DOCUPAK VOLUME 1

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WOZPAK II

INTRODUCTION

At last the mythical WOZPAK] [is here.

For those who have waited a long, long time – it finally does exist. A note of appreciation to the people who contributed to this project:

First to **KEN SMITH** who worked long hours editing both the text and programs, and with his Diablo Printer produced the final copy of this book;

To **BOB CLARDY** and **RALPH THIERS** for editorial assistance;

To **STU BRUMMETT**, for entering into the word processor many pages of text;

To **DICK SEDOWICK**, and **DAVE McINTOSH** for the "Sweet 16" compendium.

Many thanks to **STEVE WOZNIAK ("WOZ")** and **APPLE COMPUTER** for all the other untitled articles in this volume.

Finally to the publishers of *MICRO* and *DR. DOBBS JOURNAL* for permission to reprint their articles.

The optional WOZPAK Cassette contains the programs in this volume. The first program on the cassette is an index giving the address instructions for all the machine language programs. All programs are recorded twice on the tape.

The second set are recorded with a different recorder and a short voice input separates the two recordings.

Dick Hubert – November 15, 1979

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WOZPAK II
(DOCUPAK Volume 1)

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TED II+ EDITOR/ASSEMBLER

a Beginning Review
of a Beginner's Assembler
by Ken Smith (a Beginner)

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WOZPAK II

From the stories I've heard, this is probably the 697th version of the TED II ASSEMBLER. Hopefully it is as good or better than the previous versions. This review of TED II+ is the result of a great deal of trial and error, and a little bit of luck!

The version of TED II ASSEMBLER that I have used was designed to be used on a 48K APPLE][with DOS 3.2. However, it now works on 32K or 36K APPLE][s, and it can be used on systems without disk. Source files can be saved to tape from within TED II+ itself (see LOAD & SAVE commands).

There are two modes of operation used in TED II+, EXEC and TED (for EXECutive and Text EDitor). The prompt character for EXEC is '%'. ':' is the prompt character for TED mode. The EXEC mode provides the interface for all disk functions. The following is a summary of EXEC commands.

C :DISK CATALOG
Displays disk catalog. Source files are saved by TED II+ as <NAME>.S" The ".S" subscript allows TED II+ to identify source files. Hit any key to return to EXEC menu.

D :DIRECT COMMAND TO DISK
Allows direct access to DOS without leaving program. This can be used to rename or delete files, load printer routines, or specify a drive# for subsequent L & S commands. For example, "CATALOG,D2" will set drive #2 as the specified disk drive. Add the ".S" subscript for commands, if applicable.

L :LOAD FILE FROM DISK
Loads existing source file from disk. <NAME> should not include ".S", as TED II+ will provide it for a Load.

S :SAVE FILE TO DISK
Source file will be saved to disk with <NAME> provided by user. TED II+ will provide ".S" subscript.

A :APPEND FILES (CREATES '-A' FILE)

Loads two existing disk files, puts them together, and saves the new file to disk in one operation. User is asked for 'ORIGINAL FILE' and 'FILE TO APPEND'. The new file created will be '<ORIGINAL FILE NAME>-A', and the other files will be unchanged. The new file will also be in memory.

T :ENTER TED II+ EDITOR/ASSEMBLER
This shifts operation from EXEC mode to TED mode. TED mode commands are covered in detail in the next section.

Q :QUIT TED II+
This exits the program when 'Q' is entered in EXEC mode. A 'Q' entered while in TED mode will return control to EXEC mode. Should you accidently exit the program, 'RUN' [RETURN] will restart without losing the source file in memory.

Should you change your mind, the D,L, S, and A commands can be aborted with a carriage return.

After entering TED mode, the following commands apply. These are direct commands. Note the upper and lower case letters of the commands. Those letters in upper case are required; the lower case letters optional. An example of command syntax is included, where needed.

Add
Puts user into 'Add Lines' mode. If a source file is in memory, 'Add' will start with the next available line number. If not, it will start with 'Line 1'. Add is terminated with a CONTROL-D as the first character on the line.

Insert I<line#>
Operates like 'Add', except lines are inserted into source starting at <line#>. Also terminated with a CONTROL-D. Lines after the insertion line are automatically renumbered. Lines may be inserted before any existing line.

The following commands allow the user to specify the range or ranges of lines upon which the command will act. If no range is specified, the entire file will be acted upon. A range may be a single <line#> or '<line#>,<line#>'. In addition, multiple ranges may be specified as '<range>/<range>' using "/" as a delimiter.

Delete D<line#> or D<range>

Deletes line or lines specified. The remaining lines are renumbered by TED II+. Because of this, be sure to specify the ranges from highest to lowest. Otherwise, the wrong lines will be deleted! 'Delete' requires a <line#> or a <range> as part of the command.

Find F<range>"<string>"

Locates and prints all lines in which <string> occurs. If a <range> is specified, only that range will be searched.

Change C<range>"<s1>"<s2>"

Provides selective substitution of <s2> for <s1>. When Change command is entered, user is asked if "ALL OR SOME (A/S)" occurrences are to be changed. If 'All' is chosen, <s2> will be substituted for <s1> at every occurrence of <s1> within the range, if specified. I have found it better to use the 'Some' choice since it allows the user to monitor the changes. Each line is displayed as it will appear with the change made. If the user hits the 'ESC' key, the change will NOT be made in that line. Any other key will allow the change to be made. Be sure to enter the " as shown in the example.

COPY COPY<l#1>,<l#2> TO <l#3>

Copies the range of lines specified by <l#1>,<l#2> to BEFORE <l#3>. After the move is made, the original lines (while possibly renumbered) are not deleted. The user must do this seperatly.

Edit E<range> or E<line#>

This is where we fix the mistakes! Each line to be edited is printed on the screen with the cursor at the beginning. Editing of lines is accomplished with the following controls:

[RETURN]	Accept the line as it appears on the screen.
CTRL-D	Deletes the character under the cursor.
CTRL-I	Inserts character(s) into the line at the cursor position. Terminated with a space, a forward arrow or a [RETURN].
CTRL-F	Moves the cursor to character entered after 'CTRL-F'. (find)
CTRL-Q	accept line from beginning to cursor position.
CTRL-R	Restart editing of current line with previous changes deleted.
CTRL-X	Exit editing mode.

The forward and back arrows can be used to position the cursor on the line being edited. CTR-U and CTRL-H can be used for cursor moves, also.

List L<line#> or L<range>

Lists the line(s) specified. If no <range> is specified, the entire file will be listed. The listing can be stopped at any time by hitting the space bar. The list will advance one line each time that the space bar is hit. Any other key will continue the listing. CTRL-C will abort.

General TED II+ Housekeeping commands:

HImem: HI:<decimal#>

Sets highest memory limit for source and symbol tables.

LOmem: LO:<decimal#>

Sets lowest memory limit for source table and performs a NEW. Normally set to 7424. If LOMEM: is set below this point, TED II+ may overwrite itself.

NEW

Deletes existing source file. NEW does not reset memory limits.

IN#

Same as Basic IN#, but pretty much useless. A CTRL-C exit from listing or an 'END ASSEMBLY' resets to IN#0.

PR#

Same as Basic PR#. Quitting to EXEC resets to PR#0. This command is used for hard copy listing of the source file. PR# is also a 'PSEUDO-OP', as discussed in that section, and is used as such for hard copy assembly listings.

LEN

Provides display of size of source table and remaining memory available.

TABS TABS<col>/<col>/<col>" "

This seems to be the one command most likely to bomb the program if incorrectly entered. TABS is used to set tab stops for listing the source file. <col> is the decimal column of the stop. The quotes are used to define the tab character, (a space).

LOAD

This load command is available for non-disk systems. It loads a source file from Tape.

SAVE
Saves source file to Tape.

Note for non-disk users: TED II+ can be saved to tape as a machine-language program. After loading and running this Integer Basic version, exit the program and go into Monitor. Save it to tape with "800.1CFFW". Tape files can be saved and transferred to disk later. The Cold Start entry is $800; Warm Start is $803. (A warm start does not reset source pointers, thus source is not erased on reentry)

An instruction line entered into the source file consists of four parts:
LABEL....OPERATOR....OPERAND....COMMENT
If the label field is not used on a line, a space must be entered in this field. The remaining fields are seperated from each other by a space each. An asterisk '*' entered into the label position on a line is used for Title or Comment lines. On single byte op-codes (i.e. ROL,ROR,etc), a ";" can be used in the operand field so that comment indexing is maintained. No space is needed between ';' and <comment>.

PSEUDO-OPS

TED II+ supports all 6502 Mnemonics, Sweet-16 operators, and it's own Pseudo-Operator set:

....ORG....$<addr>
Sets address where final program will run. Object code may be actually written elsewhere, but is written to run at the specified address.

....OBJ....$<addr>
Specifies starting address where object code is actually written. The default address of OBJ and ORG is $7000 on a 48K APPLE][. ($5000 on a < 48K APPLE).

<label>....EQU....<expr>
Assigns value of <expr> to <label>. <expr> is used for a decimal value <256. '$<expr>' is used for Hex addresses or constants. Zero-page addresses may be expressed in decimal, if desired.

....DS....<expr>
Reserves <expr> number of bytes at the location of DS in the program. <expr> may be decimal or Hex ($<expr>).

....DA....<label>
Stuffs address of <label> into memory, low byte first, then high byte.

....DW....<expr>
Stuffs hex equivalent of <expr> into memory. <expr> may be any legal type of expression.

....HEX....<hex bytes>
Writes listed hex bytes into memory. Only first 3 bytes will be listed during assembly. Use 2-digit numbers (3A01FF)etc.

....ASC....'<string>' or "<string>"
Writes ASCII characters of <string> into memory. If <string> is delimited by ', then high bit of character is clear. If " is used, high bit is set. Only the first three bytes stored will be printed during Assembly, but all characters are written into memory.

....DCI....'<string>' or "<string>"
Similar to ASC, except the last character will have the high bit clear or set OPPOSITE of that set by choice of ' or ".

....PAG....
Clears screen or Form-Feeds printer.

....LST.<ON> or <OFF>
Turns assembly listing on or off as specified. Any portion or all of the listing may be turned on or off with this command. Default is 'ON'.

....PR#.<expr> or $<addr>
Sends assembly listing to Slot #<expr> =1-7. If '$<addr>, listing will be sent to routine at <addr>.

....END....
Optional operator signaling End of source file. Assembler will stop at END. If target labels or EQUs are located after END, errors will occur.

TED II+ also accepts:
....BLT....<label>, branch less than.
Same as BCC operator.
....BGE....<label>, branch greater than/ equal. Same as BCS operator.

Legal Immediate Operands are:
('#' is used to signal Immediate)

#<LABEL	Low byte of LABEL adress.
#>LABEL	High byte of LABEL address.
#"<chr>	ASCII of <chr> High bit set.
#'<chr>	ASCII of <chr> High bit clear.
#$<num>	Hex number.
#<num>	decimal number.

Operands may be modified with the arithmetic operators:'+','-', and '*'. These are one-byte modifiers only.

ASM is the direct command given to TED II+ to start the assembly process. If the list option is on, the assembler will halt at any errors detected. It stops at the line BEFORE the line with the error in it. Hitting the space bar will advance one line each time it is hit. Any other key will allow the assembler to continue running. A CTRL-C will exit the assembler at any time. Also, during assembly, the space bar may be used to temporarily halt the listing for examination. Any other key will continue assembly.

Any errors detected during LST OFF will not halt the assembler and will be displayed. A CTRL-C will exit the assembler at any time.

At the completion of assembly, the number of errors (in Dec.) will be shown, as well as the number of Bytes generated. This number does NOT include memory saved with the DS op-code, so take that into consideration when saving the object code. I generally put a 'NOP' at the very end of the source, and use the address to figure the length of the program.

After assembly, the user is in TED II+ Mode for editing or whatever.

While not perfect, TED II+ is probably the easiest assembler to use, especially for a beginner. There are occasions when it bombs for no apparent reason. The only thing to do then is to try to recover the source file and save it. RESET will get you out. Re-entering BASIC often does not work, since some pointers may have been destroyed. I have found that 'EFECG'(the BASIC run entry point) in monitor will restart the EXEC program. Save the file to disk and then COMPLETELY restart the whole thing over. This generally will take care of any problems when everything else fails. For some reason, TED II+ syntax errors occasionally write over the assembler itself.

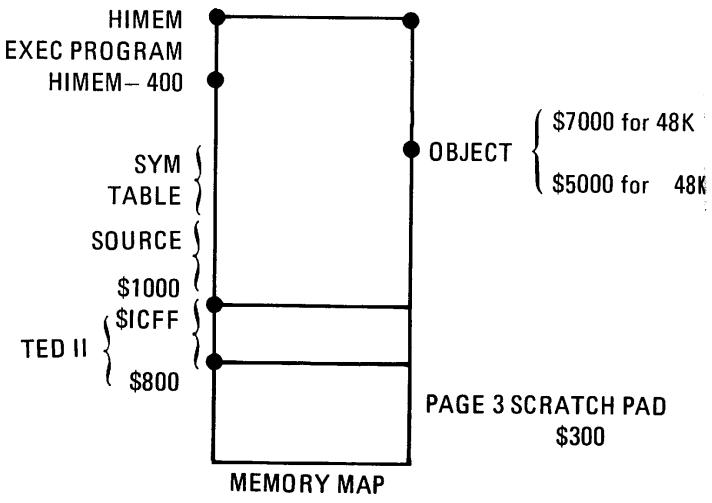
Non-disk users can examine locations $0A-0F to find the source table pointers. $0A-0B contain the LOMEM (start of source) address, low byte first. $0C-0D is HIMEM. $0E-0F is the 'end of source' pointer. Thus, even if the assembler is totally destroyed, the source can be recovered using these pointers. With a little figuring, the disk user can BSAVE the source to disk using these pointers. In this case, the user MUST add the ".S" subscript to the File name, so that TED II+ can find the file when the program is re-run.

The symbol table, which is created just above the end of the source, can be overwritten if the OBJ location is set too low. This usually is indicated by an 'UNDEFINED LABEL' error, when you KNOW that you used that label somewhere!

The SET operator (SWEET 16) does not recognize an immediate mode label. For this operator to work, the value to be assigned to a SWEET 16 register must be assigned a label, and that label entered as the register assignment (see the LAZARUS source listing, for example).

When creating a 'Title Box' using the asterisk, it's a good idea to keep the box as narrow as possible. I have found that a wide title box has an annoying habit of bombing the EDITOR.

That's all, folks! I think that I included all of the features of TED II+. The best way to learn how to use this assembler is to USE IT! A little practice will make its use almost automatic. I think you'll find it an easy and effective program development tool.



MEMORY MAP

CREDIT WHERE CREDIT IS DUE DEPT:

This version of the Editor/Assembler represents a major overhaul of earlier versions of TED II, due to the efforts of Gary Shannon, Andy Hertzfeld, and Neil Konzen. I take the blame for the Integer Basic EXECUTIVE part of the program. It was based on some routines from an EXEC program written by Andy Hertzfeld, added to, subtracted from, and ended up as the EXEC front end that is presented here.

LINE NUMBER CROSS REFERENCE

for APPLE][
Integer BASIC Programs

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LINE NUMBER CROSS REFERENCE (LINE X-REF) generates a cross reference listing of all line numbers in an APPLE][Integer BASIC program. This routine scans a program, displays each line number that is referenced by statements in other lines, and displays those line numbers. Complex line number references such as "GOTO 100 +X" are flagged, notifying the user of possible renumbering conflicts.

Because LINE X-REF will flag complex line references, it should be used to check a program before renumbering (using RENUMBER/APPEND). A flagged line can be noted, and then hand-patched after the program is renumbered.

To use LINE XREF, simply load the routine ($800.$8F6), make sure the program to be checked is in memory, and call the routine. An output slot may be specified, if desired, before the routine is called.

LINE XREF contains no absolute memory references, so it may be moved without modification. CAUTION: you should not be in 'AUTO LINE NUMBER' mode when LINE XREF is called.

References to non-existant lines are not flagged. 'RUN <line number>' references are not flagged as it is very unlikely that such a statement exists in a program. Hand-patched delete statements (DEL 0,40) are flagged.

A source listing for LINE XREF was unavailable, but an APPLE disassembled listing of LINE XREF appears on the following page.

An example of the output from LINE XREF is shown below. An asterisk is used to flag line numbers that may provide renumbering conflicts.

```
>LIST
    5 GOSUB 10: GOSUB 10
   10 IF I=1 THEN GOTO 5
   15 PRINT
   20 GOTO I
   25 PRINT
   30 GOTO I*10
   35 PRINT
   40 GOTO 5: GOTO 5: GOTO I+5
   45 PRINT
   50 GOTO 10*I
  100 LIST 5,100

>CALL2048
                    LINE 10 references LINE 5
5- 10 40 40 100

10- 5 5 50*

100- 100        LINE 50 references LINE 10*I
                        (note the '*' flag)
***** 20 30* 40*
>
```

References such as 'GOTO X' or 'GOTO X+10' are displayed on last line. (note 5 '*')

```
0800-  A6 CA     LDX   $CA
0802-  A5 CB     LDA   $CB
0804-  A0 00     LDY   #$00
0806-  84 0C     STY   $0C
0808-  F0 0A     BEQ   $0814
080A-  88        DEY
080B-  A5 06     LDA   $06
080D-  18        CLC
080E-  71 06     ADC   ($06),Y
0810-  AA        TAX
0811-  98        TYA
0812-  65 07     ADC   $07
0814-  86 06     STX   $06
0816-  85 07     STA   $07
0818-  E4 4C     CPX   $4C
081A-  E5 4D     SBC   $4D
081C-  90 07     BCC   $0825
081E-  A5 0C     LDA   $0C
0820-  F0 01     BEQ   $0823
0822-  60        RTS
```

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```
0823-  E6 0C     INC   $0C
0825-  C8        INY
0826-  84 0E     STY   $0E
0828-  B1 06     LDA   ($06),Y
082A-  85 08     STA   $08
082C-  C8        INY
082D-  B1 06     LDA   ($06),Y
082F-  85 09     STA   $09
0831-  A6 CA     LDX   $CA
0833-  A5 CB     LDA   $CB
0835-  88        DEY
0836-  86 04     STX   $04
0838-  85 05     STA   $05
083A-  E4 4C     CPX   $4C
083C-  E5 4D     SBC   $4D
083E-  B0 CA     BCS   $080A
0840-  B1 04     LDA   ($04),Y
0842-  85 0A     STA   $0A
0844-  C8        INY
0845-  B1 04     LDA   ($04),Y
0847-  85 0B     STA   $0B
0849-  84 0D     STY   $0D
084B-  90 14     BCC   $0861
084D-  C8        INY
084E-  B1 04     LDA   ($04),Y
0850-  C8        INY
0851-  C5 08     CMP   $08
0853-  D0 06     BNE   $085B
0855-  B1 04     LDA   ($04),Y
0857-  C5 09     CMP   $09
0859-  F0 06     BEQ   $0861
085B-  A5 0C     LDA   $0C
085D-  F0 04     BEQ   $0863
085F-  EA        NOP
0860-  EA        NOP
0861-  E6 0D     INC   $0D
0863-  C8        INY
0864-  B1 04     LDA   ($04),Y
0866-  C9 C1     CMP   #$C1
0868-  90 05     BCC   $086F
086A-  C8        INY
086B-  B1 04     LDA   ($04),Y
086D-  30 FB     BMI   $086A
086F-  C9 B0     CMP   #$B0
0871-  B0 DA     BCS   $084D
0873-  C6 0D     DEC   $0D
0875-  F0 5D     BEQ   $08D4
0877-  C9 28     CMP   #$28
0879-  F0 EF     BEQ   $086A
087B-  C9 5D     CMP   #$5D
087D-  F0 EB     BEQ   $086A
087F-  C9 02     CMP   #$02
0881-  A2 07     LDX   #$07
0883-  5D EF 08  EOR   $08EF,X
0886-  F0 04     BEQ   $088C
0888-  CA        DEX
```



```
0889-  10 F8     BPL   $0883
088B-  8A        TXA
088C-  05 0C     ORA   $0C
088E-  85 0D     STA   $0D
0890-  B0 D1     BCS   $0863
0892-  A0 00     LDY   #$00
0894-  A5 04     LDA   $04
0896-  71 04     ADC   ($04),Y
0898-  AA        TAX
0899-  98        TYA
089A-  65 05     ADC   $05
089C-  C8        INY
089D-  D0 97     BNE   $0836
089F-  A6 08     LDX   $08
08A1-  A5 09     LDA   $09
08A3-  20 1B E5  JSR   $E51B
08A6-  A9 AD     LDA   #$AD
08A8-  20 ED FD  JSR   $FDED
08AB-  A2 01     LDX   #$01
08AD-  A5 24     LDA   $24
08AF-  C9 21     CMP   #$21
08B1-  90 05     BCC   $08B8
08B3-  20 8E FD  JSR   $FD8E
08B6-  A2 07     LDX   #$07
08B8-  20 4A F9  JSR   $F94A
08BB-  A6 0A     LDX   $0A
08BD-  A5 0B     LDA   $0B
08BF-  20 1B E5  JSR   $E51B
08C2-  68        PLA
08C3-  48        PHA
08C4-  C9 0B     CMP   #$0B
08C6-  90 09     BCC   $08D1
08C8-  C9 75     CMP   #$75
08CA-  F0 05     BEQ   $08D1
08CC-  A9 AA     LDA   #$AA
08CE-  20 ED FD  JSR   $FDED
08D1-  68        PLA
08D2-  10 A3     BPL   $0877
08D4-  48        PHA
08D5-  C6 0E     DEC   $0E
08D7-  D0 D2     BNE   $08AB
08D9-  20 8E FD  JSR   $FD8E
08DC-  20 8E FD  JSR   $FD8E
08DF-  A5 0C     LDA   $0C
08E1-  F0 BC     BEQ   $089F
08E3-  A2 05     LDX   #$05
08E5-  A9 AA     LDA   #$AA
08E7-  20 ED FD  JSR   $FDED
08EA-  CA        DEX
08EB-  D0 F8     BNE   $08E5
08ED-  F0 BC     BEQ   $08AB
08EF-  0D 03 7C  ORA   $7C03
08F2-  01 50     ORA   ($50,X)
08F4-  78        SEI
08F5-  03        ???
08F6-  5F        ???
```

SYMBOL CROSS REFERENCE
for APPLE][
Integer BASIC Programs

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WOZPAK II

SYMREF is a useful aid for APPLE][Integer BASIC Program development. It provides a complete listing of all variables that appear in the program, as well as all of the line numbers in which that variable appears. SYMREF can be used by the programmer to find misspellings, extra variables, and unassigned variable names. This routine will flag a FOR statment that has no corresponding NEXT statment. SYMREF also provides extra documentation for the programmer's records to assist later modifications to the program.

TO USE SYMREF:

Load BASIC program into memory.
Set LOMEM to '2560'
Load SYMREF (800.9E5)
Select printer, if desired.
'CALL 2048'{RETURN}
(or $800G in monitor)

Be sure to set LOMEM before calling SYMREF, as the routine creates a table of variable names above LOMEM. If LOMEM is not set above SYMREF, the routine will overwrite itself.

All variable names used in the BASIC program will be printed in alphabetic order on the left edge of the output device. Each is followed by a list of all of the line numbers in which it appears, in ascending sequence. If the name is never assigned a value, an asterisk (*) is printed with the name as an "Undefined Variable" warning. Input variables are considered as being "undefined", unless the name is defined elsewhere in the BASIC program.

If there is insufficient memory for SYMREF to create its name table, the message 'MEM FULL' is displayed and SYMREF halts and returns control to the user.

SYMREF can be relocated by changing the 'JMP & JSR' destinations in lines 140,220, and 320 of the assembled listing.

The following is a sample Integer BASIC Program to illustrate the operation of SYMREF:

```
>LIST
   10 FOR UNDEFINED=1 TO 100
   15 FOR DEFINED=1 TO 100
   20 A=1
   25 PRINT I: PRINT I
   30 PRINT A: PRINT A: PRINT I
   35 NEXT DEFINED
   40 A$="12345"
   45 INPUT "INPUT VAR",INPUTVAR$

   50 PRINT A$: PRINT I$

>CALL2048


A- 20 30 30

A$- 40 50

DEFINED- 15 35

I*- 25 25 30

I$*- 50

INPUTVAR$*- 45

UNDEFINED*- 10
>
```

```
                        WOZPAK II
2     ************************************************
3     *                                              *
4     *          APPLE ][ INTEGER BASIC              *
5     *          SYMBOL CROSS-REFERENCE              *
6     *                                              *
7     * APPLE PUGET SOUND PROGRAM LIBRARY EXCHANGE *
8     *   6708 39TH AVE. SW     SEATTLE, WA 98136  *
9     *                                              *
10    *     SOURCE CODE FROM 'THE WOZPAK'            *
11    * COURTESY OF S. WOZNIAK  APPLE COMPUTER CO. *
12    *                                              *
13    *          DECIPHERED AND ASSEMBLED            *
14    *         (AND SLIGHTLY MODIFIED BY)           *
15    *    KEN SMITH   TACOMA, WA  JUNE 10, 1979     *
16    *                                              *
17    ************************************************
18    IBEGL    EQU   $4
19    IBEGH    EQU   $5
20    NENDL    EQU   $6
21    NENDH    EQU   $7
22    IENDL    EQU   $8
23    IENDH    EQU   $9
24    NBEGL    EQU   $A
25    NBEGH    EQU   $B
26    PL       EQU   $C
27    PH       EQU   $D
28    PO       EQU   $E
29    PN       EQU   $F
30    IL       EQU   $10
31    IH       EQU   $11
32    JL       EQU   $12
33    JH       EQU   $13
34    KL       EQU   $14
35    KH       EQU   $15
36    LL       EQU   $16
37    LH       EQU   $17
38    ML       EQU   $18
39    MH       EQU   $19
40    MODE     EQU   $1A
41    REF      EQU   $1B
42    HIMEML   EQU   $4C
43    HIMEMH   EQU   $4D
44    PPL      EQU   $CA
45    PPH      EQU   $CB
46    *
47    CH       EQU   $24
48    MEMFULL  EQU   $E36B
49    PRDEC    EQU   $E51B
50    PRBL     EQU   $F94A
51    CROUT    EQU   $FD8E
52    COUT     EQU   $FDED
53    *
54             ORG   $800
55    *                      INIT SYMBOL TABLE POINTERS
56    *                      PPL,H (BASIC 'START
57    *                      OF PROGRAM)
58    *
0800: A2 03    59    SYMREF   LDX   #$3      ->  IBEGL,H AND IENDL,H
0802: B5 CA    60    INIT     LDA   PPL,X     PVL,H ('END OF
0804: 95 04    61             STA   IBEGL,X   VARIABLES)
```

WOZPAK II

```
0806:  95 08     63              STA   IENDL,X  -> NBEGL,H AND NENDL,H
0808:  CA        64              DEX   .        THEN SCAN PROGRAM WITH
0809:  10 F7     65              BPL   INIT     MODE $FP TO FILL
080B:  30 39     66              BMI   SCANPROG SYMBOL TABLE
080D:  20 8E FD  67   PRSYM      JSR   CROUT
0810:  20 8E FD  68              JSR   CROUT    OUTPUT 2 CAR RET'S
0813:  A0 00     69              LDY   #$0
0815:  B1 18     70              LDA   (ML),Y   ML,H POINTS TO NAME TABLE
0817:  18        71              CLC   .        INDEX -RELATIVE TO
0818:  65 0A     72              ADC   NBEGL    NBEGL,H- FOR CURRENT
081A:  85 16     73              STA   LL       XREF SYMBOL
081C:  C8        74              INY
081D:  B1 18     75              LDA   (ML),Y   CALC POINTER TO FIRST
081F:  65 0B     76              ADC   NBEGH    CHAR OF NAME TABLE
0821:  85 17     77              STA   LH       ENTRY IN LL,H
0823:  88        78              DEY
0824:  38        79              SEC
0825:  B1 16     80   PRNAME     LDA   (LL),Y   NAME TABLE BYTE IN FORM
                 81   *                        ASCII * 2 +(NOT LAST)
0827:  6A        82              ROR
0828:  08        83              PHP
0829:  C9 C0     84              CMP   #$C0     SUBSTITUTE ASCII '$'
082B:  D0 02     85              BNE   PRNAM1   FOR STRING TOKEN
082D:  A9 A4     86              LDA   #$A4
082F:  20 ED FD  87   PRNAM1     JSR   COUT     OUTPUT CHAR OF NAME
0832:  28        88              PLP
0833:  C8        89              INY   .        INCREMENT INDEX
0834:  B0 EF     90              BCS   PRNAME   LOOP IF NOT LAST CHAR
0836:  B1 16     91              LDA   (LL),Y
0838:  F0 05     92              BEQ   PRNAM2   IF ATTRIBUTE BYTE (FOLLOWING
083A:  A9 AA     93              LDA   #$AA     NAME) IS NON ZERO THEN
083C:  20 ED FD  94              JSR   COUT     OUTPUT '*' AS UNDEFINED
083F:  A9 AD     95   PRNAM2     LDA   #$AD     SYMBOL WARNING
0841:  20 ED FD  96              JSR   COUT     OUTPUT '-'
0844:  A2 00     97              LDX   #$0
0846:  86 1A     98   SCANPROG   STX   MODE     MODE IS NONZERO FIRST
0848:  A6 CA     99              LDX   PPL      TIME ONLY (AFTER INIT)
084A:  A5 CB     100             LDA   PPH      BASIC 'START OF PROGRAM'
084C:  86 0C     101  NXTLINE    STX   PL
084E:  85 0D     102             STA   PH       INIT PROGRAM SCAN POINTER
0850:  E4 4C     103             CPX   HIMEML   (POINTS TO START OF LINES)
0852:  E5 4D     104             SBC   HIMEMH   IF <'END OF PROGRAM' THEN
0854:  90 1C     105             BCC   SCANLIN  CONTINUE--(SCAN THIS LINE)
0856:  A4 04     106             LDY   IBEGL
0858:  A5 05     107             LDA   IBEGH    FIRST TIME--(MODE NON ZERO)
085A:  A6 1A     108             LDX   MODE     SET 'CURRENT SYMBOL POINTER'
085C:  D0 09     109             BNE   NEXTSYM  ML, MH TO 'START OF SYMBOL
085E:  A5 18     110             LDA   ML       INDICES' IBEGL,H
0860:  69 01     111             ADC   #$1
0862:  A8        112             TAY   .        AFTER--ADD 2 TO ML,H
0863:  A5 19     113             LDA   MH       TO ADVANCE ONE SYMBOL
0865:  69 00     114             ADC   #$0      INDEX (2 BYTES EACH)
0867:  84 18     115  NEXTSYM    STY   ML
0869:  85 19     116             STA   MH       IF 'CURRENT SYMBOL POINTER'
086B:  C4 08     117             CPY   IENDL    ML,H < 'END OF INDICES'
086D:  E5 09     118             SBC   IENDH    (IENDL,H)  THEN BEGIN SCAN
086F:  90 9C     119             BCC   PRSYM    FOR THIS SYMBOL
0871:  60        120             RTS   .        ELSE, DONE
                 121  *
0872:  A0 00     122  SCANLIN    LDY   #$0      LINE SCAN INDEX REL TO PL,H
```

