that material through the keyboard again is unthinkable. Finding myself in this position, but still wanting to move batches of information from the FILE CABINET to other application programs, I decided to investigate whether there is a way to link the FILE CABINET with other programs.

**Figure 1**

```
1 CATALOGS1
DISK VOLUME 254

K80N
  REC#: 1
  1 CITY: ALBANY NY
  2 LAT.: 42.85
  3 LONG.: -73.75

K80N
  REC#: 2
  1 CITY: ANNAPOLIS MD
  2 LAT.: 38.98
  3 LONG.: -76.50

K80N
  REC#: 3
  1 CITY: ATLANTA GA
  2 LAT.: 33.75
  3 LONG.: -84.39

K80N
  REC#: 4
  1 CITY: AUGUSTA ME
  2 LAT.: 44.31
  3 LONG.: -69.77

K80N
  REC#: 5
  1 CITY: AUSTIN TX
  2 LAT.: 30.26
  3 LONG.: -97.74

K80N
  REC#: 6
  1 CITY: BATON ROUGE LA
  2 LAT.: 30.45
  3 LONG.: -91.18

K80N
  REC#: 7
  1 CITY: BISMARCK ND
  2 LAT.: 46.81
  3 LONG.: -100.79

K80N
  REC#: 8
  1 CITY: BOISE ID
  2 LAT.: 43.62
  3 LONG.: -116.2
```

I soon developed a simple program to do just that. Before analyzing this program, let's take a look at what we are starting with, and what we are going to wind up with. To make things clear, we'll use some real data.

The example I have chosen is data for a GREAT CIRCLE program which computes distances and bearings to various places in the country. To accomplish this task the GREAT CIRCLE program needs the identity (city and state), plus the latitude and longitude of the distant city. This information is entered into a file in the FILE CABINET program. A typical printout of the records of this file appears in figure 1. Each record contains the data on one location.

As with most Applesoft programs, the GREAT CIRCLE program works on data in the form of DATA statements. Figure 2 shows a listing of some of the data statement lines from the GREAT CIRCLE program. Our task, then, is to get the information out of the FILE CABINET records and into the data statements of GREAT CIRCLE. The program listing NA DATA WRITER EXEC does the trick.

Line 1 establishes three maxfiles; a necessity if we have been playing around with FILE CABINET which reduces maxfiles to one. Line 100 shows us what is going on. Line 300 sets up the program to wind things up after the last piece of data has been read. Lines 400 to 600 establish a file called "NA DATA WRITER", while line 700 determines the line number of the first data statement to be used in the final program. Lines 800 and 900 open up the FILE CABINET index file, in this case called "NA BEARINGS INDEXFILE". Figure 3 shows us the contents of this file as compiled by FILE CABINET. It reveals that all of the needed data is nicely arranged in the order that we need it. Depending on which version of the FILE CABINET program we are using, there is some

'housekeeping' information stored as a preamble to the meat of the file. In this case, just before the first entry, 'ALBANY NY', there is the figure 51, which represents the number of records currently existing in this indexfile. Necessary information for FILE CABINET, but a problem for GREAT CIRCLE.

Looking at NA DATA WRITER, we see that lines 1000 to 1300 read out the data from the indexfile into strings A through D. Line 1500 starts writing this information into the text file NA DATA WRITER. Lines 1600 and 1700 start the data statement with a line number and the reserved word DATA. Line 1800 increments the line number counter, line 1900 writes in the information stored in B\$, C\$, and D\$, and line 2000 prepares for more data. Line 2100 starts us through the process over again. Note that A\$ is collected once and not used. This is the housekeeping data and is collected just to get it out of the way. Consequently, we loop back to line 1100 and not line 1000. When we run out of data the program jumps to line 2400 where it prints out a final data statement containing the 'END DATA' string, which the GREAT CIRCLE program needs to complete its assignment.

Here is the way this routine is brought into play. First we enter all our data into the FILE CABINET program. We can sort, change, delete, or add records as we wish. When we have the information the way we want it, it is stored in the INDEXFILE, in this case NA BEARINGS INDEXFILE. Now we load and run our interconnecting program, NA DATA WRITER EXEC. This program must be run with the disk containing the FILE CABINET file, NA BEARINGS INDEXFILE, in the disk drive. It will create the text file, NA DATA WRITER.

We now load the program that we wish to add the data statements to, in this case GREAT CIRCLE. At this point we delete any old data statements which may exist in the block of data statement numbers we are about to add. In this example we would delete lines 3000 through 3999. We are now ready for the final step.

With the disk containing the text file NA DATA WRITER in the slot, we exec this file. This file, shown in figure 4, is added to GREAT CIRCLE and the data statements are now added. Our task is complete.

The advantage of this system is that it can be adapted to almost any program

that can use data statements. We can use the FILE CABINET program to manipulate our raw data into the form we want before committing it to data statements. I'm sure you can find lots of ways to use this procedure to shuttle basic data from file cabinet files to a variety of other programs.

The author may be contacted at 19 Damon Road, Scituate, MA 02066.

Figure 2

```
3000 DATA ALBANY NY,42.65,-73.75
3003 DATA ANNAPOLIS MD,38.98,
      -76.56
3006 DATA ATLANTA GA,33.75,-84.39
3009 DATA AUGUSTA ME,44.31,-69.77
3012 DATA AUSTIN TX,30.26,-97.74
3015 DATA BATON ROUGE LA,30.45,
      -91.18
3018 DATA BISMARCK ND,46.81,
      -100.79
3021 DATA BOISE ID,43.62,-116.2
```

Figure 3:

Printout of NA Indexfile Bearings

```
51
ALBANY NY
42.65
-73.75
ANNAPOLIS MD
38.98
-76.56
ATLANTA GA
33.75
-84.39
AUGUSTA ME
44.31
-69.77
AUSTIN TX
30.26
-97.74
BATON ROUGE LA
30.45
-91.18
BISMARCK ND
46.81
-100.79
BOISE ID
43.62
-116.2
```

Figure 4: Printout of NA Data Writer

```
1 PRINT "MAXFILES 3": REM CONTROL-D AFTER FIRST QUOTE
2 DEE$ = CHR$(4): REM CONTROL-D
100 PRINT DEE$;"NON C,I,O"
200 REM
```

<<< NA DATA WRITER EXEC >>>

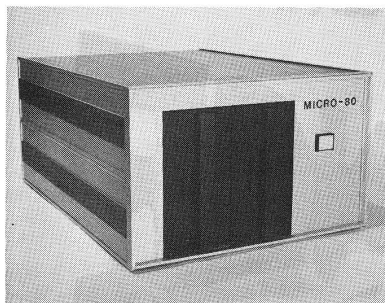
by David P. Allen

July 14, 1981

```
300 ONERR GOTO 2400
400 PRINT DEE$;"OPEN NA DATA WRITER"
500 PRINT DEE$;"DELETE NA DATA WRITER"
600 PRINT DEE$;"OPEN NA DATA WRITER"
700 LINENUMBER = 3000
800 PRINT DEE$;"OPEN NA BEARINGS INDEXFILE"
900 PRINT DEE$;"READ NA BEARINGS INDEXFILE"
1000 INPUT A$
1100 INPUT B$
1200 INPUT C$
1300 INPUT D$
1500 PRINT DEE$;"WRITE NA DATA WRITER"
1600 PRINT LINENUMBER;
1700 PRINT "DATA";
1800 LINENUMBER = LINENUMBER + 3
1900 PRINT B$;",";C$;",";D$
2000 PRINT DEE$;"READ NA BEARINGS INDEXFILE"
2100 GOTO 1100
2200 PRINT DEE$;"CLOSE"
2300 END
2400 LINENUMBER = LINENUMBER + 3
2500 PRINT DEE$;"WRITE NA DATA WRITER"
2600 PRINT LINENUMBER;
2700 PRINT "DATA";
2800 PRINT "END DATA 1,1,1"
2900 GOTO 2200
```

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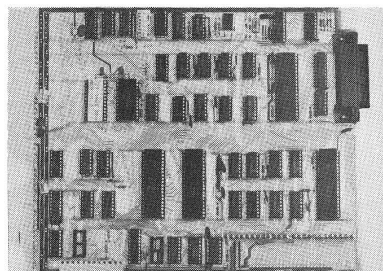
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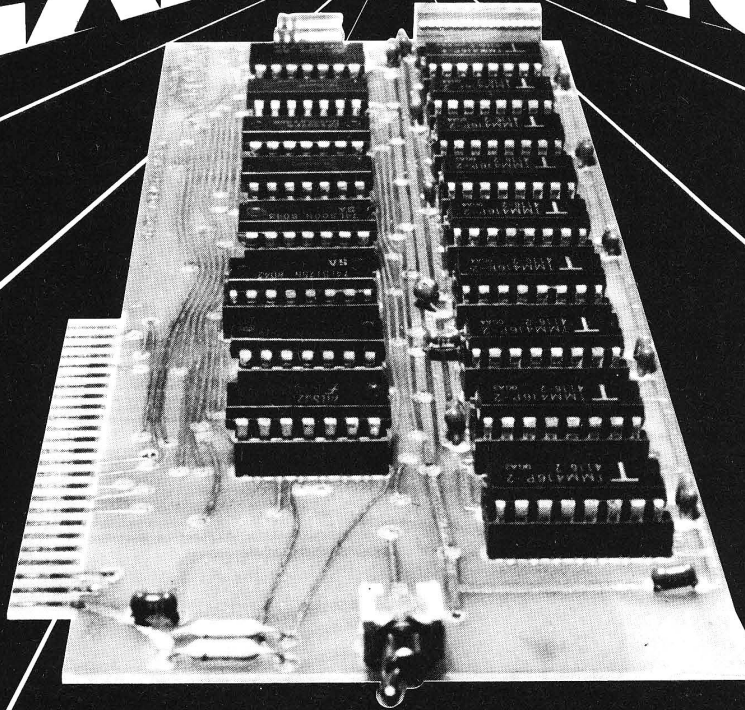
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# Duty Cycle Monitor for the VIC-20

by Bob Kovacs

This VIC-20 utility program determines the correct volume level when reading cassette tapes from a conventional tape recorder. Techniques are presented for using the VIC's built-in timers in conjunction with a machine-language program to measure waveform pulse widths. In addition, an interface circuit is provided.

## Duty Cycle Monitor requires:

VIC-20 with properly  
interfaced cassette recorder.  
May be modified for Apple.

Although the VIC-20 cassette tape interface was designed for use with Commodore's own data tape recorder, it can readily be adapted for use with a standard audio tape recorder. My own design (see figure 1) has proven adequate, although several variations are possible.

In general, the output of the adapter circuit will be dependent on the playback volume level. At least three conditions must be satisfied before consistent, error-free loading can be attained. First, there must be sufficient amplitude to exceed the adapter's detection threshold. Next, the level must be such that the "sync" tone at the beginning of the tape has a 50 percent duty cycle. (This tone is easily distinguished from the noisy sounds of data by actually listening to the tape. I've modified my recorder as shown in figure 2 so that I can hear these sounds during a LOAD.) Then, the variability (i.e. jitter) in both the playback frequency and duty cycle must be limited.

The ability to read tapes is a function of how they were recorded. Tapes played back on the machine on which they were recorded are generally read more easily than those recorded elsewhere. This is primarily due to variations in recording head alignment from

Figure 1: VIC-20 Cassette Tape Recorder Adapter

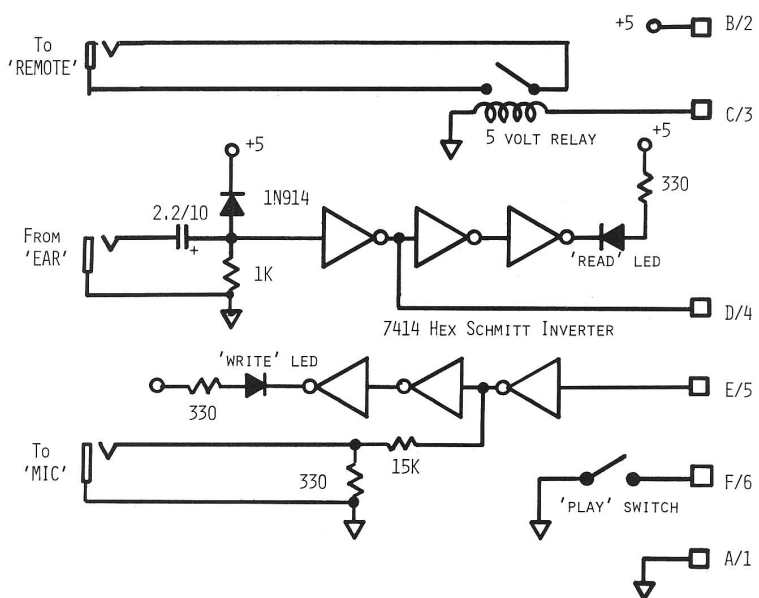
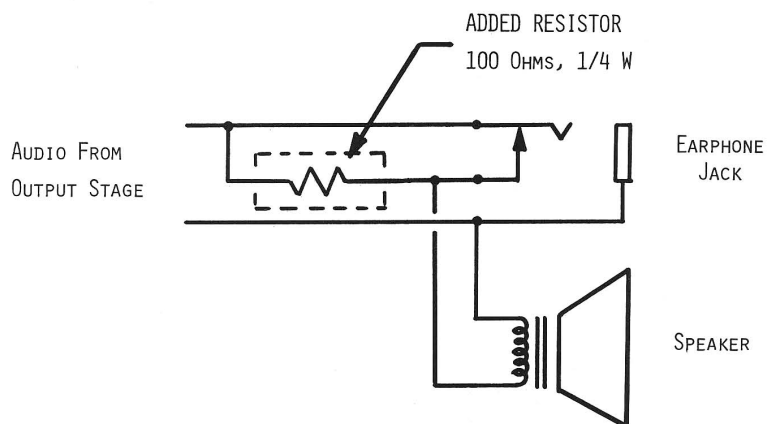


Figure 2: Cassette Recorder Modification — Allows tape to be heard at reduced volume during a 'LOAD'



one machine to another, which can have a significant effect on preserving the fidelity of the waveform during playback. Most recorders are provided with a small alignment screw near the record/playback heads.

Setting the volume level is usually done by trial and error. Eventually upper and lower level limits are established so that a given tape can be read consistently. Tapes that originated on other recorders can occasionally be troublesome, making the whole process frustrating. The program shown in listing 1 is an aid for establishing the proper volume level and for assessing playback jitter. It does this by separately measuring the duration of the positive and negative portions of the playback waveform. The results are displayed graphically for ease of interpretation so that a sync tone having a 50 percent duty cycle is displayed with equal positive and negative values. In addition, the stability of the display is a direct indication of phase and frequency jitter due to amplitude variations and motor speed fluctuations.

The Duty-Cycle program presented here is easy to use. Just run the program while playing the tape to be loaded. The volume level is adjusted during the sync tone until the display indicates a 50 percent duty cycle. This condition is met when the two "+" symbols line up. After the level is adjusted, the program is halted and the tape is read in using the LOAD command. (If your tape recorder also has a tone control, then it should be set for maximum treble.)

### How it Works

A machine-language routine (shown in listing 2) performs the main task of measuring and displaying pulse widths. This routine is already incorporated in DATA statements of the BASIC program in listing 1. The routine was initially developed, assembled and tested on an Apple II using a John Bell dual 6522 VIA parallel board. The program was adapted to the VIC-20 by redefining the VIA and screen addresses.

The signal from the cassette tape adapter is input on pins D and 4 of the cassette I/O connector. This goes directly to the CA1 pin of VIA #2. (Note: VIA is short for Versatile Interface Adapter and the VIC-20 contains two of them. Each VIA contains two programmable 8-bit ports and two control lines per port. In addition, each VIA contains two 16-bit timer/counters and one shift register. See reference 2 for more details on the VIC-20 and VIA operation.) The

### Listing 1: Duty Cycle Monitor for VIC-20

```

5 PRINT""
10 PRINT"CASSETTE RECORDER VOL"
15 PRINT"CONTROL ADJUSTMENT PGM"
20 PRINT"ADJUST VOLUME SO THAT"
25 PRINT"BOTH '+' SYMBOLS LINE"
30 PRINT"UP DURING THE PURE"
35 PRINT"'SYNC' TONE AT THE"
40 PRINT"BEGINNING OF THE TAPE"
80 REM -----
90 A=832
100 READ N:FOR M=0 TO N-1:READ H#
105 HH=ASC(LEFT$(H#,1))-48
110 IF HH>9 THEN HH=HH-7
115 HL=ASC(RIGHT$(H#,1))-48
120 IF HL>9 THEN HL=HL-7
125 H=HL+HH*16
130 POKE A+M,H:NEXT M
135 PRINT:PRINT"<HIT ANY KEY TO START>"
140 GET A$:IF A#="" THEN 140
145 L$=" [-----]"
150 PRINT"<HIT ANY KEY TO STOP>"
155 PRINT""L$
160 FOR I=38576TO38641:POKEI,0:NEXT I
165 POKE251,0:POKE252,0
170 SYS A:GET A$:IF A#="" THEN 170
180 PRINT:PRINT:PRINT"NOW LOAD THE PROGRAM"
190 END
299 REM -----
300 DATA 115
310 DATA 20,66,03,20,7D,03,20,5D
320 DATA 03,A2,00,20,8B,03,20,5D
330 DATA 03,20,7D,03,20,66,03,A2
340 DATA 01,20,8B,03,60,A9,01,0D
350 DATA 2C,91,20,6F,03,60,A9,FE
360 DATA 2D,2C,91,20,6F,03,60,8D
370 DATA 2C,91,AD,21,91,A9,02,2C
380 DATA 2D,91,F0,FB,60,A9,FF,8D
390 DATA 18,91,A9,00,8D,19,91,60
400 DATA A9,00,AC,19,91,D0,0A,38
410 DATA A9,FF,ED,18,91,4A,4A,4A
420 DATA 4A,48,A9,B3,CA,EB,F0,02
430 DATA A9,DF,85,D1,84,FB,A9,20
440 DATA 91,D1,6B,AB,94,FB,A9,2B
450 DATA 91,D1,60

```

### Listing 2

#### DUTY CYCLE MONITOR FOR VIC-20

```

1000 * VIC-20 CASSETTE TAPE LEVEL ADJUST UTILITY
1010 *
1020 * BY BOB KOVACS - 16 MAR 82
1030 * 41 RALPH ROAD, WEST ORANGE NJ 07052
1040 *
1050 *
1060 * THIS ROUTINE DISPLAYS THE DURATION
1070 * OF + AND - CYCLES OF THE CASSETTE
1080 * TAPE WAVEFORM INPUT ON CA1 OF VIA2
1090 * -----
1100 * USE CASSETTE FILE BUFFER SPACE
1110 *
1120 .OR $0340 832 DECIMAL
1130 .TA $0800
1140 *
1150 * .LISTOFF
1160 * -----
1170 *
00D1- 1180 LINE .EQ $D1,D2 START ADDRESS OF CURRENT
SCREEN LINE
00FB- 1190 IMP .EQ $FB PLOT INDEX
1200 *
1EB3- 1210 LINE9 .EQ $1EB3 START ADDRESS OF LINE #9 + 3
1EDF- 1220 LINE11 .EQ $1EDF START ADDRESS OF LINE #11 + 3
1230 *
9110- 1240 VIA1 .EQ $9110 USER VIA BASE ADDRESS
9120- 1250 VIA2 .EQ $9120 INTERNAL VIA BASE ADDRESS
1260 *
1270 * 6522 REGISTER DEFINITIONS
1280 *
0000- 1290 INOUT.B .EQ $00 PORT B INPUT/OUTPUT REGISTER
0001- 1300 INOUTH.A .EQ $01 PORT A INPUT/OUTPUT
REG W/HANDSHAKE

```

(Continued)

Listing 2 (Continued)

```

0002-      1310 DDIR.B .EQ #02      PORT B DATA DIRECTION REGISTER
0003-      1320 DDIR.A .EQ #03      PORT A DATA DIRECTION REGISTER
0004-      1330 T1C.LO .EQ #04      TIMER 1 COUNTER LOBYTE
0005-      1340 T2C.HI .EQ #05      TIMER 1 COUNTER HIBYTE
0006-      1350 T1.LO .EQ #06      TIMER 1 LATCH LOBYTE
0007-      1360 T1.HI .EQ #07      TIMER 1 LATCH HIBYTE
0008-      1370 T2.LO .EQ #08      TIMER 2 LOBYTE
0009-      1380 T2.HI .EQ #09      TIMER 2 HIBYTE
000A-      1390 SHIFT .EQ #0A      SERIAL I/O SHIFT REGISTER
000B-      1400 AUXCON .EQ #0B      AUXILIARY CONTROL REGISTER
000C-      1410 PERCON .EQ #0C      PERIPHERAL CONTROL REGISTER
000D-      1420 INTFLG .EQ #0D      INTERRUPT FLAG REGISTER
000E-      1430 INTEN .EQ #0E      INTERRUPT ENABLE REGISTER
000F-      1440 INOUT.A .EQ #0F      PORT A INPUT/OUTPUT REGISTER
          1450 *-----*
          1460 *
0340- 20 66 03 1470 START JSR NEG      WAIT FOR NEG CA1
0343- 20 7D 03 1480 JSR SETT2    START TIMER
0346- 20 5D 03 1490 JSR POS      WAIT FOR POS CA1
0349- A2 00      1500 LDX #*00    INIT LINE INDEX
034B- 20 88 03 1510 JSR PLOT    DISPLAY TIME OF NEG CYCLE
          1520 *
034E- 20 5D 03 1530 JSR POS      WAIT FOR POS CA1
0351- 20 7D 03 1540 JSR SETT2    START TIMER
0354- 20 66 03 1550 JSR NEG      WAIT FOR NEG CA1
0357- A2 01      1560 LDX #*01    INIT LINE INDEX
0359- 20 88 03 1570 JSR PLOT    DISPLAY TIME OF POS CYCLE
          1580 *
035C- 60          1590 RTS          RETURN BACK TO BASIC
          1600 *-----*
          1610 * WAIT FOR POS TRANSITION ON CA1
          1620 *
035D- A9 01      1630 POS      LDA #*01
035F- 0D 2C 91 1640 OKA PERCON+VIA2 SET LOBIT
0362- 20 6F 03 1650 JSR TRAN
0365- 60          1660 RTS
          1670 *-----*
          1680 * WAIT FOR NEG TRANSITION ON CA1
          1690 *
0366- A9 FE      1700 NEG      LDA #*FE
0368- 2D 2C 91 1710 AND PERCON+VIA2 CLR LOBIT
036B- 20 6F 03 1720 JSR TRAN
036E- 60          1730 RTS
          1740 *-----*
          1750 * WAIT FOR ANY TRANSITION ON CA1
          1760 *
036F- 8D 2C 91 1770 TRAN  STA PERCON+VIA2 SETUP CA1 CONTROL
0372- AD 21 91 1780 LDA INOUTH.A+VIA2 CLR CA1 INTERRUPT FLAG
0375- A9 02      1790 LDA #*02    CA1 INTERRUPT MASK
0377- 2C 2D 91 1800 .10  BIT INTFLG+VIA2 TEST FOR CA1 TRANSITION
037A- F0 FB      1810 BEQ .10    LOOP UNTIL FOUND
037C- 60          1820 RTS
          1830 *-----*
          1840 * INITIALIZE & START T2 TIMER
          1850 *
037D- A9 FF      1860 SETT2 LDA #*FF    INIT LOBYTE
037F- 8D 18 91 1870 STA T2.LO+VIA1
0382- A9 00      1880 LDA #*00    INIT HIBYTE &
0384- 8D 19 91 1890 STA T2.HI+VIA1 START COUNTDOWN
0387- 60          1900 RTS
          1910 *-----*
          1920 * READ TIMER & DISPLAY COMPLEMENT
          1930 *
0388- A9 00      1940 PLOT  LDA #*00    CHECK TIMER FOR UNDERFLOW
038A- AC 19 91 1950 LDY T2.HI+VIA1
038D- D0 0A      1960 BNE .05    BRANCH IF NG
          1970 *
038F- 38          1980 SEC          SETUP FOR SUBTRACTION
0390- A9 FF      1990 LDA #*FF    DETERMINE PULSE DURATION
0392- ED 18 91 2000 SBC T2.LO+VIA1 IN CPU CYCLES
0395- 4A          2010 LSR          DIVIDE BY 4
0396- 4A          2020 LSR          TO LIMIT RESULT
0397- 4A          2030 LSR          BETWEEN 0 & 16
0398- 4A          2040 LSR
0399- 4B          2050 .05  PHA
039A- A9 B3      2060 LDA #LINE9  LOAD SCREEN LINE OFFSET
039C- CA          2070 DEX
039D- EB          2080 INX          IS X=0 ?
039E- F0 02      2090 BEQ .10
03A0- A9 DF      2100 LDA #LINE11 ALTERNATE OFFSET
03A2- 85 D1      2110 .10  STA LINE    SET LINE POINTER
03A4- B4 FB      2120 LDY TMP,X  PREVIOUS PLOT INDEX
03A6- A9 20      2130 LDA #*20    SPACE
03A8- 91 D1      2140 STA (LINE),Y CLEAR OLD PLOT
03AA- 68          2150 PLA
03AB- AB          2160 TAY
03AC- 94 FB      2170 STY TMP,X  SAVE NEW PLOT INDEX
03AE- A9 2B      2180 LDA #*2B    '+'
          2190 *-----*
          2200 *
          2210 *
DUTY CYCLE MONITOR FOR VIL-20
03B0- 91 D1      2190 STA (LINE),Y DISPLAY TO SCREEN
03B2- 60          2200 RTS
          2210 *-----*

```

VIA can be programmed to detect either a positive or negative transition at the CA1 pin via the Peripheral Control Register. (This is just one of sixteen registers contained in each VIA.)

The approach is fairly straightforward. First set the VIA to detect a negative transition of CA1, and wait for that transition to occur. Then immediately start one of the VIA timers that counts down at the basic CPU clock rate. While the timer is counting, set the VIA to detect a positive transition of CA1, and wait for the transition. When it occurs, read the contents of the timer. Subtracting this value from the initial one results in the duration (in CPU cycle time units) of the negative portion of the input waveform. Since the ideal sync waveform is a square wave with a frequency of about 3 KHz (3000 cycles per second), its half-cycle duration is about 167 microseconds. For a CPU clock speed of 1 MHz this is equivalent to 167 timer units.

Allowing a measurement range of 0 to 255 seems reasonable and limits the arithmetic to the low byte of the 16-bit timer value. A graphic display is more desirable than a numeric one, but the VIC's display is limited to 22 columns per line. Although higher resolution could have been obtained by defining special plot characters through screen bit mapping techniques, I found that a lo-res plot was adequate. The timer measurement was divided by 16 to limit the range from 0 to 15. The '+' symbol was plotted on the screen by storing it directly in screen memory, using the time duration as an offset.

Next, this entire operation was repeated for the positive portion of the input waveform. This measurement is plotted below the previous one. When the plot symbols line up, both cycles have the same time duration.

Apparently the VIC is occasionally interrupted by the other VIA timers to perform routine housekeeping functions. No attempt was made to disable this activity and this sometimes results in a scrambled plot. A check is made on the timer high byte to help clean up this interference. Since the timer is initialized to 255 at the start of the count-down and a duration of 176 is normally expected, if the high byte is found to be nonzero, it is likely that this measurement was corrupted and the results invalid. An invalid measurement is indicated by locating the plot symbol at the leftmost position.

## The BASIC Program

The BASIC program shown in listing 1 includes the machine-language routine just described. Of the various methods considered to combine machine language with BASIC, I decided that a simplified approach was less prone to error, although less memory efficient. The first hurdle to overcome was a conflict in number bases. BASIC requires that numbers be in decimal, whereas hexadecimal is more natural for machine code. As can be seen from the listing, the machine-language routine is entered as a hexadecimal string and lines 105 through 125 perform a conversion to decimal. The resultant value is then POKED into the RAM space allocated to the cassette file buffer. Since no file data is input during this measurement, this space remains unused and is a convenient place to put the machine-language program. (Note that it takes about four seconds to convert and store 115 bytes.)

Line 145 defines a plotting scale with time increasing toward the right with a scale factor of about 16 microseconds per column. Line 160 sets the

screen color from white to black for those lines (9, 10, and 11) that will contain plot characters. Line 165 initializes two temporary page-zero locations which hold the location of the previous plot position. Before plotting the new point the old plot symbol must be erased by writing a space over it. Finally, line 170 calls the machine-language routine with the SYS command. After a pair of points are plotted, control returns to that line where the keyboard is tested for input. Hitting any key exits the program, otherwise it loops back to plot another pair of points. Remember that control returns to BASIC only if a signal is detected on the cassette input line (but you can use RESTORE to quit at any time).

Just a final word on the printout shown in listing 1. My Epson MX-80 printer does not print those special VIC-20 display control characters which show up as graphics symbols. Thus the inverse heart symbol used to indicate 'clear screen' is not printed within the quote marks on lines 5 and 150. Similarly the nine 'cursor down'

inverse Q symbols did not get printed in line 155. Make sure you include them when you type in the program. Lines 140 and 170, however, are just null strings with nothing between the quote marks.

## References

1. "Add a Cassette Interface to Your VIC-20," *BYTE*, March 1982.
2. "VIC-20 Programmer's Reference Guide," Commodore Business Machines, Inc.

Bob Kovacs has been captivated by microcomputers since the Apple II made its debut four years ago. He has recently been unraveling some of the mysteries of the VIC-20 and is actively involved with several microcomputer hardware and software projects. He may be contacted at 41 Ralph Road, West Orange, NJ 07052.

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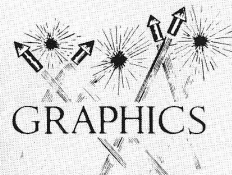
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- ERR:** Stack fix for Applesoft ONERR handling.
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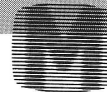
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# Interfacing the Color Computer

by John Steiner

**Circuits to interface the Color Computer to an RS-232 port and a motor control relay are presented. A Morse Code send/receive program is included as a demonstration.**

## Morse Code

requires:

TRS-80 C  
Interface hardware  
Code-send hardware

One of my goals was to write a program that would send machine-quality Morse code, but two good friends beat me to it. Arlin Karger and Ken Christiansen spent many hours learning how to interface the computer to other equipment. The techniques discussed here will assist you in your particular application.

## Interfacing to the Outside World

The Color Computer has three output ports built into its system — the motor control relay, the RS-232 port, and the cassette port. The program listed here can use two of them. The motor control relay is used to key a transmitter. The REM statement in line 35 outlines the changes that must be made to the program to implement an RS-232 option.

The output ports on the TRS-80C are peripheral interface adapters (PIAs). These versatile ICs look like just another memory location to the processor, while allowing the programmer to use them to input or output data. Since these devices are memory mapped, a simple PEEK will read data from the outside world, while a POKE will write data out. The programmer must initialize the PIA to perform either an input or output function, upon power-up. The BASIC interpreter has done this for us, so using these locations is simple. A POKE 65313,60 will close the cassette motor control relay, allowing the cassette to run if it is in play. POKE 65313,52 turns off this relay.

Another output port, the RS-232 data-out line, is controlled by memory location 65312. POKE 65312,0 and POKE 65312,2 change the logic state of the data-out pin on the RS-232 port. After the program description, several interface circuits are shown, which can be used to connect the Color Computer to a transmitter, or almost any external device.

## Program Details

This program was inspired by a Morse send-receive program for the model I/III TRS-80 in *QST* magazine. After lamenting that the program would not run on the TRS-80C, Arlin attempted to duplicate its transmit functions. He ran into quite a few problems trying to adapt the program to the Color Computer. This listing barely resembles the original version, and many additions and features have been added that make it a real ham operator's program. However, credit for the algorithm belongs to J.C. Sprott, W9AV, and is gratefully acknowledged.

After Arlin finished work on the program, he found that there were timing and processing problems. The code it sent had a real "banana boat swing." Programming to precision timing in BASIC is a challenge in itself, so Arlin called upon Ken to assist in fine-tuning the program. The program now only lacked a receive function. This was not considered to be a serious handicap, since most Morse code programs have difficulty decoding all but the most precisely sent text. Ken thought it would be nice, however, to add a keyboard routine the operator could use to copy the message as it is being sent. The operator would be able to review the text of the contact at his leisure.

Meanwhile, Arlin was not content to leave the transmit section alone, so he went back to work. First he added a cursor that followed along, sending text behind the type-ahead buffer, then adding three message buffers to be called

at the operator's request. These buffers are probably the most useful accessory a code operator can have. Each buffer can store up to 254 characters, so you could store nearly an entire contact in the buffer.

## Program Initialization

The program REMarks indicate changes that can be made if you have a 32K machine. Essentially you are able to store a larger receive buffer. You also have two options for interfacing your computer with the transmitter. You may use either the cassette motor relay or the RS-232 interface. Included are a few inexpensive, easily built circuits that perform the interface function. More details on these later.

The program execution begins with a POKE command, which switches the microprocessor into the high speed mode. As a result, internal timing of the machine is increased by a factor of two. One caution is in order here: do not exit this program with the BREAK key. If you do, you will still be in high speed, and tape saves and loads will crash with an error. Press the < \$ > key to end the program. This will return the computer to normal speed. Or press the RESET button on the right rear of the computer. Another caution: if you have a Color Computer disk system, you will have to unplug it and load this program from cassette or rewrite the timing loops to work in low speed, as the disk system will not support the high-speed POKE. If you attempt to execute the POKE with a disk in the drive, you may lose all information on the disk. Some non-disk Color Computers will not support the high-speed POKE because the PIAs that handle keyboard and other interfacing duties are not fast enough. If, after running this program, the computer locks up, or operates erratically, you will have to remove the POKE commands and rewrite the timing routine. Maximum reliable sending speed will drop to about 20 WPM.

After reserving memory, program control branches to line 760, where memory is reserved, and the code look-up table is entered into memory. Though DIM statements are usually put at the beginning of a program, timing of the sending was erratic until the two array statements were moved closer to the lines associated with the send routine. We're still trying to figure out why. You will be asked to input the speed in words per minute, after which the instructions are printed. Then the dot/dash ratio is optimized in the routine starting at line 450, and the main program routine begins in the receive mode with line 200.

### Operation of the Receive Section

A control loop, initiated in lines 210 to 300, gets characters from the keyboard using the INKEY\$ function. Lines 230 to 250 check each key entered for the command symbols that allow branching away from the receive section. To switch between transmit and receive, just press the up arrow. To end the program, you must press the dollar sign key. Pressing the <@> key will display the transmit menu and allow you to change speed; transmit; or review, load, and/or send the three transmit buffers.

If the ampersand key (&) is found, control will branch to the display receive buffer routine, so you may review the receive text as desired. Upon entering the transmit mode, the latest receive text is added to the end of the receive buffer. As a result, this breaks the buffer into blocks of text that can be reviewed one at a time. Line 440 contains the subroutine that increments the text block counter as each group of text is being stored, and also increments if the string length reaches 200 characters. You may look at any section of the receive buffer or, by entering <1000>, return to receive.

Line 260 helps to keep words from being broken up at the right edge of the screen. For the user, the computer becomes an electric typewriter with CRT readout.

### The Transmit Section

When you are ready to transmit, you have two choices: you can press the up arrow to go directly to transmit, or press the <@> key to display the transmit menu. The transmit section begins at line 1100, where the screen clears and TX appears in the upper left-hand corner. You may begin typing, and the transmit cursor will follow

### Listing 1: Morse Code Send-Receive

```

5 REM THIS CW SENDING PROGRAM WAS WRITTEN FOR THE TR880 COLOR COMPUTER BY ARLIN
  KARGER, WDOHXD AND THE RECEIVE, TYPING FUNCTION WAS ADDED BY KENNETH CHRISTIAN-
  EN, WOCZ. THE IDEA WAS INSPIRED BY AN ARTICLE IN JULY 81 QST BY W9AV.
15 REM QUESTIONS MAY BE DIRECT- ED TO WDOHXD MOORHEAD, MINN OR WOCZ FARGO, N.D.
25 REM FOR 32K CHANGE LINE 60 TO CLEAR 18000; CHANGE LINE 760 TO DIM RA$(300)
35 REM FOR RS232 OUTPUT CHANGES IN LINES 990 AND 1210 TO POKE 65312,0 AND L
  INES 1020 AND 1240 TO POKE 65312,2
40 POKE65495,0
50 FCLEAR1
60 CLEAR5000
70 GOTO750
80 RX=1
90 CLS:PRINT@19B,"<ENTER> SPEED (WPM)";:INPUT S
100 GOSUB630
110 SS=800/S-19
120 CLS:PRINT@10,"INSTRUCTIONS"
130 PRINT"PRESS <^> TO TRANSMIT";:PRINT
140 PRINT"PRESS <^> TO RETURN TO RECEIVE";:PRINT
150 PRINT"PRESS <SHIFT AND $> TO REVIEW RECEIVE PART OF QSD";:PRINT
160 PRINT"PRESS <@> FOR SPECIAL TRANSMIT FUNCTIONS";:PRINT
170 PRINT"PRESS <SHIFT AND $> TO END PROGRAM";:PRINT:PRINT
180 INPUT"PRESS <ENTER> TO CONTINUE";:RR
190 GOSUB8450
200 CLS:PRINT"RECEIVE"
210 RA$=INKEY$
220 IF RA$=""THEN210
230 IF RA$="^"GOSUB440:GOTO1100
240 IF RA$="$"GOTO1330
250 IF RA$="@"THEN800
260 IF POS(0)>22THEN IF RA$=CHR$(32)THEN RA$=CHR$(13)
270 PRINT RA$;
280 IF RA$="&"THEN310
290 IF LEN(RA$(RX))<200THEN RA$(RX)=RA$(RX)+RA$ ELSE GOSUB440
300 GOTO210
310 FOR RY=1TORX-1
320 PRINT RY"---"RA$(RY)
330 NEXT RY
340 INPUT"PRESS<ENTER> TO CONTINUE";:RR
350 CLS:PRINT@67,"NUMBER OF SEGMENT OF QSD"
360 PRINT@16B,"TO BE REVIEWED"
370 PRINT@257,"1000 TO RETURN TO MAIN PROGRAM"
380 INPUT RS
390 IF RS=1000GOTO200
400 IF RS>RX-1 OR RS<1THEN380
410 CLS:PRINT RA$(RS)
420 INPUT"PRESS <ENTER> TO CONTINUE";:RR
430 GOTO350
440 RX=RX+1:RETURN
450 D=-30
460 F=.6
470 IF S>7THEND=-20:F=.6
480 IF S>8THEND=-10:F=.6
490 IF S>11THEND=-1:F=.7
500 IF S>14THEND=1:F=.8
510 IF S>16THEND=2:F=.9
520 IF S>18THEND=0:F=1
530 IF S>22THEND=0:F=1.2
540 IF S>24THEND=10:F=1.4
550 IF S>25THEND=5
560 IF S>26THEND=5:F=1.7
570 IF S>28THEND=20:F=2
580 IF S>29THEND=5
590 IF S>30THENDF=2.4
600 IF S>32THEND=5:F=2.8
610 IF S>34THEND=5:F=3.5
620 RETURN
630 IF S>30THEN90
640 IF S>30THENS=35
650 IF S>29THENS=33
660 IF S>28THENS=30
670 IF S>27THENS=28
680 IF S>26THENS=27
690 IF S>25THENS=26
700 IF S>24THENS=25
710 IF S>24THENS=5
720 IF S>5THENS=5
730 RETURN
740 GOTO 750
750 CLS:PRINT@200,"PLEASE STAND BY"
760 DIM RA$(200)
770 DIM P(47,6)
780 FOR Q=1TOD47:FOR U=1TOD6:READ P(Q,U):NEXT U,Q
790 GOTO80
800 PRINT:PRINT:PRINT"0= SEND FROM KEYBOARD","1= SEND BUFFER #1","2= SEND BUFFER
  #2","3= SEND BUFFER #3","4= STORE BUFFERS","5= CHANGE SPEED","6= REVIEW BUFFER
  S","7= RECEIVE";:PRINT
810 INPUT"WHICH ACTION?(1-7)";:WA:CLS
820 IF WA=0THEN1100
830 IF WA=1THEN B$=MA$:IF MA$=""THEN800:GOTO940
840 IF WA=2THEN B$=MB$:IF MB$=""THEN800:GOTO940
850 IF WA=3THEN B$=MC$:IF MC$=""THEN800:GOTO940
860 IF WA=4THEN1350
870 IF WA=5THEN90
880 IF WA=6THEN1530
890 IF WA=7THEN200
900 IF WA>7THEN800
910 DATA 5,5,1,1,5,5,1,5,1,5,1,0,1,5,1,5,1,5,5,1,1,5,1,0,5,5,5,5,0,1,5,5,5,0
  ,1,5,5,5,0,1,1,1,5,5,0,1,1,1,5,0,1,1,1,1,0,5,1,1,1,1,0,5,5,1,1,1,0,5,5,5,1
  ,1,0,5,5,5,5,1,0,5,5,5,1,1,1,5,1,5,1,5,1,1,1,1,0,5,1,1,1,5,0

```

(Continued)

**Listing 1 (Continued)**

```

920 DATA 1,1,1,5,1,5,1,5,5,1,1,0,0,0,0,0,1,5,0,0,0,0,5,1,1,1,0,0,5,1,5,1,0,0
,5,1,1,0,0,0,1,0,0,0,0,0,1,1,5,1,0,0,5,5,1,0,0,0,1,1,1,1,0,0,1,1,0,0,0,0,1,5,5,5
,0,0,5,1,5,0,0,0,1,5,1,1,0,0,5,5,0,0,0,0,5,1,0,0,0,0,5,5,5,0,0,0,1,5,5,1,0,0
930 DATA 5,5,1,5,0,0,1,5,1,0,0,0,1,1,1,0,0,0,5,0,0,0,0,1,1,5,0,0,0,1,1,1,5,0,0
,1,5,5,0,0,0,5,1,1,5,0,0,5,1,5,5,0,0,5,5,1,1,0,0
940 X=0
950 X=X+1:V$=MID$(B$,X,1):IF V$="@"THEN1100
960 Q=ASC(V$)-43
970 IF Q<1 OR Q>47 THEN PRINT " ":FOR U=1 TO 16*SS/5:NEXT:GOTO 1060 ELSE PRINT
V$:
980 FOR T=1TO10:NEXT
990 FOR U=1TO 6:IF P(Q,U)=0 THEN GOTO 1060 ELSE POKE 65313,60
1000 FOR Y=D TO F*(SS*P(Q,U)):NEXT
1010 FOR T=1TO10:NEXT
1020 POKE 65313, 52
1030 FOR Y=2 TO SS:NEXT
1040 FOR T=1TO10:NEXT
1050 NEXT U
1060 FOR U=6 TO 2*SS:NEXT
1070 FOR T=1TO10:NEXT
1080 B$=INKEY$:IF B$="@"THEN1100
1090 GOTO 950
1100 CLS:PRINT "TX":B$="":X=0:V$=""
1110 CS#=CHR$(143+112)
1120 B$=MID$(B$,2)
1130 Z$=V#+CS#+MID$(B$,2)
1140 PRINT@X,Z$:
1150 E$=INKEY$:B$=B#+E$:PRINT E$:
1160 V$=MID$(B$,1,1):IF V$="" THEN 1150
1170 IF V$="@" THEN 800
1180 IF V$="^" THEN 200
1190 Q=ASC(V$)-43
1200 IF Q<1OR Q>47 THEN PRINT"":FOR U=1 TO 4*SS/5:E$=INKEY$:B$=B#+E$:PRINT$:;
NEXT:GOTO 1290
1210 FOR U=1 TO 6:IF P(Q,U)=0 THEN GOTO 1290 ELSE POKE 65313, 60
1220 FOR Y=D TO F*(SS*P(Q,U)):NEXT
1230 E$=INKEY$:B$=B#+E$:PRINT E$:
1240 POKE 65313, 52
1250 E$=INKEY$:B$=B#+E$:PRINT E$:
1260 FOR Y=2 TO SS:NEXT
1270 E$=INKEY$:B$=B#+E$:PRINT E$:
1280 NEXT U
1290 FOR U= 6 TO 2*SS:NEXT
1300 E$=INKEY$:B$=B#+E$:PRINT E$:
1310 X=X+1:IF X=415 THEN X=0:CLS
1320 GOTO 1120
1330 POKE 65494,0
1340 END
1350 PRINT"ENTER BUFFER #1 (Y/N)"
1360 YN$=INKEY$:IF YN$="@"THEN1360
1370 IF YN$="Y" THEN 1390
1380 IF YN$<>"Y"THEN1400
1390 CLS:LINE INPUT"ENTER BUFFER #1 ";MA$:MA$=MA$+"@"
1400 PRINT"ENTER BUFFER #2 (Y/N)"
1410 YN$=INKEY$
1420 IF YN$="@"THEN1410
1430 IF YN$="Y"THEN1450
1440 IF YN$<>"Y"THEN1460
1450 LINE INPUT"ENTER BUFFER #2 ";MB$:MB$=MB$+"@"
1460 PRINT"ENTER BUFFER #3 (Y/N)"
1470 YN$=INKEY$
1480 IF YN$="@"THEN1470
1490 IF YN$="Y"THEN1510
1500 IF YN$<>"Y"THEN1520
1510 LINE INPUT"ENTER BUFFER #3 ";MC$:MC$=MC$+"@"
1520 GOTO 800
1530 PRINT "BUFFER #1 =",MA$:INPUT"PRESS <ENTER>";RR:PRINT:PRINT "BUFFER #2 =",
,MB$:INPUT"PRESS <ENTER>";RR:PRINT:PRINT "BUFFER #3 =",MC$:INPUT "PRESS <ENTER>";
,RR:GOTO800

```

**Table 1: Parts List**

Component	Radio Shack Part Number
Q1 NPN	276-2016
Q1 PNP	276-2023
D1, D2	275-1101
RL1	275-004
R1	1 K ½ watt
R2	10 K ½ watt
RS-232 Plug	26-3020 four-pin DIN cable that Radio Shack provides for the Color Computer. Cut it in two pieces, and save the remainder for another project.

Mini Phone Jack — 2 conductor 1/8 inch to connect to motor control plug on cassette cable.

Miscellaneous hardware, etc., to connect to your transmitter.

along behind you sending what has been entered from the keyboard. Again, the INKEY\$ function is used to get keys from the keyboard. The keyboard is checked between each element of each character being sent. This gives the operator plenty of access to the keyboard, but you must develop a consistent typing stroke. Typing speed will be affected by code speed. You will have to slow your typing, and use a consistent entry speed, or you may lose characters.

Each character is converted to its ASCII value, minus 43, in line 1190, where it is compared to the look-up table array. Note that the code is actually stored in this array. Initial values are one for a "dit," and five for a "dah," with correction applied after the speed is selected.