```
                                        WOZPAK II
0874:  98          124                   TYA    .         START OF LINE.  CLR REF.
0875:  C8          125   CONST           INY    .         SKIP 2 BYTE CONSTANT
0876:  C8          126                   INY
0877:  85 1B       127   ITEM            STA    REF       SET REF (0='ASSIGN MODE')
0879:  C8          128   ITEM1           INY
087A:  B1 0C       129                   LDA    (PL),Y    NEXT ITEM OF BASIC PROGRAM
087C:  30 27       130                   BMI    NOTOKN    IF NEG, THEN CONST OR NAME.
087E:  C9 28       131                   CMP    #$28      'STRCON'
0880:  F0 04       132                   BEQ    SKPASC
0882:  C9 5D       133                   CMP    #$5D      'REM'
0884:  D0 05       134                   BNE    TOKN1     IF $STRCON OR REM TOKENS
0886:  C8          135   SKPASC          INY    .         THEN SKIP ALL SUBSEQUENT
0887:  B1 0C       136                   LDA    (PL),Y    NEG (ASCII) BYTES
0889:  30 FB       137                   BMI    SKPASC
088B:  C9 02       138   TOKN1           CMP    #$2       CLEARS CARRY ONLY IF EOL
088D:  A2 09       139                   LDX    #$9
088F:  5D DC 09    140   REFTST          EOR    REFTB,X   IF COLON, THEN, FOR, LET,
0892:  F0 E3       141                   BEQ    ITEM      INPUT, STRING INP,INP COMMA,
0894:  CA          142                   DEX    .         OR STRINCOM, THEN SET
0895:  10 F8       143                   BPL    REFTST    REF=0 TO INDICATE THAT
0897:  B0 DE       144                   BCS    ITEM      NEXT (IMMEDIATE) NAME
0899:  A0 00       145                   LDY    #$0       IS ASSIGNED A VALUE
089B:  A5 0C       146                   LDA    PL
089D:  71 0C       147                   ADC    (PL),Y    AT EOL, ADD LENGTH BYTE
089F:  AA          148                   TAX    .         TO LINE POINTER PL,H
08A0:  98          149                   TYA
08A1:  65 0D       150                   ADC    PH
08A3:  90 A7       151                   BCC    NXTLINE   (ALWAYS TAKEN)
08A5:  C9 C0       152   NOTOKN          CMP    #$C0
08A7:  90 CC       153                   BCC    CONST     IF <$C0 THEN FOLLOWED BY
08A9:  84 0E       154                   STY    P0        2-BYTE CONSTANT.
08AB:  84 0F       155   NAMESCAN        STY    PN        SCAN NAME (NEG ASCII)
08AD:  C8          156                   INY    .         WITH P0 AND PN INDICES
08AE:  B1 0C       157                   LDA    (PL),Y    TO FIRST, LAST CHARS.
08B0:  30 F9       158                   BMI    NAMESCAN
08B2:  C9 40       159                   CMP    #$40      INCLUDE '$' TOKEN IN NAME
08B4:  F0 F5       160                   BEQ    NAMESCAN
08B6:  A5 04       161   SEARCH          LDA    IBEGL     IBEGL,H ->  JL,H
08B8:  A6 05       162                   LDX    IBEGH     LOW POINTERS
08BA:  85 12       163                   STA    JL
08BC:  86 13       164                   STX    JH
08BE:  A5 08       165                   LDA    IENDL     IENDL,H ->  KL,H
08C0:  A6 09       166                   LDX    IENDH     HIGH POINTERS
08C2:  85 14       167   NEWK            STA    KL
08C4:  86 15       168                   STX    KH
08C6:  E4 13       169   XTEST           CPX    JH        IF JL,H = KL,H THEN
08C8:  D0 04       170                   BNE    KPLUSJ    EXIT WITH CARRY SET
08CA:  C5 12       171                   CMP    JL        (NOT FOUND)
08CC:  F0 52       172                   BEQ    ADDSYM
08CE:  29 FE       173   KPLUSJ          AND    #$FE
08D0:  18          174                   CLC    .         (JL,H+KL,H)/2 -> IL,H
08D1:  65 12       175                   ADC    JL
08D3:  29 FD       176                   AND    #$FD
08D5:  85 10       177                   STA    IL        IL,H FORCED ODD OR EVEN
08D7:  E6 10       178                   INC    IL        TO AGREE WITH JL,H
08D9:  8A          179                   TXA    .         AND KL,H
08DA:  65 13       180                   ADC    JH
08DC:  6A          181                   ROR
08DD:  85 11       182                   STA    IH
08DF:  66 10       183                   ROR    IL
```

WOZPAK II

```
08E1: AA       185          TAX
08E2: A0 00    186          LDY   #$0
08E4: B1 10    187          LDA   (IL),Y
08E6: 38       188          SEC
08E7: E5 0E    189          SBC   P0        NBEGL,H + INDEX (IL,H)L,H
08E9: 08       190          PHP   .         -P0 -> LL,H FOR BASE
08EA: 18       191          CLC   .         ADDR TO NAME TABLE ENTRY
08EB: 65 0A    192          ADC   NBEGL     CORRESPONDING TO IL,H
08ED: 85 16    193          STA   LL
08EF: C8       194          INY
08F0: B1 10    195          LDA   (IL),Y
08F2: 65 0B    196          ADC   NBEGH
08F4: 28       197          PLP
08F5: 69 FF    198          ADC   #$FF
08F7: 85 17    199          STA   LH
08F9: A4 0E    200          LDY   P0        INDEX FOR NAME SCAN
08FB: C4 0F    201 SYMSCN   CPY   PN        SET CARRY IF LAST CHAR
08FD: B1 0C    202          LDA   (PL),Y    OF USER SYMBOL
08FF: 2A       203          ROL
0900: 49 01    204          EOR   #$1       FORM ASCII * 2 + (NOT LAST)
0902: D1 16    205          CMP   (LL),Y
0904: F0 13    206          BEQ   MATCH
0906: A5 10    207          LDA   IL        IL,H -> KL,H IF USER SYMBOL
0908: 90 B8    208          BCC   NEWK      LOWER (ALPHABETICALLY)
090A: 69 01    209          ADC   #$1       THAN NAME TABLE ENTRY
090C: 85 12    210          STA   JL
090E: 8A       211          TXA   .         IL,H -> JL,H IF USER SYMBOL
090F: 69 00    212          ADC   #$0       GREATER (ALPHABETICALLY)
0911: 85 13    213          STA   JH        THAN NAME TABLE ENTRY
0913: A5 14    214          LDA   KL
0915: A6 15    215          LDX   KH
0917: 90 AD    216          BCC   XTEST     (ALWAYS TAKEN)
0919: C8       217 MATCH    INY   .         INCR INDEX IF CHAR MATCH
091A: 4A       218          LSR
091B: B0 DE    219          BCS   SYMSCN    LOOP IF NOT LAST CHAR, ELSE
091D: 4C AB 09 220          JMP   FOUND     EXIT WITH CARRY CLEAR (FOUND)
0920: A5 0F    221 ADDSYM   LDA   PN
0922: 38       222          SEC
0923: E5 0E    223          SBC   P0        NENDL,H + P0 + PN+1 -> LL,H
0925: 65 06    224          ADC   NENDL     (NEW NEND)
0927: 85 16    225          STA   LL
0929: A5 07    226          LDA   NENDH
092B: 69 00    227          ADC   #$0
092D: 85 17    228          STA   LH
092F: A5 04    229          LDA   IBEGL
0931: 85 10    230          STA   IL        IBEGL,H -> IL,H
0933: E9 01    231          SBC   #$1
0935: 85 14    232          STA   KL
0937: A8       233          TAY   .         IBEGL,H -2 -> KL,H AND Y,X
0938: A5 05    234          LDA   IBEGH     (NEW IBEG)
093A: 85 11    235          STA   IH
093C: E9 00    236          SBC   #$0
093E: 85 15    237          STA   KH
0940: AA       238          TAX
0941: C4 16    239          CPY   LL        IF NEW IBEG < NEW NEND
0943: E5 17    240          SBC   LH        THEN EXIT WITH CARRY
0945: 90 61    241          BCC   MFULLX    CLEAR (MEM FULL)
0947: 84 04    242          STY   IBEGL
0949: 86 05    243          STX   IBEGH     NEW IBEG -> IBEG
094B: A0 00    244          LDY   #$0
```

WOZPAK II

```
094D:  A5 10     246  SPREAD   LDA   IL
094F:  C5 12     247           CMP   JL        IF IL,H = JL,H THEN
0951:  A5 11     248           LDA   IH        DONE SPREADING INDEX
0953:  E5 13     249           SBC   JH        TABLE FOR INSERT
0955:  B0 12     250           BCS   ADDNAME
0957:  B1 10     251           LDA   (IL),Y    MOVE BYTE OF INDEX TABLE
0959:  91 14     252           STA   (KL),Y    2 LOCATIONS LOWER
095B:  E6 10     253           INC   IL
095D:  D0 02     254           BNE   SPRD2
095F:  E6 11     255           INC   IH        INCR IL,H AND KL,H
0961:  E6 14     256  SPRD2    INC   KL
0963:  D0 E8     257           BNE   SPREAD
0965:  E6 15     258           INC   KH
0967:  90 E4     259           BCC   SPREAD    (ALWAYS TAKEN)
0969:  A5 06     260  ADDNAME  LDA   NENDL
096B:  E5 0A     261           SBC   NBEGL
096D:  91 14     262           STA   (KL),Y
096F:  A5 07     263           LDA   NENDH     NENDL,H - NBEGL,H ->(KL,H)
0971:  E5 0B     264           SBC   NBEGH     (NEW INDEX)
0973:  C8        265           INY
0974:  91 14     266           STA   (KL),Y
0976:  A5 16     267           LDA   LL
0978:  85 06     268           STA   NENDL     NEW NENDL,H -> NENDL,H
097A:  18        269           CLC
097B:  E5 0F     270           SBC   PN        OLD NEND - P0 TO LL,H
097D:  85 16     271           STA   LL
097F:  A5 17     272           LDA   LH
0981:  85 07     273           STA   NENDH
0983:  E9 00     274           SBC   #$0
0985:  85 17     275           STA   LH
0987:  A4 0E     276           LDY   P0
0989:  C4 0F     277  ADDCHR   CPY   PN
098B:  B1 0C     278           LDA   (PL),Y
098D:  2A        279           ROL
                 280  *                       ADD CHAR TO NAME TABLE
098E:  49 01     281           EOR   #$1       ENTRY.  USE ASCII * 2
0990:  91 16     282           STA   (LL),Y    +(NOT LAST).  SCAN FROM
0992:  C8        283           INY             (PL),P0 TO (PL),PN
0993:  4A        284           LSR
0994:  B0 F3     285           BCS   ADDCHR
0996:  A5 06     286           LDA   NENDL     SET CARRY IF NENDL,H
0998:  C5 04     287           CMP   IBEGL     = IBEGL,H (NO ROOM
099A:  A5 07     288           LDA   NENDH     FOR ATTRIBUTE BYTE)
099C:  E5 05     289           SBC   IBEGH
099E:  E6 06     290           INC   NENDL     INCR 'NAME TABLE END'
09A0:  D0 02     291           BNE   ADDREF    POINTER NENDL,H
09A2:  E6 07     292           INC   NENDH
09A4:  A5 1B     293  ADDREF   LDA   REF       REF AS ATTRIBUTE
09A6:  90 07     294           BCC   FOUND1    (0=UNASSIGNED)
09A8:  4C 6B E3  295  MFULLX   JMP   MEMFULL   -ERROR-
09AB:  A5 1B     296  FOUND    LDA   REF       IF REF=0  (UNASSIGNED)
09AD:  D0 02     297           BNE   FOUND2    THEN SET ATTRIBUTE
09AF:  91 16     298  FOUND1   STA   (LL),Y    BYTE TO 0
09B1:  A2 FF     299  FOUND2   LDX   #$FF
09B3:  B5 19     300  SYMTST   LDA   MH,X      IF NOT CURRENT SYMBOL
09B5:  55 11     301           EOR   IH,X      (IL,H NOT = TO ML,H)
09B7:  05 1A     302           ORA   MODE      OR MODE = NONZERO
09B9:  D0 1C     303           BNE   TOITEM    THEN DON'T PRINT REF
09BB:  E8        304           INX   .         LINE NUMBER
09BC:  F0 F5     305           BEQ   SYMTST    (LEAVES X=1)
```

WOZPAK II

```
09BE:  A5 24     307            LDA   CH        IF CURSOR BEYOND COL#32
09C0:  C9 21     308            CMP   #$21      THEN OUTPUT CARR RET
09C2:  90 05     309            BCC   PREF      AND TAB 6 SPACES
09C4:  20 8E FD  310            JSR   CROUT
09C7:  A2 06     311            LDX   #$6
09C9:  20 4A F9  312  PREF      JSR   PRBL      ELSE, OUTPUT SINGLE SPACE
09CC:  A0 01     313            LDY   #$1
09CE:  B1 0C     314            LDA   (PL),Y
09D0:  AA        315            TAX   .         PRINT CURRENT LINE
09D1:  C8        316            INY   .         NUMBER (POINTED TO
09D2:  B1 0C     317            LDA   (PL),Y    BY ML,H)
09D4:  20 1B E5  318            JSR   PRDEC
09D7:  A4 0F     319  TOITEM    LDY   PN        RESTORE LINE SCAN
09D9:  4C 79 08  320            JMP   ITEM1     GET NEXT BASIC ITEM
               321  *
09DC:  01 75 06  322  REFTB     HEX   017506    INT BASIC TOKENS
09DF:  0A 0B 70  323            HEX   0A0B70    TO IDENTIFY VARIABLES
09E2:  26 03     324            HEX   2603
09E4:  55 58     325            HEX   5558
```

```
--- END ASSEMBLY ---

TOTAL ERRORS: 00

486 BYTES OF OBJECT CODE
WERE GENERATED THIS ASSEMBLY.


:PR#0

:ASM
```

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RENUMBERING AND APPENDING BASIC PROGRAMS

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WOZPAK II

The answer to the question "What do 5, 11, 36, 150, 201, and 588 have in common?" is given as "Adjacent rooms in the Warsaw Hilton"(1) but might just as well be "Adjacent line numbers in my last BASIC program." The laws of entrophy insure that the line numbers of a debugged and operational BASIC program give the appearance of having been selected by a KENO machine.* Many a time I have spent an extra hour to retype a finished program while spacing the line numbers evenly just to make it "look good".

Another difficulty which I have experienced is joining two BASIC programs into a single, larger one. This 'append' operation is easier to accomplish by hand than renumbering. The sophistocated user can examine the BASIC memory map and perform some manual manipulations to join the programs providing that the line numbers do not overlap. Still, the manual append operation is highly prone to error.

The APPLE][Basic user now has a solution to these needs in the form of a hand- or tape-loadable program, RENUM/APPEND, described herein. The CALL command is used to activate 1 of 3 machine level programs The renumber operation (RENUM) requires user specification of the original line number range over which renumbering is to occur, the new initial line number to be applied to the range, and the new line number increment to use. The example below specifies that lines 200 to 340 be renumbered starting with 100 and spaced by 10's.

```
START  100

STEP    10

FROM   200

TO     340
```

A second RENUM entry renumbers the entire program, relieving the user of the need to specify the range of begin and end parameters. The append operation (APPEND) reads the second user (BASIC) program off tape with the first in memory.

Renumber and Append error conditions (memory full and line number overlap) are detected just as in BASIC. In case of error, the user is notified and no program alteration occurs.

[ed. note] RENUM/APPEND has been relocated to eliminate DOS pointer conflicts. It is necessary to set Basic LOMEM: to 2304 (or higher) to prevent the routine from overwriting itself. The user is reminded to convert the addresses given in the text for entry points.

OLD ENTRY	NEW ENTRY
CALL 768	CALL 2048
CALL 776	CALL 2056
CALL 999	CALL 1255
CALL 1016	CALL 1272

---

(1) The Official Polish/Italian Joke Book, L. Wilde, Pinnacle Books, New York, N.Y., 1973, p. 17

* In fact, while several texts detail how the boundary conditions of a KENO game lead to predictable outcomes, finished programs seldom exhibit this property.

WOZPAK II

USING RENUM/APPEND

1. Load RENUM/APPEND (* 300.3FF R)

   Note that the '*' is generated by the MONITOR, not the user.

2. Load a BASIC program.

3. To renumber an entire program.

   > CLR (clears variable table)

   > START = expr

   > STEP = expr

   > CALL 768

   Note: START and STEP must be specified in the order shown.

4. To renumber a range of the program.

   > CLR (clears variable table)

   > START = expr

   > STEP = expr

   > FROM = expr

   > TO = expr

   > CALL 776

5. To append program #2 (larger line numbers) to program #1 (smaller line numbers).

   (a) Load Program #2

   (b) CALL 999

   Be sure you are running the tape of program #1 as this command will load it.

   (c) If you get a memory full error, then use the command CALL 1016 to recover the original program.

ERRORS

1. If not enough free memory exists to contain the line number table during pass 1 of RENUM, then the message '(beep) *** MEM FULL ERR' is displayed and no renumbering occurs. The same message is displayed if not enough free memory exists to hold the product of an APPEND. In the case of APPEND, the user will have to type the BASIC command CALL 1016 to recover his original program. The user can free additional memory by eliminating all active BASIC variables with the CLR command.

2. If renumbering results in a line number overlap (detected during pass 1 of RENUM) then the message '(beep) *** RANGE ERR' is displayed, and no renumbering occurs. This error may mean that one or more parameters were not specified or were incorrectly specified.

CAUTIONS

1. When appending a program, always load the one with the greater line numbers first.

2. The user must be aware that branch target expressions may not be renumbered. For example, the statement GO TO ALPHA will not be modified by RENUM. The statement, GOTO 100 + ALPHA, will be modified only to reflect the new line number assigned to the old line 100.

APPLE][BASIC STRUCTURE

An understanding of the internal representation of a BASIC program is necessary in order to develop RENUMBER and APPEND algorithms. Figure 1 illustrates the significant pointers for a program in memory. Variable and symbol table assignment begins at the location whose address is contained in the pointer LOMEM ($4A and $4B where '$' stands for hex). This is $800 (2048) on the APPLE][unless changed by the user with the LOMEM: command. a second pointer, PV (Variable Pointer, at $CC and $CD) contains the address of the location immediately following the last location allocated to variables. PV is equal

to LOMEM if no variables are actively assigned as is the case after a NEW, CLR, or LOMEM: command. As variables are assigned PV increases.

The BASIC program is stored beginning with the lowest numbered line at the location whose address is contained in the pointer PP (Program Pointer, at $CA and $CB). The pointer HIMEM ($4C and $4D) contains the address of the location immediately following the last byte of the last line of the program. This is normally the top of memory unless changed by the user with the HIMEM: command. As the program grows, PP decreases. PP is equal to HIMEM if there is no program in memory. Adequate checks in the BASIC insure that PV never exceeds PP. This, in essence, says that variables and program are not permitted to overlap.

Lines of a BASIC program are not stored as they were orginally entered (in ASCII) on the APPLE][due to a pre-translation stage. Internally each line begins with a length byte which may serve as a link to the next line. The length byte is immediately followed by a two-byte line number stored in binary, low-order byte first. Line numbers range from 0 to 32767. The line number is followed by 'items' of various types, the final of which is an 'end-of-line' token ($01). Refer to Figure 2.

Single bytes of value less than $80 (128) are 'tokens' generated by the translator. Each token stands for a fixed unit of text as required by the syntax of the language BASIC. Some stand for keywords such as PRINT or THEN while others stand for punctuation or operators such as ',' or '+'.

Integer constants are stored as three consecutive bytes. The first contains $B0-$B9 (ASCII '0'-'9') signifying that the next two contain a binary constant stored low-order byte first. The line number itself is not preceded by $B0-$B9. All constants are in this form including line number references such as 500 in the statement GOTO 500. Constants are always followed by a token. Although one or both bytes of a constant may be positive (less than $80) they are not tokens.

Variable names are stored as consecutive ASCII characters with the high-order bit set. The first character is between $C1 and $DA (ASCII 'A'-'Z'), distinguishing names from constants. All names are terminated by a token which is recognizable by a clear high-order bit. The '$' in string names such as A$ is treated as a token.

String constants are stored as a token of value $28 followed by ASCII text (with high-order bits set) followed by a token of value $29. REM statements begin with the REM token ($5D) followed by ASCII text (with high-order bits set) followed by the 'end-of-line' token.

FIGURE 1 - MEMORY MAP

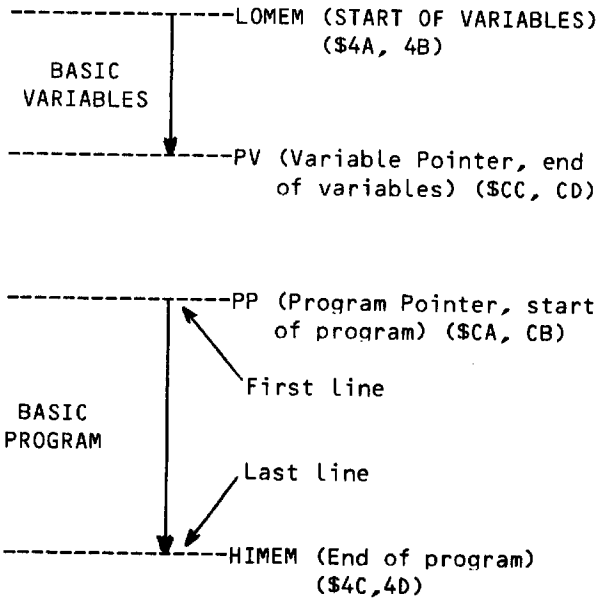
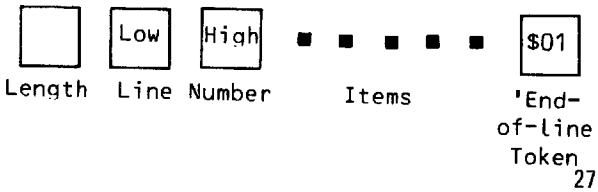
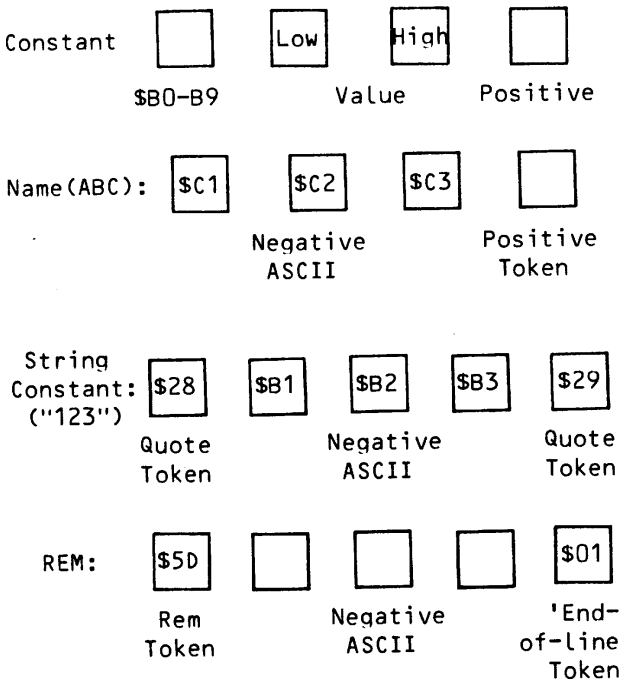


FIGURE 2 - LINE REPRESENTATION



WOZPAK II

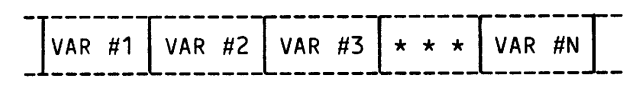
FIGURE 3 - ITEMS



Tokens: $00-$7F

GOTO	- $5F	
GOSUB	- $5C	
THEN ln	- $24	
LIST	- $74	(tokens used
LIST	- $75	(by RENUMBER)
STR CON	- $28	
REM	- $5D	
EOL	- $01	
DEL	- $09	
DEL	- $0A	
RUN ln	- $07	

INTEGER BASIC
VARIABLE STORAGE



LOMEM ($4A,4B)
'Start of Vars'

PV ($CC,CD)
'End of Vars'

Contains absolute address of next variable

Name (negative ASCII)

Value

For each simple variable, 3 bytes plus the number of characters in the variable name precede it's value.

Location of values for first 4 variables START, STEP, FROM, AND TO as used by RENUM.

VARIABLE	VALUE AT
START	LOMEM + $08 ($ For Hex)
STEP	LOMEM + $11
FROM	LOMEM + $1A
TO	LOMEM +$21

RENUMBER - THEORY OF OPERATION

Because of the rigid internal representation of APPLE][BASIC programs (insured by the translator syntax check) writing a renumber program was a somewhat easier task than it would have been on many small BASICS. Fortunately all constants in APPLE][BASIC (including line number references) are preconverted to binary.

The normal renumber subroutine entry point is RENUM ($308). The RENX entry conviently sets the renumber range for the user such that the entire program will be renumbered. RENUM extensively uses SWEET 16 the code-saving 16-bit interpretive machine built into the APPLE][.(1) Occasional 6502 code is interspersed throughout RENUM for even greater code efficiency.

RENUM scans the entire program from beginning to end twice. During pass 1 a line number table is built containing all line numbers of the program found to be within the renumber range. This table begins at the address specified by the BASIC variable pointer, PV, and is limited in length by the program pointer, PP. Each entry is two bytes long. A memory full error occurs if not enough free memory is available for the table.

As line numbers are entered in the table, corresponding new line numbers are generated, and both new and old are displayed. Should the new line numbers result in an 'out of ascending sequence' condition, then a range error occurs and renumbering is terminated. It is assumed that the line numbers of the original program are in ascending sequence.

The purpose of pass 2 is to scan the entire BASIC program while updating all references of line numbers found in the table to new assignments. Aside from the line numbers themselves, the line number references sought are identified as constants immediately preceded by one of the following tokens:

```
GOTO  ln
GOSUB ln
THEN  ln
LIST  ln
LIST  ln, ln
DEL   ln
DEL   ln, ln
RUN   ln
```

No other statement normally permitted within an APPLE][BASIC program may contain a line number reference. No errors will occur during pass 2.

Exceptions such as empty line number table and null programs are properly considered by both passes of RENUM.

---

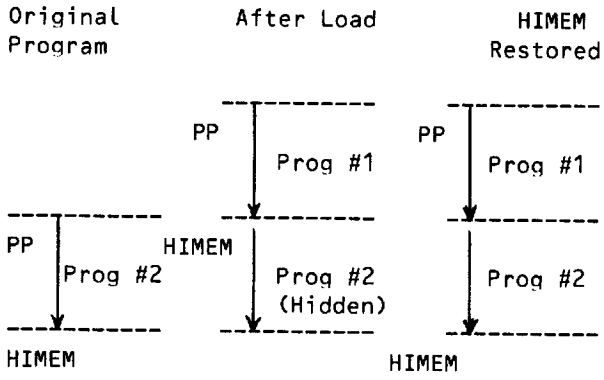
(1) Byte magazine, Nov. 1977

APPEND - THEORY OF OPERATION

When APPEND is called, the user program with larger line numbers will be in memory and the one with the smaller line numbers will be read off tape. The current program resides between pointers, PP and HIMEM. HIMEM is preserved and set to the value contained in PP.

This 'hides' the original program and prepares to load a new one immediately above it in memory.

The BASIC load subroutine is called and a normal memory full error condition will result if not enough free memory is available to contain both programs. If this error occurs then the original program will still be hidden. Fortunately, it can be recovered by calling the tail end of APPEND AT $3CD, which simply restores HIMEM. If the load is successful then HIMEM is restored to it's final value and both programs will be joined. No line number overlap check is performed.



RENUMBER EXAMPLE

Original

```
>LIST
  1 GOTO 100
  2 GOSUB 103
  3 IF TRUE THEN 170
  4 LIST 109,110
100 REM
103 REM
107 REM
109 REM
110 REM
200 FOR I=1 TO 10
210 PRINT I
220 NEXT I
230 GOTO 1
```

Renumber lines 100-110 to start at 150 spaced by 10

```
>CLR
>START=150
>STEP=10
>FROM=100
>TO=110
>CALL 776
100->150
103->160
107->170
109->180
110->190
```

```
>LIST
  1 GOTO 150
  2 GOSUB 160
  3 IF TRUE THEN 170
  4 LIST 180,190
150 REM
160 REM
170 REM
180 REM
190 REM
200 FOR I=1 TO 10
210 PRINT I
220 NEXT I
230 GOTO 1
```

RENUMBER EXAMPLE (Cont.)

Renumber all lines to start at 10 spaced by 5

```
>CLR
>START=10
>STEP=5
>CALL 768
1->10
2->15
3->20
4->25
150->30
160->35
170->40
180->45
190->50
200->55
210->60
220->65
230->70

>LIST
   10 GOTO 30
   15 GOSUB 35
   20 IF TRUE THEN 40
   25 LIST 45,50
   30 REM
   35 REM
   40 REM
   45 REM
   50 REM
   55 FOR I=1 TO 10
   60 PRINT I
   65 NEXT I
   70 GOTO 10
```

```
                        WOZPAK
3     ************************************************
4     *                                              *
5     *  APPLE ][ BASIC RENUMBER/APPEND SUBROUTINES  *
6     *                                              *
7     *                    VERSION 2                 *
8     *                                              *
9     *                    RENUMBER:                 *
10    *                      >CLR                    *
11    *                      >START=                 *
12    *                      >STEP=                  *
13    *                      >CALL 2048              *
14    *                                              *
15    *                    OPTIONAL:                 *
16    *                      >FROM=                  *
17    *                      >TO=                    *
18    *                      >CALL 2056              *
19    *                                              *
20    *                   USE RENX ENTRY             *
21    *                   FOR RENUMBER ALL           *
22    *                                              *
23    *         WOZ          APRIL 12, 1978          *
24    *                APPLE COMPUTER, INC.          *
25    *                                              *
26    ************************************************
27    *
28    ROL        EQU  $0        LOW-ORDER SW16 R0 BYTE.
29    ROH        EQU  $1         HI-ORDER.
30    R11L       EQU  $16       LOW-ORDER SW16 R11 BYTE.
31    R11H       EQU  $17        HIGH-ORDER.
32    HIMEM      EQU  $4C       BASIC HIMEM POINTER.
33    PPL        EQU  $CA       BASIC PROGRAM POINTER.
34    PVL        EQU  $CC       BASIC VARIABLES POINTER.
35    MEMFULL    EQU  $E36B     BASIC MEM FULL ERROR.
36    PRDEC      EQU  $E51B     BASIC DECIMAL PRINT SUBR.
37    RANGERR    EQU  $EE68     BASIC RANGE ERROR.
38    LOAD       EQU  $FODF     BASIC TAPE LOAD SUBR.
39    SW16       EQU  $F689     SWEET-16 ENTRY.
40    CROUT      EQU  $FD8E     CARRIAGE RETURN SUBR.
41    COUT       EQU  $FDED     CHARACTER OUT SUBR.
42    *
43    * SWEET 16 EQUATES
44    *
45    ACC        EQU  $0        SWEET 16 ACCUMULATOR.
46    NEWLOW     EQU  $1        NEW INITIAL LNO.
47    NEWINCR    EQU  $2        NEW LNO INCR.
48    LNLOW      EQU  $3        LOW LNO OF RENUM RANGE.
49    LNHI       EQU  $4        HI LNO OF RENUM RANGE.
50    TBLSTRT    EQU  $5        LNO TABLE START.
51    TBLNDX1    EQU  $6        PASS 1 LNO TBL INDEX.
52    TBLIM      EQU  $7        LNO TABLE LIMIT.
53    SCR8       EQU  $8        SCRATCH REG.
54    HMEM       EQU  $8        HIMEM (END OF PROGRAM).
55    SCR9       EQU  $9        SCRATCH REG.
56    PRGNDX     EQU  $9        PASS 1 PROGRAM INDEX.
57    PRGNDX1    EQU  $A        ALSO PROG INDEX..
58    NEWLN      EQU  $B        NEXT "NEW LNO"
59    NEWLN1     EQU  $C        PRIOR "NEW LNO" ASSIGN.
60    TBLND      EQU  $6        PASS 2 LNO TABLE END.
61    PRGNDX2    EQU  $7        PASS 2 PROG INDEX.
62    CHR0       EQU  $9        ASCII "0"
```

WOZPAK II

```
                    64  CHRA     EQU  $A        ASCII "A"
                    65  MODE     EQU  $C        CONST/LNO MODE.
                    66  TBLNDX2  EQU  $B        LNO TBL INDX FOR UPDATE.
                    67  OLDLN    EQU  $D        OLD LNO FOR UPDATE.
                    68  STRCON   EQU  $B        BASIC STR CON TOKEN.
                    69  REM      EQU  $C        BASIC REM TOKEN.
                    70  R13      EQU  $D        SWEET 16 REG. 13 (CPR REG).
                    71  THEN     EQU  $D        BASIC THEN TOKEN.
                    72  LIST     EQU  $D        BASIC LIST TOKEN.
                    73  DEL      EQU  $D        BASIC DEL TOKEN.
                    74  SCRC     EQU  $C        SCRATCH REG. FOR APPEND.
                    75  *
                    76           ORG  $800
                    77  *
                        ***********************************************
                    79  *  APPLE ][ INTEGER BASIC RENUMBER SUBROUTINE-PASS 1
                        ***********************************************
                    81  *
0800: 20 89 F6      82  RENX     JSR  SW16      RENUMBER ALL ENTRY
0803: B0            83           SUB  ACC
0804: 33            84           ST   LNLOW
0805: 34            85           ST   LNHI
0806: 01 06         86           BR   RNUM2
0808: 20 89 F6      87  RENUM    JSR  SW16      OPTIONAL RANGE ENTRY.
080B: 14 01 00      88           SET  LNHI,1
080E: 19 4E 00      89  RNUM2    SET  SCR9,HIMEM+2
0811: C9            90           POPD @SCR9
0812: 38            91           ST   HMEM      BASIC HIMEM POINTER TO HMEM.
0813: C9            92           POPD @SCR9     BASIC START OF VARS.
0814: 39            93           ST   SCR9
0815: 69            94           LDD  @SCR9     SKIP NAME 'START' (8 BYTES)
0816: 69            95           LDD  @SCR9      OF FIRST BASIC VAR. IN SYM. TBL.
0817: 69            96           LDD  @SCR9
0818: 69            97           LDD  @SCR9
0819: 69            98           LDD  @SCR9     (VALUE OF 'START')
081A: 31            99           ST   NEWLOW
081B: 69           100           LDD  @SCR9     SKIP NAME 'STEP' (7 BYTES)
081C: 69           101           LDD  @SCR9
081D: 69           102           LDD  @SCR9
081E: 49           103           LD   @SCR9
081F: 69           104           LDD  @SCR9     (VALUE OF 'STEP')
0820: 32           105           ST   NEWINCR
0821: F4           106           DCR  LNHI      DECREMENT 'TO' TO -1 IF 'ACC'.
0822: 08 0B        107           BM1  RNUM3
0824: 69           108           LDD  @SCR9     SKIP NAME 'FROM' (7 BYTES)
0825: 69           109           LDD  @SCR9
0826: 69           110           LDD  @SCR9
0827: 49           111           LD   @SCR9
0828: 69           112           LDD  @SCR9     (VALUE OF 'FROM')
0829: 33           113           ST   LNLOW
082A: 69           114           LDD  @SCR9     SKIP NAME 'TO' (5 BYTES).
082B: 69           115           LDD  @SCR9
082C: 49           116           LD   @SCR9
082D: 69           117           LDD  @SCR9     (VALUE OF 'TO')
082E: 34           118           ST   LNHI
082F: 19 CE 00     119  RNUM3    SET  SCR9,PVL+2
0832: C9           120           POPD @SCR9     BASIC VAR PNTR TO
0833: 35           121           ST   TBLSTRT    TBLSTRT AND TBLNDX1.
0834: 36           122           ST   TBLNDX1
0835: 21           123           LD   NEWLOW    COPY NEWLOW (INITIAL)
```

```
                                        WOZPAK II
0836: 3B          125              ST   NEWLN      TO NEWLN.
0837: 3C          126              ST   NEWLN1
0838: C9          127              POPD @SCR9     BASIC PROG. PNTR
0839: 37          128              ST   TBLIM      TO TBLIM AND PRGNDX.
083A: 39          129              ST   PRGNDX
083B: 29          130  PASS1       LD   PRGNDX
083C: D8          131              CPR  HMEM       IF PRGNDX >= HMEM
083D: 03 46       132              BC   PASS2      THEN DONE PASS 1.
083F: 3A          133              ST   PRGNDX1
0840: 26          134              LD   TBLNDX1
0841: E0          135              INR  ACC        IF < TWO BYTES AVAIL IN
0842: D7          136              CPR  TBLIM      LNO TABLE THEN RETURN
0843: 03 38       137              BC   MERR       WITH 'MEM FULL' MESSAGE.
0845: 4A          138              LD   @PRGNDX1
0846: A9          139              ADD  PRGNDX     ADD LENGTH BYTE TO PROG INDEX.
0847: 39          140              ST   PRGNDX
0848: 6A          141              LDD  @PRGNDX1   LINE NUMBER.
0849: D3          142              CPR  LNLOW      IF <LNLOW THEN GOTO P1B.
084A: 02 2A       143              BNC  P1B
084C: D4          144              CPR  LNHI       IF >LNHI THE GOTO P1C.
084D: 02 02       145              BNC  P1A
084F: 07 30       146              BNZ  P1C
0851: 76          147  P1A         STD  @TBLNDX1   ADD TO LNO TABLE.
0852: 00          148              RTN
0853: A5 01       149              LDA  ROH        **** 6502 CODE ****
0855: A6 00       150              LDX  ROL
0857: 20 1B E5    151              JSR  PRDEC      PRINT OLD LNO "->" NEW LNO
085A: A9 AD       152              LDA  #$AD        (R0,R11) IN DECIMAL.
085C: 20 ED FD    153              JSR  COUT
085F: A9 BE       154              LDA  #$BE
0861: 20 ED FD    155              JSR  COUT
0864: A5 17       156              LDA  R11H
0866: A6 16       157              LDX  R11L
0868: 20 1B E5    158              JSR  PRDEC
086B: 20 8E FD    159              JSR  CROUT
086E: 20 8C F6    160              JSR  SW16+3     **** END 6502 CODE ****
0871: 2B          161              LD   NEWLN
0872: 3C          162              ST   NEWLN1     COPY NEWLN TO NEWLN1 AND INCR
0873: A2          163              ADD  NEWINCR     NEWLN BY NEWINCR.
0874: 3B          164              ST   NEWLN
0875: 0D          165              HEX  0D         'NULL' (WILL SKIP NEXT INSTR.
0876: D1          166  P1B         CPR  NEWLOW     IF LOW LNO < NEW LNO THEN RANGE ERR.
0877: 02 C2       167              BNC  PASS1
0879: 00          168  RERR        RTN            ;PRINT "RANGE ERR" AND RETURN.
087A: 4C 68 EE    169              JMP  RANGERR
087D: 00          170  MERR        RTN            ;PRINT "MEM FULL" AND RETURN.
087E: 4C 6B E3    171              JMP  MEMFULL
0881: EC          172  P1C         INR  NEWLN1     IF HI LNO <= MOST RECENT NEWLN
0882: DC          173              CPR  NEWLN1      THEN RANGE ERROR.
0883: 02 F4       174              BNC  RERR
                  175  *
                       ***********************************************
                  177  *  APPLE ][ BASIC RENUMBER/APPEND SUBROUTINE - PASS 2
                       ***********************************************
                  179  *
0885: 19 B0 00    180  PASS2       SET  CHR0,B0    ASCII "0".
0888: 1A C1 00    181              SET  CHRA,C1    ASCII "A".
088B: 27          182  P2A         LD   PRGNDX2
088C: D8          183              CPR  HMEM       IF PROG INDEX=HIMEM THEN DONE PASS
088D: 03 6F       184              BC   DONE
```

```
088F: E7          186             INR  PRGNDX2   SKIP LENGTH BYTE.
0890: 67          187             LDD  @PRGNDX2  LINE NUMBER.
0891: 3D          188  UPDATE     ST   OLDLN     SAVE OLD LNO.
0892: 25          189             LD   TBLSTRT
0893: 3B          190             ST   TBLNDX2   INIT LNO TABLE INDEX.
0894: 21          191             LD   NEWLOW    INIT NEWLN TO NEWLOW.
0895: 1C 00 00    192             SET  NEWLN1,0  (WILL SKIP NEXT 2 INSTRUCTIONS)
                  193             ORG  *-2
0896: 2C          194  UD2        LD   NEWLN1
0897: A2          195             ADD  NEWINCR   ADD INCR TO NEWLN1.
0898: 3C          196             ST   NEWLN1
0899: 2B          197             LD   TBLNDX2   IF LNO TBL IDX=TBLND THEN DONE
089A: B6          198             SUB  TBLND       SCANNING LNO TABLE.
089B: 03 07       199             BC   UD3
089D: 6B          200             LDD  @TBLNDX2  NEXT LNO FROM TABLE.
089E: BD          201             SUB  OLDLN     LOOP TO UD2 IF NOT SAME AS OLDLN.
089F: 07 F5       202             BNZ  UD2
08A1: C7          203             POPD @PRGNDX2  REPLACE OLD LNO WITH CORRESPONDING
08A2: 2C          204             LD   NEWLN1      NEW LINE.
08A3: 77          205             STD  @PRGNDX2
08A4: 1B 28 00    206  UD3        SET  STRCON,28 STR CON TOKEN.
08A7: 1C 00 00    207             SET  MODE,0    (SKIPS NEXT TWO INSTRUCTIONS)
                  208             ORG  *-2
08A8: 67          209  GOTCON     LDD  @PRGNDX2
08A9: FC          210             DCR  MODE      IF MODE=0 THEN UPDATE LNO REF.
08AA: 08 E5       211             BM1  UPDATE
08AC: 47          212  ITEM       LD   @PRGNDX2  BASIC TOKEN.
08AD: D9          213             CPR  CHR0
08AE: 02 09       214             BNC  CHKTOK    CHECK TOKEN FOR SPECIAL.
08B0: DA          215             CPR  CHRA      IF >= "0" AND < "A" THEN SLIP CONST
08B1: 02 F5       216             BNC  GOTCON      OR UPDATE.
08B3: F9          217  SKPASC     DCR  PRGNDX
08B4: 67          218             LDD  @PRGNDX2  SKIP ALL NEG. BYTES OF STR CON,
08B5: 05 FC       219             BM   SKPASC      REM, OR NAME.
08B7: F7          220             DCR  PRGNDX2
08B8: 47          221             LD   @PRGNDX2
08B9: DB          222  CHKTOK     CPR  STRCON    STR CON TOKEN?
08BA: 06 F7       223             BZ   SKPASC      YES, SKIP SUBSEQUENT BYTES.
08BC: 1C 5D 00    224             SET  REM,5D
08BF: DC          225             CPR  REM       REM TOKEN?
08C0: 06 F1       226             BZ   SKPASC      YES, SKIP SUBSEQUENT LINE.
08C2: 08 1F       227             BM1  CONTST    GOSUB, LOOK FOR LINE NUMBER.
08C4: FD          228             DCR  R13
08C5: FD          229             DCR  R13       (TOKEN $5F IS GOTO)
08C6: 06 1B       230             BZ   CONTST
08C8: 1D 24 00    231             SET  THEN,24
08CB: DD          232             CPR  THEN
08CC: 06 15       233             BZ   CONTST    'THEN' LNO, LOOK FOR LNO.
08CE: F0          234             DCR  ACC
08CF: 06 BA       235             BZ   P2A       EOL (TOKEN 01)
08D1: 1D 09 00    236             SET  DEL,9     'DEL' OR 'DEL X,X', LOOK FOR LNO.
08D4: DD          237             CPR  DEL       (TOKENS $9, $A)
08D5: 08 0C       238             BM1  CONTST
08D7: 06 0A       239             BZ   CONTST
08D9: ED          240             INR  R13
08DA: ED          241             INR  R13
08DB: 08 06       242             BM1  CONTST    (RUN LN= TOKEN 7)
08DD: 1D 74 00    243             SET  LIST,74
08E0: BD          244             SUB  LIST      SET MODE=0 IF LIST OR LIST COMM
08E1: 09 01       245             BNM1 CONTS2      (TOKENS $74, $75)
```

WOZPAK II

```
08E3: B0          247  CONTST    SUB  ACC       CLEAR MODE FOR LNO.
08E4: 3C          248  CONTS2    ST   MODE        UPDATE CHECK.
08E5: 01 C5       249            BR   ITEM
                  250  *
                       ************************************************
                  252  *   APPLE ][ BASIC APPEND SUBROUTINE
                       ************************************************
                  254  *
08E7: 20 89 F6    255  APPEND    JSR  SW16
08EA: 1C 4E 00    256            SET  SCRC,HIMEM+2
08ED: CC          257            POPD @SCRC     SAVE HIMEM
08EE: 38          258            ST   HMEM
08EF: 19 CA 00    259            SET  SCR9,PPL
08F2: 69          260            LDD  @SCR9
08F3: 7C          261            STD  @SCRC     SET HIMEM TO PRESERVE PROGRAM.
08F4: 00          262            RTN
08F5: 20 DF F0    263            JSR  LOAD      LOAD FROM TAPE.
08F8: 20 89 F6    264            JSR  SW16
08FB: CC          265            POPD @SCRC     RESTORE HIMEM TO SHOW BOTH
08FC: 28          266            LD   HMEM        PROGRAMS (OLD AND NEW)
08FD: 7C          267            STD  @SCRC
08FE: 00          268  DONE      RTN
08FF: 60          269            RTS
```

```
--- END ASSEMBLY ---

TOTAL ERRORS: 0

260 BYTES GENERATED THIS ASSEMBLY
```

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APPLE][INTEGER BASIC SUBROUTINE PACK and LOAD

by

Richard F. Suitor

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[ed. note] This routine was written by Richard F. Suitor and published in MICRO #6. Apple Pugetsound Program Library Exchange wishes to thank Dick Suitor and MICRO magazine for their permission to reprint this article.

The first issue of CONTACT, the APPLE newsletter, gave a suggestion for loading assembly language routines with a BASIC program. Simply summarized, one drops the pointer of the BASIC beginning below the assembly portion, adds a BASIC statment that will restore the pointer and SAVEs. The procedure is simple and effective, but has two limitations. First, it is inconvenient if BASIC and the routines are widely seperated (and is very tricky if the routines start at $800, just above the display portion of memory). Second, a program so saved cannot be used with another HIMEM and is thus inconvenient to share or to submit to a software exchange.

The subroutine presented here avoids these difficulties at the expense of the effort to implement it. It is completely position independent; it may be moved from place to place in core with the monitor move command and used at the new location without modification. It makes extensive use of SWEET 16, the 16 bit interpreter supplied as part of the Apple Monitor ROM.

To use the routine from Apple Integer BASIC, CALL MKUP, where MKUP is 128 (decimal) plus the first address of the routine. The prompt shown is "@". Respond with the hex limits of the routine to be stored, as BBBB.EEEE (BBBB is the beginning address, EEEE is the ending; the same format that the monitor uses). Several groups may be specified on one line seperated by spaces, or several lines. Type 'S' after the last group to complete the pack and return to BASIC. The program can now be saved.

To load, enter BASIC and LOAD. When complete, RUN. The first RUN will move all routines back to their original location and return control to BASIC. It will not RUN the program; subsequent RUNs will. (*1)

A LIST of the program after calling MKUP and before the first RUN will show one BASIC statment (which initiates the restoration process) and gibberish. If this is done, RESET followed by CTRL-C will return control to BASIC.

WARNING #1: The routine must be placed in core where it will not overwrite itself during the Pack. The start of the routine must be above HIMEM (e.g. in the high resolution display region), or $17A+4*N+W below the start of the BASIC program where N is the number of routines stored and W is the total number of words in all of these routines. Also, those routines that are highest in memory should be packed first to avoid overwriting during pack or restore. Otherwise it is not necessary to worry about overwriting during the restore process; only $1A words just below the BASIC program are used.

WARNING #2: Do not attempt to edit the program after calling MKUP. If editing is necessary, RUN once to unpack, then edit and call MKUP again.

The routine works as follows. It first packs the restore routine just below the BASIC program. It then packs other routines as requested, with the first address and the number of bytes (words). When S is given, it packs itself with the information to restore LOMEM and the beginning of the BASIC program. The first $46 words of the routine form a BASIC statment which will initiate the restoration process when RUN is typed.

If a particular HIMEM is needed by the program (e.g. for high resolution programs) it must be entered before LOADing. The LOMEM will be reset by the restoration process to the value it had when MKUP was called.

I do not have a SWEET 16 assembler, hence all of those op codes are listed as tables of data.(*2) In the listing, comments indicate where constants and relative displacments are differences between labels in the routine.

Some convenient load and entry points are:

BASO (load)	MKUP (entry)	
hex	hex	decimal
800	880	2176
A90	B10	2832
104C	10CC	4300
2050	20D0	8400
3054	30D4	12500

[ed. notes]

(*1) Since this article was written, the RUNning entry to basic has been added, allowing only one RUN to be required. See assembly listing.

(*2) Listing has been rewritten on TED II+ showing SWEET 16 op-codes.

```
                                    WOZPAK II
                                2    *
                                3    *INT BASIC SUBR PACK & LOAD
                                4    *CALL BAS0+128(DEC)
                                5    *
                                6    * CONVERTED 5/17/79
                                7    * CONTAINS SW16 MACRO DEFS
                                8    *
                                9    * SEE MICRO#6 OR BEST OF MICRO
                                10   * FOR DOC.
                                11   *
                                12   * CHANGE LAST INST. TO
                                13   * JMP BRUN TO UNPACK&RUN
                                14   * IN ONE STEP
                                15   *
                                16   * POSITION INDEPENDENT PROG.
                                17            OBJ   $3000
                                18            ORG   $800
                                19   *
                                20   ACCL     EQU   $00
                                21   BSOL     EQU   $02
                                22   TABL     EQU   $04
                                23   TBCL     EQU   $06
                                24   HIMS     EQU   $08
                                25   LMRT     EQU   $0A
                                26   BPRG     EQU   $0C
                                27   FRML     EQU   $0E
                                28   NBYT     EQU   $10
                                29   BPR2     EQU   $12
                                30   PTLL     EQU   $14
                                31   XTAB     EQU   $16
                                32   SKPL     EQU   $18
                                33   MODE     EQU   $31
                                34   YSAV     EQU   $34
                                35   PRMP     EQU   $33
                                36   LMML     EQU   $4A
                                37   HIML     EQU   $4C
                                38   LMWL     EQU   $CC
                                39   BBSL     EQU   $CA
                                40   JSRL     EQU   $CE
                                41   BSC2     EQU   $E003 BASIC
                                42   BRUN     EQU   $EFEC RUN BASIC
                                43   BUFF     EQU   $0200
                                44   SW16     EQU   $F689
                                45   GTNM     EQU   $FFA7
                                46   PBL2     EQU   $F94A
                                47   COUT     EQU   $FDED
                                48   BELL     EQU   $FF3A
                                49   GTLN     EQU   $FD67
                                50   *
                                51   *BASIC INST. TO RESTORE
0800:  46 00 00                 52   BAS0     HEX   460000
0803:  64 B1 01                 53            HEX   64B101
0806:  00 65 B7                 54            HEX   0065B7
0809:  4C 00 03                 55            HEX   4C0003
080C:  64 B2                    56            HEX   64B2
080E:  02 00 65                 57            HEX   020065
0811:  38 2E 3F                 58            HEX   382E3F
0814:  B2 CA                    59            HEX   B2CA
0816:  00 72 12                 60            HEX   007212
0819:  B7 46 00                 61            HEX   B74600
```

```
                                WOZPAK II
081C:  72 1F     63             HEX   721F
081E:  B2 00 01  64             HEX   B20001
0821:  U3 64 B3  65             HEX   0364B3
0824:  03 00     66             HEX   0300
0826:  65 38 2E  67             HEX   65382E
0829:  3F B2 CB  68             HEX   3FB2CB
082C:  00 72     69             HEX   0072
082E:  12 38 2E  70             HEX   12382E
0831:  3F B2 CA  71             HEX   3FB2CA
0834:  00 72     72             HEX   0072
0836:  12 B7 46  73             HEX   12B746
0839:  00 72 15  74             HEX   007215
083C:  B2 00     75             HEX   B200
083E:  01 72 03  76             HEX   017203
0841:  4D B1 01  77             HEX   4DB101
0844:  00 01     78             HEX   0001
               79   *INIT. RESTORE OP
0846:  D8        80   PTBK       CLD
0847:  A2 01     81              LDX   #1
0849:  B5 CA     82   PT02       LDA   BBSL,X
084B:  95 02     83              STA   BSOL,X
084D:  B5 4C     84              LDA   HIML,X
084F:  95 08     85              STA   HIMS,X
0851:  CA        86              DEX
0852:  10 F5     87              BPL   PT02
0854:  20 89 F6  88              JSR   SW16
0857:  10 52 01  89              SET   0,(PTLP-BAS0)
085A:  18 57 01  90              SET   8,(PTLP+5-BAS0)
085D:  A1        91              ADD   1
085E:  37        92              ST    7
085F:  67        93              LDD   @7
0860:  35        94              ST    5
0861:  67        95              LDD   @7
0862:  36        96              ST    6
0863:  24        97              LD    4
0864:  B6        98              SUB   6
0865:  36        99              ST    6
0866:  1A 11 00  100             SET   10,(ST16+1-PLP1)
0869:  BA        101             SUB   10
086A:  3A        102             ST    10
086B:  67        103             LDD   @7
086C:  33        104             ST    3
086D:  00        105             RTN
086E:  A2 01     106             LDX   #1
               107  *SET LOMEM & BASIC PROG START
0870:  B5 0A     108  PT04       LDA   LMRT,X
0872:  95 4A     109             STA   LMML,X
0874:  95 CC     110             STA   LMWL,X
0876:  B5 0C     111             LDA   BPRG,X
0878:  95 CA     112             STA   BBSL,X
087A:  CA        113             DEX
087B:  10 F3     114             BPL   PT04
087D:  6C 14 00  115             JMP   (PTLL) TO RESTORE LP
               116  *SUBR TO SET UP PACK
0880:  A2 01     117  MKUP       LDX   #1
0882:  B5 4A     118  MK21       LDA   LMML,X
0884:  95 0A     119             STA   LMRT,X
0886:  B5 CA     120             LDA   BBSL,X
0888:  95 12     121             STA   BPR2,X
088A:  95 0C     122             STA   BPRG,X
```

WOZPAK II

```
088C:  B5 CE     124            LDA   JSRL,X
088E:  95 04     125            STA   TABL,X
0890:  B5 4C     126            LDA   HIML,X
0892:  95 08     127            STA   HIMS,X
0894:  CA        128            DEX
0895:  10 EB     129            BPL   MK21
                 130   *INIT & PACK RESTORE LP
0897:  20 89 F6  131            JSR   SW16
089A:  24        132            LD    4
089B:  B9        133            SUB   9
089C:  39        134            ST    9
089D:  11 80 00  135            SET   1,(MKUP-BAS0)
08A0:  22        136            LD    2
08A1:  B1        137            SUB   1
08A2:  31        138            ST    1
08A3:  10 52 01  139            SET   0,(PTLP-BAS0)
08A6:  A1        140            ADD   1
08A7:  32        141            ST    2
08A8:  18 18 00  142            SET   8,(ST16-PTLP)
08AB:  A8        143            ADD   8
08AC:  33        144            ST    3
08AD:  E3        145            INR   3
08AE:  1C 50 00  146            SET   12,($50) *SW16 STACK
08B1:  0C 42     147            BS    MV52
08B3:  00        148   MK22     RTN
08B4:  A9 C0     149   MK01     LDA   #$C0
                 150   *GET LIMITS & PACK PROGS
08B6:  85 33     151            STA   PRMP
08B8:  A9 00     152            LDA   #0
08BA:  85 31     153            STA   MODE
08BC:  20 67 FD  154            JSR   GTLN
08BF:  86 16     155            STX   XTAB
08C1:  A0 00     156            LDY   #0
08C3:  B9 00 02  157            LDA   BUFF,Y
08C6:  C9 D3     158            CMP   #$D3 S
08C8:  F0 68     159            BEQ   MK10
08CA:  20 A7 FF  160   MK06     JSR   GTNM
08CD:  C9 A7     161            CMP   #$A7 F(.) (SEE MON.)
08CF:  F0 10     162            BEQ   MK02
08D1:  98        163   MERR     TYA
08D2:  AA        164            TAX
08D3:  20 4A F9  165            JSR   PBL2 ERROR INDICATOR
08D6:  A9 DE     166            LDA   #$DE '^'
08D8:  20 ED FD  167            JSR   COUT
08DB:  20 3A FF  168            JSR   BELL
08DE:  18        169   MK05     CLC
08DF:  90 D3     170            BCC   MK01
08E1:  E6 31     171   MK02     INC   MODE
08E3:  20 A7 FF  172            JSR   GTNM
                 173   *A1 & A3 NOW HAVE 1ST #,A2 2D
                 174   *SET UP MOVE TO JUST BELOW (BBSL)
                 175   *AND LOWER BBSL
08E6:  20 89 F6  176            JSR   SW16
08E9:  01 1E     177            BR    SM02
08EB:  18 3C 00  178   MV51     SET   8,($3C)
08EE:  68        179            LDD   @8
08EF:  32        180            ST    2
08F0:  68        181            LDD   @8
08F1:  33        182            ST    3
08F2:  B2        183            SUB   2
```

WOZPAK II