Don't use the backspace key or try to type too far ahead of the text being sent. Either of these actions will cause sending problems. Try to keep only a line or so ahead, although no problems should begin until you get more than 255 characters ahead. As characters are being sent directly from the buffer string (B\$), a backspace could branch to a subroutine that eliminates the last character of B\$. This, however, will affect the timing, so modifications in the send routine will result in modifications to the statements in lines 450 to 730.

To return to receive, just press the up arrow. If you wish to use the transmit buffers, press the <@> key, which will transfer control to line 800, where the Transmit menu will be displayed. The menu allows the following options: send from the keyboard; send message 1, 2, or 3; store messages; change speed; review messages; or, return to receive.

Choosing the store message option will send program control to line 1350. The "ENTER MESSAGE #1 (Y/N)" prompt will appear. Enter a Y and you may enter a message, otherwise you will be asked if you want to enter the second message. After stepping through each message, control returns to the transmit menu. The messages are stored with an <@> symbol at the end, which will send control immediately to the menu so you may choose another message or return to transmit or receive.

**Interface Circuits**

This section describes five circuits that allow you to interface the computer to the transmitter, or any device that needs a logic state change to perform a desired function. Do not key a

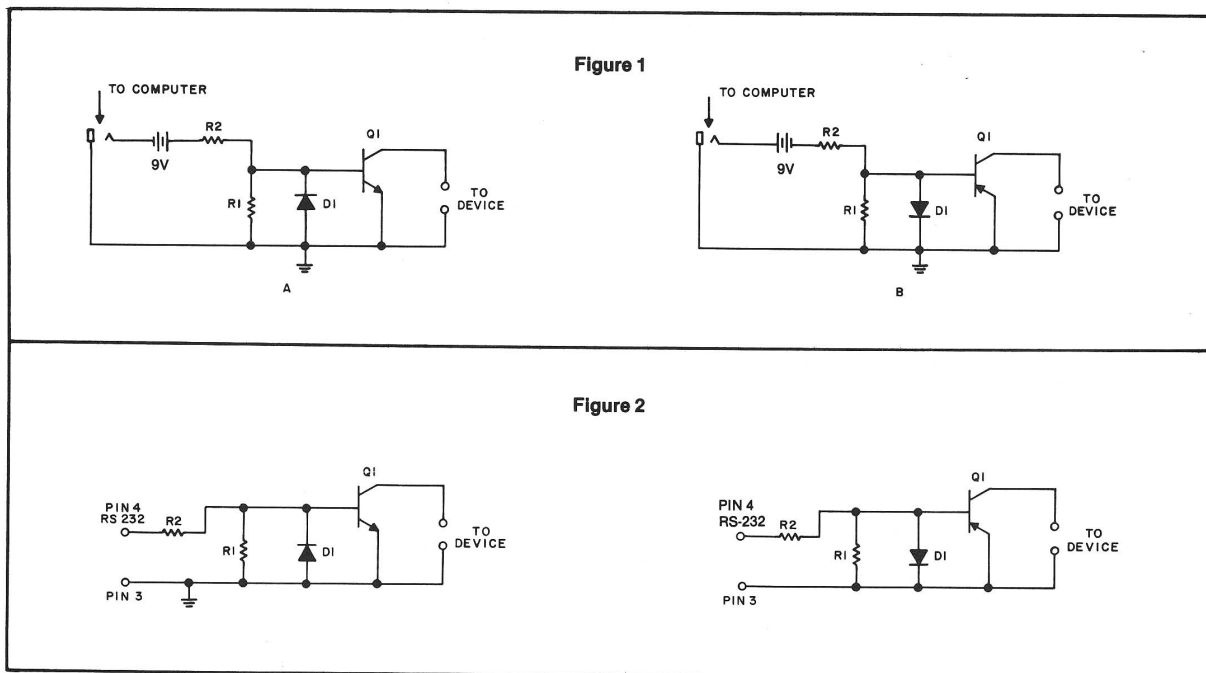
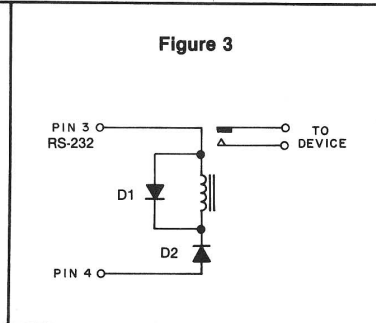


Figure 1

Figure 2

Figure 3



logic level of the RS-232 will key the transmitter on until the program initiates and shuts it off. Figure 3 contains another RS-232 circuit that uses only a relay and a couple of diodes. The advantage of using the RS-232 is that no external voltage source is required.

All parts are available from Radio Shack, and their part numbers are listed in table 1. All circuits could be easily wired onto perfboard, or mounted on a PC board.

The program listing is quite long, and if you decide not to type it in, a cassette version is available. Just send \$5.00 to:

Arlin Karger  
2214 South Eleventh St.  
Moorhead, MN 56560

We hope this article will inspire you to develop techniques that let you interface your computer to the world around it. The applications are limited only by the imagination.

John Steiner is an electronics instructor in the Fargo, ND school system. His hobbies include programming, amateur radio, and writing. He has written articles for several publications, and is at present completing a book on electronics. John's computer system includes a 32K TRS-80C with Radio Shack disk system, and an Epson MX-80 printer.

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transmitter, or other high current device, directly from the motor control relay. It is not built for that kind of demand.

Figure 1 contains two circuits — either can be used to interface the computer. Figure 1A is for positive-going logic, while 1B is for transmitters with grid-block keying or other negative-going bias circuits. Figure 2 contains two circuits that can be used to connect to the RS-232 interface. Again, figure 2A is for positive logic, and 2B is for negative bias circuits. If you have grid-block keying, and you intend to use the RS-232 jack, you must reverse the data in the POKE statements from what is stated in the REM in line 35. In other words, lines 990 and 1210 must contain POKE 65312,2 and 1020, and line 1240 uses POKE 65312,0. Also, if you have grid-block keying, you must be careful not to turn on the transmitter until the program is running and ready to send. This is because the normal



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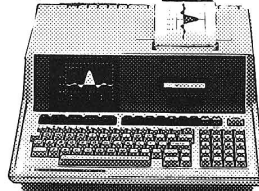
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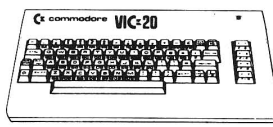
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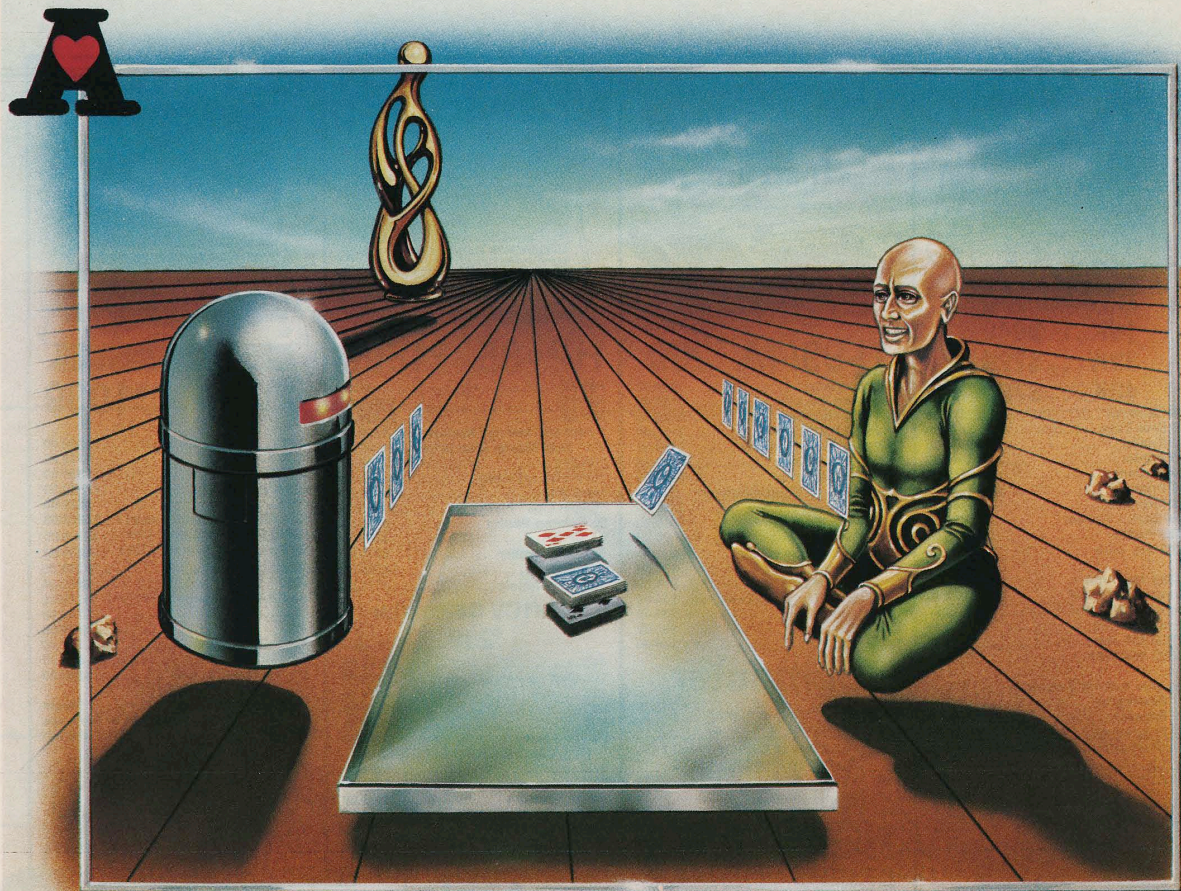
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## Reviews in Brief

---

**Product Name:** Disassembler 6809  
**Equip. req'd:** TRS-80C Color Computer with 16K memory  
**Price:** \$19.95  
**Manufacturer:** Soft Sector Marketing  
6250 Middlebelt  
Garden City, MI 48135

**Description:** This product is a disassembler written in BASIC and distributed in Color Computer cassette format. Besides the intended disassembly function, which basically goes to the screen, it has a printer output and a rather nice subroutine trace function. It also has a "Zap" display mode which zips through code and displays three columns of two-byte values, without regard for opcodes, etc; in other words, a screen dump. The subroutine mode allows the user to stop the current disassembly pass and trace down a subroutine, with nesting to 20 levels. At the end of a side excursion, the program will return to the same page of disassembly it was on when diverted.

**Pluses:** Low cost and reasonable speed of operation, thus greatly expanding the capability of the computer's BASIC to include assembly-language experimentation. Easy to use, with short learning curve. Although the program is not able to directly handle data tables, it flags inappropriate values with "bad opcode" and this should alert the user to the possibility of the presence of a data table at the address being disassembled. The experienced 6809 programmer will be able to define quickly the data table, and the disassembler quickly "syncs up" with valid code following the data.

**Minuses:** No problems noted except that for instructions of the form LEAX LABEL,PCR, the output fails to specify the ,PCR mode for instructions using 16-bit offset (8-bit offset instructions are correctly specified). This is a relatively minor bug, and does no harm as long as the user is aware of it.

**Skill level required:** In general, a user would need to be quite familiar with the computer's assembly language before being able to derive a significant amount of information from any disassembler.

**Reviewer:** Ralph Tenny

---

**Product Name:** Compuvoice Synthesizer  
**Equip. req'd:** TRS-80 Color Computer, 16K or 32K with Extended BASIC  
**Price:** \$44.95  
**Manufacturer:** Spectral Associates  
141 Harvard Avenue  
Tacoma, WA 98466

**Description:** The *Compuvoice Synthesizer* is a completely software-based phoneme speech generator for the TRS-80C. It is a machine-language routine that resides in high memory. Access to the synthesizer is via USR calls. The phonemes are generated in software and are sent to the

audio circuit in the monitor. Using the synthesizer is not difficult. Strings are defined that contain special phoneme symbols. These strings are the arguments in the USR call. For example, X\$ = "/AAAYT/":A\$ = USR0(X\$) is all the code that is required for the computer to pronounce the word "eight". You can redefine the strings and pronounce new words and phrases. String length is limited only by BASIC's 255-character limit.

**Pluses:** The routine is easy to load and execute. The phonemes are easily defined and generated. The process of learning to operate the synthesizer teaches the programmer the techniques of artificial speech generation. Though based on international language, the phonemes have been changed to single key characters for easy entry. The synthesizer needs no hardware modifications and uses only 8336 bytes.

**Minuses:** The actual speech is difficult to understand at best. I spent a lot of time trying to make it say certain phrases and was not often successful in having an interested observer understand what it was saying. Certain phrases are easier to understand than others. Even the demonstration program provided, which speaks the numbers from one to nine, had numbers that were difficult to understand.

**Documentation:** An excellent five-page manual explains the operation of the program, and loading and use in BASIC programs. Also included are instructions on creating speech using phoneme synthesis. Within only a few minutes, I had created a program that allowed me to enter and edit strings to be spoken.

**Skill level required:** Knowledge of BASIC programming, especially string handling techniques. No previous knowledge of speech synthesis is required.

**Reviewer:** John Steiner

---

**Product Name:** Dot Matrix Serial Impact Printer  
**Model 8510 Prowriter**  
**Equip. req'd:** Any computer with either parallel or serial interface  
**Price:** \$740.00  
**Manufacturer:** C. Itoh Electronics, Inc.  
5301 Beethoven Street  
Los Angeles, CA 90066

**Description:** A dot matrix printer using a 7x9 matrix for alphabetic characters, an 8x8 matrix for graphics. Both parallel and serial (to 9600 baud) interfaces are standard. Input buffer holds 1.5K bytes. Printing speed is 100 CPS or 44 LPM (80-character lines). Both sprocket and friction feed are standard. Maximum paper width 9.5", print line 8". Four type faces are standard: pica, elite, compressed, and proportional (10, 12, 17, and 14 cpi). All are available in boldface; all except proportional in elongated

## Reviews in Brief *(continued)*

(double-width). Bit-image graphics standard: 8 dots in matrix addressable by bit.

**Pluses:** Well-formed characters, true lower-case descenders, German, Swedish, and some Japanese characters. Extensive choice of options — both hardware and software — including 16 horizontal tabs, vertical tabs to any line, line-feed selectable in 1/144-inch increments.

**Minuses:** None serious. Print quality not quite equal to a daisy wheel printer although excellent for dot matrix. A wider carriage and higher printing speeds would be convenient.

**Documentation:** "Preliminary" 60-page manual. Complete and well-written. The few typographical errors do not appear at critical points.

**Skill level required:** Minimal, if the computer has a suitable output port. Considerable programming ability needed to take full advantage of all options.

**Reviewer:** Rolf B. Johannesen

---

Product Name: **"SLIM" Single Board Computer**  
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depends upon application with  
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\$ 39.95 - bare board

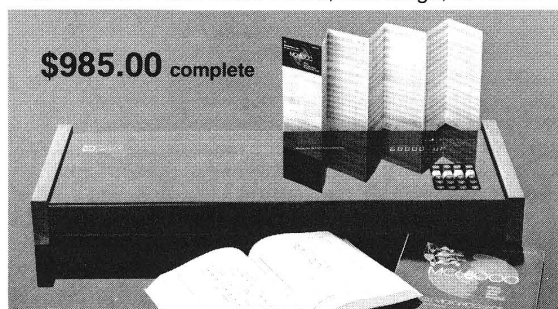
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P.O. Box 338  
Redwood City, CA 94064

**Description:** "SLIM" is an acronym for Single-board Large-scale Integration Microcomputer. It gives more power than a KIM-1 on a 4.5" x 6.5" PC board, but there is no keyboard or display. (An external terminal is used if the JBE 4K monitor ROM is used in the EPROM socket.) Otherwise, the user must furnish a mode of communication. A fully loaded SLIM has four 2114 RAM chips, one EPROM socket which may be jumpered for 2716/2516 or 2532 EPROMs, and two 6522 VIAs. Sixteen port lines and four handshake lines from each 6522 are brought to four separate 16-pin sockets, and the industry-standard dual 22-pin edge connector duplicates the KIM expansion connector pinout, except for signals which are unique to KIM. In addition, the address and data lines are fully buffered, and the address decoding scheme from KIM is used. However, since the memory map is significantly different, KIM software would require considerable modification to be used. The circuit design of this product is well done, and relatively minor modifications can be made to effect major changes in board function and capability. The JBE Monitor (\$39.95 in a 2532 EPROM) has provision for 110-2400 baud.

**Pluses:** Good design, standard size, KIM/AIM bus compatibility, and easy expansion. Kit and bare-board users will have little trouble expanding to 8K of read/write memory directly; with additional decoding, 32K or 48K of memory can be added easily with modern memory technology. Similarly, the I/O space and ROM space can be further decoded.

**Minuses:** Bare-board users may have difficulty finding a 16 MHz crystal (a 7493 TTL counter divides this down to 1 MHz), and should try to purchase the crystal with the board.

**Documentation:** Skimpy, but adequate for the experienced hacker or engineer.

**Skill level required:** Even users who buy the assembled and tested unit must have above average experience to apply this product. I found this point to be common with all single-board computer/controller products.

**Reviewer:** Ralph Tenny

---

Product Name: **DTL BASIC**  
Equip. req'd: 32K CBM/PET with CBM disk to compile. Some BASIC and adequate memory to hold object file required at run-time. Both require a cassette-port dongle protection device.  
Price: \$350; Run-time dongle \$50  
Manufacturer: Canadian Micro Distributors  
365 Main St.  
Milton, ONT L9T1P7, Canada

**Description:** PET BASIC compiler. Takes as input any normal BASIC program file on disk and converts it into a machine-language equivalent. The new file may be loaded and run normally. Uses a 4K run-time module, but compacts source lines. As a result, any program will still fit in memory after being compiled. Compiles 1-2 lines/second. Various listings and information can be printed during compilation. Errors are always shown. At run-time, errors

## Reviews in Brief *(continued)*

halt with the usual message and a decimal address. An Error Locate program calculates the matching source line number. The major benefit is speed. Even optimized BASIC programs execute twice as fast as usual, unless slowed by peripherals. Well-structured programs execute at triple speed. DTL BASIC also includes a special integer mode. Programs using only integer variables execute twenty times faster than usual. Pseudo-ops are included for changing some or all variables in existing programs to integers during compilation. A side effect of compilation is that the program becomes difficult to view or change. DTL BASIC also requires a special connector be in place at all times while the compiler or compiled programs run. If a second optional connector is placed on the other cassette port during compilation, the program may later be run with it alone. It comes in standard and custom-keyed versions.

**Pluses:** Nearly bug-free and very easy to use. Re-compiles with a few keystrokes. Integer converter is helpful, though not automatic. Variables may be seen and changed normally. Compatible with packages that extend BASIC with non-standard syntax. Stopped programs may be continued with SYS, not CONT. The STOP key may be disabled without disturbing the clock. Compiler may be backed up for safety.

**Minuses:** Major disadvantage is the required run-time dongle. Run-time protection should be a user option. Not able to pass variables between modules of multi-module programs.

**Documentation:** Quite readable and fairly brief, all in a nice binder. Could use a summary page.

**Skill level required:** Almost none for first use.

**Reviewer:** Jim Strasma

---

Product Name: **Screen Writer**  
Equip. req'd: Apple II or Apple II Plus  
(16K memory card optional)  
Price: \$125.00  
Manufacturer: On-Line Systems  
3675 Mudge Ranch Rd.  
Coarsegold, CA 93614  
Author: Michael D. Shetter  
Copy Protection: Yes  
Language: 6502 Machine Language

**Description:** A word processor with extensive features at an extremely reasonable price.

**Pluses:** Provides the owner of a minimal Apple with upper- and lower-case characters and an up to 70-character display with no additional hardware. This is done through the use of the hi-res screen and generation of hi-res characters. By an electrical modification, the shift key can be used as on a standard typewriter (otherwise ESC is used for upper/lower case). The program uses the disk as virtual memory allowing the creation of a single document as large as disk space will permit. If a 16K memory card is present, the additional memory will be used. Has all the usual commands; search and replace, cursor movement, appending files from the disk, a delete/get buffer. Also allows for tab sets. Optionally generates a key click sound through the Apple speaker.

The program consists of two modules: the editor and the runoff (for printing). The user can obtain rough draft print-

ing directly from the editor, but the listing does not contain format control. The runoff program contains many of the most desirable print control features affecting margins, paging, text positioning, headings, hyphenation, and type style.

The package also includes a form letter capability for merging two text files, one containing the letter and the other the data base of names, addresses, etc.

A printing spooler routine permits the printing of one document while editing a second. This is accomplished by first creating an output file which contains all of the correctly formatted text. This file is fed to the printer while the user continues to edit a second document.

**Minuses:** Because the program uses the hi-res screen for display, the insertion of text in the middle of existing text can be annoyingly slow. While there is an input buffer which continues to accept characters as they are printed, it is possible to type faster than the display, so that the incoming text is not visible. After a pause, the display will catch up with the typed input. By moving the cursor to the bottom of the screen, this delay can be avoided since the amount of hi-res memory to be moved is reduced.

**Skill level required:** After some training, any Apple user can get maximum benefit using this word processor.

**Reviewer:** David Morganstein

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# Structured Programming in 6502 Assembly Language

by Kim G. Woodward

**This discussion of structured programming demonstrates how to use it to improve and simplify your programming methods.**

Wouldn't it be nice if someone came along and gave you some good advice about assembly language or BASIC programming? The best advice I've heard lately has been based on the idea of structured programming. What is it, and what can it do for you?

For years the bane of programming has been that the programmer who writes the program is often not the one who will maintain it. Payroll programs are a good example of this problem. For one reason or another, over the life of a piece of software, many modifications may be made. The design, coding, and testing of a program follows the 40-20-40 rule: The design takes 40 percent of the time it takes to finish a program, coding takes 20 percent, and testing takes the last 40 percent. What is not obvious is that over the life cycle of a piece of software, the whole effort to put a program together takes only 20 percent of the time. The other 80 percent is taken up in maintenance (debugging and modification). Structured programming can make this phase much more efficient.

## What Is Structured Programming?

Structured programming limits a programmer to a finite set of control structures (elements such as loops, "if" statements, etc.). A program's flowchart is sometimes considered to be the program's logic or set of control structures. A flowchart, however, is one of the most dangerous devices ever conceived by the programming industry. When a design is made, a flowchart is usually drawn up to describe what the program is to do logically. But

once the coding is done from that flowchart, the flowchart is usually never updated to reflect any changes made to the program. As a result, a flowchart often does not reflect the actual program that it is supposed to describe. Use of that flowchart may create errors in the program when changes are made.

Structured programming is based on the mathematically-proven Structure Theorem (due in original form to Bohm and Jacopini), which states that any program with one entry and one exit is equivalent to a program that contains as logic structures only the following: sequences of two or more operations, decision (IF a THEN b ELSE c), and repetition of an operation (DOWHILE a). Variations include the case statement, which is a form of "if-then-else;" and the "do-until" loop, which is a variant of the "do-while." A flowchart representation of these constructs is shown in figure 1. The blocks can represent single or multiple statements, or one of the accepted control constructs. Over the years since structured programming was introduced, the software industry has proven over and over that these constructs reduce the complexity of the actual code writing, make the code easier to read, maintain or change, and reduce the programming problem to a number of easily defined modules.

If a programmer confines himself to the control structures of structured programming, and refrains from any others, he will find no need for a flowchart. This may be a little hard to live with from the viewpoint of the older programmers. The colleges and technical schools used to teach that a flowchart had to be drawn first before code could be put down. However, a simpler type of documentation results when you write software using structured programming and pseudo-English such as:

```
open a file
read a record
while (the record is not the end) do
  process the record
  if (the record is from a female) then
    denote female record
  else
    denote male record
  endif
  output processed information
  read a record
enddo
close the file
end of program
```

A flowchart of the above process is shown in figure 2. The "while-do-*enddo*" process is very easily defined. In a "while-do" construct you test the condition before entering the loop. If the condition is true, you do the body of the condition and come back for another test of the condition. However, if the condition is false, then the program goes to the next line following the while-do construct. Likewise, the "if-then-else-*endif*" is easily defined. If the test of the condition is true, the then clause is executed. The else clause of the "if-then-else-*endif*" construct is executed when the results of the condition are false.

Pseudo-English is a hybrid language that uses the vocabulary of one language, English, and the overall syntax of another, structured programming. Each step of a process is described in English at whatever level of detail is appropriate at the particular level of design. This type of documentation turns out to be easier to update than a flowchart could ever be. Each pseudo-English line could represent many lines of actual programming code. This introduces the concept of leveling in the documentation. As an example, the line reading "output processed information" may represent many hundreds

## PROGRAMMING TECHNIQUES

of lines of pseudo code at the next level down. If I were to code this program in BASIC using the allowable control constructs, it would look like this:

```

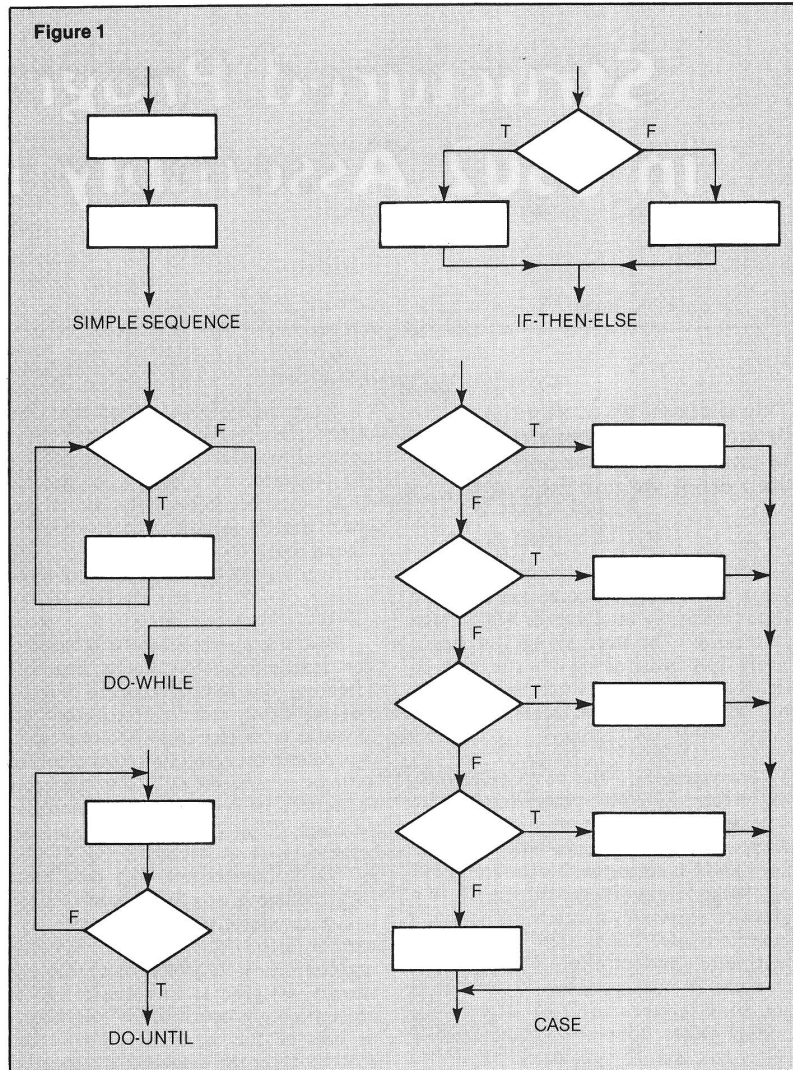
1000 REM ** open a file **
1010 REM ** read a record **
1020 IF NOT(designation-for-end?)
    THEN 1130
1030 REM ** process the record **
1040 IF NOT(female-record?)
    THEN 1070
1050 REM ** denote female record **
1060 GOTO 1090
1070 REM cont.
1080 REM ** denote male record **
1090 REM cont.
1100 REM ** output processed information **
1110 REM ** read a record **
1120 GOTO 1020
1130 REM cont.
1140 REM ** close the file **
1150 END
    
```

The advantages of programming in this manner cannot be overstated. In BASIC the use of REM statements with \*\* will designate modules that have not yet been coded. When you begin writing the code that corresponds to the module, you simply remove the \*\* from the REM statement and insert the code. If your module is a subroutine, you remove the \*\* and then insert a GOSUB. You may object to the frequent use of REM as a dummy statement (such as the continue in FORTRAN). However, the use of dummy statements allows you to insert code at will into the control constructs if you have a reasonably intelligent line renumberer. BASIC control constructs corresponding to the structured programming constructs in figure 1 are shown in figure 3.

Now that we have a handle on what can be done in BASIC programming, how do we apply the same constructs to 6502 assembly-language programming?

### What is the Problem in Assembly Language?

One problem in using decision points in 6502 assembly language is how to define the branches. A slightly more annoying problem is the 128-byte limit on the branch. We will assume that the flag registers will be set before the decision point is reached. Therefore, we can set up a number of constructs corresponding to the legal comparisons of the BASIC language. The table in figure 4 shows the flag results from a comparison between the A register and a memory location referred



to by the CMP instruction. Thus the pseudo-English (with some 6502 assembly language) for three of the allowed constructs are:

#### (1) IF-THEN-ELSE-ENDIF

```

    setup for condition
    branch on condition to LBLZ
    JMP LBL1
LBLZ NOP
    do true part
    JMP LBL2
LBL1 NOP
    do false part
LBL2 NOP
    
```

#### (2) WHILE-DO-ENDDO

```

LBL1 NOP
    setup for condition
    branch on condition to LBLZ
    JMP LBL2
    
```

```

LBLZ NOP
    do body portion
    JMP LBL1
LBL2 NOP
    
```

#### (3) REPEAT-UNTIL-ENDO

```

LBL1 NOP
    do body portion
    setup for condition
    branch on condition to LBLZ
    JMP LBL1
LBLZ NOP
    
```

Note that in each case we have allowed for constructs that exceed 128 bytes. To illustrate the use of these constructs, suppose I had the following pseudo-English statement:

```

IF a = b THEN increment z ELSE
decrement z ENDIF
    
```

## PROGRAMMING TECHNIQUES

This statement could be rendered, following our convention, in assembly language as:

```
LDA A
CMP B
BEQ LBLZ
JMP LBL1
LBLZ NOP
INC Z
JMP LBL2
LBL1 NOP
DEC Z
LBL2 NOP
```

In each of the allowed constructs the branching is done on the inverse of

the condition tested for. If we set up the conditions properly and allow for greater than 128-byte branches the conditional tests are:

(1) if  $a < b$  then part-a else part-b endif

```
LDA A
CMP B
BCC LBLZ
JMP LBL1
LBLZ NOP
do part-a
JMP LBL2
LBL1 NOP
do part-b
LBL2 NOP
```

(2) if  $a \leq b$  then part-a else part-b endif

```
LDA A
CMP B
BEQ LBLZ
BCC LBLZ
JMP LBL1
LBLZ NOP
do part-a
JMP LBL2
LBL1 NOP
do part-b
LBL2 NOP
```

(3) if  $a < > b$  then part-a else part-b endif

```
LDA A
CMP B
BNE LBLZ
JMP LBL1
LBLZ NOP
do part-a
JMP LBL2
LBL1 NOP
do part-b
LBL2 NOP
```

(4) if  $a = b$  then part-a else part-b endif

```
LDA A
CMP B
BEQ LBLZ
JMP LBL1
LBLZ NOP
do part-a
JMP LBL2
LBL1 NOP
do part-b
LBL2 NOP
```

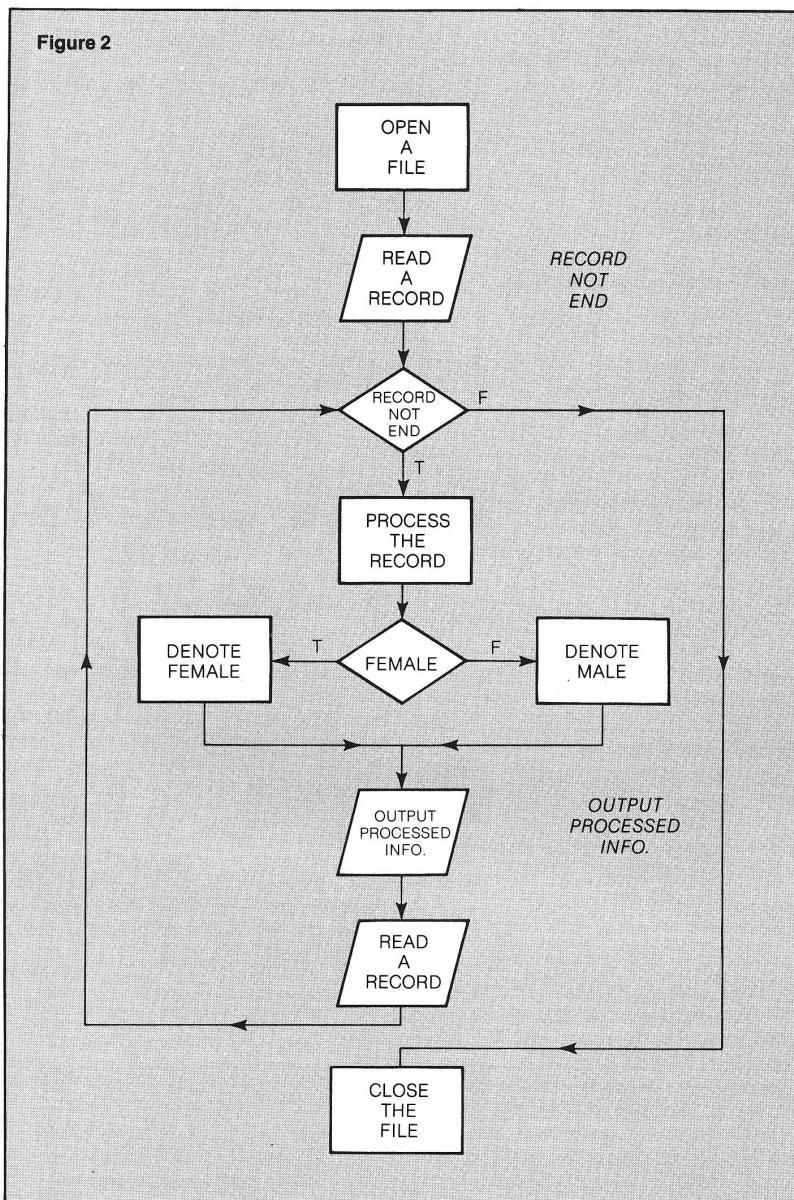
(5) if  $a > b$  then part-a else part-b endif

```
LDA A
CMP B
BEQ LBLZ
BCS LBLZ
LBLX JMP LBL1
LBLZ NOP
do part-a
JMP LBL2
LBL1 NOP
do part-b
LBL2 NOP
```

(6) if  $a \geq b$  then part-a else part-b endif

```
LDA A
CMP B
BCS LBLZ
JMP LBL1
LBLZ NOP
do part-a
JMP LBL2
LBL1 NOP
do part-b
LBL2 NOP
```

Figure 2



## PROGRAMMING TECHNIQUES

(7) while a < b do part-a enddo

```
LBL1 NOP
  LDA A
  CMP B
  BCC LBLZ
  JMP LBL2
LBLZ NOP
  do part-a
  JMP LBL1
LBL2 NOP
```

(8) while a <= b do part-a enddo

```
LBL1 NOP
  LDA A
  CMP B
  BEQ LBLZ
  BCC LBLZ
  JMP LBL2
LBLZ NOP
  do part-a
  JMP LBL1
LBL2 NOP
```

(9) while a <> b do part-a enddo

```
LBL1 NOP
  LDA A
  CMP B
  BNE LBLZ
  JMP LBL2
LBLZ NOP
  do part-a
  JMP LBL1
LBL2 NOP
```

(10) while a = b do part-a enddo

```
LBL1 NOP
  LDA A
  CMP B
  BEQ LBLZ
  JMP LBL2
LBLZ NOP
  do part-a
  JMP LBL1
LBL2 NOP
```

(11) while a > b do part-a enddo

```
LBL1 NOP
  LDA A
  CMP B
  BEQ LBLX
  BCS LBLZ
  JMP LBL2
LBLX JMP LBL2
LBLZ NOP
  do part-a
  JMP LBL1
LBL2 NOP
```

(12) while a >= b do part-a enddo

```
LBL1 NOP
  LDA A
  CMP B
  BCS LBLZ
  JMP LBL2
LBLZ NOP
  do part-a
  JMP LBL1
LBL2 NOP
```

(13) do part-a until a < b enddo

```
LBL1 NOP
  do part-a
  LDA A
  CMP B
  BCC LBLZ
  JMP LBL1
LBLZ NOP
```

(14) do part-a until a <= b enddo

```
LBL1 NOP
  do part-a
  LDA A
  CMP B
  BEQ LBLZ
  BCC LBLZ
  JMP LBL1
LBLZ NOP
```

(15) do part-a until a <> b enddo

```
LBL1 NOP
  do part-a
  LDA A
  CMP B
  BNE LBLZ
  JMP LBL1
LBLZ NOP
```

(16) do part-a until a = b enddo

```
LBL1 NOP
  do part-a
  LDA A
  CMP B
  BEQ LBLZ
  JMP LBL1
LBLZ NOP
```

(17) do part-a until a > b enddo

```
LBL1 NOP
  do part-a
  LDA A
  CMP B
  BEQ LBLX
  BCS LBLZ
  JMP LBL1
LBLX JMP LBL1
LBLZ NOP
```

(18) do part-a until a >= b enddo

```
LBL1 NOP
  do part-a
  LDA A
  CMP B
  BCS LBLZ
  JMP LBL1
LBLZ NOP
```

along the way we encounter an escape character (\$1B), then we will enter an escape routine called 'escp' instead of putting to the buffer. The pseudo-English version is as follows:

```
get a character
WHILE (character is not CR) DO
  IF (character is ESC) THEN
    do escape sequence
  ELSE
    add character to buffer
  ENDIF
  get a character
ENDDO
return
```

The assembly-language routine corresponding to this pseudo-English version is as follows:

```
JSR GET          get a character
LB1  NOP          while...
      CMP #$0D
      BNE LBZ
      JMP LB2
LBZ  NOP          ...DO
      CMP #$1B    IF...
      BEQ LBLZ
      JMP LBL1
LBLZ NOP          ...THEN
      JSR ESCP
      JMP LBL2
LBL1 NOP          ELSE...
      JSR PUT
LB2  NOP          ENDIF
      JSR GET     get a character
      JMP LB1
LB2  NOP          ENDDO
      RTS        return
```

### In Conclusion

I have shown that both 6502 assembly language and BASIC can use structured programming constructs. I have also shown that by designing the program with pseudo-English statements, the structured programming constructs of necessity stand out. I have shown that structured programming allows you to modify a program with little or no change to the logic. This method allows for simplicity of maintenance and thus reduces the cost factor of the maintenance portion of the program's life cycle.

---

The author may be contacted at 6526 Delia Dr., Alexandria, VA 22310.

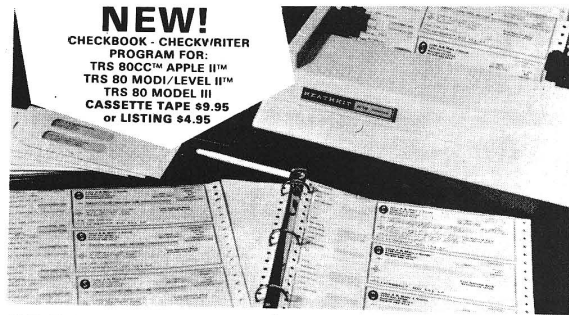
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# Pattern-Matching with the 6502 on the Apple

by Charles F. Taylor, Jr.

**Pattern-matching algorithms attempt to find one or more occurrences of a given character string in a specified range of memory. This article presents elementary and advanced algorithms.**

## Pattern Matching

Developed on an Apple II Plus, but no Apple-specific features used. Should be usable on other 6502-based microcomputers.

In this article I discuss both elementary and advanced pattern-matching algorithms and present relocatable implementations of each in 6502 assembly language. Although these programs were developed using an Apple II Plus, no Apple-specific features were used; the resulting programs should therefore be usable on the AIM, SYM, KIM, or other 6502-based microcomputer.

You may often associate pattern matching with applications such as text editing. I was motivated to pursue the topic for quite a different reason: I wanted to find and modify the jump table used for processing commands in an assembler. As I am often at least as interested in methodology as in results, I did some research on the subject and would like to share my findings.

In pattern matching we are concerned with two strings, the pattern and the target. Each string consists of a sequence of bytes. Each byte will be assumed to be devoid of any meaning other than its numerical value (0-255 decimal); for the purposes of this discussion, however, the bytes in each string will be referred to as characters and will be represented as letters in the figures.

## Elementary Pattern Matching

It is easy to tell whether a pattern occurs at a particular starting position in the target string. The first character of the pattern is lined up with that starting position in the string, and corresponding characters are compared until a mismatch is found, or until the last character of the pattern has been matched. The elementary pattern-matching algorithm thus begins by aligning the pattern with the first character of the target. If a match occurs, fine. If not, the pattern is aligned with the second character of the target, and so on. The algorithm is given in a form of structured pseudo-code in figure 1, and illustrated by example in table 1. In table 1 the \* indicates the pattern character at which the first mismatch occurred in each step.

Implementation on the 6502 of the algorithm of figure 1 presented several problems. Comparison of successive characters is easy, provided that the length of the pattern is restricted to 255 characters so that the Y register can be used for post-indexed addressing. This is certainly a reasonable restriction. Determining when the target string is exhausted would also be easy if the target string were restricted to 255 characters, but this was rejected as an unreasonable restriction. Such a restriction might be reasonable for a line editor with length limited to 255 characters, but it is not sufficiently general for our purposes here.

It therefore appeared as if a 16-bit comparison would be necessary each time through the main loop to determine whether or not the target string has been exhausted. This would obviously be a slow procedure with an 8-bit microprocessor. Consequently, I decided to post a sentinel or End-Of-String (EDS) character at the end of the target string so that the end of the target can be detected more easily. This

requires that the target string reside in RAM as opposed to ROM, but this restriction was deemed acceptable as a design trade-off. As long as a sentinel was being used for the target string, I decided to use one for the pattern string as well. Characters displaced by the sentinels are saved on the stack and replaced upon completion of the search.

If both the target and pattern were restricted as ASCII characters, selection of character for use as a sentinel would be easy: simply use \$FF, or some other unused code. Allowing each character in the pattern and target strings to take on any value from \$00 to \$FF makes the problem more difficult.

For a pattern restricted in length to 255 characters, there must be at least one character (two-digit hexadecimal number) which does not occur in the pattern. The problem is to find it. A solution is to start with \$FF as a candidate sentinel and to compare it with each character in the pattern; if a match is found, the candidate is decremented and the process repeated until a suitable sentinel is found. Typically the process takes only one or two passes.

For the target string, there is no guarantee that a sentinel exists that does not also occur somewhere in the target (because the target may consist of more than 255 characters). The solution is to use whatever sentinel is selected for the pattern. Whenever the sentinel character is found in the target string, perform a 16-bit comparison to determine whether the target string is exhausted. This procedure takes more code, but it will be relatively fast because only rarely will the sentinel occur in the target (except in bizarre cases).

The elementary pattern-matching program is shown in listing 1. To use the program the starting address of the pattern must be placed in locations

**Figure 1: Elementary Pattern-Matching Algorithm**

```

BEGIN
  BEGTAR := 0;
  J := 0;
  WHILE BEGTAR <= N-M DO
    WHILE TARGET(BEGTAR+J)=PATTERN(J) DO
      J := J + 1;
      IF J <= M THEN GOTO PATTERN.FOUND
    ENDWHILE;
    BEGTAR := BEGTAR + 1;
    J := 0;
  ENDWHILE;
  PATTERN.NOT.FOUND: RETURN 0;
  PATTERN.FOUND: RETURN BEGTAR;
END.
    
```

**Table 1: Example of Elementary Pattern-Matching Algorithm**

```

PATTERN: a b a a b c
          0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

TARGET:  a a b b a a b a a b a a b c a b c

Step: 1 a b* a a b c
      2 a b a* a b c
      3 a* b a a b c
      4 a* b a a b c
      5 a b* a a b c
      6 a b a a b c*
      7 a* b a a b c
      8 a b* a a b c
      9 a b a a b c
    
```

\* First character of PATTERN at which mismatch occurs

Comparisons:

Step	TARGET	PATTERN	Match?
1	0	0	yes
	1	1	no
2	1	0	yes
	2	1	yes
	3	2	no
3	2	0	no
4	3	0	no
5	4	0	yes
	5	1	no
6	5	0	yes
	6	1	yes
	7	2	yes
	8	3	yes
	9	4	yes
	10	5	no
7	6	0	no
8	7	0	yes
	8	1	no
9	8	0	yes
	9	1	yes
	10	2	yes
	11	3	yes
	12	4	yes
	13	5	yes

Total Comparisons: 24

**Figure 2: Knuth-Morris-Pratt Algorithm**

```

BEGIN
  Compute the NEXT table;
  BEGTAR := 0;
  J := 0;
  WHILE BEGTAR <= N-M DO
    WHILE TARGET(BEGTAR+J)=PATTERN(J) DO
      J := J + 1;
      IF J <= M THEN GOTO PATTERN.FOUND
    ENDWHILE;
    IF NEXT(J)=-1 THEN
      BEGTAR := BEGTAR + J;
      J := 0;
    ELSE
      BEGTAR := BEGTAR + (J - NEXT(J));
      J := NEXT(J);
    ENDIF
  ENDWHILE;
  PATTERN.NOT.FOUND: RETURN 0;
  PATTERN.FOUND: RETURN BEGTAR;
END.
    
```

**Table 2: Example of Advanced Pattern-Matching Algorithm**

```

PATTERN: a b a a b c
          0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

TARGET:  a a b b a a b a a b a a b c a b c

Step: 1 a b* a a b c
      2 a b a* a b c
      3 a b* a a b c
      4 a b a a b c*
      5 a b a a b c
    
```

Comparisons:

Step	TARGET	PATTERN	Match?
1	0	0	yes
	1	1	no
2	1	0	yes
	2	1	yes
	3	2	no
3	4	0	yes
	5	1	no
4	5	0	yes
	6	1	yes
	7	2	yes
	8	3	yes
	9	4	yes
	10	5	no
5	10	2	yes
	11	3	yes
	12	4	yes
	13	5	yes

Total Comparisons: 17

\$02-\$03, the starting address of the target in \$04-\$05, the ending address of the target in \$06-\$07 (all with low-order byte first), and the pattern length in \$08. The main entry point is at the beginning of the program (\$6000). The result, returned in \$00-\$01, will be the location where the pattern was found in the target, or 0000 if the pattern was not found. A secondary entry point is provided at \$6020. This may be used to continue the search for subsequent occurrences of the pattern.

**Analysis of the Elementary Algorithm**

The elementary pattern-matching algorithm described above is straightforward and relatively easy to implement. Closer examination of table 1, however, suggests that improvements can be found.