```
08F3:  38          185            ST    8
08F4:  E3          186            INR   3
08F5:  83          187  MV52      POP   @3
08F6:  96          188            STP   @6
08F7:  23          189            LD    3
08F8:  D2          190            CPR   2
08F9:  07 FA       191            BNZ   MV52
08FB:  28          192            LD    8
08FC:  33          193            ST    3
08FD:  18 08 00    194            SET   8,8
0900:  88          195            POP   @8
0901:  96          196            STP   @6
0902:  88          197            POP   @8
0903:  96          198            STP   @6
0904:  88          199            POP   @8
0905:  96          200            STP   @6
0906:  88          201            POP   @8
0907:  96          202            STP   @6
0908:  0B          203            RS
0909:  0C E0       204  SM02      BS    MV51
090B:  00          205  SM03      RTN
090C:  C9 EC       206  MK09      CMP   #$EC F(S)
090E:  F0 22       207            BEQ   MK10
0910:  C9 C6       208            CMP   #$C6 F(CR)
0912:  F0 A0       209            BEQ   MK01
0914:  C9 99       210            CMP   #$99 F( )
0916:  F0 03       211            BEQ   MK12
0918:  D0 B7       212            BNE   MERR
091A:  C8          213  MK11      INY
091B:  B9 00 02    214  MK12      LDA   BUFF,Y
091E:  C4 16       215            CPY   XTAB
0920:  B0 92       216            BCS   MK01
0922:  C9 A0       217            CMP   #$A0 BLANK
0924:  F0 F4       218            BEQ   MK11
0926:  C9 8D       219            CMP   #$8D
0928:  F0 8A       220            BEQ   MK01
092A:  C9 D3       221            CMP   #$D3 S
092C:  F0 04       222            BEQ   MK10
092E:  C6 31       223            DEC   MODE
0930:  F0 98       224            BEQ   MK06 ALWAYS
                   225  *PACK 1ST PART & CLEAN UP
0932:  20 89 F6    226  MK10      JSR   SW16
0935:  21          227            LD    1
0936:  32          228            ST    2
0937:  18 52 01    229            SET   8,(PTLP-BAS0)
093A:  A8          230            ADD   8
093B:  37          231            ST    7
093C:  25          232            LD    5
093D:  77          233            STD   @7
093E:  29          234            LD    9
093F:  77          235            STD   @7
0940:  21          236            LD    1
0941:  77          237            STD   @7
0942:  27          238            LD    7
0943:  33          239            ST    3
0944:  0C AF       240            BS    MV52
0946:  66          241  SM04      LDD   @6
0947:  66          242            LDD   @6
0948:  00          243            RTN
0949:  A5 0C       244            LDA   BPRG
```

```
094B:  85 CA     246             STA   BBSL
094D:  A5 0D     247             LDA   BPRG+01
094F:  85 CB     248             STA   BBSL+01
0951:  60        249             RTS
                 250   *RESTORE  LOOP
0952:  20 89 F6  251   PTLP      JSR   SW16
0955:  61        252   PLP0      LDD   @1
0956:  33        253             ST    3
0957:  61        254             LDD   @1
0958:  38        255             ST    8
0959:  00        256             RTN
095A:  20 89 F6  257   PLP1      JSR   SW16
095D:  41        258   MV60      LD    @1
095E:  53        259             ST    @3
095F:  F8        260             DCR   8
0960:  04 FB     261             BP    MV60
0962:  21        262             LD    1
0963:  D6        263             CPR   6
0964:  05 EF     264             BM    PLP0
0966:  00        265   PLP2      RTN
0967:  4C 03 E0  266             JMP   BSC2
                 267   * OR JMP  BRUN
096A:  00        268   ST16      HEX   00

--- END ASSEMBLY ---

TOTAL ERRORS: 00

363 BYTES OF OBJECT CODE
WERE GENERATED THIS ASSEMBLY.
```

APPLE][MACHINE CODE RELOCATION

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WOZPAK II

Quite frequently I have encountered situations calling for relocation of machine language (not BASIC) programs on my 6502-based APPLE][computer. Relocation means that the new version must run properly from different memory locations than the original. Because of the relative branch instruction, certain small 6502 programs need simply be moved and not altered. Others require only minor hand modification, which is simplified on the APPLE][by the built-in disassembler which pinpoints absolute memory reference instructions such as JMPs and JSRs. However, most of the situations which I have encountered involved rather lengthy programs containing multiple data segments interspersed with code. For example, I once spent over an hour to hand-relocate the 8K byte APPLE][monitor and BASIC to run from RAM addresses and at least one error probably went by undetected. That relocation can now be accomplished in a couple of minutes using the relocation program described herein.

The following situations call for program relocation:

(1) Two programs which were written to run in identical locations must now reside and run in memory concurrently.

(2) A program currently runs from ROM. In order to modify its operation experimentally, a version must be generated which runs from RAM (different addresses).

(3) A program currently running in RAM must be converted to run from EPROM or ROM addresses.

(4) A program currently running on a 16K machine must be relocated in order to run on a 4K machine. Furthermore, the relocation may have to be performed on the smaller machine.

(5) Due to memory mapping differences, a program running on an APPLE-I (or other 6502-based computer falls into the unusable address space on an APPLE][(or other) computer.

(6) Due to operating system variable assignment differences either the page-zero or non-page-zero variable allocation for a specific program may have to be modified when moving the program from one make of computer to another.

(7) A program exists as several chunks strewn around memory which must be combined in a single, contiguous block.

(8) A program has outgrown the available memory space and must be relocated to a larger 'free' space.

(9) A program insertion or deletion requires a chunk of the program to move a few bytes up or down.

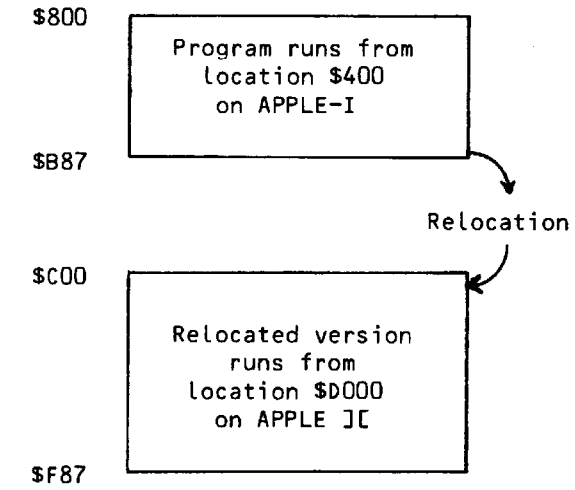
PROGRAM MODEL

It is easy to visualize relocation as taking a program which resides and runs in a 'source block' of memory and creating a modified version in a 'destination block' which runs properly. This model dictates that the relocation must be performed in an environment in which the program may, in fact, reside in both blocks. In many cases the relocation is being performed because this is impossible. For example, a program written to begin at location $400 on the APPLE-I ($ stands for hex) falls in the APPLE][screen memory range. It must be loaded elsewhere on the APPLE][prior to relocation.

A more versatile program model is as follows. A program or section of a program runs in a memory range termed the 'source block' and resides in a range termed the 'source segments'. Thus, a program written to run at location $400 may reside at location $800. The program is to be relocated so that it will run in a range termed the 'destination

block' although it will reside in a range termed 'destination segments' (not necessarily the same). Thus a program may be relocated such that it will run from location $D000 (a ROM address) yet reside beginning at location $C00 prior to being saved on tape or used to burn EPROMs (obviously, the relocated program cannot immediately reside at locations reserved for ROM). In some cases the source and destination segments may overlap.

BLOCKS AND SEGMENTS EXAMPLE



SOURCE BLOCK: $400-$787

DEST BLOCK: $D000-$D387

SOURCE SEGMENTS: $800-$B87

DEST SEGMENTS: $C00-$F87

THE RELOCATION ALGORITHM

(1) Set SOURCE PTR to beginning of source segment and DEST PTR to beginning of destination segment.

(2) Copy 3 bytes from source segment (using SOURCE PTR) to temp INST area.

(3) Determine instruction length from opcode (1,2, or 3 byte).

(4) If two byte instruction with non-zero-page addressing mode (immediate or relative) then go to (7).

(5) If two byte instruction then clear 3rd byte so address field is 0-255 (zero page).

(6) If address field (2nd and 3rd bytes of INST area) falls within source block, then substitute.

ADR-SOURCE BLOCK BEGIN + DEST BLOCK BEGIN

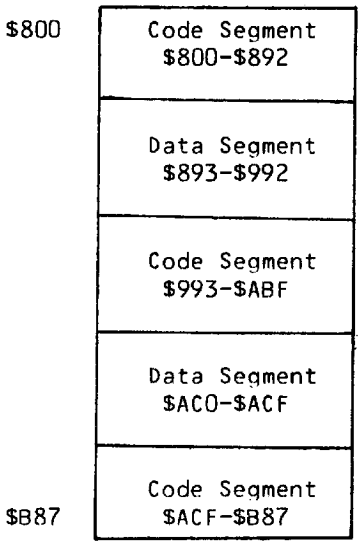
(7) Move 'length' bytes from INST area to dest segment (using DEST PTR). Update SOURCE and DEST PTRs by length.

(8) If SOURCE PTR is less than or equal to SOURCE SEGMENT END then goto (2), else done.

DATA SEGMENTS

The problem with relocating a large program all at once is that data (tables, text, etc.) may be interspersed throughout the code. Thus data may be 'relocated' as though it were code or might cause some code not to be relocated due to boundary uncertainty introduced when the data takes on the multi-byte attribute of code. This problem is circumvented by considering the 'source segments' and 'destination segments' sections to contain both code and data segments.

CODE AND DATA SEGMENTS EXAMPLE



The source code segments are relocated to the 'destination segments' area and the source data segments are moved. Note that several commands will be necessary to accomplish the complete relocation.

USAGE

1. Load RELOC by hand or off tape into memory locations $3A6-$3FA. note that locations $3FB-$3FF are not disturbed by tape load versions to insure that the APPLE][interrupt vectors are not clobbered. The Monitor user function, Control-Y, will now call RELOC as a subroutine at location $3F8.

2. Load the source program into the 'source segments' area of memory if it is not already there. Note that this need not be where the program normally runs.

3. Specify the source and destination block parameters, remembering that the blocks are the locations that the program normally runs from, not the locations occupied by the source and destination segments during the relocation. If only a portion of a program is to be relocated then that portion alone is specified as the block.

```
* DEST BLOCK BEG < SOURCE

  BLOCK BEG . END Yc *
```

Note that the syntax of this command closely resembles that of the MONITOR 'MOVE' command. The initial '*' is generated by the MONITOR, not typed by the user.

4. Move all data segments and relocate all code segments in sequential (increasing address) order.

First Segment (if CODE)

```
* DEST SEGMENT BEG < SOURCE
  SEGMENT BEG . END Yc.
```

First Segment (if DATA)

```
* DEST SEGMENT BEG < SOURCE
  SEGMENT BEG . END M
```

Subsequent segments (if CODE)

```
* SOURCE SEGMENT END Yc
      (Relocation)
```

Subsequent segments (if DATA)

```
* SOURCE SEGMENT END M   (Move)
```

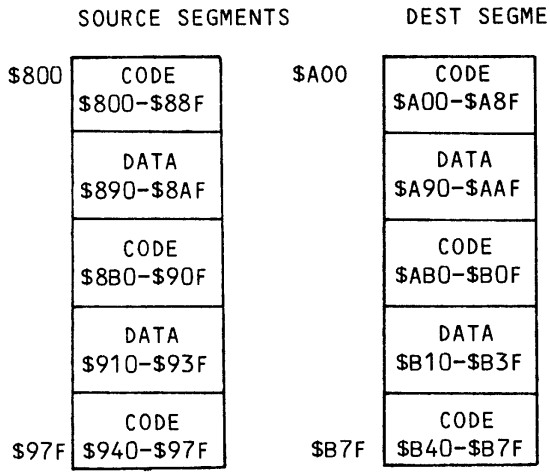
Note that it is wise to prepare a list of segments (code and data) prior to relocation.

If the relocation is performed 'in place' (SOURCE and DEST SEGMENTS reside in identical locations) then the SOURCE SEGMENT BEG parameter may be ommitted from the first segment relocate (or move).

EXAMPLES

1. Straightforward Relocation

Program A resides and runs in locations $800-$97F. The relocated version will reside and run in locations $A00-$97F.



SOURCE BLOCK $800-$97F

DEST BLOCK $A00-$B7F

SOURCE SEGMENTS $800-$97F

DEST SEGMENTS $A00-$B7F

(a) Load RELOC

(b) Define blocks

```
* A00 < 800 . 97F Yc *
```

(c) Relocate first segment (code).

```
* A00 < 800 . 88F Yc
```

(d) Move and relocate subsequent segments in order.

```
* . 8AF M   (data)
* . 90F Yc  (code)
* . 93F M   (data)
* . 97F Yc  (code)
```

Note that step (d) illustrates abbreviated versions of the following commands:

```
* A90 < 890 . 8AF M  (data)
* AB0 < 8B0 . 90F Yc (code)
* B10 < 910 . 93F M  (data)
* B40 < 940 . 97F Yc (code)
```

2. Index into block

Assume that the program of example 1 uses an indexed reference into the data segment at $890 as follows:

```
LDA  7B0,X
```

The X-REG is presumed to contain $E0-$FF. Because $7B0 is outside the source block, it will not be relocated. This may be handled in one of two ways.

(a) The exception is fixed by hand, or

(b) The block specifications begin one page lower than the addresses at which the original and relocated programs begin to account for all such 'early references'. In step (b) of example (1) change to:

```
* 900 < 700 . 97F Yc*
```

Note that program references to the 'prior page' (in this case the $7XX page) which are not intended to be relocated, will be.

3. Immediate Address References

Assume that the program of example (1) has an immediate reference which is an address. For example,

```
LDA #$3F
STA LOC0
LDA #$08
STA LOC1
JMP (LOC0)
```

In this example, the LDA #$08 will not be changed during relocation and the user will have to hand-modify it to $0A.

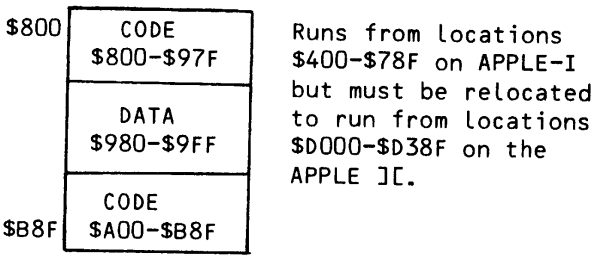
4. User function (Yc) programs

Relocating programs such as RELOC introduces another irregularity. Because RELOC uses the MONITOR user function command Control-Y (Yc), its entry point must remain fixed at $3F8. The rest of RELOC may be relocated anywhere in memory (references other than the JMP at $3F8). The user must leave the JMP at $3F8 undisturbed or find some way other than Yc to pass parameters.

5. Unusable block ranges

A program was written to run from locations $400-$78F on an APPLE-I. A version which will run in ROM locations $D000-$D38F must be generated. The source (and destination) segments may reside in locations $800-$B8F on the APPLE II where relocation is performed.

SEGMENTS, SOURCE AND DEST



SOURCE BLOCK $400-$78F

DEST BLOCK $D000-$D38F

SOURCE SEGMENTS $800-$B8F

DEST SEGMENTS $800-$B8F

(A) Load RELOC

(b) Load original program into locations $800-$B8F (despite the fact that it doesn't run there).

(c) Specify block parameters (i.e. where the original and relocated versions will run).

```
*D000 < 400 . 78F Yc *
```

(d) Move and relocate all segments in order.

```
* 800 < 800 . 97F Yc (first segment, code)
* . 9FF M           (data)
* . B8F Yc          (code)
```

Note that because the relocation is done 'in place' the SOURCE SEGMENT BEG parameter is the same as the DEST SEG BEG parameter ($800) and need not be specified. The initial segment relocation command may be abbreviated:

```
* 800 <. 97F Yc
```

6. The program of example (1) need not be relocated but the page zero variable allocation is from $30 to $3F. Because these locations are reserved for the APPLE][system monitor, the allocation must be changed to locations $80-$8F. The source and destination blocks are thus not the program but rather the variable area.

SOURCE BLOCK $20-$2F

DEST BLOCK $80-$8F

SOURCE SEGMENTS $800-$97F

DEST SEGMENTS $800-$97F

(a) Load RELOC

(b) Define blocks

```
*80 < 20.2F Yc  *
```

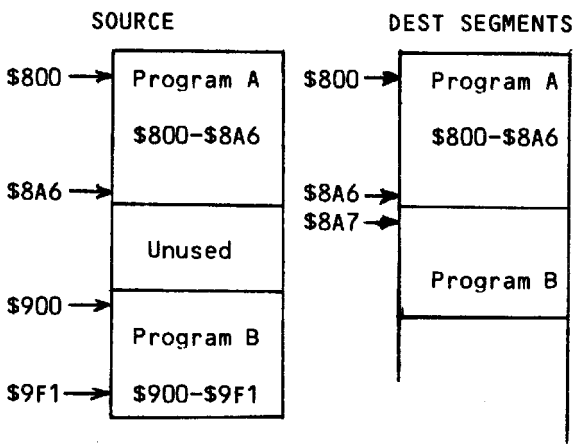
(c) Relocate code segments and move data segments in place.

```
* 800 <.88F Yc  (code)
* .8AF M        (data)
* .90F Yc       (code)
* .93F M        (data)
* .97F Yc       (code)
```

7. Split blocks with cross-referencing

Program A resides and runs in locations $800-$8A6. Program B resides and runs in locations $900-$9F1. A single, contiguous program is to be generated by moving program B so that it immediately follows program A. Each of the programs contains memory references within the other. It is assumed that the programs contain no data segments.

WOZPAK II



SOURCE BLOCK $900-$9F1

DEST BLOCK $8A7-$998

SOURCE SEGMENTS $800-$8A6 (A)
$900-$9F1 (B)

DEST SEGMENTS $800-$8A6 (A)
$8A7-$998 (B)

(a) Load RELOC

(b) Define blocks (program B only)

* 8A7 < 900 . 9F1 Yc *

(c) Relocate each of the two programs individually. Program A must be relocated even though it does not move.

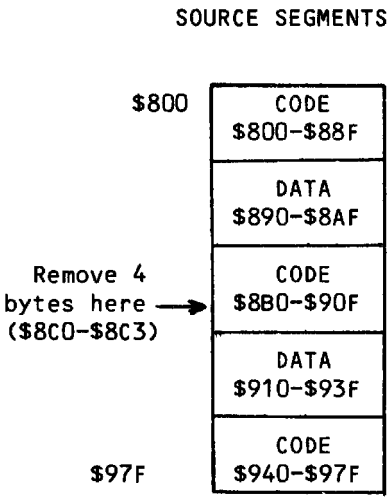
* 800 <. 8A6 Yc (program A, 'in place')

* 8A6 < 900 . 9F1 Yc (program B, not 'in place')

Note that any data segments within the two programs would necessitate additional relocation and move commands.

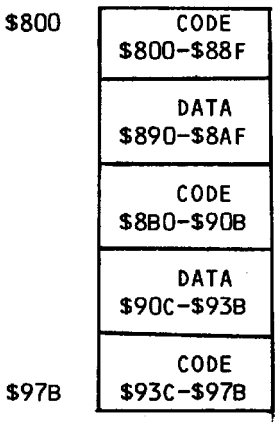
8. Code deletion.

4 bytes of code are to be removed from within a program and the program is to contract accordingly.



SOURCE BLOCK $8C4-$97F

SOURCE SEGMENTS $800-$88F (code)
$890-$8AF (data)
$8B0-$8BF (code)
$8C4-$90F (code)
$910-$93F (data)
$940-$97F (code)



DEST BLOCK $8C0-$97B

DEST SEGMENTS $800-$88F (code)
$890-$8AF (data)
$8B0-$8BF (code)
$8C0-$90B (code)
$90C-$93B (data)
$93C-$97B (code)

(a) Load RELOC

(b) Define blocks
* 8C0 < 8C4 . 97F Yc *

(c) Relocate code segments and move data segments in ascending address sequence.

```
* 800 <. 88F Yc (code, 'in place')
* . 8AF M       (data)
* . 8BF Yc      (code)
* 8C0 < 8C4 . 90F Yc (code, not
                      'in place')
* . 93F M       (data)
* . 97F Yc      (code)
```

(d) Relative branches crossing the deletion boundary will be incorrect since the relocation process does not modify them (only zero-page and absolute memory references). The user must patch these by hand.

9. Relocating the APPLE][MONITOR ($F800-$FFFF) to run in RAM ($800-$FFF).

```
   SOURCE BLOCK $F700-$FFFF
      (see example (2) )

SOURCE SEGMENTS $F800-$F961 (code)
                $F962-$FA42 (data)
                $FA43-$FB18 (code)
                $FB19-$FB1D (data)
                $FB1E-$FFCB (code)
                $FFCC-$FFFF (data)

DEST BLOCK $700-$FFF

DEST SEGMENTS $800-$961 (code)
              $962-$A42 (data)
              $A43-B18  (code)
              $B19-$B1D (data)
              $B1E-$FCB (code)
              $FCC-$FFF (data)

IMMEDIATE ADDRESS REFS (see example (3)

      $FFBF

      $FEA8

      (more if not relocating to page
       boundary)
```

(a) Load RELOC

(b) Block parameters

```
* 700 < F700 . FFFF Yc *
```

(c) Segments

```
* 800 < F800 . F961 Y   (first segment, code)
* . FA42 M              (data)
* . FB18 Y              (code)
* . FB1D M              (data)
* . FFCB Y              (code)
* . FFFF M              (data)
```

(c) Immediate address references

```
* FBF : E     (was $FE)
* EA8 : E     (was $FE)
```

OTHER 6502 SYSTEMS

The following details illustrate features specific to the APPLE][which are used by RELOC. If adapted to other systems, the convenient and flexible parameter passing capability of the APPLE][monitor may be sacrificed.

1. The APPLE][monitor command
   * A1 < A2 . A3 Yc
   (A1, A2, and A3 are addresses)
   vectors to location $3F8 with the value A1 in locations $3C (low) and $3D (high), A2 in locations $3E (low) and $3F (high), and A3 in locations $42 (low) and $43 (high). Locaton $34 (YSAV) holds an index to the next character of the command buffer (after the Yc). The command buffer (IN) begins at $200.

2. If Yc is not followed by an '*' then the block parameters are simply preserved as follows:

Parameter	Preserved at	SWEET16 Reg Name
DEST BLOCK BEG	$8, $9	TOBEG
SOURCE BLOCK BEG	$2, $3	FRMBEG
SOURCE BLOCK END	$4, $5	FRMEND

3. If Yc is not followed by an 'X' then a segment relocation is initiated at RELOC2 ($3BB). Throughout, A1 ($3C, $3D) is the source segment pointer and A4 ($42, $43) is the destination segment pointer.

4. INSDS2 is an APPLE][monitor subroutine which determines the length of a 6502 instruction in the variable LENGTH (location $2F) given the opcode in the A-REG.

Instruction type	LENGTH
Invalid	0
1 byte	0
2 byte	1
3 byte	2

5. The code from XLATE TO SW16RT ($3D9-$3E6) uses the APPLE][16-bit interpretive machine, SWEET16. The target address of the 6502 instruction being relocated (locations $C low and $D high) occupies the SWEET16 register named ADR. If ADR is between FRMBEG and FRMEND (inclusive) then it is replaced by ADR-FRMBEG + TOBEG.

6. NXTA4 is an APPLE][monitor subroutine which increments A1 (source segment index) and A4 (destination segment index). If A1 exceeds A2 (source segment end) then the carry is set, otherwise it is cleared.

NOTE: MACHINE CODE RELOCATION was originally written to run at $3A6 to $3FA. Because this wipes out DOS entry points, the routine is reassembled at $1000. The first part of the routine (lines 54-60 of the assembly listing) writes the CONTROL-Y vector at $3F8. '1000G' entered at the start of using RELOC will write the vector to allow the routine to operate properly.

WOZPAK II

```
                        3    ************************
                        4    *                      *
                        5    *    6502  RELOCATION  *
                        6    *       SUBROUTINE     *
                        7    *                      *
                        8    *   1. DEFINE BLOCKS   *
                        9    *      *A4<A1.A2 ^Y    *
                        10   *      (^Y IS CTRL-Y)  *
                        11   *                      *
                        12   *   2. FIRST SEGMENT   *
                        13   *      *A4<A1.A2 ^Y    *
                        14   *         (IF CODE)    *
                        15   *                      *
                        16   *      *A4<A1.A2 M     *
                        17   *         (IF MOVE)    *
                        18   *                      *
                        19   *   3. SUBSEQUENT SEGS *
                        20   *      *.A2 ^Y OR *.A2 M *
                        21   *                      *
                        22   *   WOZ       11-10-77 *
                        23   * APPLE COMPUTER CO.INC. *
                        24   *                      *
                        25   * (SLIGHTLY MODIFIED BY) *
                        26   * KEN SMITH    TACOMA,WA *
                        27   *                      *
                        28   ************************
                        29   *
                        30   *RELOCATION SUBROUTINE EQUATES
                        31   *
                        32   R1L       EQU  $2        ;SWEET16 REG. 1.
                        33   INST      EQU  $B        ;3-BYTE INST. FIELD
                        34   LENGTH    EQU  $2F       ;LENGTH CODE.
                        35   YSAV      EQU  $34       ;CMND BUF POINTER.
                        36   A1L       EQU  $3C       ;APPLE ][ MON PARAM AREA.
                        37   A4L       EQU  $42       ;APPLE ][ MON PARAM REG 4.
                        38   IN        EQU  $200      ;MON CMND BUF.
                        39   CTRLY     EQU  $3F8      ;CONTROL-Y VECTOR ADR.
                        40   SW16      EQU  $F689     ;SWEET16 ENTRY.
                        41   INSDS2    EQU  $F88E     ;DISASSEMBLER ENTRY.
                        42   NXTA4     EQU  $FCB4     ;POINTER INCR SUBR.
                        43   FRMBEG    EQU  $1        ;SOURCE BLOCK BEGIN.
                        44   FRMEND    EQU  $2        ;SOURCE BLOCK END.
                        45   TOBEG     EQU  $4        ;DEST BLOCK BEGIN.
                        46   ADR       EQU  $6        ;ADR PART OF INST.
                        47             OBJ  $7000
                        48             ORG  $1000
                        49   *
                             ************************************************
                        51   *  CONTROL-Y 'JMP' TO RELOC SETUP
                             ************************************************
                        53   *
1000: A9 4C             54   INITY     LDA  #$4C      ;'JMP' FOR CONTROL-Y ENTRY.
1002: 8D F8 03          55             STA  CTRLY
1005: A9 10             56             LDA  #<RELOC   ;GET ROUTINE ADDRESS AND
1007: 8D F9 03          57             STA  CTRLY+1   ;WRITE INTO $3F9&A FOR
100A: A9 10             58             LDA  #>RELOC   ;CONTROL-Y JMP DESTINATION.
100C: 8D FA 03          59             STA  CTRLY+2
100F: 60                60             RTS
```

WOZPAK II

```
                        ************************************************
                  63    *  6502 RELOCATION SUBROUTINE
                        ************************************************
                  65    *
1010: A4 34       66    RELOC     LDY  YSAV       ;CMND BUF POINTER.
1012: B9 00 02    67              LDA  IN,Y       ;NEXT CMND CHAR.
1015: C9 AA       68              CMP  #$AA       ;'*'?
1017: D0 0C       69              BNE  RELOC2       ;NO, RELOC CODE SEG.
1019: E6 34       70              INC  YSAV       ;ADVANCE POINTER.
101B: A2 07       71              LDX  #$7
101D: B5 3C       72    INIT      LDA  A1L,X      ;MOVE BLOCK PARAMS
101F: 95 02       73              STA  R1L,X        ;FROM APPLE ][ MON
1021: CA          74              DEX  .            ;AREA TO SW16 AREA.
1022: 10 F9       75              BPL  INIT         ;R1=SOURCE BEG, R2=
1024: 60          76              RTS  .            ;SOURCE END, R4=DEST BEG.
1025: A0 02       77    RELOC2    LDY  #$2
1027: B1 3C       78    GETINS    LDA  (A1L),Y    ;COPY 3 BYTES TO
1029: 99 0B 00    79              STA  INST,Y       ;SW16 AREA.
102C: 88          80              DEY
102D: 10 F8       81              BPL  GETINS
102F: 20 8E F8    82              JSR  INSDS2     ;CALCULATE LENGTH OF
1032: A6 2F       83              LDX  LENGTH       ;INST FROM OPCODE.
1034: CA          84              DEX  .            ;0=1 BYTE, 1=2 BYTE,
1035: D0 0C       85              BNE  XLATE        ;2=3 BYTE.
1037: A5 0B       86              LDA  INST
1039: 29 0D       87              AND  #$D        ;WEED OUT NON ZERO-PAGE
103B: F0 14       88              BEQ  STINST       ;2 BYTE INSTS. (IMMED)
103D: 29 08       89              AND  #$8        ;IF ZERO-PAGE ADR
103F: D0 10       90              BNE  STINST       ;THEN CLEAR HIGH BYTE.
1041: 85 0D       91              STA  INST+2
1043: 20 89 F6    92    XLATE     JSR  SW16       ;IF ADR OF ZERO-PAGE
1046: 22          93              LD   FRMEND       ;OR ABS IS IN SOURCE
1047: D6          94              CPR  ADR          ;(FRM) BLOCK THEN
1048: 02 06       95              BNC  SW16RT       ;SUBSTITUTE ADR-
104A: 26          96              LD   ADR          ;SOURCE BEG+DEST BEG.
104B: B1          97              SUB  FRMBEG
104C: 02 02       98              BNC  SW16RT
104E: A4          99              ADD  TOBEG
104F: 36         100              ST   ADR
1050: 00         101    SW16RT    RTN
1051: A2 00      102    STINST    LDX  #$0
1053: B5 0B      103    STINS2    LDA  INST,X
1055: 91 42      104              STA  (A4L),Y    ;COPY LENGTH BYTES
1057: E8         105              INX  .            ;OF INST FROM
1058: 20 B4 FC   106              JSR  NXTA4        ;SW16 AREA TO
105B: C6 2F      107              DEC  LENGTH       ;DEST SEGMENT.  UPDATE
105D: 10 F4      108              BPL  STINS2       ;SOURCE, DEST SEGMENT
105F: 90 C4      109              BCC  RELOC2       ;POINTERS.  LOOP IF NOT
1061: 60         110              RTS  .            ;BEYOND SOURCE SEG END.


                        --- END ASSEMBLY ---

                        TOTAL ERRORS: 0

                        98 BYTES GENERATED THIS ASSEMBLY
```

APPLE][TAPE VERIFY ROUTINE

for Integer Basic
and Machine Language Programs

WOZPAK II

This routine provides a method of checking programs saved on tape against a program in memory. Errors can occur due to a number of reasons, including defects in manufacture of the tape or improper operation of the tape recorder. With this routine, a program can be checked immediately after it is saved to verify that a good SAVE was accomplished. The TAPE VERIFY routine will read the program saved on tape and check it byte for byte against the program in memory.

The routine is assembled to run at memory location $1000, so that there is a minimum of interference with other routines that may need to be verified. Thus, it does not destroy DOS, either HIRES screen, HIRES routines, or most other routines.

TO VERIFY AN INTEGER BASIC PROGRAM:

Make sure that the program to be verified is in memory.
'CALL 4096' (do not hit [RETURN] yet)
Start tape in 'Play' mode.
Hit [RETURN].

TO VERIFY MACHINE LANGUAGE PROGRAM:

Enter Monitor (CALL -151)
Type '1076G [RETURN]. This activates 'CONTROL-Y'.
Enter the range to be verified, I.E. 'C00.C85 (CONTROL-Y)'.
Start tape in 'Play' mode.
Hit [RETURN]

If no errors are detected, the APPLE][will 'BEEP' and the appropriate prompt character will reappear at the end of the verify.

Should an error be found, the memory location which does not agree with the tape will be displayed. Next the byte in memory will be displayed, and then the byte which was read from the tape will be shown in parenthesis.

NOTE: The routine will return control to the user after the first error is found. After the corrections is made, the routine should be rerun to check for any other errors.

To observe the operation of the routine, first call the routine and verify a tape against an unchanged program. Then, change ONE character in the program. Call the routine, and it will find and display the non-matching byte.

TO RELOCATE THE ROUTINE:

Change the JSR addresses in lines 52 and 55 of the assembled listing. Also change the high and low address bytes that are written into the CONTROL-Y vector ($3F9-$3FA) as written in lines 104 and 106 of the assembly listing.

```
                        WOZPAK II
                 2      ********************************************
                 3      *                                          *
                 4      *        APPLE ][ TAPE VERIFY ROUTINE      *
                 5      *                                          *
                 6      * APPLE PUGET SOUND PROGRAM LIBRARY EXCHANGE *
                 7      *  6708 39TH AVE. SW      SEATTLE, WA 98138  *
                 8      *                                          *
                 9      *       SOURCE CODE FROM 'THE WOZPAK'      *
                10      * COURTESY OF S. WOZNIAK  APPLE COMPUTER CO. *
                11      *                                          *
                12      *            DECIPHERED AND ASSEMBLED      *
                13      *           (AND SLIGHTLY MODIFIED BY)     *
                14      *    KEN SMITH   TACOMA, WA  JUNE 14,1979  *
                15      *                                          *
                16      ********************************************
                17      *
                18      CHKSUM   EQU   $2E
                19      A1L      EQU   $3C
                20      HIMEMH   EQU   $4D
                21      XSAVE    EQU   $D8
                22      PPH      EQU   $CB
                23      LSTOR    EQU   $CF
                24      *
                25      BASHDR   EQU   $F11E
                26      BASREAD  EQU   $F12C
                27      HEADR    EQU   $FCC9
                28      RDBYTE   EQU   $FCEC
                29      RDBIT    EQU   $FCFD
                30      RD2BIT   EQU   $FCFA
                31      *
                32      NXTA1    EQU   $FCBA
                33      CHKSUMOK EQU   $FF26
                34      PRERR    EQU   $FF2D
                35      PRA1     EQU   $FD92
                36      COUT     EQU   $FDED
                37      PRBYTE   EQU   $FDDA
                38      *
                39               ORG   $1000
                40      *
                        ************************************************
1000:  86 D8    42      VFYBSC   STX   XSAVE     PRESERVE X-REG
1002:  38       43               SEC
1003:  A2 FF    44               LDX   #$FF
1005:  B5 4D    45      GETLEN   LDA   HIMEMH,X  CALC PROGRAM LENGTH
1007:  F5 CB    46               SBC   PPH,X     AND STORE ($CE,$CF)
1009:  95 CF    47               STA   LSTOR,X
100B:  E8       48               INX
100C:  F0 F7    49               BEQ   GETLEN
                50      *
100E:  20 1E F1 51               JSR   BASHDR    SET ADRESSES FOR BASIC
1011:  20 1F 10 52               JSR   TAPEVFY   HEADER READ
1014:  A2 01    53               LDX   #$01
1016:  20 2C F1 54               JSR   BASREAD   SET ADDRESSES  FOR BASIC
1019:  20 1F 10 55               JSR   TAPEVFY   PROGRAM READ
101C:  A6 D8    56               LDX   XSAVE
101E:  60       57               RTS
                        ************************************************
101F:  20 FA FC 59      TAPEVFY  JSR   RD2BIT
1022:  A9 16    60               LDA   #$16      SYNCRONIZE ON
1024:  20 C9 FC 61               JSR   HEADR     TAPE HEADER
```

WOZPAK II

```
1027:  85 2E     63              STA   CHKSUM
1029:  20 FA FC  64              JSR   RD2BIT
102C:  A0 24     65   VRFY2      LDY   #$24
102E:  20 FD FC  66              JSR   RDBIT
1031:  B0 F9     67              BCS   VRFY2
1033:  20 FD FC  68              JSR   RDBIT
1036:  A0 3B     69              LDY   #$3B
1038:  20 EC FC  70   VRFY3      JSR   RDBYTE    READ A BYTE FROM TAPE
103B:  F0 0E     71              BEQ   EXTDEL    (ALWAYS TAKEN)
103D:  45 2E     72   CKSUM      EOR   CHKSUM    UPDATE RUNNING CHECKSUM
103F:  85 2E     73              STA   CHKSUM    INC A1, COMPARE TO
1041:  20 BA FC  74              JSR   NXTA1     A2 (CARRY SET IF >=)
1044:  A0 34     75              LDY   #$34
1046:  90 F0     76              BCC   VRFY3     LOOP UNTIL A1>A2
1048:  4C 26 FF  77              JMP   CHKSUMOK  SOUND BELL AFTER CKSUM VFY
                 78   *
104B:  EA        79   EXTDEL     NOP   .         EXTRA DELAY TO
104C:  EA        80              NOP   .         EQUALIZE TIMING
104D:  EA        81              NOP   .         (12 USEC)
                 82   *
104E:  C1 3C     83              CMP   (A1L,X)
1050:  F0 EB     84              BEQ   CKSUM     BYTE MATCHES!
                 ***********************************************
1052:  48        86              PHA
1053:  20 2D FF  87              JSR   PRERR     OUTPUT 'ERR'
1056:  20 92 FD  88              JSR   PRA1      OUTPUT '(A1)-'
1059:  B1 3C     89              LDA   (A1L),Y
105B:  20 DA FD  90              JSR   PRBYTE    OUTPUT CONTENTS OF A1
105E:  A9 A0     91              LDA   #$A0
1060:  20 ED FD  92              JSR   COUT      OUTPUT A SPACE
1063:  A9 A8     93              LDA   #$A8
1065:  20 ED FD  94              JSR   COUT      OUTPUT '('
1068:  68        95              PLA
1069:  20 DA FD  96              JSR   PRBYTE    OUTPUT BYTE FROM TAPE
106C:  A9 A9     97              LDA   #$A9
106E:  20 ED FD  98              JSR   COUT      OUTPUT ')'
1071:  A9 8D     99              LDA   #$8D
1073:  4C ED FD  100             JMP   COUT      OUTPUT CAR RTN AND RETURN
                 ***********************************************
1076:  A9 4C     102  CTLYINIT   LDA   #$4C      INITIALIZE CONTROL
1078:  8D F8 03  103             STA   $3F8      'Y' ENTRY FOR USE WITH
107B:  A9 1F     104             LDA   #<TAPEVFY MACHINE LANGUAGE
107D:  8D F9 03  105             STA   $3F9      ROUTINES
1080:  A9 10     106             LDA   #>TAPEVFY
1082:  8D FA 03  107             STA   $3FA
1085:  60        108             RTS
```

APPLE][HI-RES GRAPHICS SUBROUTINES

WOZPAK II

The APPLE][computer comes with a high-resolution color graphics display mode of 280 horizontal by 192 vertical resolution. Because 8K Bytes of RAM are dedicated soley to maintaining the HI-RES display, a minimum 12K system (configured for HI-RES) is required to use this mode. For practical reasons, 16K Bytes is the strongly recommended minimum. A 6502 machine language subroutine package has been developed to simplify efficient use of the APPLE][HI-RES display for assembly language and BASIC programmers. The routines for initializing the HI-RES display, plotting points, drawing lines, and drawing shapes are described herein.

USING THE HI-RES SUBROUTINES

Despite the fact that HI-RES graphics commands are not built into APPLE][BASIC, a convenient scheme for referencing the subroutines and their parameters by name has been devised.

The first statment of a program using the HI-RES subroutines should be as follows:

```
0 XO=YO=COLR=SHAPE=ROT=SCALE
```

The purpose of this statment is to enter the first 6 BASIC variable names into the variable table in a fixed sequence. When executed, each of the 6 parameters will be assigned storage at fixed locations relative to the address contained in the BASIC 'start of variables' pointer (LOMEM), making them readily accessable by the HI-RES subroutines.

Different parameter names may be used provided that they retain the same number of characters. This is necessary to insure that the storage locations for each, relative to LOMEM, do not change. For example, the name XX could be used in place of XO, but XCOORD could not.

The parameters SHAPE, ROT, and SCALE are used only by the HI-RES shape draw subroutines and may be ommitted from programs using only the PLOT and LINE features. Omitting unnecessary variable definitions is one method of enhancing the overall performance of some BASIC programs on the APPLE][and is thus desirable.

FIRST LINE OF PROGRAMS NOT USING THE SHPAE DRAW SUBRROUTINES

```
0  XO=YO=COLR
```

After the parameter names have been defined, the HI-RES subroutine names themselves may be defined and assigned corresponding subroutine entry addresses as values. Calling subroutines by name is preferable to calling them by entry address because the entry addresses may vary in future versions of the HI-RES subroutines, and names are better self documenting.

```
Absolute CALL                CALL by name
     .                    5  INIT=2048
     .                         .
     .                         .
100 CALL 2048            100 CALL INIT
     .                         .
     .                         .
200 CALL 2048            200 CALL INIT
```

In the above CALL by name example, should the INIT subroutine entry address change to -12288, only line 5 need be changed. In the absolute call example, lines 100 and 200 (and any others referencing the INIT subroutine) will have to be changed. The self documenting advantage of the CALL by name example should be apparent.

The following statment lists all HI-RES subroutine entry initializations available to BASIC programs. Other names may be used.

```
5  INIT=2048:CLEAR=2062:BKGND=2865:
   POSN=2809:PLOT=2830:LINE=2836:
   DRAW=2871:DRAW1=2874:XDRAW=2884:
   XDRAW1=2887:FIND=2556
```

The allowable color specification values may also be referenced by name, if the initialization statment below is incuded in your program. Note that GREEN is preceeded by LET to avoid a syntax error due to confusion with the 'GR' command.

```
7  BLACK=0:LET GREEN=42:VIOLET=85:
   WHITE=127
```

If your APPLE][has been modified for additional HI-RES colors, the following assignments are also valid.

```
8  ORANGE=170:BLUE=213:BLACK2=128:
   WHITE2=255
```

Unnecessary variable definitions in the program should be avoided as they will slow some programs. Therefore, a program

should not define VIOLET=85 unless it uses the color VIOLET. The example given below illustrates condensed initialization statments for a program using only the INIT, PLOT, and DRAW subroutines, and the colors GREEN and WHITE.

```
0  XO=YO=COLR=SHAPE=ROT=SCALE
5  INIT=2048:PLOT=2830:DRAW=2871
7  LET GREEN=42:WHITE=127
```

In extreme cases, any of the following techniques will further enhance program performance.

(1) Omit the color and subroutine name initializations. Refer to colors and subroutines by value, not name. This does not apply to the parameter references.

(2) Define the most frequently used program variable names PRIOR to the subroutine and color name initializations (Lines 5 & 7 in the prior examples). The example below will speed up programs extensively referencing variables I, J, and K.

```
0  XO=YO=COLR=SHAPE=ROT=SCALE
2  I=J=K
5  INIT=2048:CLEAR=2062:BKGND=2865:
   POSN=2809.....etc.
7  BLACK=0:LET  GREEN=42:.....etc.
```

(3) Use the parameter names as program variables when possible, the parameters are the most quickly accessed BASIC variables.

INITIALIZATION SUBROUTINES

The normal HI-RES display consists of a 280 horizontal by 160 vertical grid above 4 lines of text and is initiated with the BASIC command:

```
> CALL INIT
```

The INIT subroutine also clears the HI-RES display and initializes other HI-RES subroutines. After calling INIT, the programmer may eliminate the 4 line text display, extending the HI-RES display to a 192 line vertical resolution, with the following command:

```
> POKE -16302,0
```

The 4-line text display may be restored at any time as follows:

```
> POKE -16301,0
```

Valid X-coordinates vary from 0 (leftmost) to 279 (rightmost). Valid Y-coordinates vary from 0 (topmost) to 159 or 191 (bottommost), depending on whether or not the 4 line text display is enabled.

At any time after INIT is called, the entire HI-RES display may be cleared with the CLEAR subroutine as shown below.

```
> CALL CLEAR
```

The HI-RES display may be quickly set to any background color with the BKGND subroutine. BKGND expects a color specification in the BASIC variable COLR. The example below turns the entire HI-RES display green.

```
 0  XO=YO=COLR
 5  INIT=2048:BKGND=2865:LET GREEN=42
10  CALL INIT
20  COLR=GREEN
30  CALL BKGND
40  END
```

Only the colors previously mentioned (BLACK, GREEN, VIOLET, and WHITE)* may be specified in COLR. Do not make up your own. For example, COLR=YELLOW is not allowed.

If COLR is greater than 255 when BKGND is called, a range error will occur. The message "***RANGE ERR" will be displayed and the program will halt.

POINTS AND LINES

The PLOT subroutine is used to plot a single point of the HI-RES display in a specified color. COLR must be less than 255, XO must be 0 to 279, YO must be 0 to 191 when PLOT is called or a range error will result and the program will halt. The program below plots one white dot at X-coordinate 35, and Y-coordinate 55 (35, 55) and one at (85,90).

```
 0  XO=YO=COLR
 5  INIT=2048:PLOT=2380:WHITE=127
10  CALL INIT
20  COLR=WHITE
30  XO=35:YO=55:CALL PLOT
40  XO=85:YO=90:CALL PLOT
50  END
```

Connecting any two coordinates with a straight line is almost as easy as plotting points. After plotting one end point as shown in the example above, the other end point is specified in X0 and Y0 and the LINE subroutine is called. As with the PLOT subroutine, COLR must be less than 256, X0 must be 0 to 279, and Y0 must be 0 to 191 or a range error will result and the program will halt. The following example draws a white line from (35,40) to (170,100), a green line from (270,10) to (5,145), and a violet line from (20,70) to (190,110).

```
 0  X0=Y0=COLR
 5  INIT=2048:PLOT=2830:LINE=2836:
    LET GREEN=42:VIOLET=85:WHITE=127
10  CALL INIT
20  COLR=WHITE:X0=35:Y0=40:CALL PLOT
25  X0=170:Y0=100:CALL LINE
30  COLR=GREEN:X0=270:Y0=10:CALL PLOT
35  X0=5:Y0=145:CALL LINE
40  COLR=VIOLET:X0=20:Y0=70:CALL PLOT
45  X0=190:Y0=110:CALL LINE
50  END
```

The following example illustrates that the parameter variables may be used as FOR loop indices. Horizontal violet lines are drawn on a green background at every tenth vertical coordinate.

```
 0  X0=Y0=COLR
 5  INIT=2048:BKGND=2865:PLOT=2830:
    LINE=2836:LET  GREEN=42:VIOLET=85
10  CALL INIT
20  COLR=GREEN:CALL BKGND
30  COLR=VIOLET
40  FOR Y0=5 TO 155 STEP 10
50  X0=10:CALL PLOT:X0=270:CALL LINE
60  NEXT Y0:END
```

Multiple lines which are connected endpoint to endpoint may be drawn without intervening PLOT calls. In the example below, a white line connects (10,20) to (250,70), and a green line connects (250, 70) to (20,150), and a violet line connects (20,150) to (260,30).

```
 0  X0=Y0=COLR
 5  INIT=2048:PLOT=2830:LINE=2836:
    LET GREEN=42:VIOLET=85:WHITE=127
10  CALL INIT
20  COLR=WHITE:X0=10:Y0=20:CALL PLOT
30  X0=250:Y0=70:CALL LINE
40  X0=20:Y0=150:COLR=GREEN:CALL LINE
50  X0=260:Y0=30:COLR=VIOLET:CALL LINE
60  END
64
```

CAUTION

Do not attempt to draw a line prior to the first PLOT. Because the first endpoint has not been defined, the line may be drawn in random memory locations, not necessarily restricted to the screen memory.

DRAWING SHAPES

Up to 255 different shapes may be defined, edited, and saved with the SHAPEGEN program, available from APPLE. (See HIRES Shape Generator program-next sect.) After loading the HI-RES subroutines such a 'shape tape' (containing a shape table) may be read as follows:

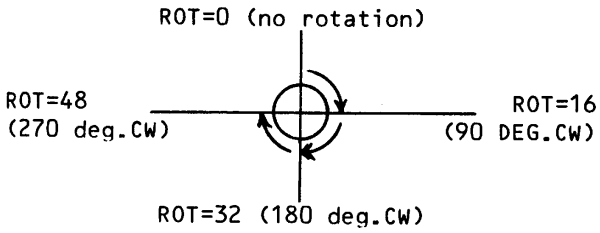
1. Position shape tape in recorder.
2. Load shape tape with the BASIC COMMAND: >CALL 3001
3. Start the recorder (PLAY). The above command immediately begins reading tape.
4. Wait for two beeps.

Shape tables always load at address $C00 with the HI-RES subroutines located at $800-$BFF. Upon loading a shape table, the BASIC 'start of variables' pointer (LOMEM) is set to contain the address of the location immediately following the last shape table byte.

If not enough free memory is available to contain the shape table then the message '***MEM FULL ERR' will be given. If no beep is heard when loading a shape table then something is probably wrong with the tape connection and you will have to hit RESET and re-enter BASIC. If you hear a single beep and then the system hangs, it means your shape tape is probably bad, and after hitting RESET and re-entering BASIC, you may have to restore the LOMEM setting to $C00 (3072) with the command: >LOMEM:3072.

The DRAW subroutine is used to display any of the predefined shapes included in the current shape table. The origin, or 'beginning point', of the shape is specified in X0 and Y0, and the color is specified in COLR, as with PLOT. The shape number desired is specified in SHAPE. For example, SHAPE=3 specifies that the third shape of the current shape table is to be drawn. A scale factor is specified in the variable SCALE and a rotation in ROT. A scale factor of 4 implies a shape 4 times the defined size.

A scale factor of 0 is always interpreted as 256.



COLR must be 0 to 255, X0 must be 0 to 279, Y0 must be 0 to 191, ROT must be 0 to 255 (due to MOD 64 arithmetic, ROT=64 is equivalent to ROT=0), SCALE must be 0 to 255, and SHAPE must be greater than zero and less than or equal to the current number of shape table shapes, or else a range error will result when DRAW is called and the program will halt. In other words, the programmer will always be notified if HI-RES subroutines are called with any invalid parameters.

The following program example draws shape number 3 in white at a 90 degree clockwise rotation and a scale factor of 2. The origin is at (140,80). It is assumed that a shape table with at least 3 shape definitions has been loaded.

```
 0  X0=Y0=COLR=SHAPE=ROT=SCALE
 5  INIT=2048:DRAW=2871
 7  WHITE=127
10  CALL INIT
20  X0=140:Y0=80:COLR=WHITE
30  SHAPE=3:ROT=16:SCALE=2
40  CALL DRAW
50  END
```

The XDRAW subroutine is identical in operation to the DRAW subroutine except that the defined shape is exclusive-ORed onto the screen. The EX-OR operation complements all screen memory bits of the shape, 0's become 1's and vice-versa. No color need be specified. A unique property of XDRAW is that 2 successive calls with identical parameters will first cause a shape to be drawn (in white) and then erased. The following program example causes the rotation of shape number 3 to track paddle 0. XDRAW is used for both the draw and erase operations. Although the color is optional, the variable COLR may not be omitted from the parameter declarations (line 0), or the SHAPE, ROT, and SCALE parameters will not be assigned storage in their standard locations relative to LOMEM.

```
 0  X0=Y0=COLR=SHAPE=ROT=SCALE
 5  INIT=2048:XDRAW=2884
10  CALL INIT
20  X0=140:Y0=80:SHAPE=3:SCALE=2
30  R=0:GOTO 60:REM DRAW FIRST SHAPE
40  R=PDL(0):IF R=ROT THEN GOTO 30
50  CALL XDRAW:REM ERASE AT OLD ROT
60  ROT=R:CALL XDRAW:REM DRAW AT NEW ROT
70  GOTO 40:REM CHECK FOR ROT CHANGE
80  END
```

DRAW1 and XDRAW1 are identical to DRAW and XDRAW respectively, except that the most recently plotted (or drawn) point serves as the shape origin and the current color is not updated. Thus, X0,Y0, and COLR are not specified.

If you draw a shape and then wish to draw a line from the final plot position of that shape to a fixed coordinate, you may do so. After drawing the shape, you must call FIND prior to calling LINE. The FIND subroutine determines the X-Y coordinates of the final shape plot position (or current plot position if used after other subroutines) and uses it as the beginning endpoint of the following call to LINE. The following program example draws a shape and then a violet line from the final plot position of the shape to (10,25).

```
 0  X0=Y0=COLR=SHAPE=ROT=SCALE
 5  INIT=2048:LINE=2836:DRAW=2871:
    FIND=2556
 7  VIOLET=85:WHITE=127
10  X0=140:Y0=80:COLR=WHITE:SHAPE=3
    ROT=0:SCALE=1:CALL DRAW
20  CALL FIND
30  X0=10:Y0=25:COLR=VIOLET:CALL LINE
40  END
```

COLLISIONS

Overlapping shapes define points of 'collision'. The DRAW and XDRAW subroutines return a collision count in the absolute location $32A (810 decimal). The collision count will be constant for a fixed shape, rotation, scale, and background, provided that no collisions with other shapes are detected. The difference between the 'standard' collision value and the encountered value (while drawing a shape) is a true collision indicator.

```
100  CALL DRAW

110  COUNT=PEEK (810)
```

WOZPAK II

The HI-RES subroutines may be appended to an INTEGER BASIC program, using the PACK&LOAD routine that appears elsewhere in this book, making a two-step loading unnecessary.

SUMMARY

SUBROUTINE	CALL-ADDRESS	PARAMETERS
INIT	2048	
CLEAR	2062	
BKGND	2865	COLR
POSN	2809	XO, YO, COLR
PLOT	2830	XO, YO, COLR
LINE	2836	XO, YO, COLR
DRAW	2871	XO, YO, COLR SHAPE, ROT, SCALE
DRAW1	2874	SHAPE, ROT, SCALE
XDRAW	2884	XO, YO, COLR SHAPE, ROT, SCALE
XDRAW1	2887	SHAPE, ROT, SCALE
FIND	2556	
SHAPE LOAD	3001	

For NO TEXT display----------POKE -16302,0
For mixed GRAPHICS/TEXT------POKE -16301,0
Select secondary screen display----------
----------POKE -16299,0
Select primary screen display------------
----------POKE -16300,0
Select secondary screen plotting---------
----------POKE 806,64
Select primary screen plotting-----------
----------POKE 806,32
(Defaults are: GRAPHICS/TEXT, primary screen display, and primary screen plotting)
Collision Detect (shape draw only)--------
----------PEEK (810)

HIGH-RES SUBROUTINES SEGMENT MAP

CODE $800-$9E8
DATA $9E9-$9FB
CODE $9FC-$BFF

HI-RES PARAMETER LOCATIONS
(beyond LOMEM)

PARAMETER	Locations beyond LOMEM
XO	$05, $06
YO	$0C, $0D
COLR	$15, $16
SHAPE	$1F, $20
ROT	$27, $28
SCALE	$31, $32

Note: Each parameter is two bytes in length. The low-order byte is stored in the lesser of the two locations assigned.

HCOLOR

COLOR	EVEN HNDX	ODD HNDX
BLACK	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0
GREEN	0 0 1 0 1 0 1 0	0 1 0 1 0 1 0 1
VIOLET	0 1 0 1 0 1 0 1	0 0 1 0 1 0 1 0
WHITE	0 1 1 1 1 1 1 1	0 1 1 1 1 1 1 1
BLACK2	1 0 0 0 0 0 0 0	1 0 0 0 0 0 0 0
ORANGE	1 0 1 0 1 0 1 0	1 1 0 1 0 1 0 1
BLUE	1 1 0 1 0 1 0 1	1 0 1 0 1 0 1 0
WHITE2	1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1

HI-RES INTERNAL VARIABLES

SHAPEL, SHAPEH ($1A, $1B) On-the-fly shape pointer.
HCOLOR1 ($1C) on-the-fly color byte.
COUNTH ($1D) High-order byte of step count for LINE.
HBASL, HBASH ($26, $27) On-the-fly base address.
HMASK ($30) On-the-fly BIT MASK.
QDRNT ($53) 2 LSB's are rotation quadrant for DRAW.
XOL, XOH ($320, $321) Most recent X-coordinate. Used for initial endpoint of LINE. Updated by PLOT, LINE, and FIND; not DRAW.
YO ($322) Most recent Y-coordinate (see XOL, XOH).
BXSAV ($323) Saves 6502 X-Register during HI-RES calls from BASIC.
HCOLOR ($324) color specification to PLOT, POSN.
HNDX ($325) On-the-fly byte index from BASE ADDRESS.
HPAG ($326) Starting page of plot memory. Normally $20 for plotting in primary HI-RES display memory ($2000-$3FFF).
SCALE ($327) On-the-fly scale factor for DRAW.
SHAPXL, SHAPXH ($328, $329) 'Start of shape table' pointer.
COLLSN ($32A) Collision count for DRAW and XDRAW.

NOTES:

(*) Since this article was written, APPLE Computer Company made a production change in the APPLE][. Only the early APPLE][computers displayed 2 HI-RES colors (besides Black and White). See the HI-RES Color Modification article for information on the additional colors available on the later models.

The APPLESOFT programming manual has further information on the creation of SHAPE TABLES and SHAPE TAPES. Refer to Chapter 9 for further information.