For convenience, let us refer to the target and the pattern as arrays of characters whose subscripts begin with 0. The first element of the pattern is thus PATTERN(0), etc. At the completion of step 2 of table 1, we have just compared TARGET(3), the fourth element of the target string, with PATTERN(2) and found a mismatch. The

elementary algorithm would next compare TARGET(2) with PATTERN(0). Earlier in step 2, however, we established that TARGET(2) is a "b" (because it matches PATTERN(1)) and cannot possibly match PATTERN(0), which is an "a". Step 3 of the elementary algorithm is therefore unnecessary.

Step 4 of the elementary algorithm compares TARGET(3) with PATTERN(0). Step 2, however, established that TARGET(3) didn't match PATTERN(2), which is an "a", and that it therefore cannot match PATTERN(0), which is also an "a". Step 4 is therefore also unnecessary. Similar analysis will show that steps 7 and 8 are also unnecessary.

The problem with the elementary pattern-matching algorithm can be characterized by stating that it does not make full use of the information available to it at any given time. What information is available to it at a given time? Suppose that we are now about to look at TARGET(I) and PATTERN(J) and that all previous characters of the pattern matched the corresponding target characters. We thus know PATTERN(0), PATTERN(1),... PATTERN(J-1). In addition, because of the fact

that they match, we also know TARGET(I-J+1), TARGET(I-J+2),..., TARGET(I-1). Since all previous (before TARGET(I-J+1)) target characters have not resulted in a successful match, it is not necessary to keep track of them. It is therefore sufficient at any given time for the algorithm to have knowledge of the current characters in the target and pattern strings and the previously examined characters of the pattern string. It should never be necessary to go backwards in the target string!

**Advanced Pattern Matching**

The algorithm demonstrated in table 2 corrects the deficiencies noted. It is called the Knuth-Morris-Pratt (KMP) algorithm, and was independently discovered by J. H. Morris in 1969 and by D.E. Knuth in 1970. V.R. Pratt, in collaboration with Knuth, refined the algorithm.

Recall that the elementary algorithm sometimes backs up to reconsider characters in the target that have already been considered. (For example, see step 7 of table 1.) It was Morris's objective to develop an algorithm that would eliminate the need to back up

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## PROGRAMMING TECHNIQUES

the target string. This would allow him to consider characters of the target string one at a time as they were received from a file, thus eliminating the need to provide buffer space for the target file. (Notice that the KMP algorithm achieves this goal.) Considerations of efficiency were otherwise secondary. Pratt discovered that the running time of the KMP algorithm was proportional to  $M + N$ , where  $M$  is the pattern length and  $N$  is the target length. The running time of the elementary algorithm required 24 comparisons and the KMP algorithm 17 comparisons.

### Elementary vs. Advanced Pattern Matching

The Knuth-Morris-Pratt algorithm is certainly more sophisticated than the elementary algorithm, but is it any better in practice? How each algorithm performs in a particular instance depends most importantly on the number of partial matches that will be encountered before the final match is found. The KMP algorithm is at its best, and the elementary algorithm at its

worst, when such partial matches are numerous. When there are few partial matches, the sequence of comparisons generated by each algorithm is about the same. In such cases, however, the extra complexity required to implement the KMP algorithm incurs a penalty in speed.

It is my conclusion that for most microcomputer applications the elementary algorithm is preferable to the advanced algorithm. Not only is it simpler and more compact, it is often faster as well. A test was conducted to compare execution speed. A four-character pattern was imbedded near the end of a 32K target text. It took the elementary algorithm 1.6 seconds to find it; the KMP algorithm took 2.6 seconds.

The KMP algorithm is not the only advanced pattern-matching algorithm around. A new algorithm by Boyer and Moore shows promise for cases in which there are few partial matches. The algorithm is unfortunately even more complex in its implementation than the KMP algorithm, requiring not

one but two precomputed tables. It thus seems likely that microcomputer users would do well to stay with the elementary algorithm.

### References

1. Knuth, Donald E., Morris, James H. Jr., Pratt, Vaughn R., "Fast Pattern Matching in Strings," *SIAM Journal of Computing*, Vol.6, No.2, June 1977.
2. Boyer, R.S., and J.S. Moore, "A Fast String Searching Algorithm," *Communications of the ACM*, 20 (No.10), November 1977.

Charles F. Taylor may be reached at 587F Sampson Lane, Monterey, California 93940.

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**Listing 1**

```

0010 ;ELEMENTARY PATTERN MATCHING
0020 ;FOR THE 6502
0030 ;
0040 ; BY C. F. TAYLOR, JR.
0050 ; 19 MAY 1981
0060 ;
0070 ;
0080 ; PATTERN: UP TO 255 CHARS
0090 ; PUT ADDR IN #02-#03 (LD-HI)
0100 ; PUT LENGTH OF PATTERN IN #08
0110 ; TARGET: ANY LENGTH (IN RAM)
0120 ; PUT START ADDR IN #04-#05
0130 ; PUT END ADDR IN #06-#07
0140 ; RESULT: #00-#01 WILL CONTAIN LOC
0150 ; WHERE PATTERN FOUND OR
0160 ; 0000 IF PATTERN NOT FOUND
0170 ;
0180 ;
0190 ;
0200 ; PAGE ZERO EQUATES
0210 ;
0220 LOC .DE #00 ;RESULT LEFT HERE
0230 PADDR .DE #02 ;PTR TO 1ST BYTE OF PATTERN
0240 TADDR .DE #04 ;PTR TO 1ST BYTE OF TARGET
; STRING
0250 TRGTEND .DE #06 ;PTR TO LAST BYTE OF TARGET
0260 LENGTH .DE #08 ;LENGTH OF PATTERN
0270 ;
0280 ;
0290 .BA #09
0290 EDS .DS 1 ;END-OF-STRING CHAR
0300 BEGTAR .DS 2 ;POINTER TO TARGET STRING
0310 TEMP .DS 2
0320 ;
0330 ;
0340 ;
0350 ;
0360 ;INITIALIZE POINTER TO TARGET STRING
0370 ;
6000- A5 04 0300 MATCH LDA *TADDR
6002- B5 0A 0390 STA *BEGTAR
6004- A5 05 0400 LDA *TADDR+1
6006- B5 0B 0410 STA *BEGTAR+1
;
6008- A9 FF 0430 LDA #FF ;EOS CHAR
600A- B5 09 0440 STA *EDS
600C- A4 08 0450 L1 LDY #LENGTH ;BE SURE EOS CHAR
600E- B8 0A 0460 L2 DEY ;IS NOT IN PATTERN
600F- B1 02 0470 LDA (PADDR),Y
6011- C5 09 0480 CMP *EDS
6013- D0 05 0490 BNE L3
0500 ;
0510 ;EOS CHAR IN PATTERN, SO TRY ANOTHER
0520 ;
6015- C6 09 0530 DEC *EDS
6017- 18 0540 CLC
6018- 90 F2 0550 BCC L1
;
601A- 98 0570 L3 TYA ;LOOP UNTIL ALL
601B- D0 F1 0580 BNE L2 ;CHARS CHECKED
601D- 18 0590 CLC
601E- 90 06 0600 BCC MATCH2
0610 ;
0620 CONTINUE ;
0630 ;ALTERNATE ENTRY
0640 ;CONTINUE SEARCH AT BEGTAR+1
0650 ;
6020- E6 0A 0660 INC *BEGTAR
6022- D0 02 0670 BNE MATCH2
6024- E6 0B 0680 INC *BEGTAR+1
6026- A0 01 0690 MATCH2 LDY #1
6028- B1 06 0700 LDA (TRGTEND),Y
602A- 48 0710 PHA ;SAVE ORIG VALUE
602B- A5 09 0720 LDA *EDS ;SENTINEL VALUE
602D- 91 06 0730 STA (TRGTEND),Y ;SENTINEL FOR TARGET
602F- A4 08 0740 LDY #LENGTH
6031- B1 02 0750 LDA (PADDR),Y
6033- 48 0760 PHA ;SAVE
6034- A5 09 0770 LDA *EDS
6036- 91 02 0780 STA (PADDR),Y ;SENTINEL FOR PATTERN
0790 ;
0800 ;MAIN LOOP
0810 ; TEST FOR END OF TARGET
6038- A4 08 0820 WHILE1 LDY #LENGTH
603A- B1 0A 0830 LDA (BEGTAR),Y

```

(Continued)

**Listing 1 (Continued)**

```

603C- C5 09 0840 CMP *EDS ;SENTINEL REACHED?
603E- D0 17 0850 BNE OK
0860 ;
0870 ;IF EOS FOUND IN TARGET,
0880 ;MAKE SURE PAST TRGTEND
0890 ;
6040- 18 0900 CLC
6041- 98 0910 TYA ;TEMP:=BEGTAR+Y
6042- C5 0A 0920 ADC *BEGTAR
6044- B5 0C 0930 STA *TEMP
6046- A5 0B 0940 LDA *BEGTAR+1
6048- 69 0D 0950 ADC #0 ;ADD IN CARRY
604A- B5 0D 0960 STA *TEMP+1
604C- 38 0970 SEC
604D- A5 0E 0980 LDA *TRGTEND ;TRGTEND-TEMP
604F- E5 0C 0990 SBC *TEMP
6051- A5 07 1000 LDA *TRGTEND+1
6053- E5 0D 1010 SBC *TEMP+1
6055- 90 23 1020 BCC ENDMH1 ;IF PAST TRGTEND
6057- A0 00 1030 OK LDY #0 ;NOT PAST TRGTEND
6059- B1 02 1040 LDA (PADDR),Y
;
1050 ;
1060 ;CHECK FOR MATCH
1070 ;
605B- D1 0A 1080 WHILE2 CMP (BEGTAR),Y ;INNER LOOP
605D- D0 12 1090 BNE ENDMH2
605F- C8 1100 INY
6060- B1 02 1110 LDA (PADDR),Y
6062- C5 09 1120 CMP *EDS
6064- D0 F5 1130 BNE WHILE2
1140 ;
1150 ;PATTERN FOUND
1160 ;
6066- A5 0A 1170 LDA *BEGTAR
6068- B5 00 1180 STA #LOC
606A- A5 0B 1190 LDA *BEGTAR+1
606C- B5 01 1200 STA #LOC+1
606E- 18 1210 CLC
606F- 90 0F 1220 BCC EXIT
;
6071- E6 0A 1240 ENDMH2 INC *BEGTAR ;ADVANCE POINTER
6073- D0 C3 1250 BNE WHILE1
6075- E6 0B 1260 INC *BEGTAR+1
6077- 18 1270 CLC
6078- 90 0E 1280 BCC WHILE1
;
1290 ;
1300 ENDMH1 ;PATTERN NOT FOUND
1310 ;
607A- A9 00 1320 LDA #0
607C- B5 00 1330 STA #LOC
607E- B5 01 1340 STA #LOC+1
1350 ;
6080- A4 08 1360 EXIT LDY #LENGTH ;REPLACE SENTINELS
6082- 68 1370 PLA
6083- 91 02 1380 STA (PADDR),Y
6085- A0 01 1390 LDY #1
6087- 68 1400 PLA
6088- 91 06 1410 STA (TRGTEND),Y
608A- 60 1420 RTS
;EN
1430

```

**Listing 2**

```

0010 ;ADVANCED PATTERN MATCHING
0020 ;KNUTH-MORRIS-PRATT ALGORITHM
0030 ;
0040 ; 6502 VERSION BY C. F. TAYLOR, JR.
0050 ; 20 MAY 1981
0060 ;
0070 ;
0080 ; PATTERN: UP TO 255 CHARS
0090 ; PUT ADDR IN #02-#03 (LD-HI)
0100 ; PUT LENGTH OF PATTERN IN #08
0110 ; TARGET: ANY LENGTH (IN RAM)
0120 ; PUT START ADDR IN #04-#05
0130 ; PUT END ADDR IN #06-#07
0140 ; RESULT: #00-#01 WILL CONTAIN LOC
0150 ; WHERE PATTERN FOUND OR
0160 ; 0000 IF PATTERN NOT FOUND
0170 ;
0180 ;
0190 ;
0200 ; PAGE ZERO EQUATES

```

(Continued)

# PROGRAMMING TECHNIQUES

Listing 2 (continued)

```

0210 ;
0220 LOC .DE #00 ;RESULT LEFT HERE
0230 PADDR .DE #02 ;PTR TO 1ST BYTE OF PATTERN
0240 TADDR .DE #04 ;PTR TO 1ST BYTE OF TARGET STRING
0250 TRGTEND .DE #06 ;PTR TO LAST BYTE OF TARGET
0258 LENGTH .DE #08 ;LENGTH OF PATTERN
0270 ;
0280 .BA #09
0290 EDS .DS 1 ;END-OF-STRING CHAR
0300 BEGTAR .DS 2 ;POINTER TO TARGET STRING
0310 TEMP .DS 2
0320 M .DS 1 ;LENGTH-1
0330 T .DS 1 ;POINTER
0340 J .DS 1 ;POINTER
0350 ;
0360 .BA #6000
0370 ;
6000- A6 08 0390 SETUP LDX #LENGTH ;COMPUTE NEXT TABLE
6002- CA 0390 DEX
6003- 06 0E 0400 STX #M ;LENGTH-1
6005- A2 FF 0410 LDX #FF
6007- 06 0F 0420 STX #T
6009- A0 00 0430 LDY #0
600B- 04 10 0440 STY #J
600D- 0A 0450 TXA
600E- 99 0B 61 0460 STA NEXT,Y ;NEXT(0)=-1
6011- C4 0E 0470 WHIL3 CPY #M ;FINISHED?
6013- B0 39 0480 BCS ENDMHIL3 ;J#M
6015- A6 0F 0490 LDX #T
6017- 30 12 0500 BMI ENDMHIL4 ;T<=0
6019- A4 10 0510 WHIL4 LDY #J
601B- B1 02 0520 LDA (PADDR),Y ;PATTERN(J)
601D- A4 0F 0530 LDY #T
601F- D1 02 0540 CMP (PADDR),Y ;=PATTERN(T)?
6021- F0 08 0550 BEQ ENDMHIL4
6023- BD 0B 61 0560 LDA NEXT,X
6025- AA 0570 TAX
6027- 06 0F 0580 STX #T ;T:=NEXT(T)
6029- 10 EE 0590 BPL WHIL4
602B- E8 0600 ENDMHIL4 INX
602C- 06 0F 0610 STX #T ;T:=T+1
602E- E6 10 0620 INC #J ;J:=J+1
6030- A4 10 0630 LDY #J
6032- B1 02 0640 LDA (PADDR),Y ;PATTERN(J)
6034- A4 0F 0650 LDY #T
6036- D1 02 0660 CMP (PADDR),Y ;=PATTERN(T)?
6038- D0 0B 0670 BNE L5
603A- 09 0B 61 0680 LDA NEXT,Y
603D- A4 10 0690 LDY #J
603F- 99 0B 61 0700 STA NEXT,Y ;NEXT(J)=NEXT(T)
6042- 18 0710 CLC
6043- 90 CC 0720 BCC WHIL3
6045- A4 10 0730 L5 LDY #J
6047- 0A 0740 TXA
604B- 99 0B 61 0750 STA NEXT,Y ;NEXT(J)=T
604B- 18 0760 CLC
604C- 90 C3 0770 BCC WHIL3
0780 ENDMHIL3
0790 ;
0800 ;INITIALIZE POINTER TO TARGET STRING
0810 ;
604E- A5 04 0820 MATCH LDA #TADDR
6050- 05 0A 0830 STA #BEGTAR
6052- A5 05 0840 LDA #TADDR+1
6054- 05 0B 0850 STA #BEGTAR+1
0860 ;
6056- A9 FF 0870 LDA #FF ;EDS CHAR
6058- 05 09 0880 STA #EDS
605A- A4 08 0890 L1 LDY #LENGTH ;BE SURE EDS CHAR
605C- 08 0900 L2 DEY ;IS NOT IN PATTERN
605D- B1 02 0910 LDA (PADDR),Y
605F- C5 09 0920 CMP #EDS
6061- D0 05 0930 BNE L3
0940 ;
0950 ;EDS CHAR IN PATTERN, SO TRY ANOTHER
0960 ;
6063- C6 09 0970 DEC #EDS
6065- 18 0980 CLC
6066- 90 F2 0990 BCC L1
1000 ;
6068- 90 1010 L3 TYA ;LOOP UNTIL ALL
6069- D0 F1 1020 BNE L2 ;CHARS CHECKED
606B- 18 1030 CLC
606C- 90 06 1040 BCC MATCH2
    
```

(continued)

Listing 2 (continued)

```

1050 ;
1060 CONTINUE ;
1070 ;ALTERNATE ENTRY
1080 ;CONTINUE SEARCH AT BEGTAR+1
1090 ;
606E- E6 0A 1100 INC #BEGTAR,
6070- D0 02 1110 BNE MATCH2
6072- E6 0B 1120 INC #BEGTAR+1
1130 ;
6074- A0 01 1140 MATCH2 LDY #1
6076- B1 06 1150 LDA (TRGTEND),Y
6078- A8 1160 PHA ;SAVE ORIG VALUE
6079- A5 09 1170 LDA #EDS ;SENTINEL VALUE
607B- 91 06 1180 STA (TRGTEND),Y ;SENTINEL FOR TARGET
607D- A4 08 1190 LDY #LENGTH
607F- B1 02 1200 LDA (PADDR),Y
6081- A8 1210 PHA ;SAVE
6082- A5 09 1220 LDA #EDS
6084- 91 02 1230 STA (PADDR),Y ;SENTINEL FOR PATTERN
1240 ;
1250 ;MAIN LOOP
1260 ;
6086- A0 00 1270 LDY #0
6088- 04 10 1280 STY #J ;INITIALIZE POINTER
1290 ;
1300 ;END OF TARGET?
1310 ;
608A- A4 08 1320 WHIL1 LDY #LENGTH
608C- B1 0A 1330 LDA (BEGTAR),Y
608E- C5 09 1340 CMP #EDS ;SENTINEL REACHED?
6090- D0 17 1350 BNE OK
1360 ;
1370 ;IF EDS FOUND IN TARGET,
1380 ;MAKE SURE PAST TRGTEND
1390 ;
6092- 18 1400 CLC
6093- 98 1410 TYA ;TEMP:=BEGTAR+Y
609A- 65 0A 1420 ADC #BEGTAR
609E- 05 0C 1430 STA #TEMP
6099- A5 0B 1440 LDA #BEGTAR+1
609A- 69 0B 1450 ADC #0 ;ADD IN CARRY
609C- 05 0D 1460 STA #TEMP+1
609E- 38 1470 SEC
609F- A5 06 1480 LDA #TRGTEND ;TRGTEND-TEMP
60A1- E5 0C 1490 SBC #TEMP
60A3- A5 07 1500 LDA #TRGTEND+1
60A5- E5 0D 1510 SBC #TEMP+1
60A7- 90 51 1520 BCC ENDMH1 ;IF PAST TRGTEND
60A9- A4 10 1530 OK LDY #J ;NOT PAST TRGTEND
60AB- B1 02 1540 LDA (PADDR),Y
1550 ;
1560 ;CHECK FOR MATCH
1570 ;
60AD- D1 0A 1580 WHIL2 CMP (BEGTAR),Y ;INNER LOOP
60AF- D0 12 1590 BNE ENDMH2
60B1- C8 1600 INY
60B2- B1 02 1610 LDA (PADDR),Y
60B4- C5 09 1620 CMP #EDS
60B6- D0 F5 1630 BNE WHIL2
1640 ;
1650 ;PATTERN FOUND
1660 ;
60B8- A5 0A 1670 LDA #BEGTAR
60BA- 85 0B 1680 STA #LOC
60BC- A5 0B 1690 LDA #BEGTAR+1
60BE- 85 01 1700 STA #LOC+1
60C0- 18 1710 CLC
60C1- 90 3D 1720 BCC EXIT
1730 ;
1740 ENDMH2 ;COMPUTE WHICH PATTERN CHAR TO EXAMINE NEXT
1750 ;
60C3- 09 0B 61 1760 LDA NEXT,Y
60C5- C9 FF 1770 CMP #FF ;SPECIAL CASE
60C8- F0 18 1780 BEQ L6
60CA- 98 1790 TYA ;BEGTAR:=
60CB- 38 1800 SEC ;BEGTAR+(Y-NEXT(Y))
60CC- F9 0B 61 1810 SBC NEXT,Y
60CF- 18 1820 CLC
60D0- 65 0A 1830 ADC #BEGTAR
60D2- 85 0A 1840 STA #BEGTAR
60D4- A5 0B 1850 LDA #BEGTAR+1
60D6- 69 0B 1860 ADC #0
60D8- 85 0B 1870 STA #BEGTAR+1
60DA- 09 0B 61 1880 LDA NEXT,Y
    
```

(continued)



Listing 2 (continued)

```


60DD- 85 10 1890 STA *J
60DF- 18 1900 CLC
60E0- 90 A8 1910 BCC WHIL1
60E2- C8 1920 L6 ;GET NEW TARGET CHAR
60E3- 98 1930 INY ;BEGTAR:=
60E4- 18 1940 CLC ;BEGTAR+Y
60E5- 65 0A 1950 ADC *BEGTAR
60E7- 85 0A 1960 STA *BEGTAR
60E9- A5 0B 1970 LDA *BEGTAR+1
60EB- 69 0B 1980 ADC #0
60ED- 85 0B 1990 STA *BEGTAR+1
60EF- A0 0B 2000 LDY #0
60F1- 84 10 2010 STY *J
60F3- F0 95 2020 BEQ WHIL1 ;ALWAYS TAKEN
60F5- E6 0B 2030 INC *BEGTAR+1
60F7- 18 2040 CLC
60F8- 90 90 2050 BCC WHIL1
        ;
        ; PATTERN NOT FOUND
2070 ENDWH1
        ;
60FA- A9 00 2090 LDA #0
60FC- 85 00 2100 STA *LOC
60FE- 85 01 2110 STA *LOC+1
        ;
        ;
2120
6100- A4 08 2130 EXIT ;REPLACE SENTINELS
6102- 68 2140 PLA
6103- 91 02 2150 STA (PADDR),Y
6105- A0 01 2160 LDY #1
6107- 68 2170 PLA
6108- 91 06 2180 STA (TRGTEND),Y
610A- 60 2190 RTS
610B- 2200 NEXT ;ROOM FOR TABLE
        ;
2210 .EN
    
```

Figure 3: Construction of NEXT Table

```

BEGIN
T := -1;
J := 0;
NEXT(0) := -1;
WHILE J(M DO
    WHILE T)0 AND PATTERN(J)()PATTERN(T) DO
        T := NEXT(T)
    ENDWHILE;
    T := T + 1;
    J := J + 1;
    IF PATTERN(J)=PATTERN(T) THEN
        NEXT(J) := NEXT(T)
    ELSE
        NEXT(J) := T
    ENDIF
ENDWHILE;
END.
    
```

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# Random Number Generator in Machine Language for the Apple

by Arthur Matheny

**This simple subroutine can easily be implemented in a machine-language program whenever random numbers are needed. Two examples are provided.**

**Random Number Generator requires:**

Apple II or Apple II Plus

A random-number generator is needed in many applications — games, simulations, Monte Carlo methods, etc. The BASIC interpreter in my Apple II has a pseudo-random-number generator built in, but what about machine-language programs? I need to find the random-number routine in the BASIC ROM, but my manual does not tell me where it is located!

I decided to make a trip to the library, where I found several shelves of books about random numbers. I selected one: *The Generation of Random Variates*, written by T.G. Newman and P.L. Odell. Chapter 2 tells how to design a random-number generator, and chapter 9 tells how to test it.

The program I wrote passed all three tests that I put to it: the frequency test, the run test, and the serial test. In comparison, the random-number generator used by Apple's Integer BASIC passed the frequency test and the run test, but not the serial test. Failure to pass the serial test indicates that sequential pairs are not perfectly uncorrelated. That does not mean that the routine used by BASIC is no good; it means that mine is even better.

The execution speed can be a big factor in some applications. In the form presented here, the routine runs in 68 cycles or occasionally a few more. You can speed it up considerably by eliminating the loops and counters, thus making it into a straight-through calculation with absolute addressing.

The random number generator is given in listing 1. Before this routine is called for the first time, the main program should load seed values into memory locations \$10, \$11, \$12, and \$13. This is a pseudo-random-number generator, which means that the random sequence is predetermined by the values used to initialize these four locations.

There are two general methods to pick the seed values. At execution time you can input a number that your program uses to load the four bytes above. (The specific method that it would use to do this is not important.) If you enter the number that you executed yesterday, then you will get the results that

you did yesterday. This may or may not be desirable, depending on what the program does.

The second method is to generate the seed values in some unpredictable way. For example, if you have a real-time clock, you could use its reading as a random-number seed. I do not have a real-time clock, but on the Apple, the values in memory locations \$4E and \$4F roll around and around whenever the computer is waiting for a keystroke from the keyboard. These make excellent seed values. All I have to do is move \$4E to \$10 and \$12, and move \$4F to \$11 and \$13. Whatever method

## Listing 1

```

*****
;*                               *
;* 6502 MACHINE LANGUAGE        *
;* RANDOM NUMBER GENERATOR      *
;*                               *
;*      BY ART MATHENY          *
;*                               *
*****
;
; SUBROUTINE FOR USE WITH ML PROGRAMS
; USAGE: JSR $800
;
ARRAY EQU $10
;
; ARRAY IS A 4-BYTE INTEGER.
; MOST SIGNIFICANT BYTE IS AT LOCATION $10.
; LEAST SIGNIFICANT BYTE IS AT LOCATION $13.
; LOCATIONS $10 THROUGH $13 SHOULD BE SEEDED BEFORE
; THE SUBROUTINE IS FIRST CALLED.
; RESULT APPEARS IN LOCATION $10.
;
0800          ORG $800
0800 18      RND      CLC
0801 A203    LDX #3      ; NUMBER OF BYTES IN ARRAY - 1
0803 B510    LDA ARRAY,X
0805 CA      DEX
0806 7510    LOOP1   ADC ARRAY,X
0808 9510    STA ARRAY,X
080A CA      DEX
080B 10F9    BPL LOOP1
080D A203    LDX #3      ; ADD 1 TO ARRAY
080F F610    LOOP2   INC ARRAY,X
0811 D003    BNE RTS1
0813 CA      DEX
0814 10F9    BPL LOOP2
0816 60      RTS1     RTS
                          ENT

```

## PROGRAMMING TECHNIQUES

you use, you only need to seed these memory locations once. When that is done, you can call the random-number generator as many times as you like.

To call the routine from a machine-language program, use JSR \$800. This randomizes memory location \$10. Its new value is virtually uncorrelated with its previous value. Memory location \$11 is also randomized, but to a lesser degree. To call the routine from a BASIC program, use CALL 768, and then retrieve the random value by PEEK(16).

The "period" of this random-number generator is rather long. The sequence of numbers in memory location \$10 will not begin to repeat itself until after  $2^{32}$  numbers have been generated. If you expect to generate more numbers than that, change lines \$801 and \$80D to LDX #\$4 and include memory location \$14 in the initialization process.

The program in listing 2 is an example of an application of the random-number generator. It only works on an Apple II or Apple II Plus, and produces a visual effect that I call "Globular Cluster." Enter the monitor and input the program beginning at \$800. To execute it, type 800G in the monitor, and use the RESET key to stop it.

I have included this program to make a point: the pattern of stars will eventually repeat, but according to a crude calculation, I estimate that this will not happen until about four years from now.

### Reference

1. T.G. Newman and P.L. Odell, *The Generation of Random Variates*, Hafner Publishing Company, New York, 1971.

Art Matheny is director of computer-assisted instruction in the Biology Department at the University of South Florida. He has an MS degree in physics from Purdue University and taught physics for several years before recently turning to full-time programming. At home he has a personal computer that he uses for writing games and learning assembly language. He lives at 1405 Four Seasons Blvd., Lutz, Florida 33549.

Listing 2

```

;*****
;*
;* GLOBULAR CLUSTER *
;* FOR APPLE II *
;*
;* BY ART MATHENY *
;*
;*****
;
; TO EXECUTE FROM MONITOR: 800G
;
QUOT EPZ $4 ; QUOTIENT
REM EPZ $5 ; REMAINDER
DIVDEND EPZ $6 ; DIVIDEND
DUSER EPZ $7 ; DIVISOR
SCRNX EPZ $8 ; X-LOCATION
KNTR EPZ $A ; STAR COUNTER
DENS EPZ $B ; NUMBER OF STARS IN VIEW
SPEED EPZ $C ; SPEED OF TRAVEL
POINT EPZ $D
TUBE EPZ $E
RANBYT EPZ $10 ; RANDOM BYTE
HORIZL EPZ $18 ; HORIZONTAL COORD TABLE
HORIZH EPZ $19
VERTL EPZ $1A ; VERTICAL COORD TABLE
VERTH EPZ $1B
BASEL EPZ $1C ; DEPTH COORD TABLE
BASEH EPZ $1D
TINTL EPZ $1E ; STAR COLOR TABLE
TINTH EPZ $1F
COLOR EPZ $30 ; COLOR FOR PLOT ROUTINE
RNDL EPZ $4E ; APPLE'S RANDOM NUMBER SEED
RNDH EPZ $4F
;
; ROUTINES IN APPLE'S ROM
;
PLOT EQU $F800 ; LO-RES PLOT ROUTINE
CLRSCR EQU $F832 ; CLEARS LO-RES SCREEN
;
; * * * INITIALIZATION * * *
;
0800 ORG $800
0800 A90C LDA #C ; SETS NUMBER OF STARS IN VIEW
0802 8508 STA DENS
0804 A903 LDA #3 ; SETS WARP FACTOR
0806 850C STA SPEED
0808 A90D LDA #D
080A 850D STA POINT
080C A9FE LDA #FE
080E 850E STA TUBE
0810 AD56C0 LDA $C056 ; SET LOW-RES MODE
0813 AD54C0 LDA $C054 ; DISPLAY PAGE 1
0816 AD52C0 LDA $C052 ; ALL GRAPHICS
0819 2032FB JSR CLRSCR ; CLEAR SCREEN
081C AD50C0 LDA $C050 ; SET GRAPHICS MODE
081F A54E LDA RNDL ; TRANSFER APPLE'S RANDOM SEED
0821 8510 STA $10 ; TO LOCATION $10 THRU $13
0823 8512 STA $12
0825 A54F LDA RNDH
0827 8511 STA $11
0829 8513 STA $13
082B A90C LDA #C ; LOAD BASE ADDRESSES OF
; THE 4 TABLES
082D 8519 STA HORIZH
082F A90D LDA #D
0831 851B STA VERTH
0833 A90E LDA #E
0835 851D STA BASEH
0837 A90F LDA #F
0839 851F STA TINTH
083B A900 LDA #0
083D 8518 STA HORIZL
083F 851A STA VERTL
0841 851C STA BASEL
0843 851E STA TINTL
0845 A40B LDY DENS ; CHOOSE INITIAL STAR COORDINATES
0847 20F00B NEXT JSR NEW1
084A 88 DEY
084B DOFA BNE NEXT
084D ;
084D ; * * * MAIN LOOP * * *
084D ;
084D A40B RESCAN LDY DENS
084F 840A STY KNTR
0851 A40A ERASE LDY KNTR
0853 A900 LDA #0
0855 8530 STA COLOR ; SET COLOR TO BLACK

```

(Continued)

## Listing 2 (Continued)

```

0857 208008      JSR CALC      ; FIND OLD STAR AND ERASE IT
085A A40A      LDY KNTR      ; MOVE STAR TOWARD OBSERVER
085C B11C      LDA (BASE),Y
085E 38        SEC
085F E50C      SBC SPEED
0861 911C      STA (BASE),Y
0863 B11E      LDA (TINT),Y  ; RECALL THIS STAR'S COLOR
0865 8530      STA COLOR
0867 208008      JSR CALC      ; PLOT STAR IN ITS NEW POSITION
086A C60A      DEC KNTR      ; NEXT STAR
086C D0E3      BNE ERASE
086E F0DD      BEQ RESCAN    ; ALWAYS TAKEN
0870           ;
0870           ; * * * CALC ROUTINE * * *
0870           ;
0870           ; IF STAR IS ON SCREEN, PLOT IT, ELSE CREATE NEW ONE.
0870           ; ENTER WITH STAR INDEX IN Y-REG AND COLOR SET.
0870           ;
0880           ORG $880
0880 B118      CALC      LDA (HORIZ),Y ; HORIZONTAL COORDINATE
0882 20B008      JSR TAN      ; FIND HORIZONTAL SCREEN POSITION
0885 A504      LDA QUOT
0887 18        CLC
0888 6914      ADC #14      ; SHIFT ORIGIN
088A 8508      STA SCRNX
088C C928      CMP #28
088E B013      BCS EDGE     ; OFF SCREEN?
0890 B11A      LDA (VERT),Y  ; LIKewise FOR VERTICAL COORDINATE
0892 20B008      JSR TAN
0895 A504      LDA QUOT
0897 18        CLC
0898 6914      ADC #14
089A C928      CMP #28
089C B005      BCS EDGE
089E A408      LDY SCRNX    ; POSITION IS ON THE SCREEN
08A0 4C00FB     JMP PLOT     ; PLOT THE STAR AND RETURN
08A3 A982      EDGE     LDA #82     ; OLD STAR WENT OUT OF VIEW...
08A5 911C      STA (BASE),Y ; CREATE A NEW STAR...
08A7 4CF908     JMP NEW2     ; AND RETURN
08AA           ;
08AA           ; * * * PROJECT 3-D POSITION ONTO 2-D SCREEN * * *
08AA           ;
08AA           ; USES THE APPROXIMATION: X = TAN(X)
08AA           ; ACCUMULATOR = DISTANCE PERPENDICULAR TO LINE OF TRAVEL
08AA           ; (BASE),Y = DISTANCE PARALLEL TO LINE OF TRAVEL
08AA           ;
08B0           ORG $8B0
08B0 8506      TAN      STA DVNDEND ; DIVIDE PERPENDICULAR DISTANCE...
08B2 B11C      LDA (BASE),Y
08B4 8507      STA DVSER     ; BY THE PARALLEL DISTANCE
08B6 A506      LDA DVNDEND  ; CHECK THE SIGN
08B8 1016      BPL DIV      ; IF +, DIVIDE AND RETURN
08BA 49FF      EOR #FF     ; TWO'S COMPLEMENT DIVIDENT
08BC 8506      STA DVNDEND
08BE E606      INC DVNDEND
08C0 20D008     JSR DIV      ; DIVIDE
08C3 A504      LDA QUOT     ; TWO'S COMPLEMENT QUOTIENT
08C5 49FF      EOR #FF
08C7 8504      STA QUOT
08C9 E604      INC QUOT
08CB 60        RTS
08CC           ;
08CC           ; * * * DIVISION ROUTINE * * *
08CC           ;
08CC           ; QUOT = 32 * DVNDEND / DVSER
08CC           ; REM = REMAINDER
08CC           ;
08D0           ORG $8D0
08D0 A900      DIV      LDA #0
08D2 8504      STA QUOT
08D4 8505      STA REM
08D6 A60D      LDX POINT    ; POSITION OF DECIMAL POINT
08D8 0604      DIV1     ASL QUOT
08DA 0606      ASL DVNDEND
08DC 2605      ROL REM
08DE A505      LDA REM
08E0 38        SEC
08E1 E507      SBC DVSER
08E3 9004      BCC DIV2
08E5 8505      STA REM
08E7 E604      INC QUOT
08E9 CA        DIV2     DEX
08EA D0EC      BNE DIV1
08EC 60        RTS
    
```

(Continued)

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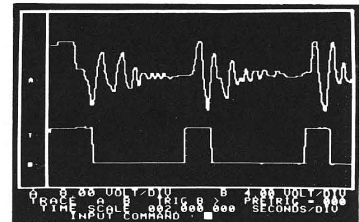
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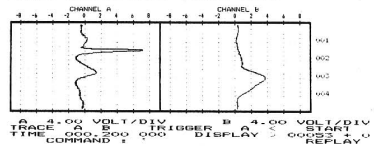
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Listing 2 (Continued)

```

08ED      ;
08ED      ; * * * RANDOMIZE * * *
08ED      ;
08F0      ORG $8F0
08F0 203009 NEW1 JSR RND      ; CHOOSE DISTANCE
08F3 A510      LDA RANBYT
08F5 297F      AND #7F
08F7 911C      STA (BASE),Y
08F9 203009 NEW2 JSR RND      ; CHOOSE HORIZONTAL COORDINATE
08FC A510      LDA RANBYT
08FE 250E      AND TUBE      ; AVOID COLLISIONS
0900 F0F7      BEQ NEW2
0902 9118      STA (HORIZ),Y
0904 203009 NEW3 JSR RND      ; CHOOSE VERTICAL COORDINATE
0907 A510      LDA RANBYT
0909 250E      AND TUBE      ; AVOID COLLISIONS
090B F0F7      BEQ NEW3
090D 911A      STA (VERT),Y
090F 203009 NEW4 JSR RND      ; CHOOSE COLOR
0912 A510      LDA RANBYT
0914 290F      AND #F
0916 F0F7      BEQ NEW4      ; COLOR SHOULD NOT BE BLACK
0918 8505      STA REM      ; LET UPPER NIBBLE OF COLOR-
091A 0A        ASL          ; MASK EQUAL LOWER NIBBLE
091B 0A        ASL
091C 0A        ASL
091D 0A        ASL
091E 0505      ORA REM
0920 911E      STA (TINT),Y
0922 60        RTS
0923      ;
0923      ; * * * RANDOM NUMBER GENERATOR * * *
0923      ;
0923      ; IDENTICAL TO LISTING 1
0923      ;
0930      ORG $930
0930 18        RND      CLC
0931 A203      LDX #3
0933 B510      LDA #10,X
0935 CA        DEX
0936 7510      LOOP1    ADC #10,X
0938 9510      STA #10,X
093A CA        DEX
093B 10F9      BPL LOOP1
093D A203      LDX #3
093F F610      LOOP2    INC #10,X
0941 D003      BNE RTS1
0943 CA        DEX
0944 10F9      BPL LOOP2
0946 60        RTS1    RTS
END
    
```

Listing 3

```

;* STOCHASTIC MUSIC DEMONSTRATION *
;* FOR APPLE II *
;* BY ART MATHENY *
;*****
; MERGE WITH LISTING 1
; TO EXECUTE FROM MONITOR: 820G
;
PITCH EPZ $5      MUSICAL PITCH
TIME EPZ $6      DURATION OF THE SOUND
RANBYT EPZ $10
RNDL EPZ $4E
RNDH EPZ $4F
RND EQU $800
SPKR EQU $C030
;
0820      ORG $820
0820 A54E      BEGIN    LDA RNDL      ; TRANSFER APPLE'S RANDOM SEED
0822 8510      STA #10      ; TO LOCATIONS $10 THRU $13
0824 8512      STA #12
0826 A54F      LDA RNDH
0828 8511      STA #11
082A 8513      STA #13
082C 200008      NUNOTE   JSR RND      ; CHOOSE PITCH
082F A510      LDA RANBYT
0831 0980      ORA #21000000 ; PUTS ALL NOTES IN SAME OCTAVE
0833 29F0      AND #211110000 ; SPACES THE PITCHES WITHIN THE
0835          ; MUSICAL SCALE
0835 8505      STA PITCH
0837 200008      JSR RND      ; CHOOSE DURATION OF NOTE
083A A510      LDA RANBYT
083C 8504      STA TIME
083E A605      PLAY    LDX PITCH      ; X-REG TIMES THE CYCLES
0840 88        YCOUNT DEY          ; Y-REG TIMES THE PLAYING TIME
0841 D004      BNE XCOUNT
0843 C606      DEC TIME
0845 F0E5      BEQ NUNOTE
0847 CA        XCOUNT DEX
0848 D0F6      BNE YCOUNT
084A 2C30C0      BIT SPKR      ; CLICK THE APPLE SPEAKER
084D 18        CLC
084E 90EE      BCC PLAY
END
    
```

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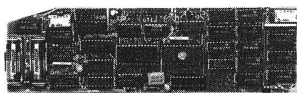
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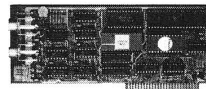
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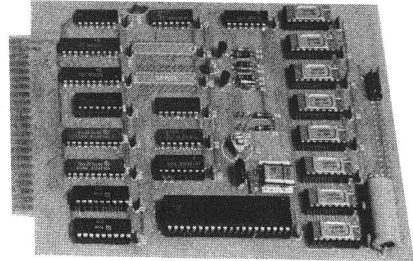
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```
xxx PRINT "PLEASE ENTER THE DATE."; : & INPUT,DATES
```

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# A New Character Set for the VIC-20

by Mike Bassman

**A technique to design your own VIC characters is described. This involves changing the character-ROM printer and copying character definitions into RAM from their ROM locations.**

**Custom Characters requires:  
VIC-20**

The new VIC-20 from Commodore packs a lot of wallop for \$300. It includes many features that were previously found only on more expensive computers. The VIC uses a character set nearly identical to the PET's and very similar to those of Ohio Scientific, Sorcerer, and Atari computers. Special graphic characters are provided along with the regular alphanumerics. With these graphic characters, you can draw lines, build pictures, etc. The problem is that there are never enough characters available.

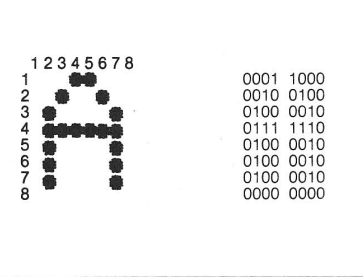
Although the VIC allows you to draw almost anything made of straight or curved lines, many games are more difficult to program because of the lack of tank, boat, or plane characters such as those found in OSI computers. Though the manual does not document it, it is possible to change some of the VIC's characters to those of your own choosing.

To create new characters, you must understand how the VIC stores its old ones. As with most computers, the VIC's characters are defined in an 8 by 8 dot matrix. That is, any character can be made of up to eight small dots (called pixels) across by eight down. Each pixel is represented in memory by one bit. If the bit is a 1, then the corresponding pixel will be lit when the character is

displayed on the screen. An entire character consists of 64 bits, or eight bytes. The format in which the bytes are stored is as follows: the first byte represents the first row of pixels going across, the second byte is the second row, and so forth. For a more detailed example, see figure 1, where the character 'A' is shown in both pixel and binary formats.

The VIC keeps all of its characters in 4K of ROM. Since each character occupies eight bytes of memory, the ROM must contain 512 characters. At first glance, it does not seem to have that many, but this is how the 4K is used. The first 128 characters (1K) are the familiar upper case/graphics set. The next 128 are the same ones, only in reverse. This is followed by the lower/upper case set and its reverse set.

**Figure 1: Binary Representation of Character in Memory**



On most computers, including the PET, the character ROM is not addressed in the microprocessor's normal memory space, but is addressed so that it is only available to the CRT controller chip. In the VIC the ROM is actually addressed from \$8000 to \$8FFF in the 6502's address space!

Since the character information is stored in ROM, it can't be changed. However, since the pointer to the

character ROM is stored in RAM, it can be changed to point anywhere else, including RAM. The pointer is at 36869, 36870. Its normal value is 240, enabling the upper case/graphic set, while a value of 242 will enable the alternate lower/upper case set. POKEing a 255 into 36869 will move the pointer from its normal 32768 address to 7168. This just happens to be right at the top of BASIC RAM, which normally runs from 4096 to 7679. By lowering the upper limit from 7679 to 7168, we have stolen 512 bytes from BASIC, or enough for 64 characters. Since it is impossible to put 4K worth of characters into 512 bytes, you have to select the 64 used most. Normally these would be the upper case letters, the numbers, and various punctuation marks, or the characters with screen codes ranging from 0 to 63. Of these, certain ones, such as the @ and the British pound sterling symbol, are seldom used, and can be replaced with your custom characters.

There are a few tricks you should know before attempting to make new characters. Most importantly, you have to reserve locations 7168 to 7679 so they are not disturbed by BASIC. There are two pointers that must be adjusted to accomplish this: the top-of-BASIC pointer (51-52), and the top-of-string storage pointer (55-56). As with every

**Figure 2: Alien Character**

	Binary	Hex	Decimal
○○○○○○○○	00011000	18	24
○○○○○○○○	00111100	3C	60
○○○○○○○○	01011010	5A	90
●●●●●●●●	11111111	FF	255
●●●●●●●●	11111111	FF	255
●●●●●●●●	11111111	FF	255
●●●●●●●●	01111110	7E	106
●●●●●●●●	01111110	7E	106

## PROGRAMMING TECHNIQUES

6502 pointer, the low byte is stored first, followed by the high byte. Both pointers point to 7680, and must be changed to point to 7168. Instead of recreating all of these characters, it is faster to copy them from their original ROM locations.

We are now ready to define a custom character — an alien, which you might find useful in game programs. The easiest way to go about this is to take a piece of graph paper, mark off an 8 by 8 segment, and fill in the appropriate squares. Now take each row and make a binary representation for it. Convert the binary for each row into decimal, because this information will be stored in BASIC DATA statements. Our alien is defined and digitized in figure 2.

This program will put the character shown in figure 2 over the character with screen code 0 (the '@'). Now when you hit the '@' key, you will get an alien. The alien can now be used in your own program for gaming or anything else. The unfortunate part is that all those other characters are no longer available; only the 64 you originally moved down are available. If you try to use any others, you will get whatever random gibberish happens to lie beyond 7679.

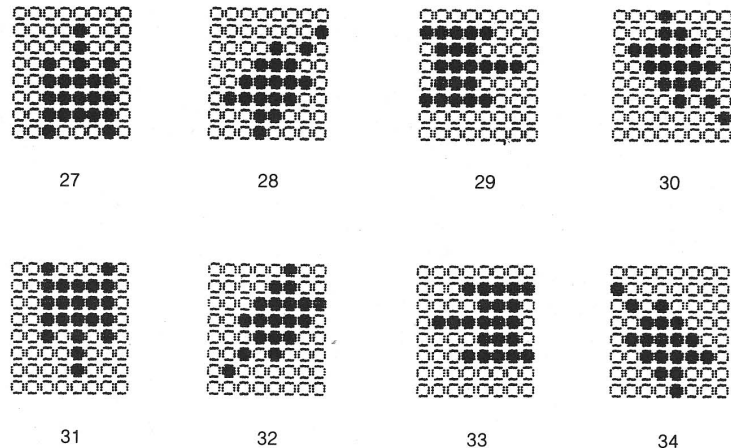
Listing 2 is a program that defines a whole series of tank characters — one for each of eight 45-degree angles. They are shown in figure 3, in their pixel formats. Below them are the screen codes they will be assuming. Now many games that were before restricted to the computers with the appropriate game characters can be programmed on the VIC.

The screen codes for the tank characters are from 27 to 34, as shown in figure 3. They are contiguous for programming ease. The tanks replace the brackets, the up and left arrows, the British pound sign, the space, the exclamation point, and the quote (in that order). If you list a program with this character set implemented, your punctuation is going to look awfully funny!

In addition to defining the tank characters, the program lets you drive the tank around the screen. The controls are 'Z' to turn left, '/' to turn right, and space to move in the direction you are pointed. To make a complete program, the lines of the program in listing 2 must be overlaid onto those of the program in listing 1.

Contact the author at 39-65 52nd St., Woodside, NY 11377.

Figure 3: Eight Tank Characters



### Listing 1

```

10 POKE 52,28
20 POKE 56,28
30 S=7168
40 F=32768
50 FOR K=0 TO 63*8
60 X=PEEK(F+K)
70 POKE S+K,X
80 NEXT K
90 READ X
100 IF X=-1 THEN POKE 36869,255: GOTO 1000
110 FOR K=0 TO 7
120 READ N
130 POKE S+8*K,N
140 NEXT K
150 GOTO 90
160 DATA 00,24,60,90,255,255,255,126,126
500 DATA -1
1000 PRINT "CHARACTER SET COMPLETED": END

```

### Listing 2

```

5 PRINT "Q": FOR K=7680 TO 8185: POKE K,35: NEXT
200 DATA 27,0,8,8,42,62,62,62,34
210 DATA 28,0,1,10,28,62,124,24,16
220 DATA 29,0,248,112,126,112,248,0,0
230 DATA 30,16,24,124,62,28,10,1,0
240 DATA 31,34,62,62,62,42,8,8,0
250 DATA 32,4,12,31,62,28,40,64,0
260 DATA 33,0,31,14,126,14,31,0,0
270 DATA 34,0,128,80,56,124,62,24,8
280 DATA 35,0,0,0,0,0,0,0,0
1000 POKE 36879,14: UL=7680: LL=22: S=35
1005 FOR K=0 TO 21: POKE UL+K,45: POKE 8164+K,45
1010 POKE UL+K*LL,45: POKE UL+K*LL+21,45: NEXT
1020 L=UL+LL*5+5:C=27:D(1)=-22:D(2)=-21:D(3)=1:D(4)=23:D(5)=22
1025 D(6)=21: D(7)=-1: D(8)=-23
1030 POKE L,C
1050 GET A#: IF A#="" THEN 1050
1060 IF A#<>"Z" THEN 1090
1070 C=C-1: IF C=26 THEN C=34
1080 GOTO 1030
1090 IF A#<>"/" THEN 1120
1100 C=C+1: IF C=35 THEN C=27
1110 GOTO 1130
1120 IF A#<>" " THEN 1050
1130 IF PEEK(L+D(C-26))<>35 THEN 1050
1140 POKE L,S: L=L+D(C-26): GOTO 1030

```

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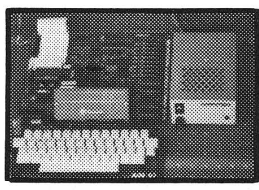
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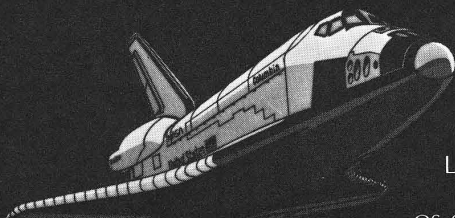
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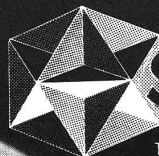
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By Loren Wright

### PET and the IEEE-488 Bus

The PET is one of the few personal computers to incorporate, as standard, support of the IEEE-488 bus. In fact, the system is built around it! Nearly all communication with peripheral devices is through the bus, and even the PET's internal devices — the screen, keyboard, and cassette interfaces — are treated as IEEE devices. Most PET owners probably know that CBM printers and disk drives are driven from the IEEE bus. However, in addition to CBM devices, the PET can also communicate with a wide variety of peripherals, produced by different manufacturers, who never even thought of connecting them to a PET. These manufacturers include Hewlett-Packard, Tektronix, Fluke, and many others; the devices include non-CBM disk drives, logic analyzers, X-Y plotters, frequency analyzers, digital voltmeters, and much more sophisticated instruments. Most other computers that can act as controllers on the bus cost much more than the PET.

A typical IEEE system includes a controller and one or more devices, which are considered listeners or talkers. Each device is assigned a number, and it will neither talk nor listen unless addressed using this number. There can be as many as 32 devices on the PET's bus, all connected at once.

The PET manipulates the devices through logical files. When a file (identified with a unique number) is OPENed, the device number is specified, as well as a secondary address, which identifies a particular function of the device. For instance, for the CBM cassette units, a secondary address of 0 allows the PET to read from the unit, a 1 to write to it, and a 2 to write, with an end-of-tape mark written when the file is CLOSED. Once a file is open, all subsequent operations involving the specified function of the specified device need only refer to the file number.

Control of the devices is not limited to the secondary addresses. Many devices are set up to handle commands in the form of character strings. CBM disk drives are good examples of this. The secondary address 15 is the command channel, and information in the form of characters is passed in both directions on this channel. For instance, the strings "10" and "INITIALIZE0" both mean to initialize the disk in drive 0. Error and status information is sent over the channel in the other direction. For devices such as digital X-Y plotters, a character string may tell it to move the pen to 5,7 and draw a line from there to 10,12.

Programming control of IEEE devices is very easy, but physically putting together the system is even easier. Every instrument (besides the PET itself) has the same connector, and it doesn't matter which end of a cable goes where.

### IEEE Tricks

When running a program that outputs data to a printer, it is often handy to be able to try it out on the screen first. You might expect to have to write your output routine first with PRINT statements, and then go back and replace them all with PRINT# statements. Here is an illustration of a technique to avoid this.