```
                    WOZPAK II
2     ********************************
3     *                              *
4     *    APPLE ][ HI-RESOLUTION    *
5     *     GRAPHICS SUBROUTINES     *
6     *                              *
7     *       BY WOZ   9/13/77       *
8     *                              *
9     *     ALL RIGHTS RESERVED      *
10    *                              *
11    ********************************
12    *
13    *        HI-RES EQUATES
14    *
15    SHAPEL   EQU   $1A        POINTER TO
16    SHAPEH   EQU   $1B          SHAPE LIST.
17    HCOLOR1  EQU   $1C        RUNNING COLOR MASK.
18    COUNTH   EQU   $1D
19    HBASL    EQU   $26        BAS ADR FOR CURRENT
20    HBASH    EQU   $27          HI-RES PLOT LINE.
21    HMASK    EQU   $30
22    A1L      EQU   $3C        MONITOR A1.
23    A1H      EQU   $3D
24    A2L      EQU   $3E        MONITOR A2.
25    A2H      EQU   $3F
26    LOMEML   EQU   $4A        BASIC 'START OF VARS'.
27    LOMEMH   EQU   $4B
28    DXL      EQU   $50        DELTA-X FOR HLIN, SHAPE.
29    DXH      EQU   $51
30    SHAPEX   EQU   $51        SHAPE TEMP.
31    DY       EQU   $52        DELTA-Y FOR HLIN, SHAPE.
32    QDRNT    EQU   $53        ROT QUADRANT (SHAPE).
33    EL       EQU   $54        ERROR FOR HLIN.
34    EH       EQU   $55
35    PPL      EQU   $CA        BASIC 'START OF PROG'.
36    PPH      EQU   $CB
37    PVL      EQU   $CC        BASIC 'END OF VARS'.
38    PVH      EQU   $CD
39    ACL      EQU   $CE        BASIC ACC.
40    ACH      EQU   $CF
41    XOL      EQU   $320       PRIOR X-COORD SAVE
42    XOH      EQU   $321         AFTER HLIN OR HPLOT.
43    YO       EQU   $322       HLIN, HPLOT Y-COORD SAVE.
44    BXSAV    EQU   $323       X-REG SAVE FOR BASIC.
45    HCOLOR   EQU   $324       COLOR FOR HPLOT, HPOSN.
46    HNDX     EQU   $325       HORIZ OFFSET SAVE.
47    HPAG     EQU   $326       HI-RES PAGE ($20-NORM).
48    SCALE    EQU   $327       SCALE FOR SHAPE, MOVE.
49    SHAPXL   EQU   $328       START OF
50    SHAPXH   EQU   $329         SHAPE TABLE.
51    COLLSN   EQU   $32A       COLLISION COUNT.
52    SHSTRT   EQU   $C00       START OF SHAPE TABLE.
53    HIRES    EQU   $C057      SWITCH TO HIRES SCREEN.
54    MIXSET   EQU   $C053      SELECT TEXT/GRAPHICS.
55    TXTCLR   EQU   $C050      SELECT GRAPHICS MODE.
56    MEMFULL  EQU   $E36B      BASIC 'MEM FULL ERR'.
57    RANGERR  EQU   $EE68      BASIC 'RANGE ERR'.
58    ACADR    EQU   $F11E      2-BYTE TAPE READ SETUP.
59    RD2BIT   EQU   $FCFA      TWO-EDGE TAPE SENSE.
60    READ     EQU   $FEFD      TAPE READ (A1.A2).
61    READX1   EQU   $FF02      READ WITHOUT HEADER.
```

```
                                WOZPAK II
                        ************************************************
                        *     HIGH RESOLUTION GRAPHICS INITS
                        *        RAM VERSION  $800 TO $BFF
                        ************************************************
                        *
                                ORG   $800
                        *
0800: A9 20       70    SETHRL  LDA   #$20        INIT FOR $2000-3FFF
0802: 8D 26 03    71            STA   HPAG          HI-RES SCREEN MEMORY.
0805: AD 57 C0    72            LDA   HIRES       SET HIRES DISPLAY MODE
0808: AD 53 C0    73            LDA   MIXSET        WITH TEXT AT BOTTOM.
080B: AD 50 C0    74            LDA   TXTCLR      SET GRAPHICS MODE.
080E: A9 00       75    HCLR    LDA   #$0
0810: 85 1C       76    BKGND0  STA   HCOLOR1     SET FOR BLACK BKGND.
0812: AD 26 03    77    BKGND   LDA   HPAG
0815: 85 1B       78            STA   SHAPEH      INIT HI-RES SCREEN MEM
0817: A0 00       79            LDY   #$0           FOR CURRENT PAGE, NORMALLY
0819: 84 1A       80            STY   SHAPEL        $2000-3FFF OR $4000-5FFF.
081B: A5 1C       81    BKGND1  LDA   HCOLOR1
081D: 91 1A       82            STA   (SHAPEL),Y
081F: 20 A2 08    83            JSR   CSHFT2      (SHAPEL,H) WILL SPECIFY
0822: C8          84            INY   ;             32 SEPERATE PAGES
0823: D0 F6       85            BNE   BKGND1        THROUGHOUT THE INIT.
0825: E6 1B       86            INC   SHAPEH
0827: A5 1B       87            LDA   SHAPEH
0829: 29 1F       88            AND   #$1F        TEST FOR DONE.
082B: D0 EE       89            BNE   BKGND1
082D: 60          90            RTS
                  91    *
                        ************************************************
                  93    *  HI-RES GRAPHICS POSITION AND PLOT SUBRS
                        ************************************************
                  95    *
082E: 8D 22 03    96    HPOSN   STA   YO          ENTER WITH Y IN A-REG,
0831: 8E 20 03    97            STX   XOL           XL IN X-REG,
0834: 8C 21 03    98            STY   XOH           AND XH IN Y-REG.
0837: 48          99            PHA
0838: 29 C0      100            AND   #$C0
083A: 85 26      101            STA   HBASL       FOR Y-COORD=00ABCDEF
083C: 4A         102            LSR   ;             CALCULATES BASE ADDR
083D: 4A         103            LSR   ;             IN HABSL,HBASH FOR
083E: 05 26      104            ORA   HBASL         ACCESSING SCREEN MEMORY
0840: 85 26      105            STA   HBASL         VIA (HBASL),Y
0842: 68         106            PLA   ;             ADDRESSING MODE.
0843: 85 27      107            STA   HBASH
0845: 0A         108            ASL   ;           CALCULATES
0846: 0A         109            ASL   ;             HBASH=PPPFGHCD,
0847: 0A         110            ASL   ;             HBASL=EABAB000
0848: 26 27      111            ROL   HBASH
084A: 0A         112            ASL   ;           WHERE PPP=001 FOR $2000
084B: 26 27      113            ROL   HBASH         SCREEN MEM RANGE AND
084D: 0A         114            ASL   ;             PPP=010 FOR $4000-7FFF
084E: 66 26      115            ROR   HBASL         GIVEN Y-COORD=ABCDEFGH
0850: A5 27      116            LDA   HBASH
0852: 29 1F      117            AND   #$1F
0854: 0D 26 03   118            ORA   HPAG
0857: 85 27      119            STA   HBASH
0859: 8A         120            TXA   ;           DIVIDE XO BY 7 FOR
085A: C0 00      121            CPY   #$0           INDEX FROM BASE ADR
085C: F0 05      122            BEQ   HPOSN2        (QUOTIENT) AND BIT
```

WOZPAK II

```
085E:  A0 23     124            LDY   #$23         WITHIN SCREEN MEM BYTE
0860:  69 04     125            ADC   #$4          (MASK SPEC'D BY REM'DR.
0862:  C8        126   HPOSN1   INY
0863:  E9 07     127   HPOSN2   SBC   #$7        SUBTRACT OUT SEVENS.
0865:  B0 FB     128            BCS   HPOSN1
0867:  8C 25 03  129            STY   HNDX       WORKS FOR XO FROM
086A:  AA        130            TAX   ;            0 TO 279, LOW-ORDER
086B:  BD EA 08  131            LDA   MSKTBL-$F9,X BYTE IN X-REG, HIGH
086E:  85 30     132            STA   HMASK        IN Y-REG ON ENTRY.
0870:  98        133            TYA
0871:  4A        134            LSR
0872:  AD 24 03  135            LDA   HCOLOR      IF ON ODD BYTE (CARRY SET)
0875:  85 1C     136   HPOSN3   STA   HCOLOR1       THEN ROTATE (*)
0877:  B0 29     137            BCS   CSHFT2        BIT FOR 180 DEGREE SHIFT
0879:  60        138            RTS   ;             PRIOR TO COPY TO (*)
087A:  20 2E 08  139   HPLOT    JSR   HPOSN
087D:  A5 1C     140   HPLOT1   LDA   HCOLOR1     CALC BIT POSN IN HBASL,H
087F:  51 26     141            EOR   (HBASL),Y     HNDX, AND HMASK FROM
0881:  25 30     142            AND   HMASK         Y-COORD IN A-REG,
0883:  51 26     143            EOR   (HBASL),Y     X-COORD IN X,Y-REGS.
0885:  91 26     144            STA   (HBASL),Y   FOR ANY '1' BITS OF H(*)
0887:  60        145            RTS   ;             SUBSTITUTE CORRESPONDING
                 146   *                          BIT OF HCOLOR1.
                 147   *
                       ***********************************************
                 149   *   HI-RES GRAPHICS L,R,U,D SUBRS
                       ***********************************************
                 151   *
0888:  10 24     152   LFTRT    BPL   RIGHT      USE SIGN FOR LFT/RT SUBR.
088A:  A5 30     153   LEFT     LDA   HMASK
088C:  4A        154            LSR   ;          SHIFT LOW-ORDER
088D:  B0 05     155            BCS   LEFT1        7 BITS OF HMASK
088F:  49 C0     156            EOR   #$C0         ONE BIT TO LSB.
0891:  85 30     157   LR1      STA   HMASK
0893:  60        158            RTS
0894:  88        159   LEFT1    DEY   ;          DECR HORIZ INDEX.
0895:  10 02     160            BPL   LEFT2
0897:  A0 27     161            LDY   #$27       WRAP AROUND SCREEN.
0899:  A9 C0     162   LEFT2    LDA   #$C0       NEW HMASK, RIGHTMOST
089B:  85 30     163   NEWNDX   STA   HMASK        DOT OF BYTE.
089D:  8C 25 03  164            STY   HNDX       UPDATE HORIZ INDEX.
08A0:  A5 1C     165   CSHIFT   LDA   HCOLOR1
08A2:  0A        166   CSHFT2   ASL   ;          ROTATE LOW-ORDER
08A3:  C9 C0     167            CMP   #$C0         7 BITS OF HCOLOR1
08A5:  10 06     168            BPL   RTS1         ONE BIT POSN.
08A7:  A5 1C     169            LDA   HCOLOR1
08A9:  49 7F     170            EOR   #$7F       ZXYXYXYX -> ZYXYXYXY
08AB:  85 1C     171            STA   HCOLOR1
08AD:  60        172   RTS1     RTS
08AE:  A5 30     173   RIGHT    LDA   HMASK      SHIFT LOW ORDER
08B0:  0A        174            ASL
08B1:  49 80     175            EOR   #$80         7 BITS OF HMASK
08B3:  30 DC     176            BMI   LR1          ONE BIT TO MSB.
08B5:  A9 81     177            LDA   #$81
08B7:  C8        178            INY   ;          NEXT BYTE.
08B8:  C0 28     179            CPY   #$28
08BA:  90 DF     180            BCC   NEWNDX
08BC:  A0 00     181            LDY   #$0        WRAP AROUND SCREEN IF (*)
08BE:  B0 DB     182            BCS   NEWNDX     ALWAYS TAKEN.
08C0:  18        183   LRUDX1   CLC   ;          NO 90 DEG ROT (X-OR).
```

```
                                        WOZPAK II
08C1:  A5 51     185   LRUDX2  LDA   SHAPEX
08C3:  29 04     186           AND   #$4         IF B2=0 THEN NO PLOT.
08C5:  F0 27     187           BEQ   LRUD4
08C7:  A9 7F     188           LDA   #$7F        FOR EX-OR INTO SCREEN (*)
08C9:  25 30     189           AND   HMASK
08CB:  31 26     190           AND   (HBASL),Y   SCREEN BIT SET?
08CD:  D0 1B     191           BNE   LRUD3
08CF:  EE 2A 03  192           INC   COLLSN
08D2:  A9 7F     193           LDA   #$7F
08D4:  25 30     194           AND   HMASK
08D6:  10 12     195           BPL   LRUD3       ALWAYS TAKEN.
08D8:  18        196   LRUD1   CLC   ;           NO 90 DEG ROT.
08D9:  A5 51     197   LRUD2   LDA   SHAPEX
08DB:  29 04     198           AND   #$4         IF B2=0 THEN NO PLOT.
08DD:  F0 0F     199           BEQ   LRUD4
08DF:  B1 26     200           LDA   (HBASL),Y
08E1:  45 1C     201           EOR   HCOLOR1     SET HI-RES SCREEN BIT
08E3:  25 30     202           AND   HMASK         TO CORRESPONDING HCOLOR.
08E5:  D0 03     203           BNE   LRUD3       IF BIT OF SCREEN CHANGES,
08E7:  EE 2A 03  204           INC   COLLSN        THEN INCR COLLSN DET.
08EA:  51 26     205   LRUD3   EOR   (HBASL),Y
08EC:  91 26     206           STA   (HBASL),Y
08EE:  A5 51     207   LRUD4   LDA   SHAPEX      ADD QUADRANT TO
08F0:  65 53     208           ADC   QDRNT         SPECIFIED VECTOR
08F2:  29 03     209           AND   #$3           AND MOVE LFT, RT,
                 210   EQ3     EQU   *-1           UP, OR DOWN BASED
08F4:  C9 02     211           CMP   #$2           ON SIGN AND CARRY.
08F6:  6A        212           ROR
08F7:  B0 8F     213   LRUD    BCS   LFTRT
08F9:  30 30     214   UPDWN   BMI   DOWN4       SIGN FOR UP/DOWN SELECT.
08FB:  18        215   UP      CLC
08FC:  A5 27     216           LDA   HBASH       CALC BASE ADDRESS
08FE:  2C EA 09  217           BIT   EQ1C          (ADR OF LEFTMOST BYTE)
0901:  D0 22     218           BNE   UP4           FOR NEXT LINE UP
0903:  06 26     219           ASL   HBASL         IN (HBASL,HBASH)
0905:  B0 1A     220           BCS   UP2           WITH 192-LINE WRAP AROUND.
0907:  2C F3 08  221           BIT   EQ3
090A:  F0 05     222           BEQ   UP1
090C:  69 1F     223           ADC   #$1F        **** BIT MAP ****
090E:  38        224           SEC
090F:  B0 12     225           BCS   UP3         FOR ROW = ABCDEFGH
0911:  69 23     226   UP1     ADC   #$23
0913:  48        227           PHA
0914:  A5 26     228           LDA   HBASL       HBASL=EABAB000
0916:  69 B0     229           ADC   #$B0        HBASH=PPPFGHCD
0918:  B0 02     230           BCS   UP5
091A:  69 F0     231           ADC   #$F0        WHERE PPP=001 FOR PRI(*)
091C:  85 26     232   UP5     STA   HBASL         HI-RES PAGE ($2000-3FFF).
091E:  68        233           PLA
091F:  B0 02     234           BCS   UP3
0921:  69 1F     235   UP2     ADC   #$1F
0923:  66 26     236   UP3     ROR   HBASL
0925:  69 FC     237   UP4     ADC   #$FC
0927:  85 27     238   UPDWN1  STA   HBASH
0929:  60        239           RTS
092A:  18        240   DOWN    CLC
092B:  A5 27     241   DOWN4   LDA   HBASH
092D:  69 04     242           ADC   #$4         CALC BASE ADR FOR NEXT(*)
                 243   EQ4     EQU   *-1           DOWN TO(HBASL,HBASH).
092F:  2C EA 09  244           BIT   EQ1C
```

```
                                WOZPAK II
0932:  D0 F3     246            BNE   UPDWN1
0934:  06 26     247            ASL   HBASL       WITH 192-LINE WRAPAROUND.
0936:  90 19     248            BCC   DOWN1
0938:  69 E0     249            ADC   #$E0
093A:  18        250            CLC
093B:  2C 2E 09  251            BIT   EQ4
093E:  F0 13     252            BEQ   DOWN2
0940:  A5 26     253            LDA   HBASL
0942:  69 50     254            ADC   #$50
0944:  49 F0     255            EOR   #$F0
0946:  F0 02     256            BEQ   DOWN3
0948:  49 F0     257            EOR   #$F0
094A:  85 26     258   DOWN3    STA   HBASL
094C:  AD 26 03  259            LDA   HPAG
094F:  90 02     260            BCC   DOWN2
0951:  69 E0     261   DOWN1    ADC   #$E0
0953:  66 26     262   DOWN2    ROR   HBASL
0955:  90 D0     263            BCC   UPDWN1
                 264   *
                       ***********************************************
                 266   *  HI-RES GRAPHICS LINE DRAW SUBRS
                       ***********************************************
                 268   *
0957:  48        269   HLINRL   PHA
0958:  A9 00     270            LDA   #$0         SET (XOL,XOH) AND
095A:  8D 20 03  271            STA   XOL           Y0 TO ZERO FOR
095D:  8D 21 03  272            STA   XOH           REL LINE DRAW
0960:  8D 22 03  273            STA   Y0            (DX,DY).
0963:  68        274            PLA
0964:  48        275   HLIN     PHA   ;           ON ENTRY:
0965:  38        276            SEC   ;             XL: A-REG
0966:  ED 20 03  277            SBC   XOL           XH: X-REG
0969:  48        278            PHA   ;             Y:  Y-REG
096A:  8A        279            TXA
096B:  ED 21 03  280            SBC   XOH
096E:  85 53     281            STA   QDRNT       CALC ABS(X-X0)
0970:  B0 0A     282            BCS   HLIN2         IN (DXL,DXH).
0972:  68        283            PLA
0973:  49 FF     284            EOR   #$FF        X DIR TO SIGN BIT
0975:  69 01     285            ADC   #$1           OF QDRNT.
0977:  48        286            PHA   ;             0=RIGHT (DX POS)
0978:  A9 00     287            LDA   #$0           1=LEFT  (DX NEG)
097A:  E5 53     288            SBC   QDRNT
097C:  85 51     289   HLIN2    STA   DXH
097E:  85 55     290            STA   EH          INIT (EL,EH) TO
0980:  68        291            PLA   ;             ABS (X-X0)
0981:  85 50     292            STA   DXL
0983:  85 54     293            STA   EL
0985:  68        294            PLA
0986:  8D 20 03  295            STA   XOL
0989:  8E 21 03  296            STX   XOH
098C:  98        297            TYA
098D:  18        298            CLC
098E:  ED 22 03  299            SBC   Y0          CALC -ABS(Y-Y0)-1
0991:  90 04     300            BCC   HLIN3         IN DY.
0993:  49 FF     301            EOR   #$FF
0995:  69 FE     302            ADC   #$FE
0997:  85 52     303   HLIN3    STA   DY          ROTATE Y DIR INTO
0999:  8C 22 03  304            STY   Y0            QDRNT SIGN BIT
099C:  66 53     305            ROR   QDRNT        (0=UP, 1=DOWN)
```

```
099E:  38        307            SEC
099F:  E5 50     308            SBC   DXL         INIT (COUNTL, COUNTH)
09A1:  AA        309            TAX   ;             TO -(DELTX, DELTY+1)
09A2:  A9 FF     310            LDA   #$FF
09A4:  E5 51     311            SBC   DXH
09A6:  85 1D     312            STA   COUNTH
09A8:  AC 25 03  313            LDY   HNDX        HORIZ INDEX.
09AB:  B0 05     314            BCS   MOVEX2      ALWAYS TAKEN.
09AD:  0A        315  MOVEX     ASL   ;           MOVE IN X-DIR.  USE
09AE:  20 88 08  316            JSR   LFTRT         QDRNT B6 FOR LFT/RT SET.
09B1:  38        317            SEC
09B2:  A5 54     318  MOVEX2    LDA   EL          ASSUME CARRY SET.
09B4:  65 52     319            ADC   DY          (EL,EH)-DELTY TO (EL,EH)
09B6:  85 54     320            STA   EL          NOTE: DY IS (-DELTY)-1
09B8:  A5 55     321            LDA   EH          CARRY CLR IF (EL,EH)
09BA:  E9 00     322            SBC   #$0           GOES NEG.
09BC:  85 55     323  HCOUNT    STA   EH
09BE:  B1 26     324            LDA   (HBASL),Y   SCREEN BYTE.
09C0:  45 1C     325            EOR   HCOLOR1     PLOT DOT OF HCOLOR1.
09C2:  25 30     326            AND   HMASK       CURRENT BIT MASK.
09C4:  51 26     327            EOR   (HBASL),Y
09C6:  91 26     328            STA   (HBASL),Y
09C8:  E8        329            INX   ;           DONE (DELTX+DELTY)
09C9:  D0 04     330            BNE   HLIN4         DOTS?
09CB:  E6 1D     331            INC   COUNTH
09CD:  F0 6B     332            BEQ   RTS2          YES, RETURN.
09CF:  A5 53     333  HLIN4     LDA   QDRNT       FOR DIRECTION TEST.
09D1:  B0 DA     334            BCS   MOVEX       IF CAR SET, (EL,EH) PLOT
09D3:  20 F9 08  335            JSR   UPDWN          IF CLR, NEG, MOVE (*)
09D6:  18        336            CLC
09D7:  A5 54     337            LDA   EL          (EL,EH)+DELTX
09D9:  65 50     338            ADC   DXL           TO (EL,EH).
09DB:  85 54     339            STA   EL
09DD:  A5 55     340            LDA   EH          CAR SET IF (EL,EH) GOES
09DF:  65 51     341            ADC   DXH           (*)
09E1:  50 D9     342            BVC   HCOUNT      ALWAYS TAKEN.
09E3:  81 82 84  343  MSKTBL    HEX   818284
09E6:  88 90 A0  344            HEX   8890A0
09E9:  C0        345            HEX   C0
09EA:  1C        346  EQ1C      HEX   1C
09EB:  FF FE FA  347  COS       HEX   FFFEFA
09EE:  F4 EC E1  348            HEX   F4ECE1
09F1:  D4 C5 B4  349            HEX   D4C5B4
09F4:  A1 8D 78  350            HEX   A18D78
09F7:  61 49 31  351            HEX   614931
09FA:  18 FF     352            HEX   18FF
               353  *
                    ************************************************
               355  *   HI-RES GRAPHICS COORDINATE RESTORE SUBR
                    ************************************************
               357  *
09FC:  A5 26     358  HFIND     LDA   HBASL       CONVERTS BASE ADDR
09FE:  0A        359            ASL
09FF:  A5 27     360            LDA   HBASH         TO Y-COORD.
0A01:  29 03     361            AND   #$3
0A03:  2A        362            ROL   ;           FOR HBASL=EABAB000
0A04:  05 26     363            ORA   HBASL           HBASH=PPPFGHCD
0A06:  0A        364            ASL
0A07:  0A        365            ASL   ;           GENERATE
0A08:  0A        366            ASL   ;             Y-COORD=ABCDEFGH
```

```
                                WOZPAK II
0A09:  8D 22 03 368             STA   YO
0A0C:  A5 27    369             LDA   HBASH      (PPP=SCREEN PAGE,
0A0E:  4A       370             LSR   ;            NORMALLY 001 FOR
0A0F:  4A       371             LSR   ;            $2000-$3FFF
0A10:  29 07    372             AND   #$7          HI-RES SCREEN)
0A12:  0D 22 03 373             ORA   YO
0A15:  8D 22 03 374             STA   YO         CONVERTS HNDX (INDEX
0A18:  AD 25 03 375             LDA   HNDX         FROM BASE ADR)
0A1B:  0A       376             ASL   ;            AND HMASK (BIT
0A1C:  6D 25 03 377             ADC   HNDX         MASK) TO X-COORD
0A1F:  0A       378             ASL   ;            IN (XOL,XOH)
0A20:  AA       379             TAX   ;            (RANGE $0-133)
0A21:  CA       380             DEX
0A22:  A5 30    381             LDA   HMASK
0A24:  29 7F    382             AND   #$7F
0A26:  E8       383   HFIND1    INX
0A27:  4A       384             LSR
0A28:  D0 FC    385             BNE   HFIND1
0A2A:  8D 21 03 386             STA   XOH
0A2D:  8A       387             TXA
0A2E:  18       388             CLC   ;          CALC HNDX*7 +
0A2F:  6D 25 03 389             ADC   HNDX         LOG(BASE 2) HMASK.
0A32:  90 03    390             BCC   HFIND2
0A34:  EE 21 03 391             INC   XOH
0A37:  8D 20 03 392   HFIND2    STA   XOL
0A3A:  60       393   RTS2      RTS
               394   *
                     ************************************************
               396   *   HI-RES GRAPHICS SHAPE DRAW SUBR
                     ************************************************
               398   *
0A3B:  86 1A    399   DRAW      STX   SHAPEL     DRAW DEFINITION
0A3D:  84 1B    400             STY   SHAPEH       POINTER.
0A3F:  AA       401   DRAW1     TAX
0A40:  4A       402             LSR   ;          ROT ($0-$3F)
0A41:  4A       403             LSR
0A42:  4A       404             LSR   ;          QDRNT 0=UP,1=RT,
0A43:  4A       405             LSR   ;            2=DWN, 3=LFT.
0A44:  85 53    406             STA   QDRNT
0A46:  8A       407             TXA
0A47:  29 0F    408             AND   #$F
0A49:  AA       409             TAX
0A4A:  BC EB 09 410             LDY   COS,X      SAVE COS AND SIN
0A4D:  84 50    411             STY   DXL          VALS IN DXL AND DY.
0A4F:  49 0F    412             EOR   #$F
0A51:  AA       413             TAX
0A52:  BC EC 09 414             LDY   COS+1,X
0A55:  C8       415             INY
0A56:  84 52    416             STY   DY
0A58:  AC 25 03 417   DRAW2     LDY   HNDX       BYTE INDEX FROM
0A5B:  A2 00    418             LDX   #$0          HI-RES BASE ADDR.
0A5D:  8E 2A 03 419             STX   COLLSN     CLEAR COLLISION COUNT.
0A60:  A1 1A    420             LDA   (SHAPEL,X) 1ST. SHAPE DEF BYTE.
0A62:  85 51    421   DRAW3     STA   SHAPEX
0A64:  A2 80    422             LDX   #$80
0A66:  86 54    423             STX   EL         EL,EH FOR FRACTIONAL
0A68:  86 55    424             STX   EH           L,R,U,D VECTORS.
0A6A:  AE 27 03 425             LDX   SCALE      SCALE FACTOR.
0A6D:  A5 54    426   DRAW4     LDA   EL
0A6F:  38       427             SEC   ;          IF FRAC COS OVRFL
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0A70:  65 50     429            ADC   DXL          THEN MOVE IN
0A72:  85 54     430            STA   EL           SPECIFIED VECTOR
0A74:  90 04     431            BCC   DRAW5        DIRECTION.
0A76:  20 D8 08  432            JSR   LRUD1
0A79:  18        433            CLC
0A7A:  A5 55     434   DRAW5    LDA   EH           IF FRAC SIN OVRFL
0A7C:  65 52     435            ADC   DY           THEN MOVE IN
0A7E:  85 55     436            STA   EH           SPECIFIED VECTOR
0A80:  90 03     437            BCC   DRAW6        DIRECTION+90 DEG.
0A82:  20 D9 08  438            JSR   LRUD2
0A85:  CA        439   DRAW6    DEX   ;            LOOP ON SCALE
0A86:  D0 E5     440            BNE   DRAW4        FACTOR.
0A88:  A5 51     441            LDA   SHAPEX
0A8A:  4A        442            LSR   ;            NEXT 3-BIT VECTOR
0A8B:  4A        443            LSR   ;            OF SHAPE DEF.
0A8C:  4A        444            LSR
0A8D:  D0 D3     445            BNE   DRAW3        NOT DONE THIS BYTE.
0A8F:  E6 1A     446            INC   SHAPEL
0A91:  D0 02     447            BNE   DRAW7        NEXT BYTE OF
0A93:  E6 1B     448            INC   SHAPEH       SHAPE DEFINITION.
0A95:  A1 1A     449   DRAW7    LDA   (SHAPEL,X)
0A97:  D0 C9     450            BNE   DRAW3        DONE IF ZERO.
0A99:  60        451            RTS
                 452   *
                       ***********************************************
                 454   *    HI-RES GRAPHICS SHAPE EX-OR SUBR
                       ***********************************************
                 456   *
0A9A:  86 1A     457   XDRAW    STX   SHAPEL       SHAPE DEFINITION
0A9C:  84 1B     458            STY   SHAPEH         POINTER.
0A9E:  AA        459   XDRAW1   TAX
0A9F:  4A        460            LSR
0AA0:  4A        461            LSR
0AA1:  4A        462            LSR
0AA2:  4A        463            LSR
0AA3:  85 53     464            STA   QDRNT
0AA5:  8A        465            TXA
0AA6:  29 0F     466            AND   #$F
0AA8:  AA        467            TAX
0AA9:  BC EB 09  468            LDY   COS,X        SAVE COS AND SIN
0AAC:  84 50     469            STY   DXL            VALS IN DXL AND DY.
0AAE:  49 0F     470            EOR   #$F
0AB0:  AA        471            TAX
0AB1:  BC EC 09  472            LDY   COS+1,X
0AB4:  C8        473            INY
0AB5:  84 52     474            STY   DY
0AB7:  AC 25 03  475   XDRAW2   LDY   HNDX         INDEX FROM HI-RES
0ABA:  A2 00     476            LDX   #$0            BASE ADR.
0ABC:  8E 2A 03  477            STX   COLLSN       CLEAR COLLISION DETECT.
0ABF:  A1 1A     478            LDA   (SHAPEL,X)   1ST SHAPE DEF BYTE.
0AC1:  85 51     479   XDRAW3   STA   SHAPEX
0AC3:  A2 80     480            LDX   #$80
0AC5:  86 54     481            STX   EL           EL,EH FOR FRACTIONAL
0AC7:  86 55     482            STX   EH             L,R,U,D VECTORS.
0AC9:  AE 27 03  483            LDX   SCALE        SCALE FACTOR.
0ACC:  A5 54     484   XDRAW4   LDA   EL
0ACE:  38        485            SEC   ;            IF FRAC COS OVRFL
0ACF:  65 50     486            ADC   DXL            THEN MOVE IN
0AD1:  85 54     487            STA   EL             SPECIFIED VECTOR
0AD3:  90 04     488            BCC   XDRAW5         DIRECTION.
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```
0AD5:  20 C0 08 490            JSR   LRUDX1
0AD8:  18       491            CLC
0AD9:  A5 55    492   XDRAW5   LDA   EH          IF FRAC SIN OVRFL
0ADB:  65 52    493            ADC   DY            THEN MOVE IN
0ADD:  85 55    494            STA   EH            SPECIFIED VECTOR
0ADF:  90 03    495            BCC   XDRAW6        DIRECTION+90 DEG.
0AE1:  20 D9 08 496            JSR   LRUD2
0AE4:  CA       497   XDRAW6   DEX   ;           LOOP ON SCALE
0AE5:  D0 E5    498            BNE   XDRAW4        FACTOR.
0AE7:  A5 51    499            LDA   SHAPEX
0AE9:  4A       500            LSR
0AEA:  4A       501            LSR
0AEB:  4A       502            LSR
0AEC:  D0 D3    503            BNE   XDRAW3
0AEE:  E6 1A    504            INC   SHAPEL
0AF0:  D0 02    505            BNE   XDRAW7      NEXT BYTE OF
0AF2:  E6 1B    506            INC   SHAPEH        SHAPE DEF.
0AF4:  A1 1A    507   XDRAW7   LDA   (SHAPEL,X)
0AF6:  D0 C9    508            BNE   XDRAW3      DONE IF ZERO.
0AF8:  60       509            RTS
               510   *
                     ***********************************************
               512   *    HI-RES GRAPHICS  ENTRY POINTS
               513   *     FROM APPLE ][ INTEGER BASIC
                     ***********************************************
               515   *
0AF9:  20 90 0B 516   BPOSN    JSR   PCOLR       POSN CALL, COLOR FROM
0AFC:  8D 24 03 517            STA   HCOLOR        BASIC.
0AFF:  20 AF 0B 518            JSR   GETYO       YO FROM BASIC.
0B02:  48       519            PHA
0B03:  20 9A 0B 520            JSR   GETXO       XO FROM BASIC.
0B06:  68       521            PLA
0B07:  20 2E 08 522            JSR   HPOSN
0B0A:  AE 23 03 523            LDX   BXSAV
0B0D:  60       524            RTS
0B0E:  20 F9 0A 525   BPLOT    JSR   BPOSN       PLOT CALL (BASIC).
0B11:  4C 7D 08 526            JMP   HPLOT1
0B14:  AD 25 03 527   BLIN1    LDA   HNDX        SET HCOLOR1 FROM
0B17:  4A       528            LSR
0B18:  20 90 0B 529            JSR   PCOLR         BASIC VARI COLR.
0B1B:  20 75 08 530            JSR   HPOSN3
0B1E:  20 9A 0B 531   BLINE    JSR   GETXO       LINE CALL, GET XO
0B21:  8A       532            TXA   ;             FROM BASIC.
0B22:  48       533            PHA
0B23:  98       534            TYA
0B24:  AA       535            TAX
0B25:  20 AF 0B 536            JSR   GETYO       YO FROM BASIC.
0B28:  A8       537            TAY
0B29:  68       538            PLA
0B2A:  20 64 09 539            JSR   HLIN
0B2D:  AE 23 03 540            LDX   BXSAV
0B30:  60       541            RTS
0B31:  20 90 0B 542   BGND     JSR   PCOLR       BACKGROUND CALL.
0B34:  4C 10 08 543            JMP   BKGND0
               544   *
                     ***********************************************
               546   *  HI-RES GRAPHICS DRAW SUBRS
                     ***********************************************
               548   *
0B37:  20 F9 0A 549   BDRAW1   JSR   BPOSN
```