```
10 input "to printer";y$
20 if y$ = "y" then dv = 4: goto 40
30 dv = 3
40 open 1,(dv)
```

```
.
.
.
100 print#1,"first line"
110 print#1,"second line"
.
.
.
999 close 1
```

When you answer "y" to the prompt, the file will be opened with a device number of 4 and the output will go to the printer. If you answer anything else, 3 will be the assigned device number, and all output will go to the

screen. If, instead of including the prompt, you had just written the 3 into the OPEN statement in line 40, then you would only have to change that one line when you finally wanted output to go to the printer. The same method could be used if you were offering the user a choice between writing data to cassette or to disk. However, the secondary addresses would have to be taken care of, too.

A question mark is always printed on a PET BASIC INPUT statement. What if you want to suppress that question mark? One way is to specify the keyboard (IEEE device 0) in an OPEN statement and use an INPUT# statement instead.

```
10 open 1,0
20 print"word: ";
30 input#1,w$
40 if w$ <> "end" then 20
50 close 1
```

Notice that, unlike the INPUT command, the INPUT# command cannot include a prompt string. Notice also that hitting the return key alone doesn't phase INPUT# one bit — it must have at least one character before it is happy.

The PET's CMD command can be very handy. You have probably used it often to get BASIC listings on a printer. What it actually does is direct all output that normally goes to the screen to a logical file. After you have finished sending your listing to the printer, you may have noticed that the cursor behaves peculiarly. When you hit RETURN, it will move ahead only one space, instead of moving to the next line.

One way to restore normal keyboard operation is to type PRINT#1 (if 1 is the file number). If you aren't going to use the file again right away, it is also a good idea to close it. Remember that PRINT# can be abbreviated by typing P, followed by a shifted R. My favorite method of exiting the CMD mode is to just type some nonsense, like 'dfd.' Of course you get a syntax error, but you also exit CMD.

BASIC cannot take advantage of everything the IEEE-488 bus has to offer. With machine-language programming, it is not only possible to get the maximum in speed, but you can also do some unusual things like spooling. Wordcraft 80 and other programs allow you to send a file directly from the disk drive to the printer while you have control of the PET.

For more detailed information on the IEEE-488 bus, consult the three-part article by Gregory Yob that began with the July, 1980 issue of *BYTE* ("Get Your PET on the IEEE-488 Bus") and the book *PET and the IEEE Bus* by Eugene Fisher and C.W. Jensen, published by Osborne/McGraw-Hill (1980).

### Commodore's New Machines Set Straight

With the official U.S. announcement of Commodore's newest computers at NCC in early June, it is finally clear exactly what the new models are:

Commodore-64 is a 64K color-and-sound computer designed to compete with Apple II and Atari computers. It

will be available at dealers late this summer at a suggested retail of \$595. It physically resembles the VIC-20, requiring a color TV or monitor and supporting all the VIC's peripherals. However, its 25 x 40 screen size, 64K of RAM, and more sophisticated graphics distinguish it. Options available include a PET emulator, IEEE-4888 cartridge, and Z-80 processor board.

The MAX machine (previously identified here and elsewhere as the Ultimax) also physically resembles the VIC-20, but it uses a flat membrane-type keyboard instead. The graphic and sound capabilities are more sophisticated. However, only 2K of RAM is included. Add-ons include a BASIC language cartridge, cassette machine, a wide variety of games, and, of course, more memory. The suggested retail will be \$179.95.

The P128 is billed as the third generation in Commodore's PET line (i.e. home, educational, recreational). At a suggested retail price of \$995, there is quite a bit included: 128K of

RAM, expandable 256K internally and 640K externally; 25 x 40 16-color display on the user's TV or monitor; 200 x 320-pixel high-resolution graphics; built-in RS-232 and IEEE-488 interfaces; 10 programmable function keys; individual cursor movement keys; sophisticated music synthesis capability. It is also possible to add a Z-80 processor board to allow CP/M compatibility. The P128 should be available sometime in the fall.

The B128 is the new business entry in Commodore's line at a suggested retail of \$1695. Internally it is very similar to the P128 described above. However, it includes an attached 80-column green phosphor screen, two 5 1/4" floppy disk drives, and a business keyboard. The B128 should also be available in the fall.

The BX256, very much like the B128, comes with 128K additional memory, including the 8088 processor for 16-bit capability. Suggested retail will be \$2995, and it should be available in the fall.

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# POWER-Aid for the PET

by F. Arthur Cochrane

This machine-language program adds commands to the BASIC programming utility POWER for the Commodore PET. The source code is in the MAE assembler format and takes advantage of conditional and interactive assembly. This allows the assembler to make decisions in its assembly and thus assemble Power-Aid to function with all three versions of POWER.

## POWER-Aid requires:

PET/CBM (all except original operating system)  
POWER ROM

*Editor's note: POWER was reviewed by Loren Wright in the July, 1982 "PET Vet" (MICRO 50:69).*

POWER is a programmer's utility package for the PET written by Brad Templeton and sold by Professional Software, Inc. It is programmed in a 4K ROM for the \$9000 socket inside the PET.

The manual, by Jim Butterfield, does an excellent job of describing POWER's commands: AUTO, DElete, DUMp, FIX, Call monitor (MLM), OFF, RENumber, SElect, TRaCe, WHY, Execute, Find, and Change. The manual also contains several appendices, including a thorough description of the memory locations used by POWER and a description of routines that can be called in POWER by the machine-language programmer. Another appendix covers adding more commands to POWER.

Three locations are used by POWER to add commands. Two of these are

used for an indirect jump vector that points to the added machine code. The third location is used by POWER as a checksum for the indirect vector.

This program, Power-Aid, adds 15 more commands to POWER. Power-Aid modifies the three locations to

point to itself and uses one of the POWER routines to list a BASIC line. Power-Aid can be assembled for all three POWERS by using conditional and interactive assembly available in the MAE assembler.

As presented here, Power-Aid is for

### Listing 1: POWER-Aid initialization routine demonstrates how to add commands to POWER.

```

0010 ; "POWER-AID.M2A"
0020
0030
0040
7900- 20 00 90 0050 COLD      JSR POWER
7903- AD F3 7F 0060          LDA WBEGIN          ;PROTECT EDITOR
7906- AE F4 7F 0070          LDX WBEGIN+1        ; POINTERS
7909- 85 FB 0080          STA *TMP0          ;SAVE TO PRINT RESTART
790B- 86 FC 0090          STX *TMP0+1
790D- E0 80 0100          CPX ##80          ; ABOVE RAM
790F- B0 07 0110          BCS COLD010
7911- 85 34 0120          STA *MEMSIZ
7913- 86 35 0130          STX *MEMSIZ+1
7915- 20 EB 9F 0140          JSR WRP            ; FIX POINTERS
0150
7918- AD F5 7F 0160 COLD010  LDA WENTRY
791B- AE F6 7F 0170          LDX WENTRY+1
791E- BD D7 03 0180          STA UCOMVEC        ; STORE JUMP VECTOR
7921- 8E D8 03 0190          STX UCOMVEC+1
7924- 18 0200          CLC
7925- 6D F6 7F 0210          ADC WENTRY+1
7928- 49 A5 0220          EOR #%10100101
792A- BD D6 03 0230          STA UCVCHK        ; STORE CHECK BYTE
0240
792D- A2 14 0250          LDX #MESSGE-NGMSG
792F- 20 35 79 0260          JSR PRMSG
7932- 4C 1D 7E 0270          JMP OUTDEXHEX     ; PRINT RESTART ADDRESS
0290
0300
0310 ;PRINT A MESSAGE
0320
7935- BD 6B 7F 0330 PRMSG    LDA NGMSG,X          ; OUTPUT MESSAGE
7938- F0 06 0340          BEQ MSGEND
793A- 20 D2 FF 0350          JSR PRINT
793D- EB 0360          INX
793E- D0 F5 0370          BNE PRMSG
7940- 60 0380 MSGEND      RTS
0390
0400 ; HOLD ON SPACE KEY PRESSED OR SHIFT KEY
0410
7941- 24 98 0420 AD70EE     BIT *SFST          ;SHIFT KEY DOWN
7943- D0 FC 0430          BNE AD70EE        ;YES, HOLD
7945- 20 61 79 0440          JSR AD7103
7948- D0 21 0450          BNE AD710D
794A- 20 61 79 0460 AD70FB  JSR AD7103
794D- F0 FB 0470          BEQ AD70FB
794F- C9 FF 0480          CMP ##FF
7951- F0 F7 0490          BEQ AD70FB
7953- 48 0500          PHA
7954- 20 61 79 0510 AD7100  JSR AD7103
7957- C9 FF 0520          CMP ##FF          ;WAIT FOR KEY RELEASE
7959- D0 F9 0530          BNE AD7100

```

(Continued)

a 32K PET, but the assembly location can easily be modified for any memory size PET. Power-Aid could also be assembled and burned into an EPROM and plugged into the \$A000 socket to work with POWER. In EPROM, Power-Aid would be available with a SYS and would not have to be loaded from disk each time the PET is reset or powered up.

You might question why you should go to all the trouble of machine code. Just about all of the functions of Power-Aid could be written as instant subroutines for use by POWER. This is true, but the subroutines would be written in BASIC and would run at the speed of BASIC rather than the much faster machine code. Also, Power-Aid stores itself at the top of memory and protects itself from BASIC. If these commands were written as instant subroutines they would be overwritten on any LOAD of another BASIC program. They could be merged back in with the XEC command but their line numbers might overwrite some of the lines of the BASIC program in memory.

Listing 1 is in MAE assembly language. The object code generated with this particular assembly is for the 4040 version of POWER. Appropriate responses to the prompt will generate a version that runs on your system.

#### Dump the Screen to a Printer

Syntax: CRTA (, printer#)  
CRTC (, printer#)

The screen is output to a printer connected to the PET. The CRTC command (to a Commodore printer) will be exactly like the screen. The CRTA command (to an ASCII printer) will be in upper case only if the PET is in graphics mode, or lower/upper case if the PET is in lower-case mode.

#### List a Program from the Disk

Syntax: FIL "program filename"  
(, disk#)

This command will list a BASIC program on the disk directly to the screen without affecting the contents in the memory.

#### Convert Hex and Decimal Numbers

Syntax: HEX \$hex number  
HEX decimal number

The HEX command will convert hex to decimal and decimal to hex. This will be very useful in figuring

#### Listing 1 (Continued)

```

                                0540
                                0550 ; ZERO CHARACTER COUNTER
                                0560
795B- A9 00 0570 ZEROCHAR LDA #0
795D- 85 9E 0580 STA *NDX
795F- 68 0590 PLA
7960- 60 0600 RTS
                                0610
                                0620
7961- AD 12 EB 0630 AD7103 LDA #E812
7964- CD 12 EB 0640 CMP #E812
7967- D0 FB 0650 BNE AD7103
7969- C9 FB 0660 CMP #FB ; SPACE KEY (G) / 6 (B)
796B- 60 0670 AD710D RTS
                                0680
                                0690 ; POWER-AID CHECKS FOR COMMANDS
                                0700
796C- A2 00 0710 ENTRY LDX #0
796E- 86 FE 0720 STX *CMDLEN
7970- A1 77 0730 LDA (TXTPTR,X) ; CHECK FOR TOKENS
7972- 30 1C 0740 BMI TOKEN
7974- A4 77 0750 AD715B LDY *TXTPTR
7976- B9 00 02 0760 AD715A LDA BUF0FS,Y
7979- 38 0770 SEC
797A- FD 9B 7F 0780 SBC TABLE,X
797D- F0 14 0790 BEQ AD7176
797F- C9 B0 0800 CMP #B0
7981- F0 14 0810 BEQ AD717A
7983- E6 FE 0820 INC *CMDLEN
7985- E8 0830 AD7169 INX
7986- BD 9A 7F 0840 LDA TABLE-1,X
7989- 10 FA 0850 BPL AD7169
798B- BD 9B 7F 0860 LDA TABLE,X
798E- D0 E4 0870 BNE AD715B
7990- 4C FA 9F 0880 TOKEN ; NOT FOUND
7993- E8 0890 AD7176 INX
7994- C8 0900 INY
7995- D0 DF 0910 BNE AD715A
7997- B4 77 0920 AD717A STY *TXTPTR
7999- A5 FE 0930 LDA *CMDLEN
799B- 0A 0940 ASL A
799C- AA 0950 TAX
799D- BD CF 7F 0960 LDA JMPTBL,X
79A0- AB 0970 TAY ; LOW BYTE
79A1- BD D0 7F 0980 LDA JMPTBL+1,X
79A4- AA 0990 TAX ; HIGH BYTE
79A5- 4C F7 9F 1000 JMP ENTCMD ; DO COMMAND

```

#### Listing 2: SPOOL command sends sequential file directly from disk to printer.

```

                                ;****
7E75- F0 31 3180 SPOOL BEQ UNSPOOL ; TURN OFF PRINTER & DISK
                                3190 ;****
7E77- 20 BB 79 3200 JSR PARCHK
7E7A- A5 D3 3210 LDA #BA ; SEE IF PRINTER #
7E7C- D0 02 3220 BNE SPOOL1
7E7E- A9 04 3230 LDA #4
7E80- 29 1F 3240 SPOOL1 AND #20001111
7E82- C9 04 3250 CMP #4
7E84- 90 71 3260 BCC SYNERR
7E86- 85 FB 3270 STA *TMP0
7E8B- A9 02 3280 LDA #2
7E8A- 85 FD 3290 STA *TMP2
7E8C- 20 C8 7E 3300 JSR PARSE1
7E8F- AD 40 EB 3310 LDA #E840 ; SET ATN
7E92- 29 FB 3320 AND #FB
7E94- 8D 40 EB 3330 STA #E840
7E97- A5 FB 3340 LDA *TMP0
7E99- 85 D4 3350 STA #FA ; PRINTER TO LISTEN
7E9B- 20 D5 F0 3360 JSR LISTEN ; LEAVE ATN HIGH
7E9E- 20 4B F1 3370 JSR RELATNLST ; RELEASE ATN
7EA1- A9 00 3380 LDA #0
7EA3- 85 AF 3390 STA *AF ; RESTORE INPUT TO KEYBOARD
7EA5- 85 AE 3400 STA *OPNFILE ; ZERO OPEN FILES
7EA7- 60 3410 RTS ; EXIT TO BASIC
                                3420
7EAB- A9 02 3430 UNSPOOL LDA #2
7EAA- 85 AE 3440 STA *OPNFILE ; OPEN FILES
7EAC- A9 04 3450 LDA #4
7EAE- 85 B0 3460 STA #B0 ; CMD DEVICE
7EB0- A9 08 3470 LDA #8
7EB2- 85 AF 3480 STA *AF ; INPUT DEVICE
7EB4- 20 CC FF 3490 JSR CLRCHN ; UNTALK & UNLISTEN
7EB7- 4C 3C 7C 3500 JMP AD78C6 ; CLOSE FILES
                                3510
7EBA- A9 00 3520 PARSEPRG LDA #0 ; SECOND SECONDARY FOR PRG FI
7EBC- F0 02 3530 BEQ PAR0
7EBE- A9 02 3540 PARSESEQ LDA #2 ; SECOND SECONDARY FOR SEQ
7EC0- 85 FD 3550 PAR0 STA *TMP2

```

(Continued on page 74)

# Engineers

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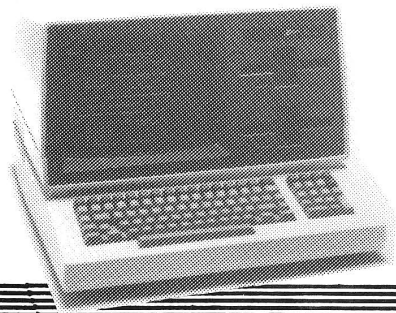
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POKE, PEEK, and SYS addresses. If the number input is preceded by a dollar symbol, then the number is taken as hex and the decimal value for it is printed. If a decimal number is entered then the hex value for it is returned. The range for conversion is 0 to 65535 or \$0000 to \$FFFF.

#### Put the PET into Lower Case

Syntax: LOW

This command puts the PET into lower-case mode, the same as a POKE 59468,14.

#### Merge a Program with One in Memory

Syntax: MRG "program filename"  
(, disk#)

This command will merge a BASIC program from the disk with one in memory. The lines of the program will be merged in just as if the program were typed in from the keyboard. Therefore, lines are merged between those in memory, if necessary, and duplicate lines in memory are replaced with the merged lines. The program is listed as it is merged. This merge uses a program file, not a sequential file, which is required by POWER's XEC command.

#### Pack a Program

Syntax: PAC

This command will remove remarks and waste spaces in a BASIC program. Be careful not to branch in a BASIC program to deleted remarks. This command is fooled easily, so keep a copy of the original in case the packing does not function properly.

*Editorial note:* There may be a bug in this command, so making a backup is especially important. It works most of the time, but occasionally fails.

#### Read a Sequential File

Syntax: VEW "seq filename"  
(, disk#)

The VEW command will read a sequential file from the disk and print it to the screen. This command can be very handy for viewing data created by programs.

#### Give the Size of a Program

Syntax: SIZ  
SIZ "program filename"  
(, disk#)

#### Listing 2 (Continued)

```

7EC2- 20 E7 FF 3560 PARSE      JSR CLOSAL      ;CLOSE ALL FILES & RESTOR
7EC5- 20 BB 79 3570           JSR PARCHK     ;SET UP FILENAME
7EC8- A6 D1 3580 PARSE1      LDX *FNLEN     ;SAVE FILENAME LENGTH
7ECA- F0 2B 3590           BEQ SYNERR
7ECC- 86 09 3600 PAR1       STX *TEMP
7ECE- A9 01 3610           LDA #1         ;OPEN1,8,15
7ED0- 85 D2 3620           STA *LF
7ED2- A9 0F 3630           LDA #15
7ED4- 85 D3 3640           STA *SA
7ED6- A9 00 3650           LDA #0
7ED8- 85 D1 3660           STA *FNLEN
7EDA- 20 63 F5 3670       JSR OPEN
7EDD- 20 CC FF 3680       JSR CLRCHN     ;RESET DEFAULT I/O
7EE0- A5 09 3690           LDA *TEMP     ;RESET FILENAME LENGTH
7EE2- 85 D1 3700           STA *FNLEN
7EE4- A9 02 3710           LDA #2         ;OPEN2,8,2,FILENAME
7EE6- 85 D2 3720           STA *LF
7EE8- A5 FD 3730           LDA *TMP2
7EEA- 85 D3 3740           STA *SA
7EEC- 20 63 F5 3750       JSR OPEN
7EEF- 20 28 7D 3760       JSR CHKERR     ;READ ERROR CHANNEL
7EF2- A2 02 3770           LDX #2
7EF4- 4C C6 FF 3780       JMP CHKIN
7EF7- A9 FF 3800 SYNERR     LDA **FF
7EF9- 85 37 3810           STA *BASLIN+1
7EFB- 4C 00 BF 3820       JMP SYNERR1

```

#### Listing 3: YOU command allows loading a machine-language program at an address different from its original location.

```

7EFE- F0 F7 3840 ;**      BEQ SYNERR
7EF0- 20 72 7D 3850 YOU   ;**
7EF3- 20 F5 BE 3860           ;**
7F00- 20 72 7D 3870           JSR INPHEX     ;GET HEX ADDRESS
7F03- 20 F5 BE 3880           JSR CHKCOM
7F06- A9 00 3890           LDA #0
7F08- 85 9D 3900           STA *VERCK
7F0A- A5 5F 3910           LDA *FACC     ;LOAD ADDRESS
7F0C- A6 60 3920           LDX *FACC+1
7F0E- 85 FC 3930           STA *TMP0+1
7F10- 86 FB 3940           STX *TMP0
7F12- 20 BA 7E 3950       JSR PARSEPRG
7F15- 20 49 F4 3960       JSR PRTER
7F18- 20 CF FF 3970       JSR INPUT     ;SKIP LOAD ADDRESS
7F1B- 20 CF FF 3980       JSR INPUT
7F1E- 20 8C F3 3990       IFE WHICH-#4030
7F21- 20 3C 7C 4000       JSR LOADIT+4B
7F24- 20 2A 7C 4010       ***
7F27- 4C FF B3 4020       IFN WHICH-#4030
7F2E- 20 8C F3 4030       JSR LOADIT+54
7F31- 20 3C 7C 4040       ***
7F34- 20 2A 7C 4050       JSR AD7BC6
7F37- 20 2A 7C 4060       JSR CHKST
7F40- 4C FF B3 4070       JMP READY

```

#### Listing 4: DSK command allows change of disk drive device number.

```

7F2A- 20 A2 F4 4090 ;**      JSR SCGBYT+3   ;NO COMMA CHECK
7F2D- 20 AD 79 4100 DSK   ;**
7F30- 85 FD 4110           ;**
7F32- 20 AA 79 4120           JSR DEVICE+3
7F35- 85 FE 4130           STA *TMP2     ;OLD
7F37- A9 00 4140           JSR DEVICE
7F39- 85 96 4150           STA *TMP2+1  ;NEW
7F3B- A5 FD 4160           LDA #0
7F3D- 85 D4 4170           STA *ST
7F3F- 20 D5 F0 4180       LDA *TMP2
7F42- A9 6F 4190           STA *FA
7F44- 20 43 F1 4200       JSR LISTEN
7F47- A2 05 4210           LDA **60+15
7F49- BD 65 7F 4220       JSR SNDSALBT
7F4C- 20 9E F1 4230       LDX #5
7F4F- CA 4240 CHG005     LDA CHGMSB, X ;SEND MESSAGE
7F52- 10 F7 4250           JSR BASOUT
7F55- 10 F7 4260           DEX
7F58- A9 20 4270           BPL CHG005
7F5A- 20 5F 7F 4280       LDA #32
7F5D- A9 40 4290           JSR CHG010
7F5F- 20 5F 7F 4300       LDA #64
7F62- 4C 9E F1 4310       JSR CHG010
7F65- 18 4320 CHG010     JMP UNLSTN
7F68- 65 FE 4330           CLC
7F6B- 4C 9E F1 4340       ADC *TMP2+1
7F6E- 4C 9E F1 4350       JMP BASOUT

```

The SIZ command will give the size of a BASIC program in memory or any program on disk. The size of a program in memory is found by subtracting the end of the program location from the start of the program location. The size of a program on disk is found by counting the bytes in the file. The size is given in decimal and hex.

#### *Spool a File from Disk to Printer*

Syntax: SP "sequential filename"  
(, disk#, printer#)  
SP

This command will send a file directly from the disk to the printer. The PET can then perform other functions, such as editing a program or running a program (but with no access to the IEEE bus). The command is started with the command and a sequential file name. Power-Aid causes the PET to open the file, set the printer to listen, and then get off the IEEE bus (allowing the disk to talk directly to the printer). When the printer stops printing, enter SP with no file name to unlisten the printer, untalk the disk, and close the file.

Use the SP command to list a long program while you use the PET for something else. Create a file with

```
OPEN8,8,8,"O:TEMP,S,W":CMD8:LIST  
PRINT#8:CLOSE8
```

Then spool this to the printer.

#### *Find the Load Address*

Syntax: STR "program filename"  
(, disk#)

This command will give the load address of a program on the disk. The load address is found by reading the first two bytes of the file, which is the address where the program is loaded. The load address is given in decimal and hex. This command is particularly useful in determining where machine-language programs load.

#### *Recover a Program after a NEW*

Syntax: UNW

If, after a NEW command is entered, it is discovered that a program has not been saved, it can be recovered with this command.

#### *Put the PET into Upper Case*

Syntax: UP

This command puts the PET into upper-case mode, the same as a POKE 59468,12.

#### *DOS Commands*

Syntax: DC (, disk#)  
DC "disk command" (, disk#)  
DC "\$0" (, disk#)  
DL "program name" (, disk#)  
EX "program name" (, disk#)

The DC command is used to read the error channel, send commands, and display the disk directory. The command alone will read the error channel and print it to the screen. The command followed by a disk command will send that command to the disk. The command followed by the dollar symbol will display the directory to the screen. The DL command will load a BASIC program from the disk. The EX command will load and run a BASIC program from the disk.

#### *Change Disk Number*

Syntax: DSK from#, to#

This command allows the disk device number to be software changed. This command performs the same function as the Change Unit Addr program on the Commodore Demo Disk.

#### *Load at an Address You Specify*

Syntax: YOU \$/hex-address/  
"file name" (, disk#)

This command will force a file to load starting at the hex address you specify instead of where it would normally load.

*Notes:* POWER's FIX command disables Power-Aid so it must be re-enabled. The default disk number in commands is eight, and the default printer number in commands is four. The commands that print to the screen (File, Merge, View, Disk Directory) can be paused, held, or stopped. You may pause by holding the shift key down, and stop with the stop key. To hold the

display, use the space bar on graphics keyboards and 6 on business keyboards. To continue the display use the < key on graphics keyboards and 9 on business keyboards.

#### **Note on Program Availability**

The full listing for POWER-Aid is too long to include in MICRO. The program is available on disk from the ASM-TED Users' Group and the Toronto PET Users' Group. For 2040/4040 disk, send \$10 (to cover disk, mailer, postage, and labor) and specify 'Power-Aid' disk to:

ATUG Disk Exchange  
c/o Brent Anderson  
200 S. Century  
Rantoul, IL 61866

For 8050 disk, send \$10 to:

ATUG Disk Exchange  
c/o Baker Enterprises  
15 Windsor Drive  
Atco, NY 08004

Or send \$10 for 4040 disk, \$12 for 8050 disk to:

TORONTO PET Users' Group  
c/o Chris Bennett  
381 Laurence Avenue West  
Toronto, Ontario  
Canada M5M 1B9

The listings show selected portions of POWER-Aid. Listing 1 shows how new commands are added to POWER. Listings 2, 3, and 4 show the code for the added SPOOL, YOU, and DSK commands. These are assembled for the 4040 version of POWER.

---

F. Arthur Cochrane is a graduate from the University of South Carolina where he earned a Master of Science in electrical and computer engineering. He currently works in an electronic development group which uses PETs for data acquisition and control. His home system consists of a Commodore 4032 PET, Commodore 4040 disk, and Epson MX-80 F/T with Grafrax. Contact Mr. Cochrane at 1402 Sand Bar Ferry Rd., Beech Island, SC 29841.

---

**MICRO**

# SURCHANGE for OSI

by Kerry Lourash

**This machine-language, search-and-change utility for OSI BASIC-in-ROM computers allows substitution of change strings longer than the original, and permits wild card characters in both search and change strings.**

## SURCHANGE

requires:

OSI machines  
with BASIC-in-ROM

SURCHANGE searches for, displays, and changes code in BASIC programs. As many as seventy-one characters may be searched for and changed. Don't care characters are allowed in both search and change strings. The user may specify change strings shorter, equal to, or longer than the search string.

To avoid confusion, here are the definitions of some terms used in this article: *search string* refers to the characters SURCHANGE is told to look for. *Workspace string* is a set of characters in the BASIC program that match the search string. The *change string* is the set of characters that SURCHANGE POKES into the BASIC program when it finds a match to the search string.

There are eight options, used singly or in pairs:

- |          |  |
|----------|--|
| Default  | Print line numbers of lines that contain workspace strings.                  |
| 1. Print | Print line numbers plus workspace strings.                                   |
| 2. Stmt  | Print line numbers plus the statements in which workspace strings are found. |

- |          |  |           |  |
|----------|--|-----------|--|
| 3. Line  | Print lines in which workspace strings are found.                            | 5. Var    | Search for occurrences of a BASIC variable (specified by the search string). |
| 4. Quote | Search only within quotes and REM statements (text).                         | 6. Change | Replace all workspace strings with the change string.                        |
| Default  | If option 4 is not chosen, search only outside of quotes and REMs (program). |           |  |
- Don't care characters are allowed in both search and change strings. To il-

### Listing 1

```

10      $ SURCHANGE
20      $BY KERRY LOURASH
30      $
40      $ ZERO PAGE
50      $
60      RUF=$97      TEMP STORAGE FOR SEARCH CHAR.
70      RUFF=$13     START OF INPUT BUFFER
80      CFLAG=$98   CHANGE OPTION FLAG
90      CHRCHT=$A8  # OF CHARS. IN CURRENT LINE
100     CLEN=$6C    LENGTH OF CHANGE STRING
110     RIF=$5D    CLEN MINUS SLEN
120     ORIGIN=$7A  START OF WORKSPACE INDEX
130     LFLAG=$9B  LINE OPTION FLAG
140     LINCNT=$5E  # OF SCREEN LINES USED
150     PFLAG=$6D  PRINT OPTION FLAG
160     POINT=$6E  POINTER TO BASIC WORKSPACE
170     QFLAG=$9C  QUOTE OPTION FLAG
180     SCNCNT=$F  # OF CHARS SINCE LAST CR/LF
190     SFLAG=$9E  STATEMENT OPTION FLAG
200     SLEN=$99   LENGTH OF SEARCH STRING
210     STAK=$9D   START OF SEARCH BUFFER IN STACK
220     START=$79  START OF BASIC WORKSPACE
230     TEXT=$60   TEXT FLAG
240     VFLAG=$70  VARIABLE OPTION FLAG
250     WPOINT=$AA ADDRESS OF WORKSPACE STRING
260     YINDEX=$9F TEMP STORAGE FOR POINT INDEX
270     YSAVE=$97  TEMP STORAGE FOR PRINT INDEX
280     $
290     $ BROM ROUTINES
300     $
310     DELETE=$014F DELETE CHARS FROM PROGRAM
320     BROM=$A2B4  BROM ROUTINES COPIED FROM STACK
330     CHAIN=DELETE+$5A RECHAIN BASIC LINES
340     FILBUF=$A946 FILL BUFFER ROUTINE
350     INCHAR=$FFEB INPUT ONE CHAR FROM KYBD.
360     LETTER=$A081 CHECK FOR LETTERS A-Z
370     LIFEED=$A86C PRINT CR/LF
380     NUMBER=$00C5 CHECK FOR NUMBER 0-9
390     NUMPRT=$B95E PRINT NUMBER IN A,X
400     OUTPUT=$A9E5 PRINT ONE CHARACTER
410     PUSHUP=DELETE+$35 MAKE ROOM FOR LINE
420     QUESTN=$A8F3 PRINT A QUESTION MARK
430     RESET=$A477 RESET BASIC POINTERS
440     SPACE=$A8E0 PRINT A SPACE

```

**Listing 1 (continued)**

```

450 TOGOUT=$A39D    TOGGLE VIDEO OUTPUT FLAG
460 TOKBUF=$A3A8   TOKENIZE LINE BUFFER
470 TOKIRI=$A0B4   START OF TOKEN TABLE
480 WARMST=$A274   ENTRY TO BASIC WARMSTART
490 ;
500 %=$7D00
510 ;
520 7D00 A200      OPTION LDX #0          SET PROMPT INDEX
530 7D02 20947F   JSR PROMPT          PRINT OPTION PROMPT
540 7D05 8598     STA CFLAG            ZERO FLAGS
550 7D07 8598     STA LFLAG
560 7D09 85AB     STA PFLAG
570 7D0B 859C     STA QFLAG
580 7D0D 859E     STA SFLAG
590 7D0F 8570     STA VFLAG
600 7D11 855E     STA LINCNT
610 7D13 2046A9   JSR FILBUF          GET CHOICE OF OPTIONS
620 7D16 EB       OP INX                AFTER FILBUF, X=$12
630 7D17 B500     LDA $0,X            EXAMINE BUFFER CONTENTS
640 7D19 F023     BEQ LOGIC          BRANCH IF DONE
650 7D1B 38       SEC                CONVERT ASCII TO NUMBER
660 7D1C F931     SEC ##31
670 7D1E A8       TAY                NUMBER TO Y REG.
680 7D1F D002     BNE OP1            SET CORRECT FLAG
690 7D21 C66D     DEC PFLAG
700 7D23 88       OP1 DEY
710 7D24 D002     BNE OP2
720 7D26 C69E     DEC SFLAG
730 7D28 88       OP2 DEY
740 7D29 D002     BNE OP3
750 7D2B C69B     DEC LFLAG
760 7D2D 88       OP3 DEY
770 7D2E D002     BNE OP4
780 7D30 C69C     DEC QFLAG
790 7D32 88       OP4 DEY
800 7D33 D002     BNE OP5
810 7D35 C670     DEC VFLAG
820 7D37 88       OP5 DEY
830 7D38 D0DC     BNE OP
840 7D3A C698     DEC CFLAG
850 7D3C D0DB     BNE OP            BRANCH ALWAYS
860 7D3E ;
870 7D3E A698     LOGIC LDX CFLAG      IS CHANGE FLAG SET?
880 7D40 F006     BEQ L1
890 7D42 859B     STA LFLAG          FORCE DEFAULT OPTION
900 7D44 856D     STA PFLAG
910 7D46 859E     STA SFLAG
920 7D48 A570     L1 LDA VFLAG          BOTH V & Q FLAGS SET?
930 7D4A 259C     AND QFLAG
940 7D4C F003     BEQ GETSUR
950 7D4E 20E3AB   JSR QUESTN        PRINT A QUESTION MARK
960 7D51 ;
970 7D51 A24C     GETSUR LDX ##4C
980 7D53 20947F   JSR PROMPT        PRINT SEARCH PROMPT
990 7D56 202E7F   JSR INPUT        GET SEARCH STRING
1000 7D59 A24E    STACK LDX ##4E        SET STACK PTR TO $014E
1010 7D5B 9A      TXS
1020 7D5C AA      TAX                SLEN TO X REG.
1030 7D5D 8699   STX SLEN
1040 7D5F EB      INX
1050 7D60 B513   ST LDA BUFF,X     PUSH SEARCH STRING
1060 7D62 48     PHA                ONTO STACK
1070 7D63 CA     JEX
1080 7D64 10FA   BPL ST
1090 7D66 BA     TSX                START OF SEARCH STRING
1100 7D67 869D   STX STAK          TO STAK
1110 7D67 869D   STX STAK          TO STAK
1110 7D69 A2FE   LDX ##FE         RESET STACK
1120 7D6B 9A     TXS
1130 7D6C ;
1140 7D6C A598   LDA CFLAG
1150 7D6E F029   BEQ SEARCH
1160 7D70 A253   GETCNG LDX ##53
1170 7D72 20947F JSR PROMPT        PRINT CHANGE PROMPT
1180 7D75 202E7F JSR INPUT        PRINT & STORE CHANGE STRING
1190 7D78 856C   STA CLEN
1200 7D7A ;
1210 7D7A A296   LDX ##96        MOVE BROM ROUTINES
1220 7D7C A089   LDY ##89        TO STACK
1230 7D7E BDB4A2 COPY LDA BROM,X

```

(continued)

lustrate what a don't care character is, consider the following example:

SEARCH? YXXX

I'm using "X" for the don't care symbol; in the actual program, it is CTRL-G, the ASCII BEL character. This search string finds all strings of four characters starting with a "Y". For an example of don't care characters in a change string:

CHANGE? YXXX

This change string changes only the first letter of the workspace string. The last three letters remain the same.

**Using SURCHANGE**

SURCHANGE can be called by POKEing its starting address into the USR vector and typing X=USR(X). To avoid typing the USR command every time, you could insert the USR command in the program you are working on as line zero. Typing RUN would then call SURCHANGE.

First, SURCHANGE prints a list of options and a prompt to select options (OPTIONS?). Options are selected by typing a combination of digits (no commas). If you make a mistake, use the usual OSI backspace (shift O). You may terminate the line and start over with a shift P, although the prompt will not be repeated. RETURN signals the end of option selection. If this procedure seems familiar, it should; you're using the Fill-the-Buffer routine of OSI BASIC.

Next, the search prompt (SEARCH?) is printed. The FTB routine is used here, too. Don't care characters are input by typing CTRL-G. If you hit RETURN without an input when typing the search or change string, SURCHANGE prints the exit prompt. If you type a "Y", SURCHANGE exits to the immediate mode. Hitting any other key causes a jump to the start of SURCHANGE.

The change prompt (CHANGE?) appears if you've chosen the change option. Only the line numbers of changes will be printed when the change option is selected. If a line is made too long (longer than 71 characters), the graphics symbol \$E9 is printed after the line number.

I have attempted to provide a paged display of SURCHANGE's output. It would be nice to be able to count the number of CR/LFs generated by the video routine to determine when the screen is full. So far, I haven't figured out how to accomplish this, short of writing a separate video routine. After a certain number of lines have been printed, SURCHANGE pauses. If the space bar is hit, the display continues. Any other key causes an exit to the immediate mode without an "OK" to scroll the screen. If you use the line print option (3), you can display lines and edit them (assuming you have an editor program).

### Options

Default options are automatically selected if options 1-3 or option 4 is not selected. When the change option is chosen, SURCHANGE automatically selects the default display option. If options 4 and 5 are both selected, SURCHANGE prints a question mark in front of the search prompt, since it is unlikely the user would look for a variable in the text area of a program.

The default display option displays the line numbers of lines that contain workspace strings. The numbers are displayed with a single space separating them. If a number is printed more than once, more than one workspace string is present in the line. This option allows a very dense display and calls attention to multiple occurrences of a workspace string in a line.

Option 1 displays line numbers plus the workspace string. Due to the presence of don't care characters in a search string, the workspace string may not be identical to the search string. This option is handy when don't care characters are used. Also, option one emphasizes multiple occurrences of workspace strings in a line, although its display format is not as compact as the default option's.

The statement option (2) prints the line number and the statement in which the workspace string is found (a line may contain multiple statements). Colons found at the beginning and end of the statement are also printed. The presence or absence of colons indicates the statement's position in the line:

X = 3:—statement at start of line.  
 :X = 3:—statement in middle of line.  
 :X = 3 —statement at end of line.  
 X = 3 —statement is the entire line.

### Listing 1 (continued)

```

1240 7D81 994E01      STA DELETE-1,Y
1250 7D84 CA          DEX
1260 7D85 E067        CFX ##67
1270 7D87 D002        BNE CP
1280 7D89 A25A        LDX ##5A
1290 7D8B 88          DEY
1300 7D8C D0F0        BNE COPY
1310 7D8E A940        LDA ##60      INSERT RTS INSTRUCTIONS
1320 7D90 8D8001      STA DELETE+#31
1330 7D93 8DA801      STA DELETE+#59
1340 7D96 8DB801      STA DELETE+#69
1350 7D99
1360 7D99 A579        SEARCH LDA START   BASIC WORKSPACE POINTER
1370 7D9B 856E        STA POINT        STOREDIN POINT, POINT+1
1380 7D9D A57A        LDA START+1
1390 7D9F 856F        STA POINT+1
1400 7DA1 A003        NEXLIN LDY #3      SKIP LINE POINTERS
1410 7DA3 849A        STY ORIGIN
1420 7DA5 A900        LDA #0          INITIALIZE TEXT FLAG
1430 7DA7 8560        STA TEXT
1440 7DA9 E69A        SETBUF INC ORIGIN
1450 7DAB A49A        LDY ORIGIN
1460 7DAD A69D        LDX STAK        SET STACK POINTER TO
1470 7DAF 9A          TXS            START OF SEARCH BUFFER
1480 7DB0 68          NEXBUF PLA        GET SEARCH CHAR.
1490 7DB1 F04D        BEQ MATCH      FOUND A MATCH?
1500 7DB3 C907        CMP #7         DON'T CARE CHAR?
1510 7DB5 D002        BNE STORBUF
1520 7DB7 B16E        LDA (POINT),Y
1530 7DB9 8597        STORBUF STA BUF   SAVE CHAR. IN BUF
1540 7DBB B16E        NEXBYT LDA (POINT),Y
1550 7DBD AA          TAX
1560 7DBE F01E        BEQ FIXLIN     END OF BASIC LINE?
1570 7DC0 E08E        REM CFX ##8E   REM TOKEN?
1580 7DC2 F011        BEQ TOGGLE    YES, TOGGLE TEXT FLAG
1590 7DC4 E022        QUOTE CFX #"
1600 7DC6 F00D        BEQ TOGGLE
1610 7DC8 A59C        CKTEXT LDA QFLAG CHECK TEXT FLAG
1620 7DCA C560        CMP TEXT
1630 7DCC D0DB        BNE SETBUF
1640 7DCE E497        COMPAR CFX BUF  DO CHARS MATCH?
1650 7DD0 D0D7        BNE SETBUF
1660 7DD2 C8          INY
1670 7DD3 D0DB        BNE NEXBUF    INCREMENT WORKSPACE INDEX
1680 7DD5 A560        TOGGLE LDA TEXT BRANCH ALWAYS
1690 7DD7 49FF        EOR ##FF     TOGGLE TEXT FLAG
1700 7DD9 8560        STA TEXT
1710 7DDB 4CCE7D      JMP COMPAR
1720 7DDE
1730 7DDE AB          FIXLIN TAY     SET POINT TO NEXT LINE
1740 7DDF B16E        LDA (POINT),Y
1750 7DE1 AA          TAX
1760 7DE2 C8          INY
1770 7DE3 B16E        LDA (POINT),Y
1780 7DE5 B46E        STX POINT
1790 7DE7 856F        STA POINT+1
1800 7DE9 D0B6        BNE NEXLIN    END OF PROGRAM?
1810 7DEB
1820 7DEB A25A        END LDX ##5A
1830 7DED 20947F      JSR PROMPT    PRINT EXIT PROMPT
1840 7DF0 20ERFF      JSR INCHAR    GET CHAR. FROM KYBD.
1850 7DF3 C959        CMP #Y
1860 7DF5 F003        BEQ DONE
1870 7DF7 4C007D      JMP OPTION    LOOP TO START OF SURCHANGE
1880 7DFA 4C74A2      DONE JMP WARMST  GOTO IMMEDIATE MODE
1890 7DFD 4C1C7F      RET JMP RETURN
1900 7E00
1910 7E00 8B          MATCH DEY     SAVE WORKSPACE INDEX
1920 7E01 849F        STY YINDEX
1930 7E03 A2FE        LDX ##FE     RESET STACK
1940 7E05 9A          TXS
1950 7E06
1960 7E06 A570        VARIABL LDA VFLAG  TEST VARIABLE FOUND
1970 7E08 F01C        BEQ LINE
1980 7E0A A49A        LDY ORIGIN    INDEX TO START OF STRING
1990 7E0C C004        CPY #4        FIRST CHAR. IN LINE?
2000 7E0E F006        BEQ V0
2010 7E10 8B          DEY
2020 7E11 B16E        LDA (POINT),Y

```



Listing 1 (continued)

```

2030 7E13 20237F      JSR LEGAL      IS IT A ALPHANUMERIC CHAR?
2040 7E16 A49F      UO  LDY YINDEX  GET CHAR. IN FRONT OF STRING
2050 7E18 CB        U1  INY
2060 7E19 B16E      LDA (POINT),Y
2070 7E1B C924      CMP #'$
2080 7E1D F0DE      BEQ RET
2090 7E1F C928      CMP #'(
2100 7E21 F0DA      BEQ RET
2110 7E23 20237F      JSR LEGAL
2120 7E26            ;
2130 7E26 A002      LINE LDY #2      GET 2-BYTE LINE #
2140 7E2B B16E      LDA (POINT),Y
2150 7E2A AA        TAX
2160 7E2B CB        INY
2170 7E2C B16E      LDA (POINT),Y
2180 7E2E 205EB9      JSR NUMPRT    CONVERT TO ASCII, PRINT
2190 7E31 EB        LIN  INX          PUT # OF DIGITS IN CHR CNT
2200 7E32 B00001     LDA #0100,X
2210 7E35 D0FA      BNE LIN
2220 7E37 B66B      STX CHR CNT
2230 7E39            ;
2240 7E39 A56D      PCHECK LDA PFLAG
2250 7E3B D044      BNE FINI
2260 7E3D A59E      SCHECK LDA SFLAG
2270 7E3F F02E      BEQ LCHECK
2280 7E41 A49F      LDY YINDEX    FIND END OF LINE
2290 7E43 B16E      SO  LDA (POINT),Y OR TERMINATING COLON
2300 7E45 F013      BEQ S2
2310 7E47 CB        INY
2320 7E48 C922      CMP #' "
2330 7E4A D006      BNE S1
2340 7E4C A560      LDA TEXT      TOGGLE TEXT FLAG
2350 7E4E 49FF      EOR #$FF     IF QUOTE IS FOUND
2360 7E50 B560      STA TEXT
2370 7E52 2460      S1  BIT TEXT    LOOP IF IN TEXT
2380 7E54 30ED      BMI S0
2390 7E56 C93A      CMP #' :
2400 7E58 D0E9      BNE S0
2410 7E5A 88        S2  DEY
2420 7E5B 849F      STY YINDEX    SAVE NEW END OF STRING
2430 7E5D A49A      LDY ORIGIN    LOOK BACK THRU LINE
2440 7E5F B16E      BACKWD LDA (POINT),Y
2450 7E61 88        DEY
2460 7E62 C93A      CMP #' :
2470 7E64 F004      BEQ BA
2480 7E66 C003      CPY #3        AT START OF LINE?
2490 7E68 D0F5      BNE BACKWD
2500 7E6A CB        BA  INY
2510 7E6B 849A      STY ORIGIN    SAVE NEW START OF LINE
2520 7E6D D012      BNE FINI
2530 7E6F A59B      LCHECK LDA LFLAG
2540 7E71 F03E      BEQ CHANGE
2550 7E73 A49F      LDY YINDEX    FIND END OF LINE
2560 7E75 CB        LC  INY
2570 7E76 B16E      LDA (POINT),Y
2580 7E78 D0FB      BNE LC
2590 7E7A 88        DEY
2600 7E7B 849F      STY YINDEX    SAVE END OF LINE
2610 7E7D A004      LDY #4
2620 7E7F 849A      STY ORIGIN    START OF LINE IS ALWAYS 4
2630 7E81 20E0A8     FINI JSR SPACE   PRINT SPACE
2640 7E84 204E7F     JSR PLINE    PRINT LINE
2650 7E87            ;
2660 7E87 F65E      COUNTR INC LINCNT  CHECK # OF CHARS. IN LINE
2670 7E89 A56B      LDA CHR CNT   AND INCREMENT COUNT AS NEEDED
2680 7E8B C917      CMP ##17     ** C2P: CHANGE TO ##3F **
2690 7E8D 9008      BCC CHEC
2700 7E8F C92F      CMP ##2F     ** C2P: CHANGE TO ##7F **
2710 7E91 9002      BCC ADD1
2720 7E93 E65E      INC LINCNT
2730 7E95 E65E      ADD1 INC LINCNT
2740 7E97 A55E      CHEC LDA LINCNT
2750 7E99 C90F      CMP ##F      COUNT <= 15 LINES?
2760 7E9B 900E      BCC CONT
2770 7E9D A900      LDA #0
2780 7E9F 855E      STA LINCNT
2790 7EA1 20EBFF     JSR INCHAR   GET KYBD. INPUT
2800 7EA4 C920      CMP ##20     IS INPUT A SPACE CHAR?
2810 7EA6 F003      BEQ CONT

```

(continued)

Option 2 allows the user to follow the use of a variable throughout a program or to examine all occurrences of any token (and its arguments) in a program. A statement is printed only once, even if it contains more than one workspace string. For example, in the statement A=A-3 the variable A occurs twice. If "A" were the search string, the statement would only be printed once.

The line option (3) lets the user see the entire line that contains the workspace string. This option displays a maximum amount of information, but also fills the screen rapidly. Like the statement option, the line option prints a line only once, even if it contains more than one workspace string. The line option can be used as an aid to edit individual lines. With SURCHANGE, find the lines to be edited; exit the SURCHANGE program; and either use an editor to change the lines, or retype them.

The quote option (4) searches the text portion of a BASIC program. Text includes PRINT statements, INPUT prompts, string variables, string DATA elements, and REM statements. Due to the structure of SURCHANGE, the initial quotation mark of a string is not considered to be part of the text. If the quote option is not chosen, SURCHANGE searches the program area outside of quotes and REMs.

The reason for defining two areas of search is that BASIC tokenizes its keywords (USR, POKE, NULL, etc.), unless the words are in REMs or quotes. A token is a one-byte code for a keyword. BASIC saves memory space and increases execution speed because it stores and reads only one byte, instead of a whole keyword. Thus, if you're searching for "ON", SURCHANGE needs to know whether you mean the word "ON" or the one-byte token for the keyword ON.

The variable option (5) helps search for a BASIC variable. In a normal search, looking for the variable "A" might find other variables such as A\$, AB, A(X), etc. When the variable option is chosen, every variable found is tested to be sure it's not a subset of another variable.

The change option (6) enables modification of a BASIC program. Change strings may be shorter, equal in length, or longer than the search string. This is a powerful option and should always be used with caution. Unless changing text, SURCHANGE will tokenize the

change string before it is inserted in the program. Therefore, the change string may look deceptively longer or shorter than the search string when it is printed on the screen. For example, "RETURN" is one byte long when tokenized, while "A=6" is three bytes long. If "A=6" is substituted for RETURN, all lines changed will be two bytes longer.

If a line is longer than 71 bytes, it can still be LISTed, SAVEd, and even RUN. When you try to LOAD a long line, however, you'll find that the line is too long to fit into the input buffer. SURCHANGE prints a graphic character \$E9 after a line number when the line becomes too long. Be sure to remember which lines are too long; they are identified only when the line is being changed, not during search operations.

### Finding Your Way Around

SURCHANGE takes getting used to. I suggest you type in a ten- to twenty-line program and practice finding and changing things before you do any serious work. Here are a few tricks I've used!

To delete all non-text spaces in a program, select option 6. Type a space and a don't care character for the search string. Now, type a single don't care character for the change string. This gets rid of almost all single spaces and partially erases multiple spaces. Repeat as needed to erase all spaces. This strategy may work with other items you wish to delete.

When typing in a program, use a "%" or other seldom-used character to stand in for a phrase which is inserted by SURCHANGE after the program is completed. Of course, you must be careful not to make a line too long by the insertion.

Lines of up to 255 characters can be created with the change option. They use less memory space and run faster than normal lines. The big disadvantage of long lines is that they have to be saved and loaded in a machine-language format.

### Changing SURCHANGE

C2/4P owners should change the COUNTR routine as noted in the listing. They may also want to eliminate the CR/LF between the two lines of options in the option prompt. The easiest method is to substitute two spaces (\$20) for the \$D, \$A after

### Listing 1 (continued)

```

2820 7EAB 4C7DA2      JMP $A27D      GOTO IMM. MODE; NO OK MESS.
2830 7EAB 206CAB     CONT JSR LIFEED PRINT CR/LF
2840 7EAE 4C1C7F     JMP RETURN     RESUME SEARCH
2850 7EB1
2860 7EB1 A598      CHANGE LDA CFLAG
2870 7EB3 F067      BEQ RETURN
2880 7EB5 18         CLC           CALCULATE ABSOLUTE ADDRESS
2890 7EB6 A59A      LDA ORIGIN   OF START OF WORKSPACE STRING
2900 7EB8 656E      ADC POINT
2910 7EBA 85AA      STA WPOINT
2920 7EBC A46F      LDY POINT+1
2930 7EBE 9001      BCC CH
2940 7EC0 C8        INY
2950 7EC1 84AB     CH  STY WPOINT+1
2960 7EC3 38        SEC
2970 7EC4 A56C     LDA CLEN     FIND CLEN MINUS SLEN
2980 7EC6 E599     SBC SLEN
2990 7EC8 F02E     BEQ CEQUAL   IF CLEN = SLEN
3000 7ECA 900C     BCC MOVDWN
3010 7ECC 855D     MOVEUP STA DIF    MAKE ROOM FOR LONGER STRING
3020 7ECE C65D     DEC DIF
3030 7ED0 20B401   JSR PUSHUP
3040 7ED3 20B57F   JSR REPLAC   INSERT CHANGE STRING
3050 7ED6 301A     BMI MV3
3060 7ED8 A47B     MOVDWN LDY $7B SET UP VARIABLES FOR DELETESUB
3070 7EDA 8471     STY $71
3080 7EDC A4AB     LDY WPOINT+1
3090 7EDE 8474     STY $74
3100 7EE0 48       PHA
3110 7EE1 38       SEC
3120 7EE2 A599     LDA SLEN
3130 7EE4 E56C     SBC CLEN
3140 7EE6 18       CLC
3150 7EE7 65AA     ADC WPOINT
3160 7EE9 9001     BCC MV2
3170 7EEB C8       INY
3180 7EEC 8472     MV2 STY $72
3190 7EEE 68       PLA
3200 7EEF 204F01   JSR DELETE   ERASE XTRA CHARS. FROM PROGRAM
3210 7EF2 2077A4   MV3 JSR RESET  RESET BASIC POINTERS
3220 7EF5 20A901   JSR CHAIN    RECHAIN LINE POINTERS
3230 7EF8 20B57F   CEQUAL JSR REPLAC
3240 7EFB 209DA3   LONG JSR TOGOUT CHECK FOR LONG LINE
3250 7EFE A0FF     LDY #$FF
3260 7F00 849F     STY YINDEX
3270 7F02 A004     LDY #4
3280 7F04 20507F   JSR PLINE+2
3290 7F07 209DA3   JSR TOGOUT
3300 7F0A 18       CLC
3310 7F0B A56C     LDA CLEN     FIND NEW END OF STRING
3320 7F0D 659A     ADC ORIGIN
3330 7F0F 859F     STA YINDEX
3340 7F11 A56B     LDA CHRCNT   IS LINE TOO LONG?
3350 7F13 C947     CMP #$47
3360 7F15 9005     BCC RETURN
3370 7F17 A9E9     TOOLNG LDA #$E9 PRINT GRAPHIC CHAR.
3380 7F19 20E5AB   JSR OUTPUT
3390 7F1C A49F     RETURN LDY YINDEX
3400 7F1E 849A     STY ORIGIN
3410 7F20 4CA97D   JMP SETRUF   RESUME SEARCH
3420 7F23
3430 7F23 20C500   LEGAL JSR NUMBER IS CHAR =0-9?
3440 7F26 90F4     BCC RETURN
3450 7F28 20B1AD   JSR LETTER   IS CHAR =A-Z?
3460 7F2B B0EF     BCS RETURN
3470 7F2D 60       RTS
3480 7F2E
3490 7F2E 850E     INPUT STA SCNCNT ZERO VIDEO CHAR COUNTER
3500 7F30 2046A9   JSR FILBUF  PRINT AND STORE INPUT
3510 7F33 88       DEY         Y=0
3520 7F34 C8       LILOOK INY   COUNT # OF CHARS. IN INPUT
3530 7F35 B91300   LDA BUFF,Y
3540 7F38 D0FA     BNE LILOOK
3550 7F3A 88       TOKIZE DEY
3560 7F3B 1003     BPL TKO
3570 7F3D 4CEB7D   JMP END     IF NULL INPUT
3580 7F40 98       TRD  TZA   SHOULD STRING BE TOKENIZED?

```

**Listing 1 (continued)**

```

3590 7F41 A49C      LDY QFLAG
3600 7F43 I008      BNE RTN
3610 7F45 EB        INX
3620 7F46 20A8A3    JSR TOKBUF      TOKENIZE STRING
3630 7F49 98        TYA            FIND LENGTH OF STRING
3640 7F4A 38        SEC
3650 7F4B E906      SBC #6
3660 7F4D 60        RTN
3670 7F4E          ;
3680 7F4E A49A      PLINE LDY ORIGIN  PRINT WORKSPACE STRING
3690 7F50 8497      FO     STY YSAVE
3700 7F52 B16E      LDA (POINT),Y
3710 7F54 F0F7      BEQ RTN      END OF LINE?
3720 7F56 101E      BPL PRINT   BRANCH IF NOT A TOKEN
3730 7F58 38        TOKEN SEC      FIND KEYWORD IN TABLE
3740 7F59 E97F      SBC ##7F
3750 7F5B AA        TAX
3760 7F5C A0FF      LDY ##FF
3770 7F5E CA        TO     DEX
3780 7F5F F008      BEQ T2
3790 7F61 C8        T1     INY      PRINT KEYWORD
3800 7F62 B984A0    LDA TOKTRL,Y
3810 7F65 10FA      BPL T1
3820 7F67 30F5      BPL TO
3830 7F69 C8        T2     INY
3840 7F6A B984A0    LDA TOKTRL,Y
3850 7F6D 3007      BPL PRINT   PRINT LAST CHAR. IN KEYWORD
3860 7F6F E66B      INC CHRCNT
3870 7F71 20E5A8    JSR OUTPUT
3880 7F74 D0F3      BNE T2
3890 7F76 297F      PRINT AND ##7F  ZERO HI BIT
3900 7F78 20E5A8    JSR OUTPUT   PRINT CHARACTER
3910 7F7B E66B      INC CHRCNT
3920 7F7D A497      LDY YSAVE   DONE PRINTING LINE?
3930 7F7F C49F      CPY YINDEX
3940 7F81 C8        INY
3950 7F82 90CC      BCC PO
3960 7F84 60        RTS
3970 7F85          ;
3980 7F85 A46C      REPLAC LDY CLEN  INSERT CHANGE STRING
3990 7F87 B91300    REO    LDA BUFF,Y
4000 7F8A C907      CMP #7      DON'T CARE CHAR?
4010 7F8C F002      BEQ RE1
4020 7F8E 91AA      STA (WPOINT),Y
4030 7F90 88        RE1    DEY
4040 7F91 10F4      BPL REO    BRANCH ALWAYS
4050 7F93 60        RTS
4060 7F94          ;
4070 7F94 BDA07F    PROMPT LDA TABL,X  PRINT A MESSAGE
4080 7F97 EB        INX
4090 7F98 C60E      DEC SCNCNT  AVOID AUTO CR/LF
4100 7F9A 20E5A8    JSR OUTPUT  PRINT ONE CHARACTER
4110 7F9D D0F5      BNE PROMPT  LOOP IF CHAR NOT A NULL
4120 7F9F 60        RTS
4130 7FA0          ;
4140 7FA0          TABL
4150 7FA0 0D        .BYTE $D,$A,'SEARCH'
4150 7FA1 0A
4150 7FA2 53
4150 7FA3 45
4150 7FA4 41
4150 7FA5 52
4150 7FA6 43
4150 7FA7 48
4150 7FA8 20
4160 7FA9 4F        .BYTE 'OPTIONS:','$D,$A
4160 7FAA 50
4160 7FAB 54
4160 7FAC 49
4160 7FAD 4F
4160 7FAE 4E
4160 7FAF 53
4160 7FB0 3A
4160 7FB1 0D
4160 7FB2 0A
4170 7FB3 20        .BYTE ' 1-PRINT 2-STMT'
4170 7FB4 31
4170 7FB5 2D
4170 7FB6 50

```

(continued)

"3-LINE" in TABL at the end of the program.

If you wish to examine the BASIC-in-ROM routines copied to the stack, or if you must move them to another location, simply change the DELETE label to the start of the new location.

SURCHANGE is relocatable from object code with the exception of references to the prompt table (TABL). All references to TABL should be adjusted to conform to its new location.

### How SURCHANGE Works

SURCHANGE occupies three pages of RAM and uses part of the stack for BASIC-in-ROM routines and the search buffer. It wipes out the NMI and IRQ vectors. To conserve zero page space for other accessory programs, SURCHANGE uses only zero page addresses normally used by BASIC. The change buffer is located in the line buffer (\$13-5A).

To start, OPTION prints a list of options and the option prompt. The option flags are zeroed and FILBUF is called to find out what options are desired. When the options have been specified, their respective flags are set. LOGIC selects the default print option if the change flag is set, and prints a question mark in front of the search prompt if both the variable and quote flags are set.

GETSUR prints the search prompt and calls INPUT. INPUT zeros the video character counter (\$E) so a full 71-character line can be typed without a premature CR/LF. FILBUF is called again to store and print the search string. After the search string is typed in, the number of characters in the string is counted. If no string has been input, the routine goes to END to see if the user wishes to start over. If the search is to be conducted within quotes, the tokenize-the-buffer routine (TOKBUF) is skipped. The number of characters in the string is returned in the A register.

INPUT returns to STACK, where the stack pointer is set to \$014E and the length of the search string is stored in SLEN. The search string is pushed onto the stack and the stack pointer position saved in STAK. The stack pointer is then reset to the top of the stack.

If the change option has been selected, GETCNG prints the change prompt and INPUT is called to get the

change string. When INPUT returns, the length of the change string is stored in CLEN.

COPY transfers BASIC-in-ROM routines for inserting, deleting, and rechainning BASIC lines to the stack, and inserts RTS instructions to make them subroutines.

### The Search Begins

The start-of-BASIC workspace pointer is transferred to SURCHANGE's workspace pointer (POINT). NEXLIN sets the Y register to index the start of the BASIC line, and TEXT, the quote status flag, is cleared. ORIGIN is initialized to the start of the line. The stack pointer is set to the start of the search buffer. A character is pulled from the stack. Naturally, the contents of the stack are not altered by this operation, and SURCHANGE can re-examine the search buffer any number of times. If the character is a null, SURCHANGE has found a match to the search string and goes to the MATCH routine. If it is a don't care character, the next character in the BASIC workspace is stored in BUF. Later, when the workspace character is compared to BUF, the two will match. If the search character is not a null or don't care byte, it's stored in BUF.

NEXBYT tests the next character in the workspace. If the workspace character is a null, the end of the BASIC line has been reached. The routine branches to FIXLIN to reset POINT to the next line or to exit, if at the end of the program. If the workspace character is a REM token or a quotation mark, the TEXT flag is toggled. This means if TEXT is zero, it's changed to \$FF, and vice versa. If TEXT is not equal to the quote option flag, SURCHANGE loops back to SETBUF. Finally, at COMPAR, the search character is compared to the workspace character. If the two are identical, the next search character is pulled from the stack and the NEXBUF loop is done again. If the characters don't match, the stack pointer is reset to the start of the search buffer, the workspace counter (ORIGIN) is incremented, and SURCHANGE starts looking for a workspace string again.

FIXLIN, as mentioned before, transfers the BASIC next-line pointer to POINT. If the high byte of the pointer is zero, the end of the BASIC program has been reached. The stack pointer is set to the top of the stack, "EXIT?" is printed, and SURCHANGE waits for an input. At this point, the user can hit Y and exit to the BASIC immediate mode

### Listing 1 (continued)

```

4170 7FB7 52
4170 7FB8 49
4170 7FB9 4E
4170 7FBA 54
4170 7FBB 20
4170 7FBC 32
4170 7FBD 2D
4170 7FBE 53
4170 7FBF 54
4170 7FC0 4D
4170 7FC1 54
4180 7FC2 20      .BYTE ' 3-LINE', $D, $A
4180 7FC3 33
4180 7FC4 2D
4180 7FC5 4C
4180 7FC6 49
4180 7FC7 4E
4180 7FC8 45
4180 7FC9 0D
4180 7FCA 0A
4190 7FCB 20      .BYTE ' 4-QUOTE 5-VAR 6-'
4190 7FCC 34
4190 7FCD 2D
4190 7FCE 51
4190 7FCF 55
4190 7FD0 4F
4190 7FD1 54
4190 7FD2 45
4190 7FD3 20
4190 7FD4 35
4190 7FD5 2D
4190 7FD6 56
4190 7FD7 41
4190 7FD8 52
4190 7FD9 20
4190 7FDA 36
4190 7FDB 2D
4200 7FDC 43      .BYTE 'CHANGE', $D, $A
4200 7FDD 48
4200 7FDE 41
4200 7FDF 4E
4200 7FE0 47
4200 7FE1 45
4200 7FE2 0D
4200 7FE3 0A
4210 7FE4 4F      .BYTE 'OPTIONS', 0
4210 7FE5 50
4210 7FE6 54
4210 7FE7 49
4210 7FE8 4F
4210 7FE9 4E
4210 7FEA 53
4210 7FEB 00
4220 7FEC 53      .BYTE 'SEARCH', 0
4220 7FED 45
4220 7FEE 41
4220 7FEF 52
4220 7FF0 43
4220 7FF1 48
4220 7FF2 00
4230 7FF3 43      .BYTE 'CHANGE', 0
4230 7FF4 48
4230 7FF5 41
4230 7FF6 4E
4230 7FF7 47
4230 7FF8 45
4230 7FF9 00
4240 7FFA 45      .BYTE 'EXIT?', 0
4240 7FFB 58
4240 7FFC 49
4240 7FFD 54
4240 7FFE 3F
4240 7FFF 00

```

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or hit any other key to rerun SURCHANGE.

### A Match is Found

If a match to the search string is found, the workspace index (Y) to POINT is stored in YINDEX. The stack pointer is set to the top of the stack.

If VFLAG is set, VARIBL tests the characters adjacent to the workspace string to see if the string is a subset of another variable. If the correct variable has not been found, LEGAL jumps back into the search loop.

LINE finds the current line number in the workspace and prints it. It also counts the number of digits in the line number for later use in the COUNTR or LONG routines.

PCHECK prints a space and the workspace string if the print flag is set.

SHECK finds the terminating colon of the statement or the end of the line. BACKWD finds the start of the statement or the start of the line. I was strapped for space here; I didn't include a check in BACKWD to be sure a colon

is really a statement separator and not part of a string.

LCHECK finds the start and end of the line. The start is easy; always the fourth byte from the beginning of the line. FINI prints a space to separate line number and line, and then PLINE prints all or part of the line and counts the characters in the line.

COUNTR looks at the number of characters in the line just printed and decides whether LINENT, the line counter, shall be incremented by one, two, or three. CHEC decides if enough lines have been printed. If so, it calls INCHAR, which waits for a keystroke. Any other key causes an exit to the immediate mode, without the "OK" message.

### Changing Things Around

CHANGE tests CFLAG and, if it is set, subtracts the length of the search string (SLEN) from the length of the change string (CLEN). If the two are equal, CHANGE goes directly to CEQUAL, where the change string replaces the workspace string. If CLEN is longer than SLEN, MOVEUP calls

PUSHUP, a routine copied from ROM. PUSHUP makes room in the BASIC workspace for the longer change string. REPLAC is called to insert the change string into the BASIC program. LONG tests the new line length to see if it's longer than 71 characters. A graphics character \$E9 is printed after the line number if the line is too long.

If CLEN is less than SLEN, CHANGE branches to MOVDWN. Part of the BASIC-in-ROM line delete routine is paraphrased in MOVDWN, then DELETE is called to move the BASIC lines down and delete the extra bytes in the program. REPLAC is called to insert the change string. CHAIN rechains the BASIC line pointers. RETURN resets the BASIC workspace index (ORIGIN) and jumps back into the search loop.

Developing SURCHANGE was a real challenge. Many thanks to Earl Morris for advice and for finding the bugs in the program.

Kerry Lourash may be contacted at 1220 North Dennis, Decatur, Illinois 62522.

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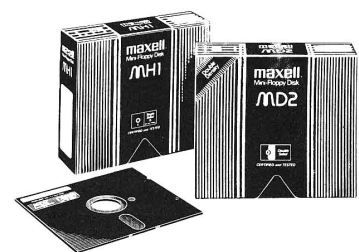
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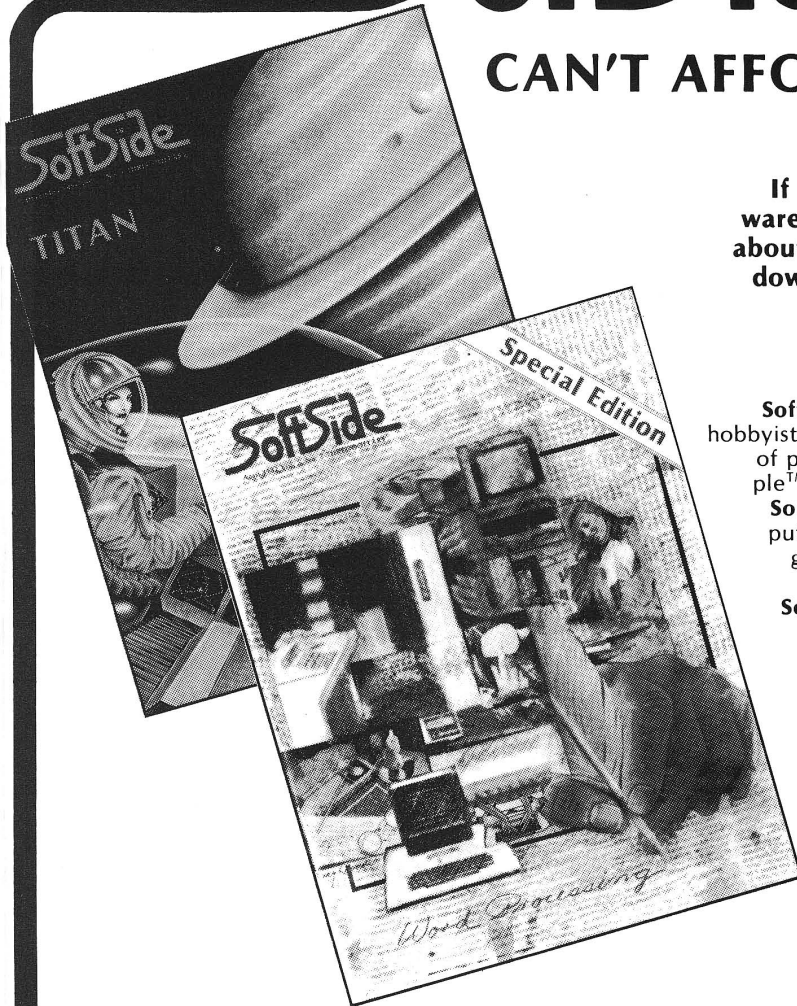
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# ON ERROR GOTO for OSI ROM BASIC

by Earl Morris and Kerry Lourash

**This run-time utility allows you to trap certain non-fatal errors and continue your program execution. You can also print out full error descriptions.**

## ON ERR

requires:

OSI C1P or 540-based computer

When OSI ROM BASIC encounters an error, program execution is halted and the screen displays the dreaded

? S\* ERROR IN LINE xx

where the \* is a graphics character rather than the correct letter. The following programs add an "ON ERR GOTO" function to your machine so that errors are detected and a jump is made to program line 50000. The line number where the error occurred is stored in the variable XX and the type of error is stored in X. At line 50000, the programmer can print out the expanded error message, fix the error, or jump back to the program. As an added bonus, the graphics character in the error message is converted to the correct alphabetic letter.

As an example, consider the program

```
10 INPUT "NUMBER"; A
20 PRINT:PRINT 1/A
30 GOTO 10
```

If a zero is input, the program will halt with a divide-by-zero error in line 20. With the error trap program in place, the following can be added:

```
50000 PRINT: IF XX < > 20 THEN END
50010 PRINT:PRINT "CAN'T DIVIDE
BY ZERO — TRY AGAIN"
50020 GOTO 10
```

If an error occurs in line 20, the error trap program will print a message and

continue program execution. Other errors will still end the program. The error trap resets the stack, effectively clearing all loops and subroutines. The jump back to the main program cannot enter within a FOR-NEXT loop or go directly to a subroutine.

Two versions of the ON ERR routine are listed: 1P and 540. Use the version appropriate for your machine. The

method used to detect errors is different for each type of computer. The 1P version uses the output vector on page two. On every carriage return, the ON ERR program searches the stack to determine which routine is writing to the screen. If an \$A252 is found on the stack, then the error routine is outputting and the ON ERR program is triggered.

```

; *****
; * ON ERROR routine for 540 video *
; *****
;
; Goes to line 50000 on error
; with line number in XX.
;
; set-up $0004=$40 $0005=$02
;
;
; *****
; * $0240
; FNA
; LDA $D740 READ SCREEN
; CMP #$3F QUESTION MARK ?
; BEQ J1 IF YES THEN ERROR OCCURED
; PLA NORMAL MESSAGE OUTPUT
; JMP $A8C3 MESSAGE PRINTER
; LDA $D742 FIX GRAPHICS CHARACTER
; AND #$7F REMOVE HIGH BIT
; STA $D742 STORE ON SCREEN
; LDA $88
; CMP $FF IMMED MODE ?
; BEQ J2 IF YES- GO TO BASIC
; PLA
; LDY $87 CURRENT LINE #
; STY $AE TO $AD,$AE
; LDA $88
; STA $AD
; LDX $90
; SEC
; JSR $B7E8 CONVERT HEX TO FLOATING
; LDA $00
; STA $5E
; STA $5F
; LDA $58 $58 = "X"
; STA $93
; STA $94
; JSR $AD49 FIND OR CREATE XX VARIABLE
; STA $97
; STY $98
; JSR $E774 PUT VALUE INTO XX
; LDA $50 HEX 50000 INTO $11,$12
; STA $11
; LDA $C3
; STA $12
; JSR $A432 FIND LINE 50000
; BCC J3
; JSR $A6D9 POINT TO LINE 50000
; JMP $ASC2 BASIC EXECUTION LOOP
; LDA $92 NO LINE 50000- PRINT "OK"
; LDY $A1
; JMP $A8C3 MESSAGE PRINTER
; *****

```

Machines other than the 1P do not have the output vector in RAM, and must use a different hook into BASIC. The ON ERR program hooks into the OK message printer at \$0003. The routine looks for the "?" which appears above the OK whenever an error occurs. A disadvantage of this hook is that the normal error message has already been printed and the type of error is no longer in memory. Thus the 540 version stores a value in XX (line number) but not in X (error type).

In both programs, after an error is detected, location \$88 is inspected. If it contains a \$FF, the computer is in the immediate mode and the ON ERROR routine is bypassed. Then the normal error message (corrected) is printed. If you wish to use ON ERROR in the immediate mode, change the following location:

1P — Change \$0243 from \$4C to \$00  
540 — Change \$0259 from \$EE to \$00

The variable XX will contain 65xxx as a line number if the error occurs in the immediate mode.

If the computer is not in immediate mode, or if the above patch is made, the current line number is converted to

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```

1000      : *****
1010      : * ON ERROR routine, 1P version *
1020      : *****
1030      :
1040      : Goes to line 50000 on error with
1050      : line number in XX, error type in X.
1060      :
1070      : Set up $021A=$22, $021B=$02
1080      :
1090 0222      : *=$0222
1100      :
1110 0222 C90D      : CMP #$0D      :OUTPUT=CR?
1120 0224 D015      : BNE BYE      :NO. EXIT
1130 0226 8A        : TXA          :SAVE X REGISTER
1140 0227 48        : PHA
1150 0228 BA        : TSX          :GET STACK POINTER
1160 0229 BD0601    : LDA $106,X   :IS CALLING ADDRESS
1170 022C C952      : CMP #$52     :$A252 ?
1180 022E D007      : BNE A1
1190 0230 BD0701    : LDA $107,X
1200 0233 C9A2      : CMP #$A2
1210 0235 F007      : BEQ ERRTRP  :YES, TO ERR TRAP
1220 0237 68        : PLA          :RESTORE X REG.
1230 0238 AA        : TAX
1240 0239 A90D      : LDA #$0D     :RESTORE A-REG.
1250 023B 4C69FF    : BYE JMP $FF69 :GOTO REG. OUTPUT
1260      :
1270 023E A588      : ERRTRP LDA $88 :IF IN IMM. MODE
1280 0240 C9FF      : CMP $FF      :PRINT ERR MESSAGE
1290 0242 F04C      : BEQ ERROR
1300      :
1310 0244 A487      : LDY $87      :STORE CURRENT LINE # IN XX
1320 0246 85AD      : STA $AD      :CURRENT LINE #
1330 0248 84AE      : STY $AE      :TO F.P.A
1340 024A A290      : LDX #$90
1350 024C 38        : SEC
1360 024D 20E8E7    : JSR $E7E8
1370 0250 A900      : LDA $0        :FIND OR CREATE XX
1380 0252 855E      : STA $5E
1390 0254 855F      : STA $5F
1400 0256 A958      : LDA #$58
1410 0258 8593      : STA $93
1420 025A 8594      : STA $94
1430 025C 2049AD    : JSR $AD49
1440 025F 8597      : STA $97      :STORE F.P.A IN XX
1450 0261 8498      : STY $98
1460 0263 2074B7    : JSR $B774
1470      :
1480 0266 68        : PLA          :STORE ERROR #/2 IN X
1490 0267 48        : PHA          :PULL ERROR #
1500 0268 9A        : LSR A        :HALVE IT
1510 0269 AB        : TAY          :STORE ERR # IN F.P.A
1520 026A A900      : LDA $0
1530 026C 20C1AF    : JSR $AFC1
1540 026F A900      : LDA $0        :FIND OR CREATE X
1550 0271 8594      : STA $94
1560 0273 2049AD    : JSR $AD49
1570 0276 8597      : STA $97      :STORE F.P.A IN X
1580 0278 8498      : STY $98
1590 027A 2074B7    : JSR $B774
1600      :
1610 027D A950      : LDA #$50     :FIND LINE 50000
1620 027F 8511      : STA $11      :HEX 50000 IN $11,12
1630 0281 A9C3      : LDA $C3
1640 0283 8512      : STA $12
1650 0285 2032A4    : JSR $A432
1660 0288 9006      : BCC ERROR    :BRANCH IF NO LINE
1670 028A 20D9A6    : JSR $A6D9    :SET PARSER AT 50000
1680 028D 4C2A5     : JMP $A5C2    :BASIC EXEC. LOOP
1690      :
1700 0290 68        : ERROR PLA    :PRINT ERR MESSAGE
1710 0291 AA        : TAX          :PULL ERR INDEX
1720 0292 20E3AB    : JSR $ABE3    :PRINT '?'
1730 0295 BD64A1    : LDA $A164,X  :FIRST LETTER
1740 0298 20E5AB    : JSR $ABE5    :PRINT IT
1750 029B BD65A1    : LDA $A165,X  :SECOND LETTER
1760 029E 297F      : AND $7F      :ZERO HI BIT
1770 02A0 4C5FA2    : JMP $A25F    :TO REG. ERR ROUTINE

```



Table 1

Index	Error Message
0	Next Without For
1	Syntax Error
2	Return Without Gosub
3	Out Of Data
4	Function Call — argument out of range
5	Overflow
6	Out Of Memory
7	Undefined Statement GOTO non-existent line
8	Bad Subscript Subscript greater than dimension
9	Double Dimension
10	Division By Zero
11	Illegal Direct Can't use in immediate mode
12	Type Mismatch
13	Long String
14	String Temporaries
15	Continue Error
16	Undefined Function

floating point and stored in the variable XX. The error index contained in the X register is halved, converted to floating point, and stored in the variable X.

Next a search is made for line 50000. If it is found, the parser pointer is set to the start of line 50000 and the program jumps to the start of the

BASIC execution loop. If no line 50000 is found, the normal error message is output and execution is halted.

#### Notes on 1P Version

Whenever the BREAK key is pressed, the 1P's vectors are reset to the original. The output vector again must

be pointed to ON ERRor after every break. This can also be done with

POKE 538,34 : POKE 539,2

For the 1P version, the error type is contained in the variable X. Table 1 lists the error types. A program can be written to print out the full error descriptions if you have trouble remembering what "T\*" means.

#### Notes on 540 Version

On error can also be set up using

POKE 4,64 : POKE 5,2

The first command in line 50000 should be PRINT. This scrolls the error message up one line to prevent retriggering ON ERRor. The 540 version does not put the error type into X, but the error type is displayed on the screen at \$D741 and \$D742. The ON ERRor program could be extended to read these locations and do a table look-up to get the error index.

Contact Mr. Morris at 3200 Washington, Midland, MI 48640. Contact Mr. Lourash at 1220 N. Dennis, Decatur, IL 62522.

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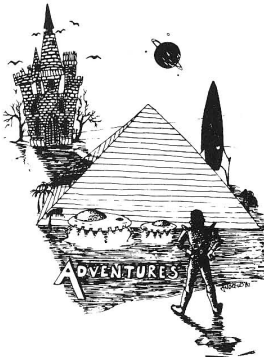
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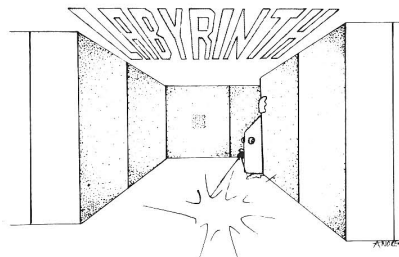
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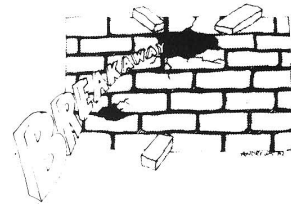
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BPO	Branch on Power Off	ST	Scratch Tape
BSO	Branch on Sleepy Operator	SRSD	Seek Record and Scar Disk
IIB	Ignore Inquiry and Branch	RD	Rewind Disk
RPB	Reverse Parity and Branch	BD	Backspace Disk
BCH	Branch on CPU Halted	ED	Eject Disk
BTAD	Branch To Auto-Destruct	TD	Throw Disk
JRL	Jump to Random Location	LCD	Launch Cartridge Disk
JSP	Jump on Sexy Programmer	FD	Flip Disk
FAG	Fold And Go	DF	Disk Feed
AI	Add Improper	UER	Update and Erase Record
DO	Divide and Overflow	CVU	ConVert to Unary
DC	Divide and Conquer	CVS	ConVert to Sesquinary
SRZ	Subtract and Reset to Zero	CRN	Convert to Roman Numerals
ARZ	Add and Reset to Zero	WRTC	Wind Real-Time Clock
XM	Exclusive Maybe	WWTC	Wind Wrong-Time Clock
PAII	Prevent All Interrupts and Interrupt	PCB	Pause for Coffee Break
PI	Punch Invalid	SPD	Start and Power Down
RI	Read Invalid	PDN	Power Down and Normalize
RCSD	Read Card and Scramble Data	EBQR	Enable Bi-Quinary Arithmetic
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RASC	Read And Shred Card	EROS	Erase Read-Only Store
BCR	Backspace Card Reader	RWOM	Read Write-Only Memory
BCP	Backspace Card Punch	WROM	Write Read-Only Memory
RCI	Read Card and Ignore	FCE	Fill Core with Epoxy
RCS	Read Card Sideways	DMPK	Destroy Memory Protect Key
SSJ	Select Stacker and Jam	UC	Unwind Core
RP	Read Printer	BPP	Blob Plotter Pen
FSRR	Forms Skip and Run Away	MPS	Move Pen Somewhere
BSP	BackSpace Printer	DPMD	Drop Pen and Mangle Drum
PBC	Print and Break Chain	APX	Apply Power and Explode
TDB	Transfer and Drop Bits	HCF	Halt and Catch Fire
MDB	Move and Drop Bits	CCP	Clear Core and Proceed
MLR	Move and Lose Record	CCCC	Conditionally Clear Core and Proceed
MWC	Move and Wrap Core	EIOC	Execute Invalid Op Code
MC	Move Continuous	EPI	Execute Programmer Immediate
CM	Circulate Memory	SPSW	Scramble Program Status Word
WWLR	Write Wrong Length Record	ERAF	Execute Relocatable Address Field
RNR	Read Noise Record	EPSW	Execute Program Status Word
RIRG	Read Inter-Record Gap	EM	EMulate 407
REOF	Read End-Of-File	SSN	Set Serial Number
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RBT	Rewind and Break Tape	PSP	Push Stack Pointer
MTI	Make Tape Invalid		
PMT	Punch Magnetic Tape		
PDT	Punch and Delete Tape		

# Straightforward Garbage Collection for the Apple

by Cornelis Bongers

**This article presents a method of garbage collection that dramatically increases program efficiency by eliminating lengthy delays caused by string processing.**

## Memory Organizer

requires:

Apple II or Apple II Plus  
with Applesoft in ROM or  
language card

## Introduction

When processing large amounts of alphanumeric data in Applesoft (or another Microsoft BASIC) by means of strings and string operations, you will be confronted with one of Applesoft's weakest points: garbage collection. A program that runs perfectly may suddenly come to a grinding halt. Depending on the number of active strings in memory, you could be put out of business for a few tenths of a second or half an hour. Consider, for instance, the following simple program:

GARBAGE TEST on 48K Apple with DOS (HIMEM:\$9600)

```
10 DIM A$(4600)
20 FOR I= 1 TO 4600
30 PRINT I
40 A$(I)="$" + STR$(I)
50 NEXT
60 PRINT CHR$(7);" READY
(AT LAST)"
```

This program runs fine until I becomes equal to 2740. At that point, the regular printing of I stops for 13 minutes, after which it continues again until I becomes 3835. This time you will have to wait for 20 minutes before the printing restarts.

In total, the time needed to finish the program is 84 minutes. Only three

minutes (or 3.5%) are spent on the actual execution of the program. The remaining time is consumed by Applesoft's garbage collection routine. A question that may arise at this point is: What is meant by garbage and why is garbage collection necessary? To answer this question, consider the following program segments:

```
1000 GOSUB 5000: REM INPUT
NAME AND CHECK NAME
1010 B$(I)=A$
1020 ....
.
.
.
5000 INPUT "GIVE NAME OF
ITEM ";A$
5010 ....CHECK INPUT ....
.
.
.
5200 RETURN
```

When a new item has to be added to the list in B\$, the subroutine at line 5000 is called, then asks for a name and checks whether this name satisfies some conditions (not listed here). At each new input the text that has been input is added to the stringpool and a pointer to this text is inserted in (the space reserved for) A\$. The variable A\$ itself is treated in the same way as a numeric variable and resides therefore in the variable space. There are seven bytes reserved for A\$. The first two bytes contain the hex values 41 and 80, which represent the name. The next three bytes form the string descriptor and the last two bytes are unused. The string descriptor contains the length of the text (string) that has been input in A\$ and the pointer to the string, in that order. So, if the text 'lens' is input, a snapshot of memory may look as displayed in figure 1.

If the checking in the subroutine is done, control returns to the main program and the assignment at line 1010 is executed. The target of the assignment is an array element. As in the case of

simple variables (like A\$), room is reserved for each array element. However, only the three bytes of the descriptor are reserved for each element of a string array. At the assignment, the top of free memory (i.e., the start of the stringpool) is decreased by four and the text 'lens' is copied to the area between the 'old' top and the 'new' top. Consequently, the text 'lens' now occurs twice in the stringpool (see figure 2).

Now, if line 5000 is executed later in the program, A\$ gets a new value, say 'shutter'. This text is again added to the stringpool in the way described above and the pointer in the descriptor of A\$ is set to the new top. The previous value of A\$, i.e. 'lens', has now become non-active, since none of the pointers in the descriptors point to it. In other words, the text 'lens' that was related to A\$ is of no use anymore and it is therefore called garbage.

Apart from assignment statements, garbage may also be generated if you make use of string expressions. In the first program listed above, where a string expression occurs at line 40, the stringpool will be filled with the strings, \$1,\$2,..., etc. But between every two strings, there is some garbage. For instance, after executing the I loop 10 times, the stringpool looks like this:

\$1010\$99\$88\$77\$66\$55\$44\$33\$22\$11

Only the underlined strings are active because they are referred to by the descriptors in the A\$ array. If the I loop has been executed 2740 times, the stringpool occupies all the memory up to the top of the array space, and at that time Applesoft takes action. It knows that garbage is likely to be present in the stringpool and therefore it starts reorganizing the stringpool, eliminating the non-active strings. This reorganization process works as follows:

A complete pass is made through the variable and the array space. In this

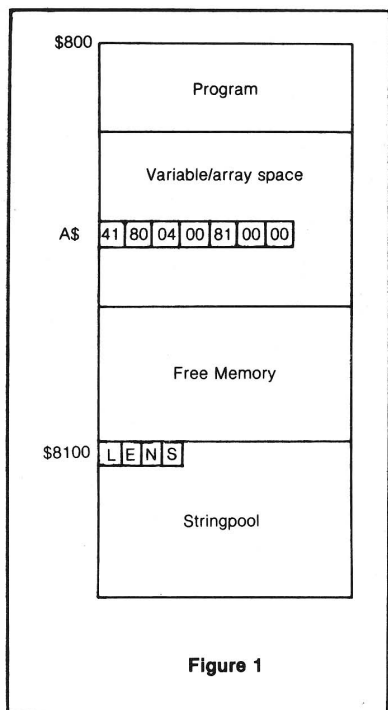


Figure 1

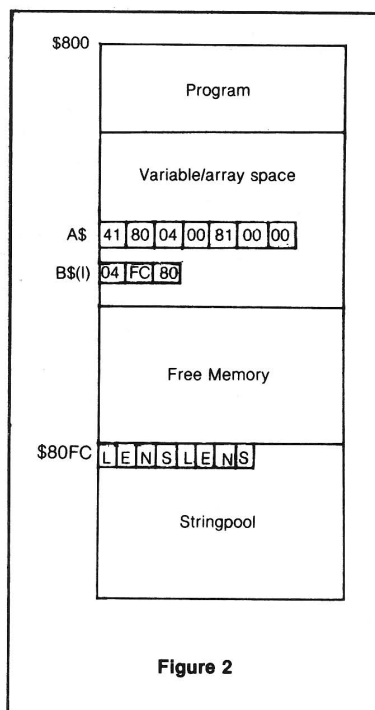


Figure 2

pass all string descriptors are examined with the purpose of finding the pointer to the highest string in the stringpool (i.e., the string nearest to HIMEM). The string that this pointer references is moved up to the top of memory and the descriptor of this string is appropriately adjusted. Next, a second pass is made through the variable and array space; now the next-but-highest pointer is searched for. The string pointed to is then moved to just below the string that was moved up during the previous pass. This process continues until all the active strings reside in a compact block that is located just below HIMEM. Then the pointer to the start of the stringpool is adjusted. Since all the garbage now has been eliminated, there will be sufficient free memory to continue the execution of the program.