```
                                WOZPAK II
0B3A:  20 51 0B 551   BDRAW    JSR   BDRAWX     DRAW CALL FROM BASIC.
0B3D:  20 3B 0A 552            JSR   DRAW
0B40:  AE 23 03 553            LDX   BXSAV
0B43:  60       554            RTS
0B44:  20 F9 0A 555   BXDRW1   JSR   BPOSN
0B47:  20 51 0B 556   BXDRAW   JSR   BDRAWX     EX-OR DRAW
0B4A:  20 9A 0A 557            JSR   XDRAW        FROM BASIC.
0B4D:  AE 23 03 558            LDX   BXSAV
0B50:  60       559            RTS
0B51:  8E 23 03 560   BDRAWX   STX   BXSAV      SAVE FOR RTS TO BASIC.
0B54:  A0 32    561            LDY   #$32
0B56:  20 92 0B 562            JSR   PBYTE      SCALE FROM BASIC.
0B59:  8D 27 03 563            STA   SCALE
0B5C:  A0 28    564            LDY   #$28
0B5E:  20 92 0B 565            JSR   PBYTE      ROT FROM BASIC &
0B61:  48       566            PHA   ;            SAVE ON STACK.
0B62:  AD 28 03 567            LDA   SHAPXL
0B65:  85 1A    568            STA   SHAPEL     START OF
0B67:  AD 29 03 569            LDA   SHAPXH       SHAPE TABLE.
0B6A:  85 1B    570            STA   SHAPEH
0B6C:  A0 20    571            LDY   #$20
0B6E:  20 92 0B 572            JSR   PBYTE      SHAPE FROM BASIC.
0B71:  F0 39    573            BEQ   RERR1
0B73:  A2 00    574            LDX   #$0
0B75:  C1 1A    575            CMP   (SHAPEL,X) > NUMBR OF SHAPES?
0B77:  F0 02    576            BEQ   BDRWX1
0B79:  B0 31    577            BCS   RERR1      YES, RANGE ERROR.
0B7B:  0A       578   BDRWX1   ASL
0B7C:  90 03    579            BCC   BDRWX2
0B7E:  E6 1B    580            INC   SHAPEH
0B80:  18       581            CLC
0B81:  A8       582   BDRWX2   TAY   ;          SHAPE# * 2.
0B82:  B1 1A    583            LDA   (SHAPEL),Y
0B84:  65 1A    584            ADC   SHAPEL
0B86:  AA       585            TAX   ;          ADD 2-BYTE INDEX
0B87:  C8       586            INY   ;            TO SHAPE TABLE
0B88:  B1 1A    587            LDA   (SHAPEL),Y   START ADDRESS
0B8A:  6D 29 03 588            ADC   SHAPXH       (X LOW, Y HI).
0B8D:  A8       589            TAY
0B8E:  68       590            PLA   ;          ROT FROM STACK.
0B8F:  60       591            RTS
               592   *
                     ***********************************************
               594   *    HI-RES GRAPHICS BASIC
               595   *    PARAMETER FETCH SUBRS
                     ***********************************************
               597   *
0B90:  A0 16    598   PCOLR    LDY   #$16
0B92:  B1 4A    599   PBYTE    LDA   (LOMEML),Y
0B94:  D0 16    600            BNE   RERR1      GET BASIC PARAM.
0B96:  88       601            DEY   ;            (ERR IF >255)
0B97:  B1 4A    602            LDA   (LOMEML),Y
0B99:  60       603   RTSB     RTS
0B9A:  8E 23 03 604   GETXO    STX   BXSAV      SAVE FOR RTS TO BASIC.
0B9D:  A0 05    605            LDY   #$5
0B9F:  B1 4A    606            LDA   (LOMEML),Y XO LOW-ORDER BYTE
0BA1:  AA       607            TAX
0BA2:  C8       608            INY
0BA3:  B1 4A    609            LDA   (LOMEML),Y XO HI-ORDER BYTE
0BA5:  A8       610            TAY
```

WOZPAK II

```
0BA6:  E0 18     612            CPX   #$18
0BA8:  E9 01     613            SBC   #$1         RANGE ERR IF >279.
0BAA:  90 ED     614            BCC   RTSB
0BAC:  4C 68 EE  615  RERR1     JMP   RANGERR
0BAF:  A0 0D     616  GETYO     LDY   #$D         OFFSET TO YO FROM LOMEM.
0BB1:  20 92 0B  617            JSR   PBYTE       GET BASIC PARAM YO.
0BB4:  C9 C0     618            CMP   #$C0          (ERR IF >191).
0BB6:  B0 F4     619            BCS   RERR1
0BB8:  60        620            RTS
                 621  *
                      ***********************************************
                 623  *   HI-RES GRAPHICS SHAPE
                 624  *      TAPE LOAD SUBR.
                      ***********************************************
                 626  *
0BB9:  8E 23 03  627  SHLOAD    STX   BXSAV       SAVE FOR RTS TO BASIC.
0BBC:  20 1E F1  628            JSR   ACADR       READ 2-BYTE LENGTH INTO
0BBF:  20 FD FE  629            JSR   READ          BASIC ACC ($CE,CF).
0BC2:  A9 00     630            LDA   #<SHSTRT
0BC4:  85 3C     631            STA   A1L
0BC6:  8D 28 03  632            STA   SHAPXL
0BC9:  18        633            CLC
0BCA:  65 CE     634            ADC   ACL
0BCC:  A8        635            TAY
0BCD:  A9 0C     636            LDA   #>SHSTRT
0BCF:  85 3D     637            STA   A1H
0BD1:  8D 29 03  638            STA   SHAPXH
0BD4:  65 CF     639            ADC   ACH
0BD6:  B0 25     640            BCS   MFULL1      NOT ENOUGH MEMORY!
0BD8:  C4 CA     641            CPY   PPL
0BDA:  48        642            PHA
0BDB:  E5 CB     643            SBC   PPH
0BDD:  68        644            PLA
0BDE:  B0 1D     645            BCS   MFULL1
0BE0:  84 3E     646            STY   A2L
0BE2:  85 3F     647            STA   A2H
0BE4:  C8        648            INY
0BE5:  D0 02     649            BNE   SHLOD1
0BE7:  69 01     650            ADC   #$1
0BE9:  84 4A     651  SHLOD1    STY   LOMEML
0BEB:  85 4B     652            STA   LOMEMH
0BED:  84 CC     653            STY   PVL
0BEF:  85 CD     654            STA   PVH
0BF1:  20 FA FC  655            JSR   RD2BIT
0BF4:  A9 03     656            LDA   #$3         .5 SEC HEADER
0BF6:  20 02 FF  657            JSR   READX1
0BF9:  AE 23 03  658            LDX   BXSAV
0BFC:  60        659            RTS
0BFD:  4C 6B E3  660  MFULL1    JMP   MEMFULL
```

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PRODUCING AND USING SHAPE TABLES

by Robert C. Clardy

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One of the most versatile graphics capabilities of the APPLE][is provided by the use of the DRAW and XDRAW routines in the HIRES graphics package provided by the APPLE company. Each of these two functions can be used to draw (virtually instantaneously) a predefined shape onto the HIRES screen. The XDRAW function has the additional characteristic that each point is exclusive-ORed to points already on the screen at that location. Each dot has it's previous color reversed. A dot which was previously white becomes black, orange becomes green, etc.

The exclusive-OR feature has several useful effects. A shape can be XDRAWN once, then erased by XDRAWing it again at the same location. Further, a shape can be XDRAWN on a background picture and then erased, leaving the original picture intact. This feature can be used to move cars/tanks/spaceships across a background display without disturbing it. A good example that many have seen is the STAR WARS program; the crosshairs are not disturbed even when a fighter moves over them.

To use the draw functions, the following steps must be taken:

(1) Load the HIRES graphics routines
(2) Obtain a shape file (255 shapes max) by:
    (a) Loading existent shape table
    (b) Creating a shape table
(3) Initialize the HIRES variables properly (see previous section).
(4) Specify SHAPE, COLR, XO, YO, and SCALE as required (see previous section).
(5) Draw the shape (Use CALL 2871 or CALL 2884. See previous section).

Each of these steps will be discussed in greater detail below.

There are several versions of the HIRES graphics routines available. The easiest to use are found in the HIRES SUBROUTINES program appearing in the previous section. These routines can be appended to an INTEGER BASIC program using the PACK & SAVE routine also appearing in this issue. Once run, it stores the HIRES routines in memory locations 2048-3071 ($800-$8FF) and sets LOMEM to 3072. Remember that the HIRES screen is stored in locations 8192-16383 ($2000-$3FFF). Set HIMEM:8192 or LOMEM:16384 so your program does not interfere with the HIRES display.

With the HIRES routines loaded, you can load a shape table from cassette by typing CALL 3001, starting your recorder, and pressing return. To load from disk, simply BLOAD <filename>,A<address>. You must then store the table's starting address in locations 808 and 809 by doing: POKE 808,<address> MOD 256 and POKE 809, <address> / 256.

If you do not have an existent shape table, you can make one with the program listed below. The program is completely self prompting, allowing the user to draw up to 255 shapes per shape table. Each shape is produced point by point. The total bytes used by each shape and the total number of memory locations used by the entire table is constantly displayed. Make certain that the table does not go beyond location 4150 (LOMEM for the program as written).

The program, as is, will run on a 16K APPLE. The room allocated for shapes is, however, rather small (see Table 1). If additional shape storage is required, it can be obtained by deleting lines 1630 through 1700 and line 0. As can be seen in the table, this gives 710 additional bytes for shapes. If your system has more than 16K, delete lines 0 and 1.

WARNING: Because of the nature of the HIRE routines, you cannot move the HIRES cursor up more than 2 units with the plot turned off. If this is done, the shape will be terminated at that point.

TABLE 1

OPTION	SYSTEM	HIMEM	LOMEM	SHAPE BYTE
1	16K	8192	4150	1078
2	16K	8192	4860	1788
3	>16K	**	16384	**

** Limited by system size.

(ed.note) This program contains 'illegal' commands. If the user is unfamiliar with the methods to enter a 'LOMEM:' into a program, the required LOMEM: must be entered before the program is run. (The version on the tape is as listed)

WOZPAK II

```
 0 LOMEM:4150: HIMEM:8192: GOTO
   8
 1 LOMEM:4860: HIMEM:8192: GOTO
   8
 2 LOMEM:16384
 8 XO=YO=COLR=SHAPE=ROT=SCALE:
   SHAPE=1: POKE 808,0: POKE 809
   ,12: GOTO 1615
10 V= PEEK (-16384): IF V<128 THEN
   10: POKE -16368,0: RETURN
11 CALL -936: PRINT : TAB 15: RETURN

31 BYTE=0: CALL INIT:PFLAG=0:YO=
   79:XO=139:COLR=255: GOSUB 800

36 PT=3072+2*SHAPE:LOC=3072+ PEEK
   (PT)+256* PEEK (PT+1):LOC1=
   LOC
38 VTAB 22: TAB 34: PRINT "ON "
   ;: POKE 50,63: PRINT "OFF":
    POKE 50,255
50 GOSUB 10
100 IF V=213 THEN 200: IF V=196
    THEN 250: IF V=210 THEN 300
   : IF V=204 THEN 350: IF V=208
    THEN 400: IF V=134 THEN 1090
   : IF V=151 THEN 31
150 GOTO 50
200 YO=OLDY-1:A=4: IF PFLAG=0 THEN
   A=0: GOTO 360
250 YO=OLDY+1:A=6: IF PFLAG=0 THEN
   A=2: GOTO 360
300 XO=OLDX+1:A=5: IF PFLAG=0 THEN
   A=1: GOTO 360
350 XO=OLDX-1:A=7: IF PFLAG=0 THEN
   A=3
360 GOSUB 1000: GOSUB 800: GOTO
   50
400 PFLAG= NOT PFLAG: IF PFLAG=
   0 THEN 410
402 VTAB 22: TAB 34: POKE 50,63
   : PRINT "ON";: POKE 50,255:
    PRINT " OFF": GOTO 50
410 VTAB 22: TAB 34: POKE 50,255
   : PRINT "ON ";: POKE 50,63:
    PRINT "OFF": POKE 50,255: GOTO
   50
800 IF YO<0 THEN YO=0: IF YO>159
    THEN YO=159: IF XO<0 THEN
   XO=0: IF XO>279 THEN XO=279

805 IF PFLAG=0 THEN 820:COLR=255

810 CALL PLOT: GOTO 840
820 COLR=0:T1=XO:T2=YO:XO=OLDX:
   YO=OLDY: CALL PLOT:XO=T1:YO=
   T2
830 COLR=255: CALL PLOT
840 OLDX=XO:OLDY=YO: RETURN

1000 F=0:D=D+1:D(D)=A: IF D<3 THEN
     RETURN
1005 IF D(3)#0 THEN 1010
1006 F=1: GOTO 1030
1010 IF D(3)<4 THEN 1030
1020 Q=D(3):D(3)=0
1030 Z=D(1)+D(2)*8+D(3)*64
1035 BYTE=BYTE+1: VTAB 22: PRINT
     "BYTES=";BYTE: PRINT "LOC  ="
     ;LOC
1040 POKE LOC,Z:LOC=LOC+1: IF LOC>
     LOW-2 THEN 1490: IF F=1 THEN
     1050
1045 IF Q=0 THEN 1070
1050 IF D(2)#0 THEN 1060
1055 D(1)=0:D(2)=Q:D(3)=0:Q=0:D=
     2: RETURN
1060 D(1)=Q:D(2)=0:D(3)=0:Q=0:D=
     1: RETURN
1070 FOR I=1 TO 3:D(I)=0: NEXT I:
     D=0: RETURN
1090 Z=D(1)+D(2)*8+D(3)*64: POKE
     LOC,Z
1100 IF Z=0 THEN 1120
1110 LOC=LOC+1: POKE LOC,0
1120 PRINT "VECTOR TABLE: FROM "
     ;LOC1;" TO ";LOC
1300 COLR=255:XO=139:YO=79:SCALE=
     1: CALL INIT: CALL DRAW
1310 PRINT "IS THIS THE SHAPE THAT YO
     U WANT (Y/N)?": GOSUB 10: IF
     V#206 THEN 1320: GOSUB 11: PRINT
     "TRY AGAIN.": GOTO 31
1320 GOSUB 11: PRINT "ANOTHER SHAPE (
     Y/N)?": GOSUB 10: CALL -936
     : IF V=206 THEN 1500
1330 GOSUB 11: PRINT "SHAPE # ";
     SHAPE+1:SHAPE=SHAPE+1
1340 IF SHAPE>SH THEN 1490:LOC=LOC+
     1: POKE 3072+2*SHAPE,(LOC MOD
     256): POKE 3073+2*SHAPE,(LOC/
     256)-12: GOTO 31
1490 GOSUB 11: PRINT "SORRY, SHAPE TA
     BLE IS FULL."
1500 PRINT "SAVE SHAPE TABLE TO TAPE
     (Y/N)?": GOSUB 10: IF V#217
      THEN 1550: PRINT "START RECORDE
     R AND PRESS RETURN": GOSUB
     10
1510 POKE 4140,(LOC-3071) MOD 256
     : POKE 4141,(LOC-3071)/256:
      POKE 60,44: POKE 61,16: POKE
     62,45: POKE 63,16: CALL -307

1520 POKE 60,0: POKE 61,12: POKE
     62,LOC MOD 256: POKE 63,LOC/
     256: CALL -307
```

WOZPAK II

```
1550 PRINT "SAVE SHAPE TABLE TO DISC
     (Y,N)?": GOSUB 10: IF V#217
      THEN END : INPUT "FILE NAME "
     ,F$
1560 PRINT "BSAVE";F$;",A3072,L"
     ;LOC-3072+5: END
1601 POKE 808,0: POKE 809,12: POKE
     3072,50: POKE 3074,102: POKE
     3075,0
1615 DIM F$(20),D(3):INIT=2048:CLEAR=
     2062:PLOT=2830:DRAW=2871
1620 TEXT : CALL -936: VTAB 10: TAB
     6: PRINT "HIRES SHAPE TABLE GENE
     RATOR": PRINT : TAB 10: PRINT
     "BY ROBERT C. CLARDY"
1625 FOR I=1 TO 1000: NEXT I
1630 VTAB 14: PRINT "THIS PROGRAM WAS
      ADAPTED FROM A SIMILAR ROUTINE
     WRITTEN BY GARY D. HAWKINS AS IT
     ";
1640 PRINT "APPEARED IN THE JULY, 197
     8 ISSUE OF     CREATIVE COMPUTIN
     G. THE PROGRAM WAS"
1650 PRINT "MODIFIED TO RUN WITH THE
     UPDATED HIRES  ROUTINES AND TO A
     LLOW DIFINITION OF"
1660 PRINT "MULTIPLE SHAPES. TO USE T
     HE PROGRAM,    USE THE FOLLOWING
      COMMANDS:"
1670 PRINT : TAB 6: PRINT "U = MOVE U
     P ONE SPACE": TAB 6: PRINT
     "D = MOVE DOWN ONE SPACE": TAB
     6: PRINT "R = MOVE RIGHT ONE SPA
     CE"
1680 TAB 6: PRINT "L = MOVE LEFT ONE
     SPACE": TAB 6: PRINT "P = INVERT
      POINT STATUS": TAB 6: PRINT
     "CONTROL W = START OVER (WIPE)"
     : TAB 6
1690 PRINT "CONTROL F = SHAPE IS FINI
     SHED": PRINT : PRINT "IF POINT S
     TATUS IS 'ON', A POINT WILL"

1700 PRINT "BE PLOTTED. IF IT IS 'OFF
     ', IT WON'T.   PRESS ANY KEY TO
     BEGIN.";: GOSUB 10: POKE 34
     ,21: CALL -936
1705 INPUT "HOW MANY SHAPES DO YOU WA
     NT (LIMIT 255)",SH: IF SH<0
      OR SH>255 THEN 1705: POKE
     808,0: POKE 809,12: POKE 3072
     ,SH
1710 POKE 3074,(2*SH+2) MOD 256:
      POKE 3075,(2*SH+2)/256:LOW=
     256* PEEK (75)+ PEEK (74): CALL
     -936: GOTO 31
```

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SWEET 16 Introduction
by Dick Sedgewick

Sweet 16 is probably the least used and least understood seed in the Apple][.

In exactly the same sense that Integer and Applesoft Basics are languages, Sweet 16 is a language. Compared to the Basics, however, it would be classed as a low level language, with a strong likeness to conventional 6502 Assembly language.

To use Sweet 16, you must learn the language - and to quote "WOZ", "The op code list is short and uncomplicated". "WOZ", of course is Mr. Apple, and the creator Sweet 16.

Sweet 16 is ROM based in every Apple][from $F689 to $F7FC, and is listed in the Red Book on pages 96-99. it has its own op codes and instruction sets, and uses the SAVE and RESTORE routines from the Apple Monitor to preserve the 6502 registers when in use, allowing Sweet 16 to be used as a subroutine.

It uses the first 32 locations on zero page to set up its 16 double byte registers, and is therefore not compatible with Applesoft Basic without some additional efforts.

The original article, "Sweet 16: The 6502 Dream Machine", first appeared in Byte Magazine, November 1977 and later in the original "WOZ PAK". this article is included again as text material to help understand the use and implementation of Sweet 16.

Additionally, a trivial introductory program is included to encourage the timid to dive in, and then Andy Hertzfeld's program 'Lazarus' is reprinted from Dr. Dobbs, Volume 3, Issue 6. Lazarus is an exceptional program written to resurrect lost Integer Basic programs, and Andy's outstanding commentary allows Lazarus to do double duty as text material.

More recent examples of the use of Sweet 16 are found in the Programmer's Aid #1, in the Renumber, Append, and Relocate programs. The Programming Aid Operating Manual contains complete source assembly listings, indexed on page 65.

Finally, the friendly help of the CALL-A.P.P.L.E. Group is available to hand-hold and counsel your adventures with Sweet 16.

The demonstration program is written to be introductory and simple, consisting of three parts:

1. Integer Basic Program
2. Machine Language Subroutine
3. Sweet 16 Subroutine

The task of the program will be to move data. Parameters of the move will be entered in the Integer Basic Program.

The "CALL 768" ($300) at line 120, enters a 6502 machine language subroutine having the single purpose of entering a Sweet 16 subroutine and subsequently returning to Basic (addresses $300,$301,$302, and $312 respectively). The Sweet 16 subroutine of course performs the move, and is entered at hex locations $303 to $311 (see listing Number 3).

After the move, the screen will display three lines of data, each 8 bytes long, and await entry of a new set of parameters. The three lines of data displayed on the screen are as follows:

Line 1: The first 8 bytes of data starting at $800, which is the fixed source of data to be moved (in this case, the string a$).

Line 2: The first 8 bytes of data starting at the hex addrss entered as the destination of the move (high order byte only).

Line 3: The first 8 bytes of data starting at $0000 (the first four Sweet 16 registers).

The display of 8 bytes of data was chosen to simply the illustration of what goes on.

Integer Basic has it's own way of recording the string A$ (see page 35 in the "Red Book"). Because the name chosen for the string "A$" is stored in 2 bytes, a total of 5 housekeeping bytes precedes the data entered as A$, leaving only 3 additional bytes available for display. Integer Basic also adds a housekeeping byte at the end of a string, known as the "string terminator". Consequently, for the purposes of the convience of the dis-

play, and to to see the string terminator as the 8th byte, the string data entered via the keyboard should be limited to two characters, and will appear as the 6th and 7th bytes. Additionally, parameters to be entered include the number of bytes to be moved. A useful range for this demonstration would be 1-8 inclusive, but of course 1-255 will work.

Finally, the starting address of the destination of the move must be entered. Again, for simplicity, the high order byte only is entered, and the program allows a choice between Decimal 9 and the H.O.B. of program pointer 1, to avoid unnecessary problems (in this demonstration enter a decimal number betweeen dec 9 and 144 for a 48K APPLE).

The 8 bytes of data displayed from $00 will enable one to observe the condition of the Sweet 16 registers after a move has been accomplished, and thereby understand how the Sweet 16 program works.

From the text article "Sweet 16: The 6502 Dream Machine", it will be remembered that Sweet 16 can establish 16 double byte registers, starting at $00. That means that Sweet 16 can use the first 32 addresses on zero page.

The "events" occurring in this demonstration program can be studied in the first 4 Sweet 16 registers, therefore the 8 byte display starting at $0000 is large enough, for this purpose. These 4 registers are established as R0, R1, R2, and R3:

```
R0  $0000  &  0001--Sweet 16 accumulator
R1  $0002  &  0003--Source address
R2  $0004  &  0005--Destination address
R3  $0006  &  0007--No. of bytes to move
.
.
.
R14 $001C  &  001D--Prior result register
R15 $001E  &  001F--Sweet 16 prgm counter
```

Additionally, an examination of registers R14 and R15 will extend an understanding of Sweet 16, being fully explained in the "WOZ" text. Notice that the HOB of R14, (located at $1D) contains $06, which is the doubled register specification (3X2 $06). R15, the Sweet 16 program counter contains the address of the next operation, (as it did for each step during execution of the program), which was $0312 when execution ended, and 6502 machine code resumes.

To try a sample run, enter the Integer basic program as shown in Listing #1. Of course, REM statements can be omitted, and line 10 is only helpful if the machine code is to be stored on disk.

The Listing #2 must also be entered starting at $300.

Note that a 6502 disassembly does not look like Listing #3, but Andy Hertzfeld's Sweet 16 disassembler would create a correct disassembly.

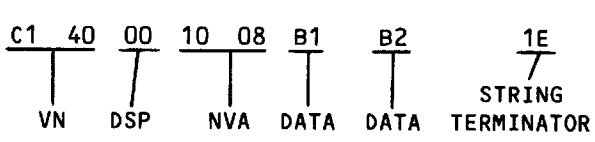
```
Enter RUN and RETURN
Enter  12  and  hit RETURN (A$ - A$ string
                                    data)
Enter  8  and  hit RETURN (number of bytes
                                 to be moved)
Enter  10  and hit RETURN (high order byte
                                 of destination)
```

The display should appear as follows:

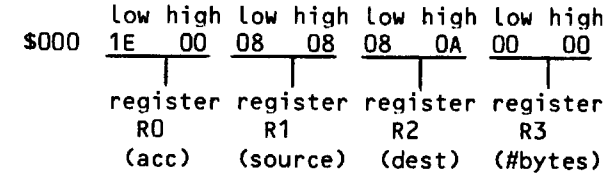
```
$0800-C1 40 00 10 08 B1 B2 1E (SOURCE)
$0A00-C1 40 00 10 08 B1 B2 1E (DEST.)
$0000-1E 00 08 08 08 0A 00 00 (Sweet 16)
```

Note that the 8 bytes stored at $0A00 are identical to the 8 bytes starting at $0800, indicating an accurate move of 8 bytes length has been made. It will be seen that they were moved one byte at a time starting with token C1 and ending with token 1E (if moving less than 8 bytes, the data following the moved data would be whatever exists at those locations before the move).

The bytes have the following significance, as defined on page 35 of the "Red Book":



The Sweet 16 registers are shown:



The low order byte of R0, the Sweet 16 accumulator, has $1E in it, which was the last byte moved, (the 8th).

The low order byte of the source register R1 started as $00 and was incremented eight times, one for each byte of moved data.

The high order byte of the destination register R2 contains $0A, which was entered as 10 (the variable A) and poked into the Sweet 16 code. The LOB of R2 was incremented exactly like R1.

Finally, register R3, the register that stores the number of bytes to be moved had been poked to 8 (the variable B) and decremented 8 times as each byte got moved, there by ending up $0000.

By entering character strings and varying the number of bytes to moved, the Sweet 16 registers can be observed and in fact, the contents predicted.

Working with this demonstration program, and study of the text material will soon enable the writing of Sweet 16 programs to perform additional 16 bit manipulations. The unassigned op codes mentioned in the WOZ "Dream Machine" article should present a most interesting opportunity to "play".

Sweet 16 as a language---or tool---opens a new direction to Apple][owners without spending a dime, and it's been there all the time.

For "Appelites" who desire to learn machine language programming, Sweet 16 can be used as a starting point. Having less op codes to learn and excellent text material to use, one could be effective very soon. Enjoy....

LISTING #1

```
 10 PRINT "BLOAD SWEET"
 20 CALL -936: DIM A$(10)
 30 INPUT "ENTER STRING A$";A$
 40 INPUT "ENTER # BYTES ";B
 50 IF B=0 THEN 40: REM AT LEAST 1
 60 POKE 778,B: REM POKE LENGTH
 70 INPUT "ENTER DESTINATION";A
 80 IF A>PEEK (203)-1 THEN 70
 90 IF A<PEEK (205)+1 THEN 70
100 POKE 776,A: REM POKE DESTINATION
110 M=8: GOSUB 160: REM DISPLAY
120 CALL 768: REM GOTO $0300
130 M=A: GOSUB 160: REM DISPLAY
140 M=0: GOSUB 160: REM DISPLAY
150 PRINT: PRINT: GOTO 30
160 POKE 60,0: POKE 61,M
170 CALL-605: RETURN
```

LISTING #2

Enter code as follows:

```
                                    A     B
300:20 89 F6 11 00 08 12 00 [00] 13 [00] 41 52
    F3 07 FB 00 60
```

LISTING #3

```
Sweet 16

$300  20 89 F6  JSR $F689

$303  11 00 08  SET R1 source address

$306  12 00 [00]  SET R2 destination address
                A
$309  13 [00] 00  SET R3 length
          B
$30C  41        LD @ R1

$30D  52        ST @ R2

$30E  F3        DCR R3

$30F  07 FB     BNZ $30C

$311  00        RTN

$312  60        RTN
```

Data will be poked from the Integer Basic program - "A" from Line 100
"B" from Line 60

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SWEET 16 - THE 6502 DREAM MACHINE

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WOZPAK II

While writing APPLE BASIC for a 6502 microprocessor I repeatedly encountered a variant of MURPHY'S LAW. Briefly stated, any routine operating on 16-bit data will require at least twice the code that it should. Programs making extensive use of 16-bit pointers (such as compilers, editors, and assemblers) are included in this category. In my case, even the addition of a few double-byte instructions to the 6502 would have only slightly alleviated the problem. What I really needed was a 6502/RCA 1800 hybrid - a powerful 8-bit data handler complemented by an easy to use processor with an abundance of 16-bit registers and excellent pointer capability. My solution was to implement a non-existent (meta) 16-bit processor in software, interpreter style, which I call SWEET 16.

SWEET 16 is based on sixteen 16-bit registers (R0-R15), actually 32 memory locations. R0 doubles as the SWEET 16 accumulator (ACC), R15 as the program counter (PC), and R14 as the status register. R13 holds compare instruction results and R12 is the subroutine return stack pointer if SWEET 16 subroutines are used. All other SWEET 16 registers are at the user's unrestricted disposal.

SWEET 16 instructions fall into register and non-register categories. The register ops specify one of the sixteen registers to be used as either a data element or a pointer to data in memory depending on the specific instruction. For example INR R5 uses R5 as data and ST @R7 uses R7 as a pointer to data in memory. Except for the SET instruction, register ops take 1 byte of code each. The non-register ops are primarily 6502 style branches with the second byte specifying a +/-127 byte displacement relative to the address of the following instruction. Providing that the prior register op result meets a specified branch condition, the displacement is added to SWEET 16 PC, effecting a branch.

SWEET 16 is intended as a 6502 enhancement package, not a stand-alone processor. A 6502 program switches to SWEET 16 mode with a subroutine call and subsequent code is interpreted as SWEET 16 instructions. The non-register op RTN returns the user program to 6502 mode after restoring the internal register contents (A, X, Y, P, and S). The following example illustrates how to use SWEET 16.