The time needed to collect garbage with this method varies approximately quadratically with the number (n) of active strings in memory. This is due to the fact that Applesoft has to make n passes through the variable/array space and each pass consists of n comparisons and some other operations. Consequently, the total time needed is proportional to n\*n. Thus if you have an array of 1000 active strings and you fill another array with 1000 strings, garbage collection will not last twice as long, but four times as long.

It is mainly the quadratic character of Applesoft's garbage collection routine that causes the long execution times if there are many active strings in memory (see table 1). Therefore, the best way to cut down execution time is to design a garbage collection method whose execution time varies linearly, rather than quadratically, with the number of active strings. Another way to speed up garbage collection, which may be used in combination with the first, is to clear (erase) all string arrays as soon as their contents are not needed anymore. This effectively reduces the number of active strings and therefore also the time to collect garbage.

Table 1: Execution times (in seconds) of garbage collection routines as a function of the number of active strings in memory.

No. of Active Strings	Applesoft(1)	'Linear' Method(1)	'Linear' Method(2)
100	1	0.05	0.06
250	5	0.11	0.14
500	19	0.21	0.26
1000	75	0.42	0.52
2000	292	0.84	1.04
3000	655	1.26	1.53
4000	1154	1.68	2.04
5000	1811	2.10	2.55

- (1) All strings are of length 3.
- (2) One string is of length 2, the others are of length 3.

The program listed in figure 3 contains a linear garbage collection routine and a selective array eraser.

### How It Works

Basically the problem with garbage collection is that there are only pointers from variables and array elements to the strings and not the other way around. Thus when looking in the stringpool one can view the strings, but it is impossible to say to which variable/array element they belong or whether they are active or non-active (garbage). If somehow the strings themselves would indicate whether they are active or non-active and to which variable/array element they belonged, garbage collection would become a simple matter. Just move up all the active strings one by one to the current top of free memory and adjust for each string the pointer in the descriptor. Note that it is necessary to retrieve the length of the string from the descriptor before the move is done, since this length is used at the execution of the move.

We now have the interesting question: is it possible to store (temporarily) the necessary information (mentioned above) in the strings themselves? Of course this must happen under the condition that no extra memory space is used, since lack of memory is just what triggered FRE(0). However, the storage of information will require memory. But let us first consider how much memory exactly is required. Suppose first that all strings in the pool have a length of at least three bytes. By making a pass through the variable and array space, we can successively store the active/non-active marker and the pointer to the descriptor in each string. The insertion of the active/non-active marker does



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Figure 3

```

;*****
;*
;* MEMORY ORGANIZER I *
;* BY *
;* CORNELIS BONGERS *
;* *
;* ORGANIZER *
;* *
;* *
;* *
;* *
;* *
;*****
;
;          ORG $9000
;          OBJ $800
;
LEN      EPZ $06      ;LENGTH STRING
STAT     EPZ $07      ;ARRAY/VAR OFFSET
SDES     EPZ $08      ;POINTER TO STRING
                    VARIABLE/ARRAY EL.
;
RCHK     EPZ $17      ;RESULT MEMORY CHECK
ALL      EPZ $3C      ;MONITOR MOVE REGISTERS
A2L      EPZ $3E      ;
A4L      EPZ $42      ;
;
VARS     EPZ $69      ;START VARIABLE SPACE
ARS      EPZ $6B      ;START ARRAY SPACE
EARS     EPZ $6D      ;END ARRAY SPACE
SPOOL    EPZ $6F      ;START STRING POOL
;
HIM      EPZ $73      ;HIMEM
SARA     EPZ $9B      ;POINTER TO START ARRAY
SPTR     EPZ $9D      ;POINTER TO STRING
ARP      EPZ $9F      ;POINTER TO NEXT ARRAY
DO3      EPZ $A1      ;3RD STEP FLAG
EPROG    EPZ $AF      ;POINTER TO END OF PROGRAM
SDES1    EPZ $FC      ;POINTER TO STRING DESCRIPTOR
TOP      EPZ $FE      ;START OF (NEW) STRING POOL
;
; ** BASIC AND MONITOR ROUTINES **
;
MOVE      EQU $FE2C    ;MONITOR MOVE ROUTINE
GNAME     EQU $F7D9    ;EVALUATE ARRAY NAME
NAME      EQU $DFE3    ;EVALUATE VARIABLE
PLET      EQU $DA63    ;PART OF BASIC'S LET
CTYP      EQU $DD6A    ;CHECK ON NUMERIC
FRE0      EQU $E2E8    ;PART OF BASIC'S FRE(0)
IT00      EQU $E84E    ;INIT MFP TO 0
CKOL      EQU $DEBB    ;CHECK ON '('
CKOR      EQU $DEBB    ;CHECK ON ')'
*SYN      EQU $DEC9    ;SYNTAX ERROR
*CHW      EPZ $B1      ;GET NEXT CHARACTER
*COL      EPZ $B7      ;GET CURRENT CHARACTER
;
; ** TOKENS AND SPECIAL CHARACTERS **
;
FRE       EPZ $D6      ;TOKEN FOR FRE
MIN       EPZ $C9      ;TOKEN FOR -
CLEAR     EPZ $BD      ;TOKEN FOR CLEAR
COM       EPZ $2C      ;COMMA
BJP       EQU $3F5     ;& VECTOR
;
; ** INITIALIZATION **
;
9000      ;
9000      ;
9000 A9 13 BEGIN LDA #START
9002 3D F6 03 STA BJP+1 ;SET & VECTOR
9005 A9 90 LDA /START
9007 8D F7 03 STA BJP+2
900A A9 00 LDA #BEGIN
900C B5 73 STA HIM ;SET HIMEM
900E A9 90 LDA /BEGIN
9010 95 74 STA HIM+1
9012 60 RTS
;
9013      ;
9013      ; ** ERASE ARRAYS **
9013      ;
9013 C9 BD START CMP #CLEAR ;TOKEN FOR CLEAR?
9015 D0 35 BNE $PART1 ;NO,CHECK ON FRE
9017 20 B1 00 NXAR JSR CHW ;ADVANCE TEXTPOINTER
901A 20 D9 F7 JSR GNAME ;EVALUATE ARRAY. NAME
901D 18 CLC
901E A0 01 LDY #S01
9020 A2 FE LDX #SFE
9022 B5 6F DOAG LDA EARS+2,X ;SET UP POINTER TO
9024 95 40 STA A2L+2,X ;END OF MOVE AREA
9026 B5 9D LDA SARA+2,X ;SET UP POINTER TO

```

(Continued)

not lead to problems because all characters have their high bit off when processing strings in the normal way. A string can thus be marked active by setting the first bit of a character in that string. The pointer to the descriptor requires two bytes and these can be substituted for two characters. Thus, if A\$ equals 'MARJO', the stringpool contains somewhere the values 4D, 41, 52, 4A, and 4F. By making a pass through the variable/array space, A\$ will be encountered and the string in the pool can be adjusted to 23, 0A, D2, 4A, and 4F. As can be seen, the third byte now has its high bit on, whereas the address of the descriptor is stored in the first and second bytes. (It is assumed that A\$ resides at \$A21). The only problem left is where to store the two characters M and A, which have been replaced by the address of the descriptor. The obvious answer is: store them in the descriptor of A\$. This descriptor contains the pointer to the string 'MARJO' or what is left of it, but this pointer is not needed anymore, once the string is located.

Having applied this operation to all strings, a pass through the stringpool is made. We start at HIMEM and search down until a character with its first bit on is encountered. This character must belong to an active string and the address of the descriptor will be stored in the next two bytes. First the length of the string and its two characters are retrieved from the descriptor. Next the two characters are restored in the string and the string is moved up as far as possible. Finally, the new starting position of the string is stored in the descriptor. Then the next string is searched for and this process continues until the start of the (old) stringpool is reached.

The remaining problem is: what to do with strings whose length equals 1 or 2? Clearly, these strings are too short to allow us to store the necessary information in them. Again the answer is not difficult. Just copy the whole string in the descriptor and forget about the string in the pool (it will thus not be marked active). The descriptor occupies three bytes. One of these bytes will be needed to flag that the descriptor itself contains the string. For this purpose the high address byte of the pointer can be used by setting it to FF if a string is stored in the descriptor. Note that the high byte cannot equal FF during normal operations because this would mean that the string resides in the Monitor. If the length of a string equals 2, the remaining two bytes of the descriptor can be used to store the character. If the length equals 1, the string is put in the first byte of the

descriptor and the second byte is put equal to FF. Note that here again use is made of the fact that during normal operations all characters in the stringpool have their high bit off.

If strings with length 1 or 2 are present in the stringpool, it will be necessary to make a second pass through the variable/array space (after the pass through the stringpool). During this pass all strings that were stored in the descriptors are replaced in the stringpool and the pointers to these strings are inserted in the descriptors.

Table 1 shows the performance of the method outlined above. As can be seen, there exists, apart from some small measurement errors, a linear relationship between the number of active strings and the execution time. The fourth column of the table shows that the extra pass, which is necessary if the stringpool contains strings with a length less than 3, increases the execution time by about 20%.

The differences in execution time between Applesoft's garbage collection routine and the 'linear' garbage collection routine are considerable. For instance, if garbage collection is done when, say, 1000 active strings reside in memory (in an array), a speed improvement with a factor of  $75/0.52 = 144$  can be realized. When doubling the number of active strings, this factor doubles (approximately) too. So, with 4000 active strings, the speed improvement is about a factor of  $4 * 144 = 576$ .

However, it should be noted that the speed improvement reduces if the (average) length of the strings increases. For instance, if there are 999 active strings of length 15 and one of length 1, the time gain is about a factor of 80. For 1999 active strings of length 15 and one of length 1, it is about a factor of 160.

## The Program

The machine language program, listed in figure 3, is linked to BASIC by means of the & statement. The syntax of the statement for this program is

```
& FRE ([ - ] digit
[,name of numeric variable])
```

or

```
& CLEAR arrayname
[(,arrayname)]
```

As indicated by the keyword FRE, the first &-line handles the garbage collection. Contrary to Applesoft's

Figure 3 (Continued)

```

9028 95 44          STA A4L+2,X          ;TARGET OF MOVE AREA
902A C8            INY
902B B1 9B        LDA (SARA),Y
902D 75 9D        ADC SARA+2,X          ;SET UP POINTER TO
902F 95 3E        STA A1L+2,X          ;START OF MOVE AREA
9031 E8          INX
9032 D0 EE        BNE DOAG          ;EXECUTE LOOP TWICE
9034 A0 00        LDY #500          ;Y MUST BE ZERO ON ENTRY MOVE
9036 20 2C FF     JSR MOVE          ;EXECUTE MOVE
9039 18          CLC
903A CA          DEX          ;X=FF
903B B5 43        DOAG1 LDA A4L+1,X          ;ADJUST POINTER TO
903D E9 00        SBC #500          ;END ARRAY SPACE
903F 95 6E        STA EARS+1,X
9041 E8          INX
9042 F0 F7        BEQ DOAG1         ;EXECUTE LOOP TWICE
9044 20 B7 00     JSR C10L         ;GET CURRENT CHARACTER
9047 C9 2C        CMP #COM          ;IS IT A COMMA?
9049 F0 CC        BEQ NXAR          ;ERASE NEXT ARRAY IF SO
904B 60          RTS          ;RETURN TO BASIC

904C          ;
904C          ; ** DRIVER PRE ROUTINE **
904C          ;
904C C9 D6        START1 CMP #FRE          ;TOKEN FOR FRE?
904E F0 03        BEQ NSYN          ;BRANCH IF SO
9050 4C C9 DE     JMP SYN          ;ELSE SYNTAX ERROR
9053 4A          NSYN  LSR          ;CLEAR FIRST BIT
9054 85 17        STA RCHK          ;SET UP CHECK REGISTER
9056 20 B1 00     JSR CHNW          ;GET NEXT CHAR
9059 20 BB DE     JSR CKOL          ;CHECK '('
905C C9 C9        CMP #MIN          ;MINUS?
905E D0 08        BNE FREAM          ;BRANCH IF NOT
9060 20 21 92     JSR CHECK          ;CHECK MEMORY ON NEG ASCII'S
9063 66 17        ROR RCHK          ;SAVE RESULT CHECK
9065 20 B1 00     JSR CHNW          ;GET DIGIT
9068 29 0F        FREAM AND #50F
906A F0 0B        BEQ DOPREL        ;DO IT ALWAYS IF 0
906C 18          CLC
906D 65 6E        ADC EARS+1
906F A6 6D        LDY EARS          ;IS EARS+DIGIT*256<SPOOL?
9071 E4 6F        CPX SPOOL
9073 E5 70        SBC SPOOL+1
9075 90 07        BCC NOFRE        ;YES, DON'T DO IT
9077 A5 17        DOPREL LDA RCHK          ;CHECK OK?
9079 30 03        BMI NOFRE        ;NO, DON'T DO IT
907B 20 A4 90     JSR DOPRE        ;COLLECT GARBAGE
907E 20 B1 00     NOFRE JSR CHNW          ;GET NEXT CHARACTER
9081 C9 2C        CMP #COM          ;IS IT A COMMA
9083 D0 1C        BNE 4AAK          ;BRANCH IF NOT
9085 20 B1 00     JSR CHNW          ;GET NEXT CHARACTER
9088 20 E3 DF     JSR NAME          ;EVALUATE NAME
908B 85 85        STA S85

908D 84 86        STY S86          ;SAVE POINTER FOR LET
908F 20 6A DD     JSR CTPY          ;MUST NOT BE A STRING
9092 20 E8 E2     JSR FREQ          ;CALCULATE FREE MEMORY
9095 A5 17        LDA RCHK
9097 10 03        BPL NZER          ;BRANCH IF TEST OK
9099 20 4E E8     JSR ITOO          ;ELSE SET MFP TO 0
909C A5 12        NZER  LDA $12          ;LOAD TYPE VARIABLE
909E 20 63 DA     JSR PLET          ;SIMULATE A LET
90A1 4C B8 DE     4AAK  JMP CKOR          ;RETURN TO BASIC

90A4          ;
90A4          ; ** COLLECT GARBAGE **
90A4          ;
90A4          ; ** STEP 1: PUT POINTERS IN STRINGS **
90A4          ;
90A4 85 A1        DOPRE STA D03          ;INIT STEP 3 FLAG TO <> 0
90A6 20 6E 91     JSR INITS          ;SET POINTERS FOR NOSTR
90A9 20 80 91     GNXST JSR NOSTR          ;SEARCH NEXT STRING
90AC B0 3B        BCS STEP2        ;BRANCH IF NO MORE STRINGS
90AE E4 AF        CPX EPROG          ;STRING IN PROGRAM?
90B0 E5 B0        SBC EPROG+1
90B2 90 F5        BCC GNXST        ;DON'T PROCESS IT IF SO
90B4 A6 06        LDY LEV
90B6 F0 F1        BEQ GNXST        ;NEGLECT IF LENGTH=0
90B8 E0 03        CPX #503
90BA 90 14        BCC APART        ;BRANCH IF LENGTH EQUALS 1 OR
2
90BC B1 9D        LDA (SPTR),Y          ;Y=2 ON EXIT NOSTR
90BE 09 80        ORA #500          ;SET 1ST BIT OF 3RD CHAR
90C0 91 9D        P2C  STA (SPTR),Y
90C2 88          DEY
90C3 30 E4        BMI GNXST
90C5 B1 9D        LDA (SPTR),Y          ;PUT FIRST 2 CHARS
90C7 C8          INY          ;IN FIRST 2 BYTES OF DESC.
90C8 91 FC        STA (SPTR),Y

```

(Continued)



Figure 3 (Continued)

```

90CA 88          DEY
90CB B9 FC 00   LDA SDES1,Y      ;PUT ADDRESS DESC. IN STRING
90CE B0 FO      BCS P2C          ;ALWAYS
90D0 A0 00      LDY #S00
90D2 84 A1      STY DO3          ;STEP 3 MUST BE DONE
90D4 B1 9D      LDA (SPTR),Y     ;PUT FIRST CHAR IN
90D6 91 FC      STA (SDES1),Y    ;LENGTH BYTE OF DESC.
90D8 A9 FF      LDA #SFF        ;PUT FF IN 2ND BYTE DESC.
90DA C8         INY            ;IF LENGTH EQUALS 1
90DB CA         DEY
90DC FO 02      BEQ AFF
90DE B1 9D      LDA (SPTR),Y     ;PUT 2ND CHAR IN 2ND BYTE
90E0 91 FC      STA (SDES1),Y    ;OF DESC. IF LENGTH EQUALS 2
90E2 C8         INY
90E3 A9 FF      LDA #SFF        ;PUT 3RD BYTE OF DESC.
90E5 91 FC      STA (SDES1),Y    ;EQUAL TO FF
90E7 30 C0      BMI GNXST       ;ALWAYS

90E9           ;
90E9           ; ** STEP 2: MOVE STRINGS UP **
90E9           ;
90E9 20 21 92   STEP2 JSR CHECK        ;SEARCH NEG ASCII'S
90EC 4C F2 90   JMP CON
90EF 20 2E 92   ESTEP2 JSR DEY          ;CONTINUE SEARCH
90F2 90 3E      CON      BCC STEP3     ;FOUND NONE IF CARRY CLEAR
90F4 A0 02      LDY #S02

90F6 29 7F      AND #S7F        ;CLEAR 1ST BIT OF CHAR
90F8 91 9D      STA (SPTR),Y     ;AND RESTORE CHAR
90FA 88         DEY
90FB B1 9D      LDA (SPTR),Y     ;NOW GET ADDRESS OF
90FD 85 09      STA SDES+1      ;OF DESCRIPTOR AND SAVE
90FF 88         DEY            ;IT IN SDES
9100 B1 9D      LDA (SPTR),Y     ;
9102 85 08      STA SDES
9104 B1 08      LDA (SDES),Y     ;GET LENGTH STRING
9106 85 06      STA LEN        ;AND SAVE IT
9108 C8         INY
9109 B1 08      LDA (SDES),Y     ;
910B 88         DEY            ;GET 1ST CHAR OF STRING
910C 91 9D      STA (SPTR),Y     ;AND RESTORE IT
910E A0 02      LDY #S02
9110 B1 08      LDA (SDES),Y     ;GET 2ND CHAR OF STRING
9112 88         DEY            ;AND RESTORE IT
9113 91 9D      STA (SPTR),Y     ;
9115 A5 FE      LDA TOP          ;CARRY IS SET
9117 E5 06      SBC LEN          ;CALCULATE NEW TOP OF
9119 85 FE      STA TOP          ;FREE MEMORY
911B B0 02      BCS NOADJ
911D C6 FF      DEC TOP+1
911F 91 08      NOADJ STA (SDES),Y   ;STORE ADDRESS STRING
9121 A5 FF      LDA TOP+1        ;IN DESCRIPTOR
9123 C8         INY
9124 91 08      STA (SDES),Y     ;
9126 A4 06      LDY LEN
9128 88         DEY
9129 B1 9D      MOV      LDA (SPTR),Y   ;MOVE STRING TO NEW
912B 91 FE      STA (TOP),Y      ;LOCATION
912D 98         TYA
912E D0 F8      BNE MOV
9130 FO BD      BEQ ESTEP2       ;ALWAYS

9132           ;
9132           ; ** STEP 3: RESTORE STRINGS OF LENGTH 1 OR 2 **
9132           ;
9132 A5 A1      STEP3 LDA DO3          ;IS THIS STEP NECESSARY?
9134 D0 08      BNE OMIT          ;BRANCH IF NOT
9136 20 6E 91   JSR INITS         ;INIT FOR NOSTR
9139 20 80 91   GNX2 JSR NOSTR        ;SEARCH NEXT STRING
913C 90 09      BCC NOKL         ;BRANCH IF FOUND
913E A5 FE      OMIT  LDA TOP          ;ALMOST READY NOW
9140 85 6F      STA SPOOL        ;UPDATE STRING POOL POINTER
9142 A5 FF      LDA TOP+1
9144 95 70      STA SPOOL+1
9146 60         RTS            ;RETURN TO DRIVER
9147 A2 01      NOKL  LDX #S01      ;NOSTR RETURNS WITH Y=2
9149 B1 FC      LDA (SDES1),Y     ;LENGTH STRING EQUAL TO 1 OR 2 ?

914B C9 FF      CMP #SFF
914D D0 EA      BNE GNX2         ;BRANCH IF NOT
914F 88         DEY
9150 B1 FC      LDA (SDES1),Y     ;LOAD 2ND BYTE OF DESC.
9152 30 05      BMI NOC4+1       ;BRANCH IN IT IS NOT A CHAR
9154 E8         INX            ;INCREMENT LENGTH COUNTER
9155 20 14 92   JSR INS          ;STORE 2ND CHAR IN STRING POOL

9158 24 88      NOC4  BIT S88
915A B1 FC      LDA (SDES1),Y     ;HIDDEN DEY INSTRUCTION
;LOAD 1ST CHARACTER

```

(Continued)

FRE(0), the arguments of the & FRE are significant. One of the reasons to include arguments in the & FRE statement is that the user must be able to prevent a regular Applesoft FRE(0) from happening. This can be done by giving the & FRE(digit) command. If digit=0 garbage collection will always be done. If digit < > 0 garbage collection will be done only if less than digit\*256 free bytes of memory remain. Thus, & FRE(4) leads only to garbage collection if the amount of free memory is less than 1K. In case no garbage collection is done, the execution time of the statement will be about 0.0004 seconds only. It is therefore advised to insert the & FRE (digit) statement frequently in your program (of course with digit < > 0) to make sure Applesoft doesn't get the chance to execute its own FRE(0).

If a variable is specified in the & FRE statement, the amount of free memory that is available after garbage collection will be assigned to it. Thus, & FRE(0,K):PRINT K prints the amount of free memory.

Finally, if a minus sign is specified before the digit, the whole stringpool will be checked on the occurrence of

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characters which have their high bit on. As will be clear from the explanation in the previous section, the occurrence of such characters will lead to a terrible crash if an & FRE(0) is forced. However, & FRE(-0,K) leads to garbage collection only if all high bits are off. If characters are found which have their high bit on, this will be flagged by putting K equal to 0.

It will usually not be necessary to use the '-' option since under normal circumstances Applesoft will store all characters with their high bit off. However, in some programs statements of the type: A\$ = CHR\$(X) are used. For X > = 128 the execution of this statement will store 'characters' in the string pool with their high bit on. Therefore, if & FRE is implemented in a program in which 'high bit on' characters might occur, it is strongly advised to check the stringpool at the first execution of the & FRE statement. If one is sure there are 'no high bit on' characters, it is better to omit the check since it increases execution time.

The second &-line can be used to clear (erase) arrays. For instance, & CLEAR A, A\$, A% clears the arrays A, A\$, and A%. An array that is mentioned in the & CLEAR statement must have

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Figure 3 (Continued)

```

915C 20 14 92      JSR INS          ;AND STORE IT IN POOL
915F 8A           TXA
9160 91 FC        STA (SDES1),Y  ;STORE LENGTH IN DESCRIPTOR
9162 C8           INY
9163 A5 FE        LDA TOP
9165 91 FC        STA (SDES1),Y  ;SAVE POINTER TO STRING
9167 C8           INY          ;IN DESCRIPTOR
9168 A5 FF        LDA TOP+1
916A 91 FC        STA (SDES1),Y
916C D0 CB        BNE GNX2          ;ALWAYS

916E             ;
916E             ; ** SET UP POINTERS FOR NOSTR **
916E             ;
916E A9 07        INITS   LDA #$07
9170 85 07        STA STAT          ;VARIABLES OFF SET
9172 38           SEC
9173 A5 69        LDA VARS
9175 E9 07        SBC #$07          ;SET SDES TO START OF
9177 85 08        STA SDES          ;VARIABLE SPACE-7
9179 A5 6A        LDA VARS+1
917B E9 00        SBC #$00
917D 85 09        STA SDES+1
917F 60           RTS

9180             ;
9180             ; ** SEARCH NEXT STRING **
9180             ;
9180 18           NOSTR   CLC
9181 A5 07        LDA STAT
9183 AA           TAX
9184 65 08        ADC SDES          ;ADVANCE DESCRIPTOR POINTER
9186 85 08        STA SDES          ;WITH 7 OR 3
9188 90 02        BCC N0IN
918A E6 09        INC SDES+1
918C E0 07        N0IN   CPX #$07          ;ARE WE DEALING WITH ARRAYS?
918E F0 36        BEQ DOVAR        ;BRANCH IF NOT
9190 A6 09        DOAR   LDX SDES+1
9192 A0 00        LDY #$00
9194 E4 A0        CPX ARP+1          ;END ARRAY REACHED?
9196 D0 19        BNE VAR2          ;BRANCH IF NOT
9198 C5 9F        CMP ARP
919A D0 15        BNE VAR2          ;BRANCH IF NOT
919C F0 3E        BEQ NEXTAR        ;YES, DO NEXT ARRAY
919E A0 00        LDY #$00
91A0 B1 08        VARSP  LDA (SDES),Y
91A2 30 DC        BMI NOSTR        ;BRANCH IF NOT A STRING
91A4 C8           INY
91A5 B1 08        LDA (SDES),Y
91A7 10 D7        BPL NOSTR        ;IDEM
91A9 88           DEY
91AA A5 08        LDA SDES
91AC 69 02        ADC #$02          ;ADD 2 BYTES TO
91AE 90 01        BCC VAR2          ;COMPENSATE FOR NAME
91B0 E8           INX
91B1 85 FC        VAR2   STA SDES1
91B3 86 FD        STX SDES1+1
91B5 B1 FC        LDA (SDES1),Y
91B7 85 06        STA LEN          ;SAVE LENGTH STRING
91B9 C8           INY
91BA B1 FC        LDA (SDES1),Y
91BC 85 9D        STA SPTR          ;SET POINTER TO STRING
91BE AA           TAX
91BF C8           INY
91C0 B1 FC        LDA (SDES1),Y
91C2 35 9E        STA SPTR+1
91C4 18           CLC
91C5 60           RTS
91C6 A6 09        RTSS   LDX SDES+1
91C8 E4 6C        DOVAR  CPX ARS+1          ;START ARRAY SPACE REACHED?
91CA D0 D2        BNE VARSP        ;BRANCH IF NOT
91CC C5 5B        CMP ARS
91CE D0 CE        BNE VARSP
91D0 46 0E        LSR STAT          ;PROCESS ARRAYS NOW, PUT STAT= 3

91D2 85 9F        STA ARP
91D4 36 A0        STX ARP+1
91D6 A5 9F        NEN    LDA ARP
91D8 A6 A0        LDX ARP+1
91DA A0 00        LDY #$00
91DC F4 E6        NEXTAR CPX EARS+1          ;END ARRAY SPACE REACHED?
91DE D0 04        BNE ARRY        ;BRANCH IF NOT
91E0 C5 6D        CMP EARS
91E2 F0 E1        BEQ RTSS          ;RTS WITH CARRY SET IF SO
91E4 85 08        ARRY   STA SDES
91E6 86 09        STX SDES+1

```

(Continued)

Figure 3 (Continued)

```

91E9 B1 08      LDA (SDES),Y      ;GET 1ST CHAR OF ARRAY NAME
91EA AA         TAX              ;SAVE IN X
91EB C9         INY
91EC B1 08      LDA (SDES),Y      ;GET 2ND CHAR OF ARRAY NAME
91EE 49         PIA              ;SAVE ON STACK
91EF C9         INY
91F0 B1 08      LDA (SDES),Y      ;ADD LENGTH ARRAY TO ARP
91F2 65 9F      ADC ARP
91F4 85 9F      STA ARP
91F6 C9         INY
91F7 B1 08      LDA (SDES),Y
91F9 65 A0      ADC ARP+1        ;ARP POINTS TO
91FB 85 A0      STA ARP+1        ;NEXT ARRAY
91FD 68         PLA              ;GET 2ND CHAR OF NAME
91FE 10 D6      BPL NEN          ;BRANCH IF NOT A STRING ARRAY
9200 8A         TXA              ;GET 1ST CHAR OF NAME
9201 30 D3      BMI NEN          ;BRANCH IF NOT A STRING ARRAY
9203 C8         INY
9204 B1 08      LDA (SDES),Y      ;GET # OF DIMS
9206 0A         ASL              ;MULTIPLY BY 2
9207 69 05      ADC #S05        ;ADDOVERHEAD
9209 65 08      ADC SDES        ;ADD SDES
920B 85 08      STA SDES        ;SDES POINTS TO FIRST DESC.
920D 90 81      BCC DOAR        ;OF ARRAY
920F E6 09      INC SDES+1
9211 4C 90 91   JMP DOAR

9214           ;
9214           ;** DEREMENT TOP AND SAVE CHARACTER **
9214           ;
9214 A4 FE      INS      LDY TOP      ;HIGH BYTE DECR. NECESSARY?
9216 D0 02      BNE OK          ;BRANCH IF NOT
9218 C6 FF      OK      DEC TOP+1
921A C6 FE      OK      DEC TOP
921C A0 00      LDY #S00
921E 91 FE      STA (TOP),Y      ;SAVE CHARACTER
9220 60         RTS

9221           ;
9221           ; ** CHECK/SEARCH NEGATIVE ASCII'S IN STRING POOL
9221           ;
9221 A2 01      CHECK    LDX #S01
9223 B5 73      CHNM     LDA HIM,X    ;COPY HIMEM IN TOP AND IN SPTR

9225 95 FE      STA TOP,X
9227 95 9D      STA SPTR,X
9229 CA         DEX
922A F0 F7      BEQ CHNM
922C A0 00      LDY #S00
922E A5 9E      DEYY     LDA SPTR+1
9230 C5 70      CMP SPOOL+1        ;IS SPTR(HIGH)<SPOOL(HIGH)?
9232 90 2B      BCC RTS2        ;RETURN WITH CARRY CLEAR IF SO

9234 C6 9E      DEYY1    DEC SPTR+1  ;SET SPTR FOR SEARCH
9236 88         DEY
9237 B1 9D      LDA (SPTR),Y
9239 30 05      BMI FOUND        ;FOUND ONE
923B 98         TYA
923C D0 F8      BNE DEYY1
923E F0 EE      BEQ DEYY        ;ALWAYS
9240 48         PIA              ;SAVE BYTE FOR A WHILE
9241 A6 9E      FOUND    LDX SPTR+1
9243 98         TYA
9244 18         CLC
9245 65 9D      ADC SPTR        ;SPTR=SPTR+Y
9247 90 01      BCC NOINCR
9249 E9         INX
924A E4 70      NOINCR   CPX SPOOL+1  ;IS SPTR<SPOOL?
924C 90 10      BCC RTS1        ;RETURN WITH CARRY CLEAR IF SO

924E D0 04      BNE SBC2
9250 C5 6F      CMP SPOOL
9252 90 0A      BCC RTS1        ;IDEM
9254 E9 02      SBC2     SBC #S02    ;SPTR=SPTR-2
9256 85 9D      STA SPTR
9259 B0 01      BCS NODECR
925A CA         DEX
925B 86 9E      NODECR   STX SPTR+1
925D 38         SEC              ;RETURN WITH CARRY SET
925E 68         RTS1     PLA        ;RESTORE BYTE
925F 60         RTS2     RTS
9260           ;
9260           ; ** END OF PROGRAM **
9260           ;
9260           END

```

been dimensioned earlier in the program, else an OUT OF DATA error will be generated.

& CLEAR can be used to reduce garbage collection time still further by timely clearing of string arrays. In addition, it can be used to clear numerical working arrays. This will especially be of use if a program consists of several subroutines, each of which require differently dimensioned array space to do data manipulations. By DIMing the working arrays on entry of the subroutine and by clearing them on exit, one prevents that memory from becoming littered with unused arrays. This reduces array access time and leads to fewer 'OUT OF MEMORY' problems.

Finally, & CLEAR can be used to initialize an array to zero, for instance by & CLEAR A: DIM A(20,20). These statements execute about 80 times faster than the usual zero-assignment within a double loop.

### Installing the Program

The program has been developed with the excellent BIG MAC assembler, recently released by Call —A.P.P.L.E. (for more information see: Call —A.P.P.L.E., Vol. IV, Number 7, page 37). Editor's note: Figure 3 was reassembled by LISA for purposes of uniformity.

The machine-language program starts at \$9000 and has a length of \$260 bytes. After assembling the text file and storing it to disk, the program can be installed by : BRUN programname. This command executes an initialization routine that sets HIMEM to \$9000 and installs the & vector. If you want to BRUN the routine from within an Applesoft program, the BRUN command should be inserted at the first line of the program, and must be followed by a CLEAR command. For example:

```

10 PRINT "BRUN program name":
CLEAR: REM control D behind first quotes.

```

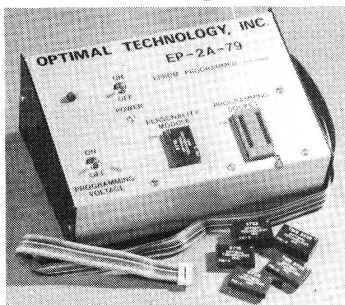
The program makes use of some Applesoft routines in ROM. If the RAM version of Applesoft is being used, the relevant subroutine calls have to be adjusted.

Contact the author at Erasmus University, P.O. Box 1738, 3000 DR Rotterdam, The Netherlands.

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# OSI Extended I/O Processor

by Michael J. Keryan

**More than thirty new functions can be added to an OSI C1P by redefining the input, output, and control-C routines. Most of the new functions are activated by either control character keyboard input, or escape sequences placed in BASIC.**

**Extended I/O requires:**

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"Cursor Control for the C1P," by Kerry Lourash (May, 1981 MICRO), added nine utility functions to the input and output routines. I have pieced together the desirable features of most of these smaller programs, and added a number of new ones, such as automatic line number generation. In all, over thirty routines are now available for use during keyboard input, screen output, etc. User-supplied software/hardware additions for a printer, bell, and bug-free garbage collection are also supported. An improved monitor program is included, which can be called at any time. All the constants — screen parameters, subroutine vectors, and flags — were put into tables, rather than imbedded into machine code, making changes relatively easy. The program was originally written for a C2-8P, but the version described here is for a C1P with 8K of memory. The 2K program is ROMable, assuming all the references to the high byte of subroutines (\$18 through \$1F) are translated to higher memory.

## The Video Screen

Several screen parameters are stored in page zero memory, as shown in figure 1 and table 1. There are no restrictions on screen size or video memory location; 32, 64, or non-standard line widths can be supported,

as well as video memory at locations other than \$Dxxx. Figure 1 shows the window starting near the top of the screen and the flags and monitor fields (described later) near the bottom, but all locations can be modified. During initialization, the parameters are copied from tables within the program (default locations) to lower memory. The parameters can be changed by POKeIng into pages zero and two, but the default values will be re-established on each warm start. Therefore, if the default values do not suit you, change them in the upper memory tables.

## Cursor Movement

The cursor position is stored in locations \$00E0 (low byte) and \$00E1 (high byte). The cursor movement functions print the character under the cursor, move the cursor, and print the cursor symbol (stored in location \$00E9) at the new position. No other output to the CRT or printer is affected. The

following control characters will cause non-destructive cursor movement to any screen location:

Up one line — control-U (\$15)  
Down one line — control-D (\$04)  
Left one space — control-L (\$0C)  
Right one space — control-R (\$12)  
Right eight spaces — control-I (\$09)

Use of these cursor movements can put the cursor outside an active window. The following movement controls keep the cursor within an active window:

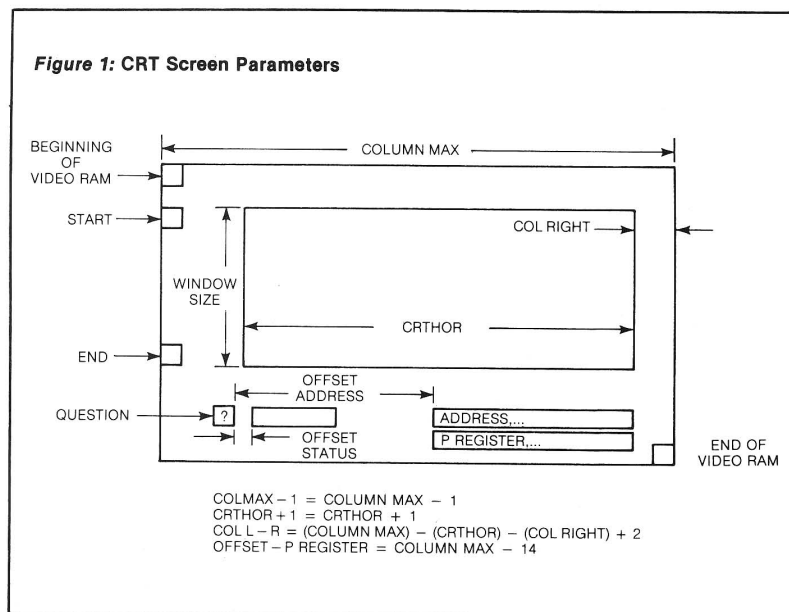
Return to the left of a line  
control-Q (\$11)

Home cursor (to bottom of window)  
control-B (\$02)

Backspace (like control L, but stays in margins)  
control-H (\$08)

Move cursor (to a preset location)  
control-N (\$0E)

Figure 1: CRT Screen Parameters



Control-N will move the cursor to the location stored in \$02DA (low byte) and \$02DB (high byte). It is now set for the top left corner of the screen. Note that if the preset location is outside the window, control-N will cause the cursor to leave the window.

### Window Controls

Active window boundaries are stored in START: \$00E2, \$00E3, and END: \$00E4, \$00E5. All CRT output, scrolling, etc., will be maintained within these boundaries. An alternate window is stored in START2: \$02D6, \$02D7, and END2: \$02D8, \$02D9. The two windows could be equivalent, partially overlapping, or completely separate.

The two windows can be switched by pressing control-W (\$17). In addition to toggling the windows, the cursor will be homed in the new active window.

The window boundaries can be changed by POKEing into the appropriate locations, but are easily changed by using the control-X (\$18) key. To use control-X, first place the cursor anywhere on the desired line by using control-U or control-D, then press control-X. You will be prompted for another key with a question mark (at location \$00E6, \$00E7) and a beep (if this function is implemented), until either a T (for top of window) or a B (for bottom) is pressed. Control-X will only change boundaries of the active window; to change the other window's boundaries, first use control-W.

If the cursor is placed above the window, it will naturally move down into (and be trapped in) the window. If the cursor is placed below the bottom boundary, however, it will not move by itself from that line. This can be used for a one-line non-scrolling window, but a two-line window is the minimum required to give readable text.

### Scroll Controls

If the cursor is placed near the top of the window, it will move down the screen as lines of text are output. No scrolling will occur until the cursor attempts to move down when at the bottom of the window; the whole window will then scroll upward and the home line will be blanked. An upward scroll can be forced at any time by pressing control-Y (\$19); similarly, a downward scroll is forced by control-Z (\$1A). These functions control only the location of the text, which is moved up or

down on the screen; they do not move the cursor, which remains stationary. The scrolling functions are useful in editing and in game programs.

### Clear Controls

To erase the entire screen, press either control-T (\$14) or ESCAPE (\$1B). To erase only the active window, press RUBOUT (\$7F); this will also home the cursor in the window.

### Edit Text

Text can be entered by typing it in as usual, or by placing the cursor anywhere on the screen and pressing control-E (\$05). This causes whatever is under the cursor to be entered into BASIC; it has the same effect as typing the character. The cursor is then indexed one space to the right.

When entering a line of text, characters can be deleted with shift O (\$5F); this moves the cursor one space backwards, deletes the character from BASIC, and erases it from the CRT. The function of shift P (\$64) is not changed; it scratches from BASIC the line being worked on, but does not erase the line from the CRT.

To summarize, text is entered by typing characters (or spaces) or by using control-E over text. Text can be deleted by typing spaces over text when using

control-E or with shift O. Text is not changed by using cursor controls; these are used only to position the cursor to allow use of a combination of control-E, character input, or space input.

### Autoline

To facilitate easy entry of text, an automatic line entering system can be invoked by inputting control-A (\$01). Control-A toggles the autoline mode off or on at any time. It can also be changed by POKEing the status flag. When the autoline mode is on, an A will appear near the bottom of the screen. You then enter a carriage return to activate autoline.

When the system is initialized, the starting line number will be 100 and the increment is 10, resulting in lines numbered 100, 110, 120, ..., 9990. The line number and increment can be changed at any time by POKEing locations \$02D0 and \$02D1 (line number) and \$02D2 (increment). These are packed BCD numbers, four bits per digit. The default values will be re-established on warm start.

When the autoline mode is on, the input routine looks at both the character being entered and the last character. If the last character was a carriage return, you are now at the beginning of a new line, possibly in

Table 1: Parameter Location and Values (for C1P)

PARAMETER	LOCATION	DEFAULT LOCATION	DEFAULT VALUE
CURSOR-LO	\$00E0	\$1C00	A0
CURSOR-HI	\$00E1	\$1C01	D0
START1-LO	\$00E2	\$1C02	A0
START1-HI	\$00E3	\$1C03	D0
END1-LO	\$00E4	\$1C04	C0
END1-HI	\$00E5	\$1C05	D2
QUESTION-LO	\$00E6	\$1C06	C5
QUESTION-HI	\$00E7	\$1C07	D3
OK SYMBOL	\$00E8	\$1C08	E5
CURSOR SYMBOL	\$00E9	\$1C09	A4
COLUMN MAX	\$00EA	\$1C0A	20
COLMAX-1	\$00EB	\$1C0B	1F
COL L-R	\$00EC	\$1C0C	07
COL RIGHT	\$00ED	\$1C0D	01
CRTHOR+1	\$00EE	\$1C0E	1A
STATUS FLAGS	\$00EF	\$1C0F	82
CONTROL C FLAG	\$0212	\$1C36	00
AUTOLINE-LO	\$02D0	\$1C10	90
AUTOLINE-HI	\$02D1	\$1C11	00
AUTOLINE INCREMENT	\$02D2	\$1C12	10
LINES/PAGE-CRT	\$02D3	\$1C13	12
LINES/PAGE-PRINTER	\$02D4	\$1C14	30
START2-LO	\$02D6	\$1C16	01
START2-HI	\$02D7	\$1C17	D3
END2-LO	\$02D8	\$1C18	80
END2-HI	\$02D9	\$1C19	D3
MOVE CURSOR-LO	\$02DA	\$1C1A	A5
MOVE CURSOR-HI	\$02DB	\$1C1B	D0
OFFSET-STATUS	\$02DC	\$1C1C	00
OFFSET-ADDRESS	\$02DD	\$1C1D	08
OFFSET-P REGISTER	\$02DE	\$1C1E	12

need of a new line number. Entering any character other than a space, a control character, a number from 0-9, a shift-O, or a rubout, will automatically generate a new line number before the key is entered. These exceptions allow certain things to be done without getting a line number put on it: immediate mode commands are invoked by first typing a space, then the command; new line numbers can be inserted between or over existing lines; and all cursor and editing commands can be used. The autoline mode can simply be toggled off by using control-A.

### Flag Changes

To change a status flag, use control-F (\$06). You will then get a prompt. You must then enter the flag number (from 1 to 8), followed by either a 0 (for off) or 1 (for on). The flag code numbers are:

Flag Number	Code	Description
1	H	Hard copy (printer) mode
2	C	CRT output mode
3	I	Intermittent output (paging) mode
4	T	Trace mode
5	S	Step mode
6	A	Autoline mode
7	M	Monitor save mode
8	E	Extended I/O mode (all functions)

After the flag number and status is entered, the status of all flags will be displayed near the bottom of the screen (these can be erased by escape or control-T). The status can also be changed at any time (e.g., during execution of a BASIC program) by POKEing bits into location \$00EF; the flag number corresponds to the bit number. Note that if the E flag is cleared, you can get back into the extended I/O mode by POKEing a number greater or equal to 128 (\$80) into \$00EF, or a warm start.

### CRT and Hardcopy Flags

When these flags are set to 1, a corresponding output to the screen or printer will be created. These flags are independent. To get printed output, a user-supplied printer subroutine must be included: change the NOP's at \$1EF7 to JSR \$YYYX (20 XX YY), where \$YYYX is the address of your subroutine. Prior to this subroutine call, 16 page-zero locations (\$00EX) are freed for additional use by the print routine, and are restored before returning to the CRT output.

### Print Window

At any time, a control-P (\$10) from the keyboard will cause the entire active window to be output to the printer, character by character. The H flag need not be set. The CRT display is not affected.

### Intermittent Output

If the I flag is set, the number of lines output to the CRT/printer are counted and stored in locations \$02F6/\$02D5. These are compared to constants stored in locations \$02D3/\$02D4. If the line count is equal to the preset page size, the computer will prompt you and wait for a keyboard entry before continuing. This will allow you to copy (or read) CRT text before it scrolls off, or change to a new sheet of paper on the printer. These counts are independent; both are reset to zero on warm start.

### Stop/Restart Output

In addition to the above intermittent output mode, a program or listing can be stopped at any time by pressing control-S (\$13) and then restarted by control-R (\$12). These commands are functional only during output. In many cases, the control S/R sequence is preferred over control C/CONT since no extraneous output is printed.

### Step and Trace Modes

If the Step mode is invoked by setting the S flag, only one line of BASIC code will be executed during RUN. You will then be prompted for a keyboard entry, after which the next line will be executed, and so on.

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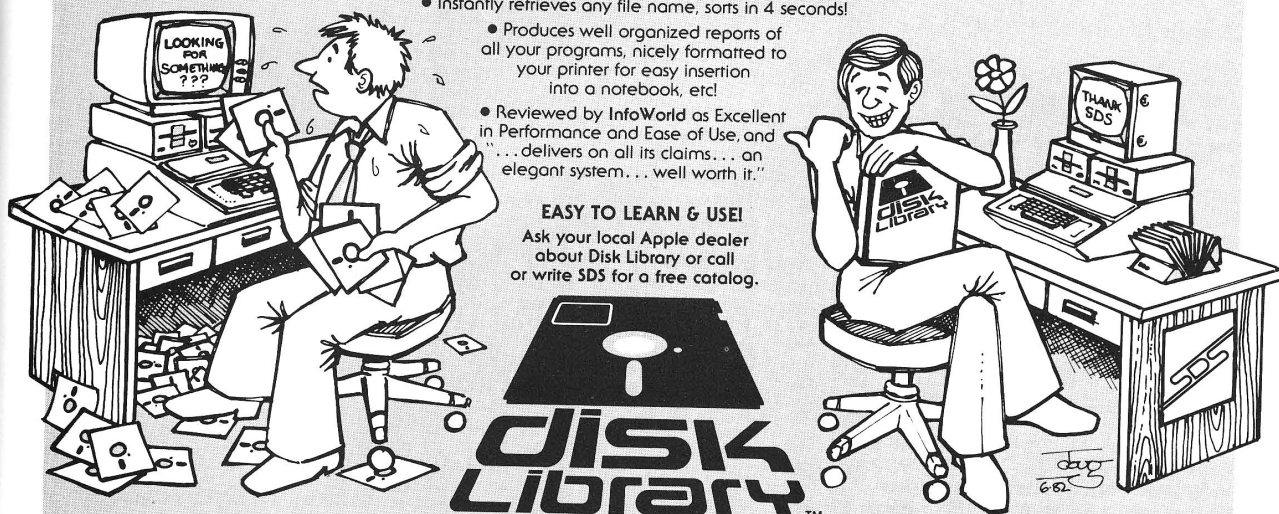
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If the Trace mode is invoked by setting the T flag, the BASIC line number will be printed when that line is executed. The output will then be a mixture of line numbers with the normal program output. The program cannot be LISTed while in T mode.

The Step and Trace modes are independent, but for most purposes, are used together for debugging programs. The control-C flag (at location \$0212) must be cleared (enabled) to activate either Step or Trace: this is done on warm start.

### View Tape

Pressing control-V (\$16) will cause entry into the cassette view mode, where BASIC tapes can be read and displayed on the CRT, but are not entered. To exit this mode, enter a space. This routine uses the old I/O vectors to eliminate accidental control character routine activation during viewing.

### Bell

An audible prompt is used in several of the above routines. This bell function is also used when a control-G (\$07) is either input or output. \$07 is output if you attempt to enter more than 71 characters on a line. As an additional feature, the bell is also sounded once after the 64th character, just like a typewriter to warn you that the end of the line is near. To use the Bell feature, the user must supply a subroutine at location \$1CEC and the appropriate hardware modifications. (See MICRO, July 1981, "A Typewriter Bell for Your Microcomputer.")

### Carriage Return on BASIC Input

With OSI computers, if you respond to an input statement with only a carriage return, you will be kicked out of your program into the immediate mode. You can usually jump back in with a CONT statement, but this is frustrating. On most large computers, such a response is legal. This feature has been added to the input routine. A carriage return will be accepted as a zero for numeric inputs, such as INPUT A, or as a space (\$20) for string inputs, such as INPUT A\$.

### Other Jumps

An input of \$1D will cause a jump to the menu (\$FF00). This duplicates the function of the Break (Reset) key, and makes it easy to jump there from inside a BASIC program. Inputs of \$1C,

\$1E, or \$1F are not used. You can add your own functions by adding your vectors to the tables located at \$1800-\$183F.

### Escape Sequence on Output

Most of the functions are accessed by entering a control character (\$01-\$1F) from the keyboard, either in immediate mode, or in response to an INPUT statement. These functions can also be accessed on output, either in immediate mode, or by a BASIC program. An escape sequence is used. The escape code (\$1B, decimal 27) is output, followed by the control code. For example, to toggle windows, execute:

```
PRINT CHR$(27);CHR$(23);
```

The last semicolon is used to keep the display from scrolling. To output the graphic character for \$1B, output two consecutive escapes:

```
PRINT CHR$(27);CHR$(27);
```

Of course, not all functions are suitable for use during a BASIC run, but many are extremely useful, including cursor movements, scrolling, window toggles, screen clear, bell, print, etc. A summary of control functions is shown in table 2.

### New Monitor

An improved machine-language monitor routine is accessed by input of control-K (\$0B). This monitor is significantly better than OSI's minimal monitor, but not as versatile as commercial monitors. The advantage of this monitor is that it can be called at any time: in immediate mode, in the middle of a BASIC program, or by a JSR machine-language call.

Once the monitor is entered, data appears at the bottom of the screen, as shown in figure 1. The screen locations of this data are set by constants stored at \$00E6 (low byte) and \$00E7 (high byte), and offsets \$02DD and \$02DE. There are eight fields shown:

- L — Location (four character address)
- H — Hexadecimal data stored in L
- C — ASCII character stored in L
- S — Stack pointer
- P — Processor status register (flags)
- A — Accumulator
- X — X register
- Y — Y register

The "cursor" in the monitor mode is controlled by the keys "," and "."; these keys were chosen because the

Table 2: Summary of Control Key Functions

CONTROL KEY	HEX	DECIMAL	FUNCTION	LOCATION
-	00	0	NONE-NULL	\$185C
A	01	1	AUTOLINE TOGGLE	\$1DF5
B	02	2	BOTTOM CURSOR (HOME)	\$19F7
C	03	3	NONE-CONT C	\$185C
D	04	4	DOWN CURSOR	\$193D
E	05	5	EDIT	\$187E
F	06	6	FLAG CHANGE	\$1DD0
G	07	7	BELL	\$1CEC
H	08	8	BACKSPACE CURSOR	\$1905
I	09	9	INCREMENT CURSOR 8 SPACES	\$1924
J	0A	10	NONE-LINE FEED	\$185C
K	0B	11	MONITOR	\$1A48
L	0C	12	LEFT CURSOR	\$18F2
M	0D	13	NONE-CARR. RETURN	\$185C
N	0E	14	MOVE CURSOR	\$1946
O	0F	15	NONE-CONT O	\$185C
P	10	16	PRINT WINDOW	\$1EA3
Q	11	17	RETURN CURSOR	\$1919
R	12	18	RIGHT CURSOR / RESTART	\$190E
S	13	19	STOP OUTPUT	\$185C
T	14	20	CLEAR SCREEN	\$1CA0
U	15	21	UP CURSOR	\$192D
V	16	22	VIEW TAPE	\$1885
W	17	23	WINDOW TOGGLE	\$18A8
X	18	24	SET WINDOW	\$18BC
Y	19	25	SCROLL UP	\$1894
Z	1A	26	SCROLL DOWN	\$189E
ESC	1B	27	CLEAR SCREEN	\$1CA0
-	1C	28	--	\$185C
-	1D	29	JMP TO \$FF00 (MENU)	\$1C7A
-	1E	30	--	\$185C
-	1F	31	--	\$185C



symbols for the left arrow and right arrow appear on these keys. The “,” will move the cursor left, the “.” will move it right. The cursor actually changes the lower case letters l, h, c, etc., to the upper case letter to be changed. Any field is changed by typing new data into it. The C field will allow any character (except “,” and “.”) to be entered; the other seven fields allow only hexadecimal (0-9, A-F) characters.

Machine-language programs can thus be entered, or memory reviewed or changed one byte at a time. The space bar is used to step forward through memory; the carriage return key is used to step backwards. To return to where you were before you entered the monitor, type R.

To jump to a subroutine (whose location is shown in L), type J; if the subroutine executes correctly and is terminated by an RTS (\$60), control will return to the monitor. All flags and registers (S, P, A, X, and Y) will be changed to what was shown on the screen just before the jump occurred. When returning to the monitor, the contents of S, P, A, X, and Y shown on the screen will reflect their status at the time of return. No provisions are made for single step, trace, trap, etc.

When the monitor mode is entered, several things happen. All flags and registers are saved, and the P field is initialized to \$04 (ignore interrupts and clear decimal mode). The S field is adjusted to prevent change to the stack. If the P register is changed, it will automatically be restored on return. However, if the stack is disturbed, you may run into problems when returning, unless the original page one (\$01XX) was saved. If the M flag of \$00EF is set, the first three pages of memory — page zero (BASIC constants and routines), page one (the stack), and page two (BASIC and Extended I/O constants) — are saved in the top three quarters of screen memory (\$D000-\$D2FF). This will allow you to use these lower memory locations for your machine-language programs. They will be restored from the screen memory when exiting the monitor mode (R). If the M flag is clear, these three pages will not be saved. Leave the M flag cleared if you merely want to examine or change a few memory locations, or if you don't want the screen display disturbed.

### Garbage Collector

A bug in OSI's BASIC-in-ROM may cause your program to bomb if you make extensive use of dimensioned strings. Provisions have been made to

allow you to add a foolproof machine-language garbage collection routine. This routine will be called through the revised control-C routine if fewer than 512 bytes of free memory are available; this will keep OSI's defective routine from being called. To use this function, insert \$20 XX YY at \$1D72, where \$YYXX is the location of your new garbage collection routine. In addition, the approximate number of free pages can be monitored at any time by PEEKing at \$02F8. This can be used in lieu of FRE(X); never call FRE(X) when using dimensioned strings, as this will force a fatal garbage collection by the defective routine.

### Initialization

First cold start, then Break-M, load the tape containing the Extended I/O routines, Break-M, then type .1D1FG. The initialization routine will then be run. The input, output, and control-C vectors are pointed to new routines. The warm start and OK routines are replaced by new ones. Tables are copied from within the program to page zero and page two, where they are used by the new routines. The memory size is adjusted to keep BASIC from overwriting the new routines. The stack is adjusted to prevent an OM error after a warm start, then a message is written to the screen.

Table 3: Hex Dump of Complete Program

\$1800

```

5C F5 57 5C 3D 7E D0 EC 05 24 5C 48 F2 5C 46 5C
A3 19 0E 5C A0 2D 85 A8 BC 94 9E A0 5C 7A 5C 5C
18 1D 19 18 19 18 1D 1C 19 19 18 1A 18 18 19 18
1E 19 19 18 1C 19 18 18 18 18 1C 18 1C 18 18
A9 AD 8D 07 02 A9 8D 8D 0A 02 A9 60 8D 0D 02 A5
E3 8D 09 02 8D 0C 02 A5 E2 8D 0B 02 60 A9 20 48
20 40 18 A4 E4 A6 E5 68 20 0A 02 EE 0B 02 D0 03
EE 0C 02 CC 0B 02 D0 F0 EC 0C 02 D0 EB 60 AD 01
02 8D 02 02 60 20 F4 FF 20 83 1C 20 7D 1C AD 03
02 D0 F5 60 20 94 19 20 A0 19 20 89 19 60 20 94
19 20 52 1E 20 89 19 60 A2 03 B5 E2 48 BD D6 02
95 E2 68 9D D6 02 CA 10 F1 4C 57 19 20 6C 19 48
A5 E1 48 20 D9 1C C9 54 D0 09 68 85 E3 68 85 E2
18 90 0A C9 42 D0 EC 68 85 E5 68 85 E4 60 20 5D
18 20 CF 19 A5 E5 85 E1 A5 E4 20 6E 19 85 E0 18
90 61 20 94 19 A5 EC 48 A9 00 85 EC 20 7B 19 68
95 EC 18 90 4E 20 94 19 20 74 19 18 90 45 20 94
19 E6 E0 D0 3E E6 E1 D0 3A 20 94 19 20 6C 19 85
E0 18 90 2F A2 08 20 0E 19 CA D0 FA 60 20 94 19
A5 E0 38 E5 EA 85 E0 80 1A C6 E1 D0 16 20 94 19
20 5D 19 18 90 0D 20 94 19 AD DA 02 85 E0 AD DB
02 85 E1 20 89 19 60 20 94 19 4C E4 18 A5 E0 18
65 EA 85 E0 90 02 E6 E1 EA EA EA 60 A5 E0 05 EB
38 E5 EE 60 20 6C 19 C5 E0 D0 0B A5 E0 38 E5 EC
85 E0 B0 02 C6 E1 C6 E0 60 A0 00 B1 E0 8D 01 02
A5 E9 D0 03 AD 01 02 A0 00 91 E0 60 A5 E8 D0 F7
20 40 18 18 65 EA 90 03 EE 09 02 8D 08 02 A6 E4
A4 E5 20 07 02 EE 08 02 D0 03 EE 09 02 EE 0B 02
D0 03 EE 0C 02 EC 0B 02 D0 E8 CC 0C 02 D0 E3 A4
EA A9 20 91 E4 88 10 FB 60 AD 02 02 C9 20 B0 F8
AA BD 00 18 8D F1 0B 20 18 8D F2 02 6C F1 02
EE D5 02 EA EA EA 18 90 1B A9 20 20 97 19 20 2D

```

Table 3 (continued)

\$1A00

```

1A 18 90 10 C6 0E A9 20 8D 01 02 20 97 19 20 74
19 20 90 19 4C F6 1F EA EA EA 8D 01 02 20 97 19
E6 E0 A5 E0 05 EB 38 E5 ED C5 E0 D0 17 EE P6 02
20 6C 19 85 E0 C5 E4 A5 E1 E5 E5 F0 04 4C 40 19
EA 20 A0 19 20 89 19 60 08 48 8A 48 98 48 BA CA
CA 86 43 24 EF 50 1C A2 00 B5 00 9D 00 D0 CA D0
F8 BD 00 01 9D 00 D1 CA D0 F7 BD 00 02 9D 00 D2
CA D0 F7 A5 E6 18 6D DD 02 85 49 A2 00 8A 20 98
1A A2 04 86 44 6D DE 02 20 98 1A A5 E7 85 4A 20
A8 1A 20 22 1B 18 90 F7 95 4B 69 06 95 4C 69 04
95 4D 69 04 95 4E 60 EA A2 07 B4 4B BD 1A 1E 91
49 CA 10 F6 A6 42 B4 4B BD 1A 1B 29 DF 91 49 A2
07 B5 40 20 FE 1A B4 4B 20 0F 1B CA E0 02 D0 F1
A0 00 B1 40 A4 4D C8 91 49 20 FE 1A A4 4C 20 0F
1B A5 41 20 FE 1A A4 4B 20 0F 1B A5 40 20 FE 1A
20 0F 1B 60 29 0F F8 18 69 90 69 40 D8 60 48 4A
4A 4A 4A 20 F4 1A 85 53 68 20 F4 1A 85 54 60 C8
A5 53 91 49 C8 A5 54 91 49 60 6C 68 63 73 70 61
78 79 20 83 1C C9 2C D0 09 C6 42 10 04 A9 07 85
42 60 C9 2E D0 0D E6 42 A6 42 E0 08 90 04 A9 00
85 42 60 A6 42 E0 02 D0 05 A2 00 81 40 60 C9 0D
D0 09 A5 40 D0 02 C6 41 C6 40 60 C9 20 D0 07 E6
40 D0 02 E6 41 60 C9 4A D0 27 BA 86 48 A6 43 9A
A6 46 A4 47 A5 44 48 A5 45 28 20 8E 1B 08 85 45
68 85 44 84 47 86 46 BA 86 43 A6 48 9A 60 6C 40
00 C9 52 D0 2E 68 68 AD 00 D0 C9 4C D0 1E EA EA
A2 00 BD 00 D0 95 00 CA D0 F8 BD 00 D1 9D 00 01
CA D0 F7 BD 00 D2 9D 00 02 CA D0 F7 68 A8 68 AA
68 28 60 48 20 93 FE 10 02 68 60 A8 68 98 A6 42
D0 0E A2 03 06 40 26 41 CA 10 F9 05 40 85 40 60
E0 01 D0 0F 85 48 A2 00 A1 40 0A 0A 0A 05 48
81 40 60 16 40 16 40 16 40 16 40 15 40 95 40 60

```

**Listing 1: BASIC Program to Print a Hex Dump**

```

100 POKE239,131
105 PRINT:PRINT"$1800"
110 FORI=6144TO6655STEP16
120 PRINT
130 FORJ=0TO15
140 K=I+J
150 A=PEEK(K):POKE85,A
160 POKE11,247:POKE12,28
170 X=USR(0):C=PEEK(83):D=PEEK(84)
180 PRINTCHR$(C);CHR$(D);" ";
190 NEXTJ,I
200 POKE239,130

```

**Odds and Ends**

A subroutine that will decode a byte into two ASCII characters is located at \$1CF7. Place the byte to be decoded into \$0055. A JSR \$1CF7 will leave the high nibble character in \$0053, the low one in \$0054. An example of this routine is shown in listing 1. The simple program generated the hexadecimal dumps of table 3. Lines 100 and 200 turned the printer on and off. Line 160 set the USR vector to \$1CF7.

A dump of the entire 2K program is shown in table 3; the underlined bytes are those that will require changing if

the program is relocated. Here are the locations that will require changing if your OSI computer is not a C1P:

Location	Function	C1P Location (low, high)
\$1C7E	Old Output Routine	69 FF
\$1C81	Old Output +3	6C FF
\$1C84	Old Input	BA FF
\$1D5D	Old Control-C Routine	9B FF

However, you *must* have a support ROM (or EPROM) containing indirect

vectors for these routines, which vector through page two of memory.

Due to its length, the assembly listing could not be reproduced here. For a copy of the 40-page listing, send \$5 to the author. (Sorry, I cannot provide copies on tape.)

The control keys can be redefined any way you see fit, by changing the pointers shown in table 2; these are stored at the beginning of the program (\$1800-\$183F). You may want to eliminate some functions (such as printer routines) and add others. You may want to let some keys generate predefined strings that can be entered into BASIC, such as DATA, or FOR I=1TO, etc. For hints on how to do this, study the autoline code. You may want to make some changes. I have yet to use a program that didn't need a few alterations.

Michael Keryan has a Master of Science in Chemical Engineering. His interest is in hardware projects; he built an OSI system a few years ago and added a number of extensions, including two printers, music generators, and a real time clock. Contact Mr. Keryan at 713 Locust Drive, Tallmadge, OH 44278.



Table 3 (continued)

```

$1C00
A5 D0 A0 D0 C0 D2 C5 D3 E5 A4 20 1F 07 01 1A 82
90 00 10 12 30 00 01 D3 80 D3 A5 D0 00 08 12 25
A9 A2 A0 1D 20 C3 A8 60 EA 4C 1F 1D 4C 9A 1E FE
1E 5E 1F 42 1D A9 00 8D 12 02 A9 00 8D F6 02 A9
AA 8D F4 02 A2 0F BD 00 1C 95 E0 CA 10 F8 A2 0F
BD 10 1C 9D D0 02 CA 10 F7 A9 18 85 86 A9 00 8D
D5 02 EA EA A2 05 BD 29 1C 95 00 CA 10 F8 A2 05
BD 2F 1C 9D 18 02 CA 10 F7 60 4C 00 FF 4C 69 FF
4C 6C FF 4C BA FF EA EA 48 8A 48 A2 0F BD E0 02
48 B5 E0 9D E0 02 68 95 E0 CA 10 F1 68 AA 68 60
48 98 48 A0 00 A9 20 99 00 D7 99 00 D6 99 00 D5
99 00 D4 99 00 D3 99 00 D2 99 00 D1 99 00 D0 C8
D0 E5 68 A8 68 60 20 D0 1C C9 0A B0 F9 48 68 60
20 D9 1C 20 93 FE 30 F8 60 20 EC 1C A2 00 A9 3F
81 E6 20 83 1C 48 A9 20 81 E6 68 60 48 EA EA EA
EA EA EA EA EA 68 60 A5 55 4C FE 1A 48 20 16 1D
C9 BE D0 10 A9 F7 20 18 1D C9 7F D0 07 20 D9 1C
C9 12 D0 F9 68 60 A9 FE 8D 00 DF AD 00 DF 60 20
A0 1C AD F4 02 C9 AA F0 00 A9 00 8D D5 02 8D F6
02 EA EA EA 20 35 1C EA EA 20 20 1C A2 FE 9A 4C
74 A2 AD 12 02 D0 1E A5 EF 29 10 F0 03 20 D9 1C
A5 EF 29 08 F0 03 20 5A B9 20 66 1D 4C 9B FF EA
EA EA EA EA EA 60 A5 82 38 E5 80 8D F8 02 C9 02
B0 03 EA EA EA 60 A2 08 A9 01 8D F0 02 8A 18 6D
DC 02 A8 AD F0 02 25 EF D0 04 A9 20 D0 03 BD 99
1D 91 E6 0E F0 02 CA D0 E4 60 45 4D 41 53 54 49
43 48 45 78 74 65 6E 64 65 64 20 49 2F 4F 20 50
72 6F 63 65 73 73 6F 72 0D 0A 43 31 50 20 56 65
72 73 69 6F 6E 20 63 2E 4D 4B 20 31 39 38 31 00
20 C6 1C AA A9 01 CA F0 03 0A D0 FA 48 20 C6 1C
D0 0A 68 49 FF 25 EF 85 EF 18 90 05 68 05 EF 85
EF 20 76 1D 60 A9 20 45 EF 85 EF 4C 76 1D AD 02

```

Table 3 (continued)

```

$1E00
02 C9 5F F0 44 C9 7F F0 40 C9 21 90 3C C9 3A 80
04 C9 30 B0 34 18 F8 AD D0 02 6D D2 02 8D D0 02
48 AD D1 02 69 00 8D D1 02 48 D8 A2 00 4A 4A 4A
4A 20 4A 1E 68 29 0F 20 4A 1E 68 48 4A 4A 4A 4A
20 4A 1E 68 29 0F 20 4A 1E 60 09 30 95 13 E8 4C
1A 1A 20 40 18 A5 E5 8D 09 02 8D 0C 02 A5 E4 05
EB 8D 08 02 38 E5 EA B0 03 CE 09 02 8D 08 02 A6
E2 A4 E3 20 07 02 CE 08 02 D0 03 CE 09 02 CE 0B
02 D0 03 CE 0C 02 EC 0B 02 D0 E8 CC 0C 02 D0 E3
A4 EB A9 20 91 E2 88 10 FB 60 A9 0D 20 5E 1F 4C
9C 19 EA 48 8A 48 98 48 A5 E0 48 A5 E1 48 EA EA
EA EA A5 E2 85 E0 A5 E3 85 E1 A0 00 A9 0D 20 F4
1E A6 EA B1 E0 20 F4 1E E6 E0 D0 02 E6 E1 CA D0
F2 A9 0D 20 F4 1E A5 E1 C5 E5 90 E5 A5 E0 C5 E4
90 DF F0 DD EA EA EA EA EA 85 E1 68 85 E0 68 A8
68 AA 68 60 20 88 1C EA EA EA 20 88 1C 60 A5 EF
30 03 4C 83 1C 20 83 1C 8D 02 02 98 48 8A 48 A9
40 C5 0E D0 03 20 EC 1C A9 0D CD F3 02 D0 1B CD
02 02 D0 08 A9 20 20 4C 1E 18 90 09 A5 EF 29 20
F0 08 20 FE 1D 8A A8 68 98 48 AD 02 02 C9 7F D0
03 20 DE 18 20 D9 19 EA EA EA EA EA EA EA EA EA
AD 02 02 8D F3 02 68 AA 68 A8 AD 02 02 60 48 8D
02 02 A5 EF 30 04 68 4C 7D 1C 8A 48 98 48 20 FC
1C A5 EF 29 01 F0 1C A5 EF 29 04 F0 10 AD D5 02
CD D4 02 90 08 20 D9 1C A9 00 8D D5 02 AD 02 02
20 F4 1E A5 EF 29 02 F0 5F A5 EF 29 04 F0 10 AD
F6 02 CD D3 02 90 08 20 D9 1C A9 00 8D F6 02 A9
02 02 C9 0A D0 03 4C F0 19 C9 D0 D0 03 4C F9 19
C9 5F D0 03 4C 04 1A C9 07 D0 03 20 EC 1C C9 1B
D0 11 AD F5 02 D0 07 A9 01 8D F5 02 D0 1A A9 00
8D F5 02 AD F5 02 F0 0A 20 D9 19 A9 00 8D F5 02
F0 06 AD 02 02 20 1A 1A 68 A8 68 AA 68 4C 80 1C

```

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<b>PEACHTREE: BIZ Packages, all</b>				HAYES S-100 MODEM				325	HAYES SMARTMODEM	219		
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Howard Real Estate Anal.				129	BPI Accounting Pkgs/ea	325	BMC 12" Green	119	BMC 12" Color	349		
Synergistic "Data Reporter"				Manages, Plots & Edits Data!	189	Electrohome RGB Intfce				275	Electrohome RGB 13" Clr	725
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Magic Wand CP/M	299	MUSE Super Text 80	150	Strobe Plotter 1-Pen	699	Strobel Apple Intfce	99					
Executive Secretary	199	Wordpower	50	Houston Inst. DMP-3	929	Houston Inst. DMP-4	1185					
Letter Perfect	125	Hebrew II	55	<b>OTHER PERIPHERALS:</b>								
Magic Window	85	Screenwriter II	110	Scott Shadow/VET	885	Street Echo II Synth.	189					
Spellguard	219	Spellstar CP/M	149	Voltrax Type-N-Talk	325	Computer Sta. Dithertizer	269					
Word Handler (Gives 80-Col. & Lower-Case with no board!)	199			ALF 9-Voice Music Bd.	155	Comp. Sta. Video Camera	375					
				ALF 3-Voice Music Bd.	199	Comp. Stat. Both above	599					

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# Delete on the OSI

by Earl Morris and Yasuo Morishita

This utility will show the ROM BASIC user how to delete blocks of lines, as well as single lines, with just a few keystrokes.

**DELETE**  
requires:  
OSI C1P

This article describes a routine to allow users of OSI ROM BASIC to delete multiple lines. Normally only a single line of BASIC can be deleted by typing in the line number followed by a carriage return. This can be tedious if a large block of lines must be removed. This often happens, for example, when programs are merged or a utility program is run with another program also in memory. The "DELETE" program creates aUSR routine which is called by

Z = USR (first line)(last line)

All of the lines of BASIC with line numbers inside the specified range are then deleted.

When OSI ROM BASIC is called on to delete a single line, two major routines are used. The code at \$A2A2 finds the line to be deleted, and then shrinks the program by the number of bytes found in the offending line. Another routine at \$A31C is responsible for refixing the pointers that rechain each line to the next. Unfortunately these routines are not written as subroutines and thus cannot be used by "outside" programs.

However, the DELETE program copies these routines from ROM into RAM and creates the needed sub-routine. The main line DELETE pro-

## BASIC Program to Set Up USR Delete Function

```

10 REM BASIC LINE DELETE
12 REM FORMAT : Z=USR<START LINE #><END LINE #>
14 M=565:REM START ADDRESS=#0235 RELOCATABLE
16 A=INT(M/256):POKE12,A:POKE11,M-A*256
18 N=64:FORN=MTOM+N-1:READJ:POKEJ,J:NEXT
20 A=41634:M=M+N:N=68:GOSUB28:REM DELETE=#A2A2
22 A=INT(M/256):B=M-256*A:POKEM-13,A:POKEM-14,B
24 A=41756:M=M+N:N=47:GOSUB28:REM REBUILD =#A31C
26 POKEM+15,96:END:REM "RTS"
28 FORX=0TON-1:J=PEEK(A+X):POKEM+X,J:NEXT:RETURN
30 DATA32.8
32 DATA180,32,173,170,32,49,184,165,175,133
34 DATA48,165,174,133,49,32,50,164
36 DATA176,27,160,1,177,170,240,26,160,3
38 DATA177,170,133,18,136,177,170,133,17
40 DATA166,48,165,49,228,17,229,18
42 DATA144,5,32,125,2,240,219,169,146,160
44 DATA161,32,195,168,76,25,163
    
```

## Source Code for Main Delete Program

```

;DELETE
;BY MORRIS & MORISHITA
;
;ASSEMBLY LANGUAGE LISTING
;
;
;          ORG $235
;
0235 20 08 B4      JSR $B408      ;1ST ARGUMENT TO BINARY INTO $
11,12 (START)
0238 20 AD AA      JSR $AAAD      ;GET 2ND ARGUMENT (LAST LINE # )
;
023B 20 31 B8      JSR $B831      ;CONVERT TO BINARY
023E A5 AF        LDA $AF
0240 85 30        STA $30      ;STORE FINAL LINE # IN $30,31
0242 A5 AE        LDA $AE
0244 85 31        STA $31
0246 20 32 A4      LBLA      JSR $A432      ;FIND ADDRESS OF BASIC LINE
0249 B0 1B        BCS LBLB      ;BRANCH IF FOUND, OTHERWISE UP
;          DATE POINTER AT $11,12
024B A0 01        LDY #$01
024D B1 AA        LDA ($AA),Y      ;LOOK AT POINTER TO NEXT LINE
024F F0 1A        BEQ LBLC      ;IF NULL MUST BE END OF PROGRAM
;          SO QUIT
;
0251 A0 03        LDY #$03
0253 B1 AA        LDA ($AA),Y      ;GET NEXT LINE # HI BYTE
0255 85 12        STA $12
0257 88          DEY
0258 B1 AA        LDA ($AA),Y      ;GET NEXT LINE # LO
025A 85 11        STA $11
;
025C A6 30        LDX $30      ;LOAD X,A WITH FINAL LINE
025E A5 31        LDA $31
0260 E4 11        CPX $11      ;COMPARE TO CURRENT LINE
0262 E5 12        SEC $12
0264 90 05        BCC LBLC      ;QUIT IF BEYOND FINAL LINE
0266 20 75 02      LBLB      JSR $0275
0269 F0 DB        BEQ LBLA      ;ALWAYS BRANCH
026B A9 92      LBLC      LDA #$92
026D A0 A1        LDY #$A1      ;$A192 IS ADDRESS OF "OK"
026F 20 C3 AB      JSR $ABC3      ;PRINT "OK"
0272 4C 19 A3      JMP $A319      ;GO BACK TO BASIC
0275
0275
;          END
    
```

gram accepts the first line to be deleted and calls the copied ROM routine to do the work. Then the line pointers are used to find the line number of the next BASIC line. This is checked for end of program, and checked to see if it exceeds the upper limit for deleting. Then the copied routines are called again and the process is repeated until completed. Lines are still deleted one at a time, but the computer, rather than your busy fingers, is doing the work.

The BASIC program listed here will create the DELETE program on page two below the start of BASIC program space. This memory is normally unused in OSI machines. If you are using this space, then the delete program can be relocated by changing the value of "M" in line 14. Line 16 sets up the USR vector, and line 18 builds the main program from the DATA statements. Line 20 moves the "memory close" routine from ROM. Line 22 calculates an absolute JSR address and POKEs it into the main program. Line 24 copies the recharging routine from ROM and line 26 adds an "RTS" to convert it to a subroutine.

After running the BASIC program, it can delete itself with:

$$Z = \text{USR}(10)(44)$$

Note that the USR function now requires two arguments and will give an "SN" error if both are not present. Everything is deleted by  $Z = \text{USR}(1)$  (-1) which of course is the same as a NEW command. The form  $Z = \text{USR}(A)(B)$  is also helpful to figure out which lines to omit.

For those readers interested in how the program works, the source code for the main program is listed with comments. The code is relocatable with the exception of the JSR at \$026E. This is a jump to the copied ROM routines. The BASIC set-up program automatically fixes this absolute address.

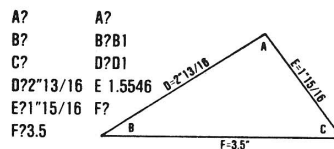
Earl Morris may be contacted at 3200 Washington, Midland, Michigan 48640. Contact Yasuo Morishita at 950 Beau Drive #106, Des Plaines, Illinois 60016.

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## Apple Slices

By Tim Osborne

This month's Apple Slices shows you how to access directly any sector on an unprotected Disk II 16-sector diskette. And I'll discuss further how to pass an Applesoft arithmetic expression from BASIC to machine language (see last month's column (50:59) ).

### The DOS RWTS Subroutine

This method uses the DOS subroutine RWTS, which stands for Read or Write a Track or Sector. You may find this method referred to as physical I/O because it deals with physical data-access locations. It can be handy in error trapping, fixing clobbered diskettes, customizing catalogs, file and space management, accessing disks from machine language, and transferring files between different operating systems.

To connect to RWTS the user program should JSR to the RWTS vector located at \$3D9. Upon entry to RWTS the A + Y registers must contain the address of the IOB (Input/Output control Block). The IOB is a table of parameters that describes to RWTS what operation it is being called to perform. For a breakdown of the IOB, see page 95 of the Apple II DOS Manual. The IOB in turn contains the address of the DCT (Device Characteristics Table) in bytes seven and eight. The DCT provides physical and timing information to the RWTS subroutine.

### The Example

I have written a handy subroutine, AMPERRWTS, which allows the user to call RWTS from BASIC using the following syntax:

1. READ; &R(T,S,B,D)  
&R(T,S,B)

2. WRITE; &W(T,S,B,D)  
&W(T,S,B)

T = A valid Applesoft arithmetic expression representing a track number (0-34).

S = A valid Applesoft arithmetic expression representing a sector number (0-15).

Listing 1: AMPERRWTS

```

0800      1 ;*****
0800      2 ;*
0800      3 ;*      APPLE SLICES
0800      4 ;*      ACCESSING RWTS FROM
0800      5 ;*      BASIC
0800      6 ;*
0800      7 ;*      TIM  OSBORN
0800      8 ;*
0800      9 ;*****
0800     10 ;
0800     11 ;      APPLESOFT ENTRY POINTS
0800     12 ;
00B1     13 CHRGET  EPZ $B1      ;INCREMENT TXTPTR AND GET CHAR
                                ACTER
00B7     14 CHRGET  EPZ $B7      ;CHRGET - INCREMENT
DEBB     15 CHKOPN  EQU $DEBB    ;CHECK FOR "(" @ TXTPTR
DEBE     16 CHKCOM  EQU $DEBE    ;CK. FOR "," @ TXTPTR
D995     17 DATA   EQU $D995    ;ADVANCE TXTPTR TO END OF STAT
                                EMENT
DD67     18 FRMNUM  EQU $DD67    ;EVALUATE EXPRESSION @ TXTPTR
                                + PUT IN FAC
E6FB     19 CONINT  EQU $E6FB    ;MODIFY FAC TO 8 BIT INTEGER
E752     20 GETADR  EQU $E752    ;MODIFY FAC TO 16 BIT INTEGER
DEC9     21 SYNERR  EQU $DEC9    ;PRINT SYNTAX ERROR MESSAGE
O3F5     22 AMPERV  EQU $3F5     ;AMPERSAND VECTOR ADDRESS
0800     23 ;
0800     24 ;      MONITOR ENTRY POINT
0800     25 ;
FDB3     26 XAM     EQU $FDB3    ;HEX DUMP ROUTINE
0800     27 ;
0800     28 ;      DOS ENTRY POINT VECTOR
0800     29 ;
03D9     30 RWTS   EQU $03D9    ;READ-WRITE-TRACK-SECTOR
0800     31 ;
0800     32 ;      ZERO PAGE EQUATES
0800     33 ;
003C     34 ALL    EPZ $3C      ;2-BYTE MONITOR PARAMETER
003E     35 A2L   EPZ $3E      ;2-BYTE MONITOR PARAMETER
0050     36 LINNUM EPZ $50
0073     37 HIMEM EPZ $73
0800     38 ;
0800     39 ;
0800     40 ;      OTHER EQUATES
0800     41 ;
0001     42 READ   EPZ $01      AD OPERATION CODE
0002     43 WRITE  EPZ $02      ;WRITE OPERATION CODE
002C     44 COMMA  EPZ $2C
0052     45 R      EPZ $52
0057     46 W      EPZ $57
0058     47 X      EPZ $58
0800     48 ;
0800     49 ;
8000     50 ;      ORG $8000
8000     51 OBJ    $800
8000     52 ;SETVEC SETS HIMEM AND AMPERSAND VECTOR
8000     53 ;
8000 A9 0F 54 SETVEC LDA #ENTRY
8002 8D F6 03 55 STA AMPERV+1
8005 85 73 56 STA HIMEM
8007 A9 80 57 LDA #ENTRY
8009 8D F7 03 58 STA AMPERV+2
800C 85 74 59 STA HIMEM+1
800E 60 60 60 RTS
800F     61 ;
800F     62 ;
800F     63 ;
800F     64 ;      MAIN PROGRAM
800F     65 ;
800F C9 52 66 ENTRY  CMP #R      ;READ REQUEST?
8011 D0 08 67 BNE WRITE?
8013 A9 01 68 LDA #READ    ;YES LD + SV READ
8015 8D D7 80 69 STA IBCMD    ;OPERATION CODE IN IOB
8018 4C 59 80 70 JMP RWTSCALL
801B C9 57 71 WRITE?  CMP #W      ;WRITE REQUEST?
801D D0 08 72 BNE XAM?    ;NO, CONTINUE
801F A9 02 73 LDA #WRITE    ;YES, LD + SV WRITE
8021 8D D7 80 74 STA IBCMD    ;OPERATION CODE IN IOB
8024 4C 59 80 75 JMP RWTSCALL
8027 C9 58 76 XAM?   CMP #X      ;MEMORY XAM REQUEST?
8029 F0 03 77 BEQ XAMINE   ;YES
802B 4C C9 DE 78 JMP SYNERR   ;NO, MUST BE ERROR
802E 20 B1 00 79 XAMINE  JSR CHRGET   ;GET NEXT CHARACTER AND
8031 20 BB DE 80 JSR CHKOPN   ;CHECK FOR "(" ADDRESS
8034 20 67 DD 81 JSR FRMNUM   ;GET BEGINNING ADDRESS
8037 20 52 E7 82 JSR GETADR   ;CONVERT TO INTEGER
803A A5 50 83 LDA LINNUM
803C 85 3C 84 STA ALL
803E A5 51 85 LDA LINNUM+1 ;AND STORE FOR XAM
8040 85 3D 86 STA ALL+1

```

**Listing 1 (Continued)**

```

8042 20 BE DE 87 JSR CHKCOM ;CHECK FOR ","
8045 20 67 DD 88 JSR FRMNUM ;GET ENDING ADDRESS
8048 20 52 E7 89 JSR GETADR ;CONVERT TO INTEGER
804B A5 50 90 LDA LINNUM
804D 85 3E 91 STA A2L ;AND STORE FOR XAM
804F A5 51 92 LDA LINNUM+1
8051 85 3F 93 STA A2L+1
8053 20 B3 FD 94 JSR XAM
8056 4C 95 D9 95 JMP DATA ;ADVANCE TXTPTR + RETURN TO BASIC
8059 97 ;
8059 20 B1 00 98 RWTSCALL JSR CHRGET ;GET NEXT CHARACTER AND
805C 20 BB DE 99 JSR CHKOPN ;GET TRACK NUMBER
805F 20 67 DD 100 JSR FRMNUM ;CONVERT TO 1 BYTE INTEGER
8062 20 FB E6 101 JSR CONINT ;TRACK LESS THAN 35?
8065 E0 23 102 CPX #$23 ;YES, CONTINUE
8067 30 03 103 BMI RWTS1 ;NO, DISPLAY MESSAGE
8069 4C C9 DE 104 JMP SYNERR
806C 8A 105 RWTS1 TXA
806D 8D CF 80 106 STA IBTRK ;AND STORE IN PARMLIST
8070 20 BE DE 107 JSR CHKCOM ;CHECK FOR ","
8073 20 67 DD 108 JSR FRMNUM ;GET SECTOR NUMBER
8076 20 FB E6 109 JSR CONINT
8079 E0 10 110 CPX #$10 ;SECTOR LESS THAN 16?
807B 30 03 111 BMI RWTS2 ;YES, CONTINUE
807D 4C C9 DE 112 JMP SYNERR ;NO, DISPLAY MESSAGE
8080 8A 113 RWTS2 TXA
8081 8D D0 80 114 STA IBSECT ;AND STORE IN PARMLIST
8084 20 BE DE 115 JSR CHKCOM ;CHECK FOR ","
8087 20 67 DD 116 JSR FRMNUM ;GET BUFFER ADDRESS
808A 20 52 E7 117 JSR GETADR ;CONVERT TO TWO BYTE INTEGER
808D A5 50 118 LDA LINNUM
808F 8D D3 80 119 STA IBBUFF ;AND STORE IN PARMLIST
8092 C8 120 INY
8093 A5 51 121 LDA LINNUM+1
8095 8D D4 80 122 STA IBBUFF+1
8098 20 B7 00 123 JSR CHRGOT ;LOAD ACCUM WITH (TXTPTR)
809B C9 2C 124 CMP #COMMA ;IS IT A COMMA
809D D0 13 125 BNE NODRIVE ;NO, DRIVE NOT SPECIFIED
809F 20 B1 00 126 JSR CHRGET ;YES, ADVANCE TXTPTR
80A2 20 67 DD 127 JSR FRMNUM ;GET DRIVE NUMBER
80A5 20 FB E6 128 JSR CONINT ;AND CONVERT TO INTEGER
80A8 8A 129 TXA ;TRANSFER DRIVE # TO ACCUM
80A9 F0 04 130 BEQ RWTS3 ;SHOULD NOT BE = ZERO
80AB E0 03 131 CPX #$03 ;DRIVE NO. < 3?
80AD 30 05 132 BMI YESDRV ;YES, CONTINUE
80AF 4C C9 DE 133 RWTS3 JMP SYNERR ;NO, DISPLAY ERROR MESSAGE
80B2 A9 01 134 NODRIVE LDA #$01 ;DEFAULT TO DRIVE #1
80B4 8D CD 80 135 YESDRV STA IBDRVN ;STORE IN PARMLIST
80B7 A9 DC 136 LDA #DCT ;GET DCT ADDRESS(LOW)
80B9 8D D1 80 137 STA IBDCPT ;AND STORE IN PARMLIST
80BC A9 80 138 LDA /DCT ;DCT(HIGH)
80BE 8D D2 80 139 STA IBDCPT+1
80C1 A9 80 140 LDA /IOB ;SET UP DCT ADDRESS PARAMETERS
80C3 A0 CB 141 LDY #IOB ;FOR RWTS
80C5 20 D9 03 142 JSR RWTS
80C8 4C 95 D9 143 JMP DATA ;ADVANCE TXTPTR TO END OF STATEMENT
;AND RETURN TO BASIC

80CB 144 ;
80CB 145 ;
80CB 146 ;INTERNAL STORAGE AREA
80CB 147 ;
80CB 148 ;
80CB 149 ;*****
80CB 150 ;*
80CB 151 ;* INPUT/OUTPUT CONTROL BLK *
80CB 152 ;*
80CB 153 ;*****
80CB 154 ;
80CB 155 IOB EQU *
80CB 156 IBTYPE DFS $01,$01 ;TYPE OF IOB
80CC 157 IBSLT DFS $01,$60 ;SLOT NUMBER
80CD 158 IBDRVN DFS $01 ;DRIVE NUMBER
80CE 159 IBVOL DFS $01,$00 ;VOLUME NO. 0=WILDCARD
80CF 160 IBTRK DFS $01 ;TRACK NO.
80D0 161 IBSECT DFS $01 ;SECTOR NO.
80D1 162 IBDCPT DFS $02 ;POINTER TO DCT
80D3 163 IBBUFF DFS $02 ;POINTER TO BUFFER
80D5 164 IBDUMY DFS $02,$00 ;UNUSED
80D7 165 IBCMD DFS $01 ;0=NULL,1=READ,2=WRITE,4=FORMAT
80D8 166 IBSTAT DFS $01,$00 ;ERROR CODE (FOLLOWING CODES APPLY)
80D9 167 ; ;$10=WRITE PROTECT
80D9 168 ; ;$20=VOLUME MISMATCH
80D9 169 ; ;$40=DRIVE ERROR
80D9 170 ; ;$80=READ ERROR
80D9 171 IBSMOD DFS $01,$00 ;ACTUAL VOLUME NO.
80DA 172 IOBPSN DFS $01,$60 ;PREVIOUS SLOT NO.
80DB 173 IOBPDN DFS $01,$01 ;PREVIOUS DRIVE NO.
80DC 174 ;
80DC 175 ;*****
80DC 176 *
80DC 177 * DEVICE CHARACTERISTICS TABLE *
80DC 178 *
80DC 179 ;*****
80DC 180 ;
80DC 181 DCT EQU *
80DC 182 DEVTPC DFS $01,$00 ;DEVICE TYPE CODE
80DD 183 PPTC DFS $01,$01 ;PHASES PER TRACK
80DE 184 MONTCL DFS $01,$EF ;TIME COUNT
80DF 185 MONTC2 DFS $01,$D8 ;TIME COUNT
80E0 186 ;
80E0 187 ;
80E0 188 END

```

B = A valid Applesoft arithmetic expression representing the starting address of a 256-byte buffer.

D = A valid Applesoft arithmetic expression representing a drive number (1-2). The D parameter is optional and the program will default to a value of 1 if it is not coded in the &R or &W statement.

I have included for convenience a routine to call the monitor routine XAM directly from BASIC. This routine can be used to examine a hex dump of the RWTS buffer, or any range of memory in the Apple II. The syntax is as follows:

& X(B,E)

B = A valid Applesoft arithmetic expression representing the beginning of the range of memory to be dumped.

E = A valid Applesoft arithmetic expression representing the ending address of the range of memory to be dumped.

When XAM is dumping a range of memory, it may have more than a screen's worth of data, in which case you may wish to use the CTRL-S key to stop-list the dump. Any key will restart the dump. When the dump is completed, control returns back to the user program or the "]" prompt if this command is issued from the immediate mode.

**How AMPERRWTS Works**

AMPERRWTS uses the following subroutines, which are essential to its performance:

**1. CHRGET \$B1**

Increments TXTPTR, loads the accumulator with the value TXTPTR is pointing at.

**2. CHRGOT \$B7**

Same as CHRGET except CHRGOT does not increment the TXTPTR.

**3. CHKOPN \$DEBB**

Checks at TXTPTR for an open parenthesis "(". Displays a syntax error if not found. Post-increments the TXTPTR through CHRGET.

**4. CHKCOM \$DEBE**

Checks at TXTPTR for a comma. Displays a syntax error if not found. Post-increments the TXTPTR through CHRGET.

#### 5. DATA \$D995

Advances the TXTPTR to the end of the current Applesoft statement.

#### 6. FRMNUM \$DD67

Evaluates the arithmetic expressions @TXTPTR, and places the result in the FAC (floating point accumulator).

#### 7. CONINT \$E6FB

Evaluates the FAC and places the result in the X-register as an 8-bit X integer (0-255).

#### 8. GETADR \$E752

Evaluates the FAC and places the result into LINNUM (\$50-\$51) as a 16-bit integer (0-65535).

#### 9. SYNERR \$DEC9

Displays a syntax error message.

To install AMPERRWTS the user must BRUN the binary object file. This sets up the ampersand vector for Applesoft (\$3F5). When the "&" is encountered, Applesoft will pass control to ENTRY at \$800F. ENTRY first looks for an R, W, or X in the accumulator. If an R is found, a 1 is placed in IBCMD (the IOB command parameter), then a jump to the internal routine RWTSCALL is performed. The parameters are: 0 = null command — position head and start drive; 1 = read specified sector; 2 = write specified sector; 4 = format disk. For more information see page 97 of the DOS manual. If a W is found, a 2 is placed in IOBCMD and a JMP to RWTSCALL is performed. If an X is found, the internal routine XAMINE is JMPed to. If the accumulator is not equal to an R, W, or X, then a syntax error message is displayed.

RWTSCALL is the heart of AMPERRWTS. It evaluates the parameters passed between the left and right parentheses for the &R and &W commands, and sets up the IOB to make a proper call to RWTS. First, RWTSCALL advances the TXTPTR through a JSR to CHRGET. Then RWTSCALL JSRs to CHKOPN because we now expect, as defined in the above syntax diagrams, that we will find a left parenthesis ("("). If "(" is found, the TXTPTR will be advanced to point to what is expected to be an arithmetic expression that will result in a value between 0 and 34 (track number). This expression is evaluated through a JSR to FRMNUM, which places the result in the FAC. A JSR to CONINT converts the FAC to an 8-bit value and places it in the X-register. RWTSCALL then checks the X-register to make sure it is less than 35 (CPX #23). If so, it is placed in IBTRK. Otherwise a syntax

```
Listing 2 1 BFR = 8192: PRINT CHR$(4)"BLOAD AMPERRWTS.CODE,A$8000"
          5 HOME : PRINT "V.T.O.C. (TRACK 17, SECT. 0)
          10 & R(17,0,BFR)
          15 GOSUB 300
          20 FOR J = 1 TO 15
          25 HOME : PRINT "CATALOG SECTOR ";J;" (TRACK 17,SECT. ";16 - J;)"
          27 & R( PEEK (BFR + 1), PEEK (BFR + 2),BFR)
          30 GOSUB 300
          40 NEXT
          50 END
          300 FOR I = 1 TO 500: NEXT
          305 & X(BFR,BFR + 191)
          310 GET A$
          320 HOME
          330 & X(BFR + 192,BFR + 255)
          340 GET A$
          350 RETURN
```

#### Listing 3: UNDELETE

```
1 PRINT CHR$(4);"BRUN AMPERRWTS.CODE,A$8000"
2 HOME
3 DT = 32: REM SEE FIGURE #3
5 PRINT "DRIVE #? ";: GET D$: PRINT D$
6 IF D$ < "1" OR D$ > "2" THEN GOTO 5
7 D = VAL (D$)
8 PRINT
10 BFR = 8192
20 & R(17,0,BFR,D): REM READ VTOC
30 T = PEEK (BFR + 1):S = PEEK (BFR + 2)
35 IF T = 0 AND S = 0 THEN END
40 & R(T,S,BFR,D): REM READ CATALOG
50 FOR J = 0 TO 210 STEP 35
55 TRK = PEEK (BFR + 11 + J)
57 IF TRK = 0 THEN END
60 IF TRK < > 255 THEN GOTO 100
70 FOR I = 0 TO 28
80 PRINT CHR$( PEEK (BFR + 14 + J + I));
85 NEXT : REM (I)
90 PRINT : PRINT "UNDELETE (Y) OR (N)? ";: GET A$: PRINT A$
91 PRINT
92 IF A$ < > "Y" GOTO 98
94 POKE (BFR + 11 + J), PEEK (BFR + 11 + DT + J)
96 POKE BFR + DT + 11 + J,160
97 & W(T,S,BFR,D): GOTO 100
98 IF A$ < > "N" THEN GOTO 90
100 NEXT : REM (J)
110 GOTO 30
```

error message will be displayed. The next step is to JSR to CHKCOM to verify that a comma separates the T and S expressions. If the comma is not found, a syntax message is displayed. If the comma is found, the expression representing the S parameter is evaluated. This evaluation is done exactly as is the T expression, except a syntax error is displayed and processing ends if the expression results in a value greater than 15. The valid result is placed in IBSECT, the IOB sector parameter.

The next step is to JSR to CHKCOM, looking for a comma between the S and B expressions. The B expression is evaluated first, like the T and S expressions by a JSR to FRMNUM, but since it is a 16-bit value, we must use GETADR to translate the FAC to an integer. This places the result in LINNUM (\$50-\$51). Once in LINNUM, RWTSCALL moves the buffer address to IBBUFP, the IOB buffer address parameter. The D (drive number) expression is optional. If the routine finds a comma, it evaluates the D expression through a sequence of: 1. JSR CHRGET; 2. JSR FRMNUM; 3. JSR CONINT. If the drive number does not equal 1 or 2, a syntax error message is displayed and processing stops, unless it is stored at IBDRVN (the IOB drive number parameter). If RWTSCALL does not

find a comma following the B parameter, then it defaults to a value of 1.

Next we must load the DCT address into IBDCTP (IOB DCT pointer parameter). Now we're ready to JSR to RWTS, which will load the requested sector into the 256-byte area starting at the address pointed to by IBBUFP. If we issued an &R command and wish to see a hex dump of the requested sector, we can issue an X & X command. The format should be & X(B,B + 255); where B is equal to the B parameter in the &R command.

Having &R and &W around allows us to examine and zap any sector on a 16-sector Disk II diskette. One use of these subroutines is given in listing 3, "UNDELETE".

#### How Undeleting is Possible

Whenever we delete a file from a diskette, the system replaces the track number of the first track/sector list (TRK in figure 1 and listing 3) with \$FF (255). Then it places the track number in byte \$1E (30) of the name filed in the file's directory entry (DT in figure 1 and listing 3). Track 17 sector 0 (VTOC) contains the track and sector number of the first directory entry in byte offsets 1 and 2 respectively. The directories also have a link to the next



## Software Catalog

**Name:** **Darkstar**  
**System:** Sinclair ZX81,  
Apple II  
**Memory:** 16K - ZX81  
48K RAM - Apple  
with DOS 3.3

**Language:** BASIC  
**Description:** Solves darkroom problems relating to print density, magnification, lens opening, neutral density, color balance, filter factors, black-and-white paper type, black-and-white paper grade, variable contrast filters; black-and-white film development. Answers fully compensated for reciprocity and enlarger type. For both black-and-white and color darkroom application. Documentation offers many examples of use.

**Price:** \$99.95 - Sinclair ZX81  
\$129.95 for Apple II  
\$550.00 for complete  
Sinclair package  
Includes tape or disk and full documentation. Sinclair package also includes 12" black-and-white monitor and tape deck as well as Sinclair ZX81 with 16K RAM.

**Author:** Bob Nadler  
**Available:**  
F/22 Press  
P.O. Box 141  
Leonia, NJ 07605

**Name:** **Hardisk Accounting Series**  
**System:** Apple II or  
Apple III  
**Memory:** 64K, 128K  
**Language:** UCSD Pascal  
**Hardware:** 5-Megabyte hard  
disk

**Description:** *The Hardisk Accounting Series* from Great Plains Software is a menu-driven, double-entry accounting system for small business management and accounting. Each module of the *Hardisk Accounting Series* is interactive and includes complete audit trails. The program is written in UCSD Pascal and currently runs on the Apple II and Apple III with a hard disk. Special features include a password security system, flexible formatting for reports, menu-driven file utilities, budget tracking, and a management

information system. Documentation includes cross-reference screen displays and step-by-step instructions. With the extensive data entry prompts and error checking, users will find the *Hardisk Accounting Series* totally comprehensive and very easy to operate and understand.

**Price:** \$395.00/module for  
GL, AR, AP, Payroll  
\$595.00 for Inventory,  
Purchase Order Entry, Sales  
Order Entry, Job Costing.

**Available:**  
Great Plains Software

**Name:** **OGI Fig-FORTH**  
**System:** Apple II  
**Memory:** 48K  
**Language:** Machine Language  
and fig-FORTH  
**Hardware:** Disk II

**Description:** This is an implementation of the FORTH programming language as defined by the Forth Interest Group (Fig). This high-level compiled language runs much faster than BASIC and requires less development and debugging time due to its structure and interaction with the user. This is a complete system including a screen disk containing a line editor, screen editor, assembler, decompiler, utilities, and more.

**Price:** \$40.00  
Includes diskette.  
**Author:** Hal Clark  
**Available:**  
On-Going Ideas  
RD #1, Box 810  
Starksboro, VT 05487

**Name:** **A2-PBI Pinball**  
**System:** Apple II or Apple  
II Plus  
**Memory:** 48K  
**Language:** Machine

**Description:** The ultimate arcade simulation program, which recreates the look and sound of a real pinball table down to the finest detail. *Pinball* offers ten user-selectable modes of play, and allows the user to create and save up to 100 custom modes of his/her own design. Forty parameters, each user-adjustable, control

the characteristics of the game.

**Price:** \$29.95  
Includes 16-page adjustment  
manual, instruction card,  
high-score label.

**Author:** Bruce Artwick  
**Available:**  
Sublogic Communications  
Corporation  
713 Edgebrook Drive  
Champaign, IL 61820

**Name:** **Personal PEARL™**  
**System:** CP/M  
**Memory:** 56K  
**Language:** Pascal  
**Hardware:** 280 or 8080 at  
present

**Description:** *Personal PEARL* lets any user create his own custom program library. Designed for non-technical users as well as those with technical expertise. Combines forms generator, report generator, program generator and database manager. May be used with WordStar and SuperCalc.

**Price:** \$295.00  
Includes user manual.

**Available:**  
Relational Systems  
Int'l. Corp.  
P.O. Box 13850  
Salem, OR 97309

**Name:** **Firebug**  
**System:** Apple II or Apple  
II Plus

**Memory:** 48K  
**Language:** Assembly Language  
**Hardware:** Disk drive  
**Description:** *Firebug* is a video game requiring fast manual response and quick thinking. It has high scoring potential and challenging maze situations from which to escape. *Firebug* includes colorful graphics and sound effects to heighten the player's involvement.

**Price:** \$24.95  
Includes disk, catalog,  
documentation.

**Author:** Silas Warner  
**Available:**  
Local dealers and  
distributors, nationwide and  
in Europe, and MUSE  
Software.

**Name:** **GRAPHVICS**  
**System:** VIC-20  
**Memory:** 3K or 8K Expander  
**Language:** Assembly Language  
**Description:** Adds 18 commands to VIC BASIC for creating both hi-resolution and multicolor objects on the VIC-20. Provides two screens: normal text screen and the graphics screen. Swap between the two with a function key. Press another function key to save the graphics screen to tape or diskette. All commands are available to BASIC programs.

**Price:** \$25.00 (\$30.00 foreign)  
Includes manual and sample  
programs.

**Author:** Roy C. Wainwright  
**Available:**  
Abacus Software  
P.O. Box 7211  
Grand Rapids, MI 49510  
(616) 241-5510

**Name:** **Atari Version -The Shattered Alliance**  
**System:** Atari 800 (400 if  
enough memory)  
**Memory:** 40K with BASICs  
cartridge  
**Language:** BASIC  
**Hardware:** Monitor, one disk  
drive

**Description:** Players have the choice of playing any of three battle scenarios on the fantasy world of Osgorth. Or they can simulate battles of ancient armies. There are a variety of units in the fantasy scenarios, including centaurs, elves, unicorns, dwarfs, lizardmen, and many more. Each is rated for strength, speed, and morale. The game moves at a quick pace due to Strategic Simulations' proprietary Rapidfire Movement system. Two-player and solitaire versions are included.

**Price:** \$39.95  
Includes diskette, rulebook,  
and data cards.

**Author:** John Lyon  
**Available:**  
Strategic Simulations Inc.  
465 Fairchild Dr.  
Suite 108  
Mountain View, CA 94043  
(415) 964-1353

## Software Catalog

(continued)

**Name:** Professional Investment System  
**System:** OS65U  
**Memory:** 48K  
**Language:** BASIC  
**Hardware:** Ohio Scientific C-2 or C-3 Series  
**Description:** This is an information management system for use by professional financial counseling and investment firms. It is fully menu driven and provides a variety of timely reports, as well as complete and up-to-date portfolios. The basic breakdowns of this system are Market Classifications, Stock/Bond Information, Portfolio, Transactions, and System Information.  
**Price:** \$1,500.00  
 Includes program disk and user's manual.  
**Available:** Electronic Information Systems, Inc.  
 P.O. Box 5893  
 Athens, GA 30604  
 (404) 353-2858

**Name:** Labyrinth  
**System:** Apple II and Apple II Plus  
**Memory:** 48K  
**Language:** Assembly  
**Description:** Beneath the City of Euqubud on the famed river Ippississim lie Prince Julian's mines — a labyrinth of hundreds of miles of tunnels and caves which was once the richest source of diamonds in the world. The mines are closed now. The yield became too meager and the cost too great, or so they said. Many men believe otherwise, and rumors abound of mysterious and terrifying creatures of the dark caverns which chased Prince Julian's company from the mines and now jealously guard their riches. Many courageous adventurers have ventured back into the deep seeking the fortune they believe to be there, but none has returned. They learned too late the terrifying secret of the labyrinth which ensures the doom of even the best prepared explorer: the walls of the mine are in constant motion, exposing entryways and sealing off exits, as its ghastly guardians

render useless both map and compass with their evil engineering.  
**Price:** \$29.95  
 Includes software package.  
**Author:** Scott Schram  
**Available:** Broderbund Software  
 1938 Fourth Street  
 San Rafael, CA 94901  
 (415) 456-6424  
 or your local computer store

**Name:** CASDUP  
**System:** Atari 400/800  
**Memory:** Less than 2K  
**Language:** Assembly  
**Hardware:** Cassette recorder  
**Description:** This cassette program will duplicate all cassette-based BASIC, data, and machine-language files. If your Atari computer can read a tape, CASDUP will copy it.  
**Price:** \$20.00  
 Includes cassette tape with detailed 21-page instruction manual.  
**Author:** Eric Verheiden  
**Available:** VERVAN Software  
 10072 Balsa Street  
 Cucamonga, CA 91730

**Name:** Problem Solving in Everyday Math  
**System:** Apple II or Apple II Plus with Applesoft in ROM  
**Memory:** 48K  
**Language:** BASIC  
**Hardware:** One disk drive, monitor, or TV  
**Description:** This new processor-oriented program takes a step-by-step approach to analyzing practical everyday mathematical problems. The diskette subjects are: how to solve problems; solving addition and multiplication problems; solving subtraction and division problems; other problem-solving processes such as reasoning without numbers, estimating solutions, and analyzing multiple-step problems.  
**Price:** \$165.00  
 Includes documentation, supportive material, four disks.  
**Author:** Dr. Florence Taber  
**Available:** Interpretive Education, Inc.  
 157 S. Kalamazoo Mall,  
 Suite 250  
 Kalamazoo, MI 49007

### OHIO SCIENTIFIC

**THE WIZARD'S CITY** — search for gold in the dungeons beneath the Wizard's city or in the surrounding forest. A dynamic adventure allowing progress in strength and experience. All OSI — cassette \$12.95, disk \$15.95.

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## Software Catalog

(continued)

Name: **EDITRIX™ 1.0**  
System: Apple II Plus  
Memory: 48K  
Language: Applesoft in ROM  
Hardware: At least one disk drive with DOS 3.3 and one of the following printers:

Anadex 9500/  
9501/9000/9001;  
Centronics  
739/122/350/351;  
Epson MX-100/  
MX-80/MX-70;  
IDS 440C/445G/  
460G/560G;  
ITOH 8510; MPI  
88G; NEC 8023;  
Okidata 82A/83A;  
Silentype

And one of the following parallel interface cards:  
Apple Standard/  
Centronics; CCS  
7728; Epson APL;  
Grappier;  
Mountain CPS;  
Prometheus  
PRT-1/Versacard;  
SSS-AIO; TYMAC

Description: A new screen-oriented text editor featuring advanced text editing with ease of learning and use. To be used with Data Transforms' Graphtrix 1.3 to form the most powerful text editing/graphics screen dump system available.

Price: \$75.00

Includes complete readable instructional manual and free updates as required.

Author: Steve Boker

Available:  
Data Transforms Inc.  
616 Washington St.  
Suite 106  
Denver, Colorado 80203  
(303) 832-1501

Name: **K-DOS**  
System: Atari 800  
Memory: 24K minimum RAM  
Language: Machine  
Hardware: Disk

Description: This command-driven *K-DOS™* is not only a more powerful and convenient DOS for the Atari 800, but it is completely compatible with the Atari 2.0S and other related software. In addition, *K-DOS* supports the Atari 850 handler which allows the use of printers and modems. *K-DOS* features a machine-language monitor which allows examination and alteration of memory

in hexadecimal and displays ATASCII representation; interception of the break instruction does not crash the system, but takes the user back into *K-DOS*; new, powerful commands reserve and erase memory and may be executed when the BASIC or assembler cartridge is in control; *K-DOS* allows the user to create his own commands.

Price: \$89.95

Includes 40-page handbook, disk, and pocket command summary card.

Author: Marcus Watts

Available:  
K-Byte  
1705 Austin  
P.O. Box 456  
Troy, Michigan 48099  
(313) 524-9878

Name: **Financial Analysis Package**

System: Apple II or IBM Personal Computer

Memory: Apple II - 48K bytes RAM memory  
IBM - 64K

Hardware: Apple II - Disk II disk controller and at least one Disk II disk drive.  
IBM - 80-column video monitor, and a printer.

Description: The Execuware *Financial Analysis Package* provides sophisticated analysis for financial executives in determining whether to lease or buy, figuring loan and lease payment schedules, analyzing capital budgeting alternatives and determining depreciation schedules based on the Economic Recovery Act of 1981. The *Financial Analysis Package* is capable of performing nine versatile functions: 1. Loan Amortization Schedule; 2. Lease Amortization Schedule; 3. Depreciation Schedules; 4. Net Present Value Schedule; 5. Present Value of an Amount; 6. Internal Rate of Return; 7. Lease versus Buy Analysis; 8. Variable Rate Loan Schedule; and 9. Variable Payment Lease Schedule.

Price: \$274.95

Includes easy to follow step-by-step instruction manual and diskette.

Author: Execuware™ Micro-computer Software Division of Aeronca, Inc.

Available:  
Apple and IBM Personal Computer dealers

Name: **Korel The Robot**

System: Apple II

Memory: 64K

Language: Pascal

Description: *Korel The Robot* implements a Pascal-like compiler/debugger environment in which to learn and explore structured programming. By programming *Korel* (in an easy to master language) to avoid walls, escape mazes, etc., he will help you break down learning walls. A course disk is available which contains all the problems and solutions in the book and can be used to help develop a classroom curriculum or as a personal learning tool.

Price: \$242.00

Includes book, *Korel Simulator*, course disks, and user's manual.

Author: Richard E. Pattis

Available:  
Cybertronics Int'l. Inc.  
999 Mt. Kemble Ave,  
Morristown, NJ 07960

Name: **Jellyfish**

System: Apple II or Apple II Plus

Memory: 48K

Language: Machine  
[Assembly]

Description: Exciting undersea action! You must recover lost nuclear waste canisters while avoiding schools of mutant jellyfish and octopuses. Can be played by one or two players and features high-resolution graphics.

Price: \$29.95

Includes complete instructions

Author: Mike Burek

Available:  
Sirius Software

Name: **TCST™ Total Inventory**

System: CP/M-compatible

Memory: 56K CP/M, 51K TPA, BDOS location: CC00

Language: MBASIC, DBOS, Agent, Machine Language

Description: *TCST™ Total Inventory* offers unique features such as the ability to handle multiple locations and departments. Reports can be keyed by department, location, or vendor with emphasis on management-oriented reporting for close control of stock and sales. When invoicing, the system automatically interrogates inventory for stock levels, item description, and pricing.

Used as an interface with *TCST™ Total Receivables*.

Price includes software, manual, documentation, utilities, sample data.

Available:

TCS Software, Inc.  
International Dealer Network

Name: **CP/M Fast Disk**

System: Apple II

Memory: 48K

Language: Assembly

Hardware: Legend 64K or 128KDE Card

Description: Add memory to CP/M and use every bit of RAM on the Legend 64K and/or 128KDE card(s). The *CP/M Fast Disk* allows you to read and write to an emulated disk and eliminates the need to wait for motor speed, track search and other time-consuming mechanical delays. As Legend cards are added, up to 512K of memory can be accessed.

Price: \$69.95

Includes disk and manual.

Author: E.S. Tobin

Available:  
Legend Industries, Ltd.  
2220 Scott Lake Rd.  
Pontiac, MI 48054  
(313) 674-0953

Name: **Easi/Arima**

System: Apple II

Memory: 48K

Language: Applesoft

Hardware: One or more disk drives and a printer

Description: A forecasting package for stock and commodity traders, which automates the approach developed by Box and Jenkins so that no statistical experience is necessary. It is usually able to forecast stock and commodity prices within 2% over a one- to five-day horizon. Reads Compu-Trac databases directly and includes programs to create, correct, print, and transform its own databases. Right- or left-hand software keypads are also part of the package.

Price: \$300.00

Includes one year of maintenance and updates.

Author: Eric Weiss, Ph.D.

Available:

The Winchendon Group  
P.O. Box 10114  
Alexandria, VA 22310

**MICRO™**

## MICRObits

Deadline for MICRObits: 20th of second month before publication; i.e., August 20th for October issue. Send typewritten copy (40-word limit) with \$25.00 per insertion. (Subscribers: first ad at \$10.00.)

### 6800/6809 Software

Includes compatible single-user, multi-user and network-operating systems, compilers, accounting and word processing packages. Free catalog.

Software Dynamics  
2111 W. Crescent, Sta. G  
Anaheim, CA 92801

### Kids Can Touch

*A Child's Guide to the Apple II Plus Computer.* A primer for all ages 8 to 88. Adult supervision not required. Forty-eight pages packed with BASIC programming, how computers work, and their history. \$4.95 plus \$1.00 shipping.

Kids Can Touch  
24 Beechwood Road  
Summit, NJ 07901

### Scientific Calculator

OSI 8K program with easy entry, input work sheet display, totals in hex and dec. Hex and dollar modes selectable. 8K tape \$15. Send SASE for data sheet and free utility program listing.

Harry Hawkins  
Box 4432  
Burton, SC 29902

### Dynamite PET/CBM Accessories!

Write-protect switches/indicators for 2040/4040 disk drives. Real world software at low cost. 2114 RAM adapter (replaces obsolete 6550s) and 4K memory expansion for "old" 8K PETs. Hundreds of satisfied customers. Write for *free* catalog!

Optimized Data Systems  
Dept. M, Box 595  
Placentia, CA 92670

### New! The Aerobics Master

Here's a day-by-day diary for exercisers designed by a runner. Tracks progress of a variety of exercise activities. 48K, DOS 3.3 and ROM Applesoft required. Warranted upon registration. SASE for more information. Introductory price \$22.95 - includes shipping.

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1806 Wickham  
Royal Oak, MI 48073

(Continued on page 117)

What  
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## Hardware Catalog

**Name: Apple Computer Case**

Description: A carrying and storage case designed for the Apple II and two disk drives, that may remain connected to a monitor and/or printer with the cover closed or removed completely. The case features a foam-padded interior, non-metallic hold-down strap, removable locking cover, no-slip bumpers and sturdy ABS plastic end-cap construction.

Price: \$64.00

Includes UPS delivery to 48 states.

Available:

Fiberbilt  
601 West 26th St.  
New York, NY 10001

**Name: Fully Extended Wirewrap Prototype Board**

System: Apple II

Description: Size: 2.8" x 10.7" 2-layer pc. Capacity: up to 57 16-pin or 12 40-pin sockets or any combination in between. Carefully designed layout for minimum electrical noise, low impedance, and maximum versatility in layout of ICs, capacitors, and other discretes.

Price: \$45.00 (CA residents add 6% tax)

Includes extensive wirewrap technique documentation.

Available:

Spectrum Systems  
P.O. Box 2262  
Santa Barbara, CA 93120

**Name: Apple Crate<sup>TM</sup>**

System: Apple

Description: *Apple Crate* is a lightweight case for the Apple computer and disk drives.

Price: \$92.00

Includes computer case with accessory pocket and case for two disk drives.

Available:

ABCORP Corporation  
16005 Sherman Way  
Suite 105  
Van Nuys, CA 91409  
or your local computer store

**Name: Micro View**

System: Almost any 8-bit microcomputer

Description: If you program, engineer, test, or repair microprocessor systems, you can debug fast, thoroughly, and with ease using this new invention. Features include: extensive 256-LED display; shows activity in real time; shows address, data, I/O, program flow, and timing information; traces instabilities; gives telescopic and microscopic views; works at full CPU speed; soldered-in CPU OK; easy to learn and easy to use; based on principle of visual pattern recognition; supports most micros; quick setup; rugged; portable; as general purpose as an oscilloscope. Also good for teaching. Lowest cost tool in its class.

Price: \$995.00

Includes complete instrument, personality pack, manual, Micro Chart.

Available:

Micro Logic Corp.  
P.O. Box 174  
100 2nd St., Dept. MC  
Hackensack, NJ 07602  
(201) 342-6518

**Name: Full-View 80 Display Card**

System: Atari 800

Memory: 32K and up

Language: Letter Perfect (80-Column Version), BASIC, Machine Language

Description: The *Full-View 80* provides 80-column capability for the Atari 800 with upper and lower case characters, while retaining the normal Atari 40-column/graphics mode. Switching is accomplished via an on-board soft-switch. The *Full-View 80* fits in slot 3. With the 32K *Memory Plus* in slot 2 the Atari 800 becomes a powerful 80-column, 48K wordprocessor.

Price: \$349.00

Includes all features - no extras.

Available:

Bit 3 Computer Corporation  
8120 Penn Ave. S. #548  
Minneapolis, MN 55431

**Name: APX-800**

**APPLE-VERTER**

System: Apple II

Description: VHF RF modulator (Ch. 7-10 tunable). Designed to mount inside the Apple II computer. Installs in seconds. Operates above normal computer harmonics. Exhibits unusually high stability. Can be used with other computer systems with power sources between 8 and 24 VDC.

Price: \$29.75

Includes direct connect 10' antenna cable.

Available:

ATV Research  
13th and Broadway  
Dakota City, NE 68731

**Name: Leggs**

Hardware: MX-80 Printer

Description: *Leggs<sup>TM</sup>* is a new 'stand' for the Epson MX-80 printer allowing the paper to be put underneath it. *Leggs* installs in seconds in existing tapered holes and requires no tools or changes to the printer. Room for three-inches of paper under the printer. Made of clear acrylic plastic — cheaper than any other stand you can buy.

Price: \$15.00

Includes set of four legs.

Available:

Argus, Inc.  
Box 9777  
Baltimore, MD 21204  
or your local computer store

**Name: Cool Stack<sup>TM</sup> Printer Pal<sup>TM</sup>**

System: Apple II

Description: The *Cool Stack-Sentry II* offers the features of locking, cooling, easy tilt action access, and efficient organization and storage for the Apple II computer system, all in one compact unit. The precision all-steel construction is designed for optimum strength and durability. An attractive textured finish is color matched to the Apple II. The *Printer Pal* stores and feeds printer paper from underneath the printer, offering space-saving convenience and efficiency. Different models are

available for other printers.

Price: \$175.00 Cool Stack-Sentry II complete.

\$29.95 Printer Pal-Model P80 complete with paper support brackets.

Available:

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P.O. Box 5281  
Torrance, CA 90510  
(213) 325-1900

**Name: AI13 Analog Input System**

System: Apple II

Description: The *AI13* is a high-performance, 12-bit Analog-to-Digital Input System including software. The *AI13* gives the Apple the ability to make precision voltage measurements. The hardware is distinguished by the following: 16 separate input channels, 8 software-selectable voltage ranges from  $\pm 5$  volts down to 0-100 millivolts, 20 microsecond conversion time, 12-bit (0.024%) resolution.

Price: \$550.00

Includes cabling, software diskette, and comprehensive manual.

Available:

Interactive Structures Inc.  
146 Montgomery Ave.  
Bala Cynwyd, PA 19004

**Name: Starwriter F-10 Wheel Printer**

Description: High-performance Daisy Wheel printer. Uses industry-standard ribbon cartridges. Standard parallel or RS-232-C interfaces and, by jumper selection, ET X/ACT, X-ON/X-OFF protocols provide maximum flexibility and installation ease. Has extensive built-in wordprocessor functions. Low noise. Choice of friction feed or bi-directional tractor feed. Universal power supply. 30.8 lbs.

Price: \$1995.00

Available:

Leading Edge Products  
225 Turnpike St.  
Canton, MA 02021

## MICRObits

(Continued from page 115)

### TRS-80 Color Computer Game

*MUNCH-O* is probably the most challenging arcade-type maze game available for the color computer, with two mazes, nine changing color schemes, sound, and at certain levels, a maze with invisible walls. Minimum 4K. Joystick required. \$12.95 cassette.

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### TRS-80 Color Computer

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DMP Systems  
319 Hampton Blvd.  
Rochester, NY 14612

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*Physics*: 11 diskettes, 75 programs — \$200. May be ordered separately.  
*Happy Face* (four word games) — \$15;  
*Dinosaurs* — \$15; *Aquarium* — \$25;  
*Christian Education* — \$15. Above programs have extensive hi-res graphics. *Peachy Writer* text editor — \$24.95; *Grade Reporter* — \$19.95. VISA/MC. Free catalog.

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(318) 255-8921

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T.I. 99/4  
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on your  
Apple II?



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- Cook, Douglas R., "Colormon," pg. 212-213.  
A monitor for the 6809-based TRS-80 Color Computer.
- Wood, James W., "You Light Up My Life," pg. 330.  
Teach the physics of light with this program for interference patterns using the TRS-80 Color Computer.

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- Gresham, Jim, "Color Computer Ramblings," pg. 3.  
Miscellaneous information on the TRS-80 Color Computer including some important ROM addresses.

### 50. Interface Age 7, Issue 4 (April, 1982)

- O'Connor, Patrick and Leah, "Game Corner," pg. 22, 149.  
*Breakout*, a game for the 6809-based TRS-80 Color Computer; discussion and listing.

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- Capouch, Brian, "Structured Programming in BASIC09," pg. 45-49.  
BASIC09 is a programming language available for 6800/6809-based OS-9 operating systems.
- Tenny, Ralph, "Extensions to the C-Bug Monitor," pg. 51-55.  
Two valuable debugging functions are added to CBUG, a monitor for the 6809-based TRS-80 Color Computer.
- Walker, Gregory and Whiteside, Tom, "Multiprecision Addition — A Comparison of 6809 and 6502 Programming," pg. 57-59.  
A comparison using 32-bit addition routines to demonstrate several advantages of programming the MC6809 over the 6502.
- Puckett, Dale, "FLEX: An Operating System for the 6809," pg. 61-65.  
FLEX is a widely supported operating system for 6800- and 6809-based microcomputers. Its history, features and applications are discussed.
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- Wilkinson, Terry, "SuperPET's Super Software," pg. 28-36.  
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A detailed description of the 6809-based Hitachi MB-6890 Personal Computer Basic Master Level 3 micro, also now known as the Hitachi Peach.

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- Kocher, Christopher P. and Keith, Michael, "Six Personal Computers from Japan," pg. 61-102.  
Information is given on several 6809-based micros including the Canon CX-1, the Hitachi MB-6890, and the Fujitsu FM-8 (two 6809 processors).
- Barden, William Jr., "Ports of Entry and Soft Breezes for the Color Computer and Model III," pg. 162-198.  
A hardware article for the Radio Shack Color Computer including an anemometer and other remote sensing projects.

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- Walker, Gregory and Whiteside, Tom, "Memory Moves with the 6502 and 6809," pg. 19-22.  
Advantages of the 6809's direct page addressing and 16-bit registers are shown in a comparison of 6502 and 6809 memory moves.
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- Harrington, John, "A Simple Multiprocessor Implementation," pg. 464-471.  
Multiprocessing with 6809-based systems.
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A short BASIC program that will help enter machine-language programs for the 6809-based Radio Shack Color Computer.

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Questions and answers related to the 6809-based SuperPET.
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A close-up look at these competing microcomputers.

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- Commander, Jake, "Spiromania," pg. 88-96.  
Use your 6809-based Color Computer to run a graphics program combining a constantly changing angle with a constantly changing radius to form a spirograph.

# Would you give \$295?

If you're currently using Apple Pascal\* on your Apple II, you're probably aware of some noticeable limitations. And you'd probably give a lot for an upgrade package, including the UCSD p-System\*, UCSD Pascal\* and TURTLEGRAPHICS, that would get your Apple\* to do what it's capable of.

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Anon., "Tape Handling," pg. 9.

Discussion of the protocol for tape handling on the Atari 810 Tape Drive, including mark and space frequencies, 600 baud rate, data files, etc.

### 2. Microcomputer Printout 3, No. 4 (March, 1982)

Butterfield, Jim, "Disk Doctor," pg. 64-67.

Two useful disk routines for the CBM micros. One is for checking the veracity of a particular disk and the other for changing your drive number with recourse to a soldering iron.

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Neils, Jody, "KIM Bouncy Keypad Cure," pg. 77-80.

A 94-byte program to eliminate the annoying key-bounce and prolong the life of the KIM-1 keypad.

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Tomczyk, Michael S., "The VIC Magician," pg. 39-51.

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How to put the Apple on an amateur radioteletype, transmitting and receiving at 110 baud ASCII or at 60, 67, 75, or 100 WPM Baudot.

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Johnson, Thomas C., "Oscar Pathfinder," pg. 46-51.

A colorful way to track amateur radio satellites using the Apple, in Applesoft BASIC.

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David, Jill, "Using Your Pascal Editor as a Word Processor," pg. 23-30.

The Apple Pascal program RJUSFY may be used with your text files to make your Pascal system work like a word processor.

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Lubar, David, "Table Lookup," pg. 160-166.

A 6502 machine-language routine to handle lookup tables, with examples for the Apple.

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A program to set up your Apple for the various typing modes.

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### Microcomputer Information Resources

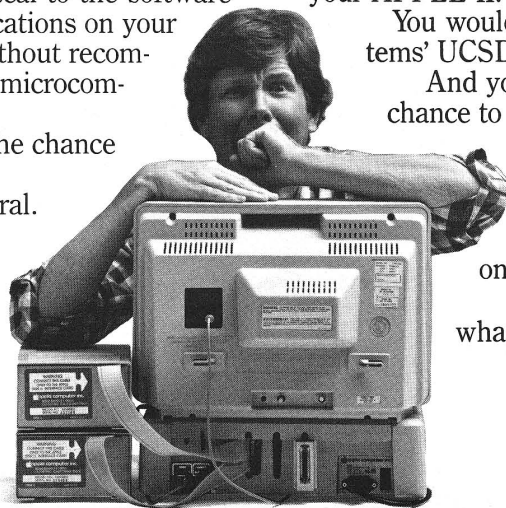
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Authors note to players — I wrote this one with a concordance in hand. It is very accurate — and a lot of fun. It was nice to wander around the ship instead of watching it on T.V.

**CIRCLE WORLD** by Bob Anderson — The Alien culture has built a huge world in the shape of a ring circling their sun. They left behind some strange creatures and a lot of advanced technology. Unfortunately, the world is headed for destruction and it is your job to save it before it plunges into the sun!

Editors note to players — In keeping with the large scale of Circle World, the author wrote a very large adventure. It has a lot of rooms and a lot of objects in them. It is a very convoluted, very complex adventure. One of our largest. Not available on OSI.

**HAUNTED HOUSE** by Bob Anderson — This one is for the kids. The house has ghosts, goblins, vampires and treasures — and problems designed for the 8 to 13 year old. This is a real adventure and does require some thinking and problem solving — but only for kids.

Authors note to players — This one was fun to write. The vocabulary and characters were designed for younger players and lots of things happen when they give the computer commands. This one teaches logical thought, mapping skills, and creativity while keeping their interest.

**DERELICT** by Rodger Olsen and Bob Anderson — For Wealth and Glory, you have to ransack a thousand year old space ship. You'll have to learn to speak their language and operate the machinery they left behind. The hardest problem of all is to live through it.

Authors note to players — This adventure is the new winner in the "Toughest Adventure at Aardvark Sweepstakes". Our most difficult problem in writing the adventure was to keep it logical and realistic. There are no irrational traps and sudden senseless deaths in Derelict. This ship was designed to be perfectly safe for its' builders. It just happens to be deadly to alien invaders like you.



**NUCLEAR SUB** by Bob Retelle — You start at the bottom of the ocean in a wrecked Nuclear Sub. There is literally no way to go but up. Save the ship, raise her, or get out of her before she blows or start WWII.

Editors note to players — This was actually plotted by Rodger Olsen, Bob Retelle, and someone you don't know — Three of the nastiest minds in adventure writing. It is devious, wicked, and kills you often. The TRS-80 Color version has nice sound and special effects.

**EARTHQUAKE** by Bob Anderson and Rodger Olsen — A second kids adventure. You are trapped in a shopping center during an earthquake. There is a way out, but you need help. To save yourself, you have to be a hero and save others first.

Authors note to players — This one feels good. Not only is it designed for the younger set (see note on Haunted House), but it also plays nicely. Instead of killing, you have to save lives to win this one. The player must help others first if he/she is to survive — I like that.

**PYRAMID** by Rodger Olsen — This is one of our toughest Adventures. Average time through the Pyramid is 50 to 70 hours. The old boys who built this Pyramid did not mean for it to be ransacked by people like you.

Authors note to players — This is a very entertaining and very tough adventure. I left clues everywhere but came up with some ingenious problems. This one has captivated people so much that I get calls daily from as far away as New Zealand and France from beary eyed people who are stuck in the Pyramid and desperate for more clues.

**QUEST** by Bob Retelle and Rodger Olsen — THIS IS DIFFERENT FROM ALL THE OTHER GAMES OF ADVENTURE!!!! It is played on a computer generated map of Alesia. You lead a small band of adventurers on a mission to conquer the Citadel of Moorlock. You have to build an army and then arm and feed them by combat, bargaining, exploration of ruins and temples, and outright banditry. The game takes 2 to 5 hours to play and is different each time. The TRS-80 Color version has nice visual effects and sound. Not available on OSI. This is the most popular game we have ever published.

**MARS** by Rodger Olsen — Your ship crashed on the Red Planet and you have to get home. You will have to explore a Martian city, repair your ship and deal with possibly hostile aliens to get home again.

Authors note to players — This is highly recommended as a first adventure. It is in no way simple—playing time normally runs from 30 to 50 hours — but it is constructed in a more "open" manner to let you try out adventuring and get used to the game before you hit the really tough problems.



**ADVENTURE WRITING/DEATHSHIP** by Rodger Olsen — This is a data sheet showing how we do it. It is about 14 pages of detailed instructions how to write your own adventures. It contains the entire text of Deathship. Data sheet - \$3.95. NOTE: Owners of OSI, TRS-80, TRS-80 Color, and Vic 20 computers can also get Deathship on tape for an additional \$5.00.

#### PRICE AND AVAILABILITY:

All adventures are \$14.95 on tape except Earthquake and Haunted House which are \$9.95. Disk versions are available on OSI and TRS-80 Color for \$2.00 additional.

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**OSI**

**VIC-20**

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— Manufactured by MOS, Synertek, Rockwell  
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- keyboard
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- disk drive controller
- teletype
- printer
- IEEE-488 controller

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— Features:

- two 8-bit bidirectional ports with handshaking
- two internal timers
- serial/parallel shift register
- input data latching

— Because of its general purpose design, the 6522 can be used with most microcomputers including the 65XX and 68XX families.

## 6522 Pinout

Vss	1	40	CA1
PA0	2	39	CA2
PA1	3	38	RS0
PA2	4	37	RS1
PA3	5	36	RS2
PA4	6	35	RS3
PA5	7	34	RES
PA6	8	33	D0
PA7	9	32	D1
PB0	10	31	D2
PB1	11	30	D3
PB2	12	29	D4
PB3	13	28	D5
PB4	14	27	D6
PB5	15	26	D7
PB6	16	25	2
PB7	17	24	CS1
CB1	18	23	CS2
CB2	19	22	R/W
Vcc	20	21	IRQ

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6522 (VIA)

Data Sheet #7

## 6522 Registers

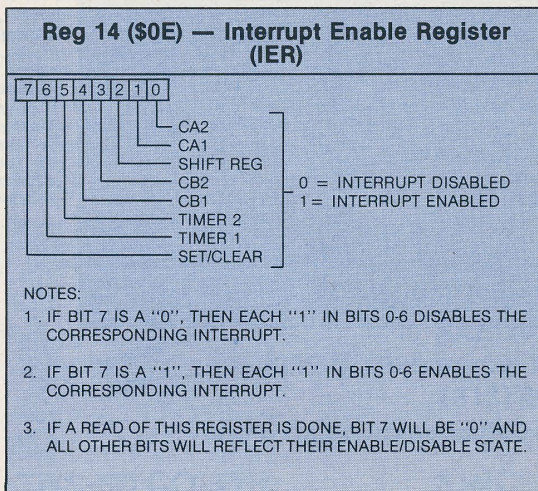
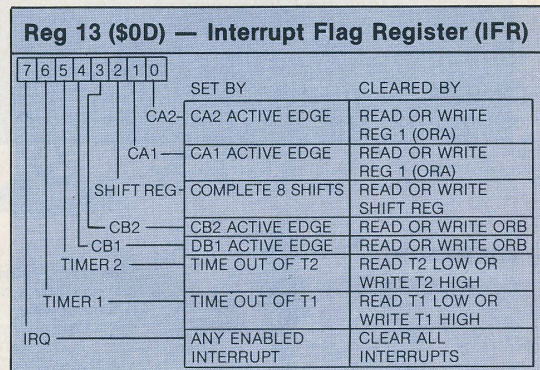
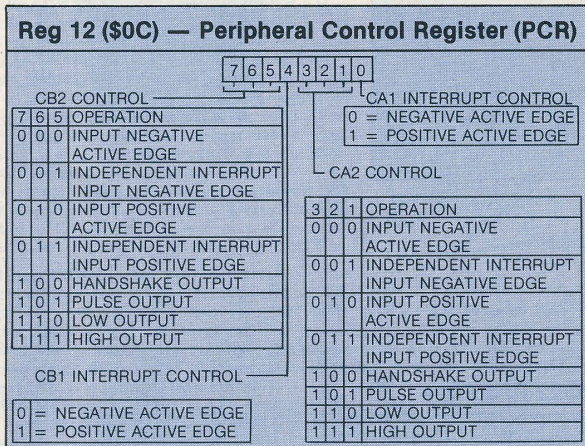
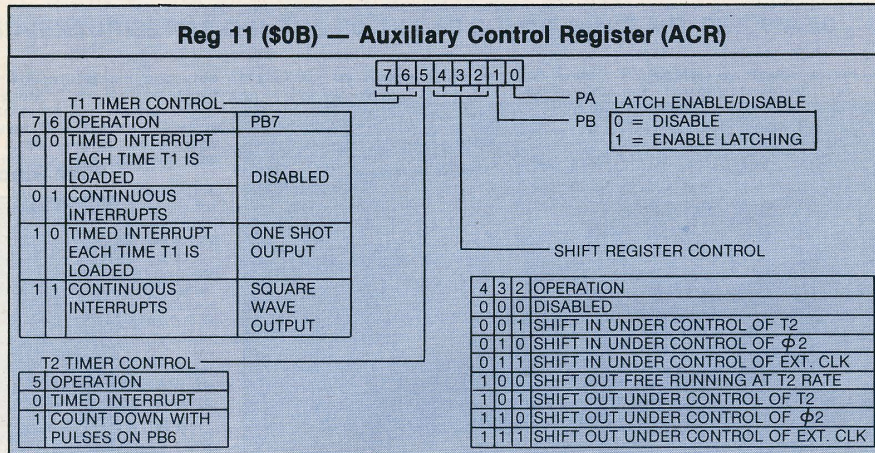
Register Number	Register Designation	Description	Write	Read
0	\$00	ORB/IRB	Output register B	Input register B
1	\$01	ORA/IRA	Output register A	Input register A
2	\$02	DDRB	Data direction register B	
3	\$03	DDRA	Data direction register A	
4	\$04	T1C-L	T1 low-order latches	T1 low-order counter
5	\$05	T1C-H	T1 high-order counter	
6	\$06	T1L-L	T1 low-order latches	
7	\$07	T1L-H	T1 high-order latches	
8	\$08	T2C-L	T2 low-order latches	T2 low-order latches
9	\$09	T2C-H	T2 high-order counter	
10	\$0A	SR	Shift register	
11	\$0B	ACR	Auxilliary	
12	\$0C	PCR	Peripheral control register	
13	\$0D	IFR	Interrupt flag register	
14	\$0E	IER	Interrupt enable register	
15	\$0F	ORA/IRA	Same as register 1, except no handshaking	

# 6522 (VIA)

6522 (VIA)

Data Sheet #7

MICRO™



### Programming Example

A simple GETKEY routine — an example of using the VIA's control registers.

```

INIT      LDA      #% 0111 1111
          STA      IER          disable all interrupts
          LDA      PCR
          AND      #% 1111 1110  enable CA1 — negative
                                   active edge

          STA      PCR
          LDA      ACR
          ORA      #% 0000 0001  latch on CA1
          LDA      ACR
          LDA      #0
          STA      DDRA          set all port A lines
                                   for input
          JSR      KGET          loop until key pressed
          BCS      KWAIT        null rejected

KWAIT

KGET      SEC
          LDA      IER
          BIT      # 0000 0010  CA1 set?
          BEQ      RETURN
          LDA      IRA          (register 2, with
                                   handshaking)

RETURN    CLC
          RTS
    
```

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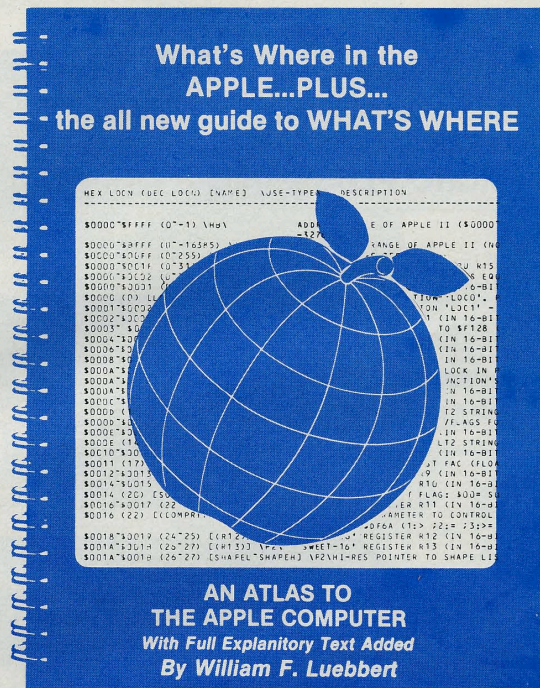
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- **An MC68000 Overview** — A discussion by Motorola of the 68000's registers and addressing modes.
- **The 68000 and the Personal Computer** — A look at how owners of 6502-based machines can benefit from the 68000.

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By Fred Huntington

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