```
300 B9 00 02        LDA IN,Y    get a char.
303 C9 CD           CMP "M"     "M" for move
305 D0 09           BNE NOMOVE  No, skip
                                  move
307 20 89 F6        JSR SW16    Yes, call
                                SWEET 16
30a 41        MLOOP LD  @R1     R1 holds
                                source addr.
30B 52              ST  @R2     R2 holds
                                dest. addr.
30C F3              DCR R3      Decr. length
30D 07 FB           BNZ MLOOP   Loop until
                                done
30F 00              RTN         Return to
                                6502 mode.
310 C9 C5     MLOOP CMP "E"     "E" char?
312 D0 13           BEQ EXIT      Yes, exit
314 C8              INY           No, cont.
```

Note: Registers A, X, Y, P, and S are not disturbed by SWEET 16.

INSTRUCTION DESCRIPTIONS

The SWEET 16 opcode list is short and uncomplicated. Excepting relative branch displacements, hand assembly is trivial. All register opcodes are formed by combining two hex digits, one for the opcode and one to specify a register. For example, opcodes 15 and 45 both specify register R5 while codes 23, 27 and 29 are all ST ops. Most register ops are assigned in complementary pairs to facilitate remembering them. Thus LD and ST are opcodes 2N and 3N respectively, while LD @ and ST @ are codes 4N and 5N.

Opcodes 0 to C (hex) are assigned to the thirteen non-register ops. Except for RTN (opcode 0), BK (0A), and RS (B), the non-register ops are 6502 style branches. branches. The second byte of a branch instruction contains a +/-127 byte displacement value (in two's complement form) relative to the address of the instruction immediately following the branch. if a specified branch condition is met by the prior register op result, the displacement is added to the PC effecting a branch. Except for BR (Branch always) and BS (Branch to Subroutine), the branch opcodes are assigned in complementary pairs, rendering them easily remembered for hand coding. For example, Branch if Plus and Branch if Minus are opcodes 4 and 5 while

WOZPAK II

Branch if Zero and Branch if NonZero are opcodes 6 and 7.

SWEET 16 OPCODE SUMMARY

REGISTER OPS

1n	SET	Rn, Constant	(Set)
2n	LD	Rn	(Load)
3n	ST	Rn	(Store)
4n	LD	@Rn	(Load Indirect)
5n	ST	@Rn	(Store Indirect)
6n	LDD	@Rn	(Load Double Indirect)
7n	STD	@Rn	(Store Double Indirect)
8n	POP	@Rn	(Pop Indirect)
9n	STP	@Rn	(Store Pop Indirect)
An	ADD	Rn	(Add)
Bn	SUB	Rn	(Sub)
Cn	POPD	@Rn	(Pop Double Indirect)
Dn	CPR	Rn	(Compare)
En	INR	Rn	(Increment)
Fn	DCR	Rn	(Decrement)

NON-REGISTER OPS

00	RTN		(Return to 6502 mode)
01	BR	ea	(Branch always)
02	BNC	ea	(Branch if No Carry)
03	BC	ea	(Branch if Carry)
04	BP	ea	(Branch if Plus)
05	BM	ea	(Branch if Minus)
06	BZ	ea	(Branch if zero)
07	BNZ	ea	(Branch if NonZero)

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NON-REGISTER OPS (continued)

08	BM1	ea	(Branch if Minus 1)
09	BNM1	ea	(Branch if Not Minus 1)
0A	BK		(Break)
0B	RS		(Return from Subroutine)
0C	BS	ea	(Branch to Subroutine)
0D			(Unassigned)
0E			(Unassigned)
0F			(Unassigned)

REGISTERS OPS

SET Rn, Constant [1n] [Low] [High] (Set)

The 2-byte constant is loaded into Rn (n=0 to F, hex) and branch conditions set accordingly. The carry is cleared.

EXAMPLE

```
15 34 A0    SET R5,A034    R5 now contains A034
```

LD Rn [2n] (Load)

The ACC (R0) is loaded from Rn and branch conditions set according to the data transferred. The carry is cleared and contents of Rn are not disturbed.

EXAMPLE

```
15 34 A0    SET R5,A034
24          LD  R5     ACC now contains A034
```

ST Rn [3n] (Store)

The ACC is stored into Rn and branch conditions set according to the data transferred. The carry is cleared and the ACC contents are not disturbed.

EXAMPLE

```
25      LD  R5   Copy the contents of
36      ST  R6     of R5 to R6.
```

LD @Rn [4n] (Load indirect)

The low-order ACC byte is loaded from the memory location whose address resides in Rn and the high-order ACC byte is cleared. Branch conditions reflect the final ACC contents which will always be positive and never minus 1. The carry is cleared. After the transfer, Rn is incremented by 1.

EXAMPLE

```
15 34 A0   SET R5,A034
45         LD  @R5      ACC is loaded
                          from memory
                         location A034
                          R5 is incre-
                         mented to A034
```

ST @Rn [5n] (Store indirect)

The low-order ACC byte is stored into the memory location whose address resides in Rn. Branch conditions reflect the 2-byte ACC contents. The carry is cleared. After the transfer Rn is incremented by 1.

EXAMPLE

```
15 34 A0   SET  R5, A034   Load point-
                           ers R5 & R6
16 22 90   SET  R6, 9022   with A034
                           and 9022.
45         LD   @R5        Move a byte
                           from A034
                           to 9022.
56         ST   @R6        Both point-
                           ers are in-
                           cremented.
```

LDD @Rn [6n] (Load double-byte indirect)

The low order ACC byte is loaded from the memory location whose address resides in Rn and Rn is then incremented by 1. The high order ACC byte is loaded from the memory location whose address resides in the incremented Rn and Rn is again incremented by 1. Branch conditions reflect the final ACC contents. The carry is cleared.

EXAMPLE

```
15 34 A0   SET R5, A034
65         LDD @R5   The low-order
                     ACC byte is
                     loaded from
                     location A034,
                     the high-order
                     byte from A035.
                     R5 is incr. to
                     A036.
```

STD @Rn [7n] (Store double-byte indirect)

The low-order ACC byte is stored into memory location whose address resides in Rn and Rn is then incremented by 1. The high-order ACC byte is stored into the memory location whose address resides in the incremented Rn and Rn is again incremented by 1. Branch conditions reflect the ACC contents which are not disturbed. The carry is cleared.

EXAMPLE

```
15 34 A0   SET R5, A034   Load point-
                          ers R5 & R6
16 22 90   Set R6, 9022   with A034
                          and 9022.
65         STD @R6        Move double
                          byte from
76         STD @R6        A034 & A035
                          to 9022 and
                          9023. both
                          pointers
                          are incr.
                          by 2.
```

POP @Rn [8n] (Pop indirect)

The low order ACC byte is loaded from the memory location whose address resides in Rn after Rn is decremented by 1 and the high order ACC byte is cleared. Branch conditions reflect the final 2-byte ACC contents which will always be positive and never minus 1. The carry is cleared. Because Rn is decremented prior to loading the ACC, single byte stacks may be implemented with the ST @Rn and POP @Rn ops (Rn is the stack pointer).

EXAMPLE

```
15 34 A0   SET R5, A034   Init stack
                          pointer
10 04 00   SET R0, 4      Load 4 into
                          ACC
35         ST @R5         Push 4 onto
                          stack.
```

```
10 05 00    SET R0, 5      Load 5 into
                           ACC
35          ST @R5         Push 5 onto
                           stack
10 06 00    SET R0, 6      Load 6 into
                           ACC
35          ST @R5         Push 6 onto
                           stack
85          POP @R5        Pop 6 off
                           stack into
                           ACC
85          POP @R5        Pop 5 off
                           stack
85          POP @R5        Pop 4 off
                           stack
```

STP @Rn [9n] (STORE POP indirect)

The low order ACC byte is stored into the memory location whose address resides in Rn after Rn is decremented by 1. Then the high-order ACC is stored into the memory location whose address resides in Rn after Rn is again decremented by 1. Branch conditions will reflect the 2-byte ACC contents which are not modified. STP @Rn and POP @Rn are used together to move data blocks beginning at the greatest address and working down. Additionally, single-byte stacks may be implemented with the STP @Rn ops.

EXAMPLE

```
14 34 A0    SET R4, A034   Init pntrs.
15 22 90    SET R5, 9022
84          POP @R4        Move byte
                           from A033
95          STP @R5        to 9021
84          POP @R4        Move byte
                           from A032
95          STP @R5        to 9020
```

ADD Rn [An] (Add)

The contents of Rn are added to the contents of the ACC (R0) and the low-order 16 bits of the sum restored in ACC. The 17th sum bit becomes the carry and other branch conditions reflect the final ACC contents.

EXAMPLE

```
10 34 76    SET R0, 7634   Init R0(ACC)
11 27 42    SET R1, 4227   and R1
A1          ADD R1         Add R1 (sum=
                           B85B, carry
                           clear)
A0          ADD R0         Double ACC
                           (R0) to 70B6
                           with carry
                           set.
```

SUB Rn [Bn] (Subtract)

The contents of Rn are subtracted from the ACC contents by performing a two's complement addition:

ACC = ACC + Rn +1

The low order 16 bits of the subtraction are restored in the ACC. The 17th sum bit becomes the carry and other branch conditions reflect the final ACC contents. If the 16-bit unsigned ACC contents are greater than or equal to the 16-bit unsigned Rn contents then the carry is set, otherwise it is cleared. Rn is not disturbed.

EXAMPLE

```
10 34 76    SET R0, 7634   Init R0(ACC)
11 27 42    SET R1, 4227   and R1
A1          SUB R1         Subtract R1
                           (diff = 340D
                           with carry
                           set)
A0          SUB R0         Clears ACC
                           (R0)
```

POPD @Rn [Cn] (Pop Double-byte indirect)

Rn is decremented by 1 and the high-order ACC byte is loaded from the memory location whose address now resides in Rn. Rn is again decremented by 1 and the low-order ACC byte is loaded from the corresponding memory location. Branch conditions reflect the final ACC contents. The carry is cleared. Because Rn is decremented prior to loading each of the ACC halves, double-byte stacks may be implemented with the STD @Rn and POPD @Rn ops (Rn is the stack pointer).

EXAMPLE

```
15 34 A0    SET  R5, A034  Init stack
                           pointer
10 12 AA    SET  R0, AA12  Load AA12
                           into ACC
75          STD @R5        Push AA12
                           onto stack
```

```
10 34 BB     SET  R0, BB34   Load BB34
                             into ACC
75           STD @R5         Push BB34
                             onto stack
10 56 CC     SET  R0, CC56   Load CC56
                             into ACC
C5           POPD @R5        Pop CC56
                             off stack
```

CPR Rn [Dn] (Compare)

The ACC (R0) contents are compared to Rn by performing the 16-bit binary subtraction ACC-Rn and storing the low order 16 difference bits in R13 for subsequent branch tests. If the 16-bit unsigned ACC contents are greater than or equal to the 16-bit unsigned Rn contents then the carry is set, otherwise it is cleared. No other registers, including ACC and Rn are disturbed.

EXAMPLE

```
15 34 A0     SET  R5, A034   Pointer to
                             memory.
16 BF A0     SET  R6, A0BF   Limit
                             address.
10 00 00 LOOP SET R0, 0      Zero data.
75           STD @R5         Clear 2
                             locs, incr
                             R5 by 2.
25           LD   R5         Compare
                             pointer R5
D6           CPR  R6         to limit
                             R6.
02 F8        BNC  LOOP       Loop if
                             carry
                             clear.
```

INR Rn [En] (Increment)

The contents of Rn are incremented by 1. The carry is cleared and other branch conditions reflect the incremented value.

EXAMPLE

```
15 34 A0     SET  R5, A034   (Pointer)
10 00 00     SET  R0, 0      Zero to R0
55           ST   @R5        Clears loc
                             A034 and
                             incrs R5
                             to A034
E5           INR  R5         Incr R5 to
                             A036.
55           ST   @R5        Clears loc
                             A036 (not
                             A035)
```

DCR Rn [Fn] (Decrement)

The contents of Rn are decremented by 1. The carry is cleared and other branch conditions reflect the decremented value.

EXAMPLE (Clear 9 bytes beginning at location A034)

```
15 34 A0     SET  R5, A034   Init pointer.
14 09 00     SET  R4, 9      Init count.
10 00 00     SET  R0, 0      Zero ACC
55     LOOP  ST   @R5        Clear a mem
                             byte.
F4           DCR  R4         Decr.count.
07 FC        BNZ  LOOP       Loop until
                             zero.
```

NON-REGISTER INSTRUCTIONS

RTN [00] (Return to 6502 mode)

Control is returned to the 6502 and program execution continues at the location immediately following the RTN instruction. The 6502 registers and status conditions are restored to their original contents (prior to entering SWEET 16 mode).

BR ea [01] [d] (Branch always)

An effective address (ea) is calculated by adding the signed displacement byte (d) to the PC. The PC contains the address of the instruction immediately following the BR, or the address of the BR op plus 2. The displacement is a signed twos complement value from -128 to +127. Branch conditions are not changed.

Note that the effective address calculation is identical to that for 6502 relative branches. The hex add & subtract features of the APPLE][monitor may be used to calculate displacements.

```
d = $80   ea = PC + 2 - 128
d = $81   ea = PC + 2 - 127

d = $FF   ea = PC + 2 - 1
d = $00   ea = PC + 2 + 0
d = $01   ea = PC + 2 + 1

d = $7E   ea = PC + 2 +126
d = $7F   ea = PC + 2 +127
```

EXAMPLE
$300: 01 50 BR $352

BNC ea [02][d] (Branch if No Carry)

A branch to the effective address is taken only if the carry is clear, otherwise execution resumes as normal with the next instruction. Branch conditions are not changed.

BC ea [03][d] (Branch if Carry set)

A branch is effected only if the carry is set. Branch conditions are not changed.

BP ea [04][d] (Branch if Plus)

A branch is effected only if the prior 'result' (or most recently transferred data) was positive. Branch conditions are not changed.

EXAMPLE (Clear mem from A034 to A03F)

```
15 34 A0        SET  R5,  A034   Init
                                 pointer
14 3F A0        SET  R4, A03F    Init
                                 limit.
10 00 00 LOOP   SET  R0, 0
55              ST   @R5         Clear
                                 mem
                                 byte,
                                 incr R5
24              LD   R4          Compare
                                 limit
D5              CPR  R5          to ptr.
04 F8           BP   LOOP        Loop
                                 until
                                 done.
```

BM ea [05][d] (Branch if Minus)

A branch is effected only if prior 'result' was minus (negative, MSB=1). Branch condtions are not changed.

BZ ea [06][d] (Branch if Zero)

A branch is effected only if the prior 'result' was zero. branch conditions are not changed.

BNZ ea [07][d] (Branch if NonZero)

A branch is effected only if the prior 'result' was non-zero. Branch conditions are not changed.

BM1 ea [08][d] (Branch if Minus 1)

A branch is effected only if the prior 'result' was minus 1 ($FFFF hex). Branch conditions are not changed.

BNM1 ea [09][d] (Branch if Not Minus 1)

A branch is effected only if the prior 'result' was not minus 1 ($FFFF hex). Branch conditions are not changed.

BRK [0A] (break)

A 6502 BRK (break) instruction is execution. SWEET 16 may be reentered nondestructively at SW16D after correcting the stack pointer to its value prior to executing the BRK.

RS [0B] (Return from SWEET 16 subroutine)

RS terminates execution of a SWEET 16 subroutine and returns to the Sweet 16 calling program which resumes execution (in SWEET 16 mode). R12, which is the SWEET 16 subroutine return stack pointer, is decremented twice. Branch conditions are not changed.

BS ea [0C] d (Branch to SWEET 16 Subroutine)

A branch to the effective address (PC +2 +d) is taken and execution is resumed in SWEET 16 mode. The current PC is pushed onto a 'SWEET 16 subroutine return address' stack whose pointer is R12, and R12 is incremented by 2. The carry is cleared and branch conditions set to indicate the current ACC contents.

EXAMPLE (Calling a 'memory move' subroutine to move A034-A03B

```
          to 3000-3007)

300: 14 34 A0     SET  R5, A034  Init
                                 ptr 1.
303: 14 3B A0     SET  R4, A03B  Init
                                 limit 1
306: 16 00 30     SET  R6, 3000  Init
                                 ptr 2.
309: 0C 15        BS   MOVE      Call
                                 move
                                 subrtn.
       .
       .
       .
320: 45    MOVE   LD   @R5      Move one
321: 56           ST   @R6      byte
322: 24           LD    R4
323: D4           CPR  R5       Test if
                                 done.
324: 04 FA        BP   MOVE     Return.
326: 0B           RS
```

THEORY OF OPERATION

SWEET 16 execution mode begins with a subroutine call to SW16. The user must insure that the 6502 is in hex mode upon entry. All 6502 registers are saved at this time, to be restored when a SWEET 16 RTN instruction returns control to the 6502. If you can tolerate indefinite 6502 register contents upon exit, approximately 30 usec may be saved by entering at SW16 + 3. Because this might cause an inadvertant switch from hex to decimal mode, it is advisable to enter at SW16 the first time through.

After saving the 6502 registers, SWEET 16 initializes its PC (R15) with the subroutine return address off the 6502 stack. SWEET 16's PC points to the location preceding the next instruction to be executed. Following the subroutine call are 1-, 2-, and 3-byte SWEET 16 instructions, stored in ascending memory locations like 6502 instructions. The main loop at SW16B repeatedly calls the 'execute instruction' routine at SW16C which examines on opcode for type and branches to the appropriate subroutine to execute it.

Subroutine SW16C increments the PC (R15) and fetches the next opcode, which is either a register op of the form OP REG with OP between 1 and 15 or a non-register op of the form 0 OP with OP between 0 and 13. Assuming a register op, the register specification is doubled to account for the 3-byte SWEET 16 registers and placed in the X-reg for indexing. Then the instruction type is determined. Register ops place the doubled register specification in the high order byte of R14 indicating the 'prior result register' to subsequent branch instructions. Non-register ops treat the register specification (right-hand half-byte) as their opcode, increment the SWEET 16 PC to point at the displacement byte of branch instructions, load the A-reg with the 'prior' result register' index for branch condition testing, and clear the Y-reg.

WHEN IS AN RTS REALLY A JSR?

Each instruction type has a corresponding subroutine. The subroutine entry points are stored in a table which is directly indexed into by the opcode. By assigning all the entries to a common page, only a single byte of address need be stored per routine. The 6502 indirect jump might have been used as follows to transfers control to the appropriate subroutine.

```
LDA  #ADRH     High-order byte.
STA  IND+1
LDA  OPTBL,X   Low-order byte.
STA  IND
JMP  (IND)
```

To save code the subroutine entry address (minus 1) is pushed onto the stack, high-order byte first. A 6502 RTS (ReTurn from Subroutine) is used to pop the address off the stack and into the 6502 PC (after incrementing by 1). The net result is that the desired subroutine is reached by executing a subroutine return instruction!

OPCODE SUBROUTINES

The register op routines make use of the 6502 'zero page indexed by X' and 'indexed by X indirect' addressing modes to access the specified registers and indirect data. The 'result' of most registers ops is left in the specified register and can be sensed by subsequent branch instructions since the register specification is saved in the high-order byte of R14. This specification is changed to indicate R0 (ACC) for ADD and SUB instructions and R13

for the CPR (compare) instruction.

Normally the high-order R14 byte holds the 'prior result register' index times 2 to account for the 2-byte SWEET16 registers and thus the LSB is zero. If ADD, SUB, or CPR instructions generate carries, then this index is incremented, setting the LSB.

The SET instruction increments the PC twice, picking up data bytes in the specified register. In accordance with 6502 convention, the low-order data byte precedes the high-order byte.

Most SWEET 16 nonregister ops are relative branches. The corresponding subroutines determine whether or not the 'prior result' meets the specified branch condition and if so update the SWEET 16 PC by adding the displacement value (-128 to +127 bytes).

The RTN op restores the 6502 register contents, pops the subroutine return stack and jumps indirect through the SWEET 16 PC. this transfers control to the 6502 at the instruction immediately following the RTN instruction.

The BK op actually executes a 6502 break instruction (BRK), transferring control to the interrupt handler.

Any number of subroutine levels may be implemented within SWEET 16 code via the BS (Branch to Subroutine) and RS (Return from Subroutine) instructions. The user must initialize and otherwise not disturb R12 if the SWEET 16 subroutine capability is used since it is utilized as the automatic subroutine return stack pointer.

MEMORY ALLOCATION

The only storage that must be allocated for SWEET 16 variables are 32 consecutive locations in page zero for the SWEET 16 registers, four locations to save the 6502 register contents, and a few levels of the 6502 subroutine return address stack. If you don't need to preserve the 6502 register contents, delete the SAVE and RESTORE subroutines and the corresponding subroutine calls. This will free the four page zero locations ASAV, XSAV, YSAV, and PSAV.

USER MODIFICATIONS

You may wish to add some of your own instructions to this implementation of SWEET 16. If you use the unassigned opcodes $0E and $0F, remember that SWEET 16 treats these as 2-byte instructions. you may wish to handle the break instruction as a SWEET 16 call, saving two bytes of code each time you transfer into SWEET 16 mode. Or you may wish to use the SWEET 16 BK (Break) op as a 'CHAROUT' call in the interrupt handler. You can perform absolute jumps within SWEET 16 by loading the ACC (R0) with the address you wish to jump to (minus 1) and executing a ST R15 instruction.

LAZARUS

A Program to Resurrect BASIC Programs
on the APPLE][Computer

By Andy Hertzfeld
Reprinted from Dr. Dobb's Journal of
Computer Calisthenics & Orthodontia,
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Many unfortunate souls have experienced the frustration which occurs when you realize that you have just accidently erased the program that you were working on. Kicking the computer may provide some emotional satisfaction, but it won't bring your program back. This article describes Lazarus, a short machine language program which can resurrect inadvertantly erased BASIC programs on the APPLE][computer.

When an APPLE][BASIC program is erased, it is usually not destroyed. It is probably still sitting around somewhere in memory; however, the BASIC interpreter no longer knows where to find it, so it is effectively lost. Lazarus scans through memory trying to find the largest valid BASIC program that it can. If it finds one it resets the interpreter's pointers to point to the found program, thereby resurrecting it. If no valid program can be found an error message is printed. In either case, control is returned to the BASIC interpreter.

Of course, things are not quite this simple. If there are many program fragments floating around the workspace, Lazarus might not resurrect the one you are interested in. If you had performed some deletions of low-numbered statements prior to the erasure, Lazarus may restore the deleted lines along with the rest of the program. If your program was located in an unusual part of memory, Lazarus may not know where to look for it. Finally, it is possible but unlikely that Lazarus could introduce spurious statements at the beginning and end of the resuscitated program. In practice these problems are rare; Lazarus should be successful most of the time.

THE DETAILS

To understand how Lazarus works, you must first know something about the internal representation of an APPLE][integer BASIC program. We will examine this briefly here; for a more detailed exposition, see Steve Wozniak's article in Dr. Dobb's #23 (vol. 3, issue 3) or the APPLE reference material, when they finally get around to putting it out (the current reference manual isn't very helpful).

The BASIC "workspace" is the area of memory used to store the currently active BASIC program and its associated variables. On the APPLE][, it is defined by two zero-page pointers: LOMEM, which points to the lowest address's byte in the workspace and HIMEM, which points one past the highest. Program statements are placed into memory starting at HIMEM, and are pushed down as each successive statement is entered. Another pointer called PP (for program pointer) is used to point to the first, lowest numbered statement. PP decreases as the program grows; a program is erased by setting PP to HIMEM. Thus, all Lazarus has to do is scan memory from LOMEM to HIMEM and isolate the beginning and end of the longest BASIC program residing there. To accomplish the resurrection, it simply stores the address of the start of the program into HIMEM.

As each line of the BASIC program is entered, it is translated into a compact internal form consisting of four parts. First there is a length byte indicating the total length of the statement. It is followed by a 2-byte line number, low order byte first. Next comes a string of code syllables or tokens which make up the body of the statement. Finally, there is a special end-of-statement token ($01) at the end of every statement.

Knowing this information, it is not too hard to find a BASIC program segment; simply scan through memory searching for an end-of-statement token. When one is found, we can check if it ends a statement by examining length bytes. The fact that the statement's line numbers must be in ascending order is used to perform an additional validity check. The program segment ends as soon as this structure is violated.

There may be valid fragments floating around the workspace (like pieces of the Star Trek program you played an hour ago); Lazarus will resurrect the largest one, since that is usually the one we are interested in. Since that is not always the one we want, another entry point is provided that causes the last segment (which tends to be the most recent program worked on) to be chosen.

Lazarus was implemented using SWEET 16, a very useful little 16-bit virtual machine that is interpreted by the APPLE-][firmware. SWEET 16 saves a lot of code at the expense of a significantly longer execution time. Since Lazarus does a lot of 16-bit operations, SWEET 16 was able to spare me a large amount of tedious coding. (See Wozniak's article elsewhere in this volume for a detailed description of SWEET 16).

USING LAZARUS

The code for Lazarus is relocatable since all of its branches are relative and the only local storage it uses is in page zero. $300 seems to be a convenient place to load it. You can load it for the first time by going into the monitor mode and typing:

```
300: A9 FF D0 02 A9 00 85 F0
308: 85 F1 20 89 F6 B0 3A E0
310: 35 13 04 00 16 4A 00 17
318: 4C 00 66 36 32 67 37 22
320: D7 03 59 42 D5 07 F8 22
328: F0 38 39 E8 48 D3 02 18
330: A9 34 44 D5 07 12 27 D4
338: 05 0E 24 F0 39 68 31 E4
340: 64 D1 05 04 29 38 01 E3
348: 22 F0 34 D9 06 D1 F4 F4
350: F4 11 05 00 84 D1 06 0D
358: E1 10 FF 00 D1 02 C0 24
360: D6 05 BC 01 EF 29 32 E2
368: B4 31 18 F0 00 68 06 04
370: 21 DA 02 AB 21 3A 24 3B
378: 29 3C 01 A3 2A 06 11 11
380: CA 00 2B 71 11 4C 00 2C
388: E0 71 00 20 3A FF 4C 03
390: E0 00 20 2D FF 4C 03 E0
```

Once it has been manually loaded, it can be saved by typing "300.3A0W" and then subsequently loaded back in by typing "300.3A0R". (Editor's note: For disk save and load, use "BSAVE LAZARUS, A$300,L$A0" and "BLOAD LAZARUS", respectively).

Lazarus is very easy to use. After cursing yourself out a few times for accidently erasing your program, return to monitor and load Lazarus. Then return to BASIC and type "CALL 768" or "CALL 772". The former will cause the longest program segment in the workspace to be restored; the latter will cause the last to be selected. When it returns, do a "LIST" to see what is found. If nothing could be dredged up, an error message is printed. If both entry points recover the wrong program, you can adjust LOMEM and HIMEM accordingly and try again. If all else fails, you can still always kick the computer.

A useful extension to Lazarus would be to recover the variable table along with the program, which could be very important in some cases. I would like to thank Bruce Tognazzini for providing the initial idea for this program.

A complete source listing follows...

```
                                WOZPAK II
                        ************************************************
                    4   *  LAZARUS SOURCE LISTING
                        ************************************************
                    6   LOMEM     EQU  $4A
                    7   HIMEM     EQU  $4C
                    8   PP        EQU  $CA
                    9   BASIC     EQU  $E000
                    10  BELL      EQU  $FF3A
                    11  ERR       EQU  $FF2D
                    12  SW16      EQU  $F689      SWEET 16 ENTRY
                    13  **** SWEET 16 EQUATES ****
                    14  4         EQU  4
                    15  5         EQU  5
                    16  F0        EQU  $F0
                    17  FF        EQU  $FF
                    18  R0        EQU  $0
                    19  R1        EQU  $1         AUXILIARY
                    20  R2        EQU  $2         MAIN SCAN POINTER
                    21  R3        EQU  $3         CONTAINS $4 FOR COMPARISON
                    22  R4        EQU  $4         AUXILARY; BACKWARDS SCAN POINTER
                    23  R5        EQU  $5         CONTAINS $1 FOR COMPARISONS
                    24  R6        EQU  $6         LOMEM
                    25  R7        EQU  $7         HIMEM
                    26  R8        EQU  $8         USED IN FORWARD SCAN
                    27  R9        EQU  $9         USED IN FORWARD SCAN
                    28  R10       EQU  10         MAXIMUM SIZE FOUND SO FAR
                    29  R11       EQU  11         PP OF MAX SEGMENT
                    30  R12       EQU  12         HIMEM OF MAX SEGMENT
                    31  *
                    32            ORG  $300
                    33  *
0300: A9 FF         34            LDA  #$FF       SET FLAG TO ALL ONES
0302: D0 02         35            BNE  STORE      ALWAYS TAKEN.
0304: A9 00         36            LDA  #$00       SET FLAG TO ALL ZEROS.
0306: 85 F0         37  STORE     STA  $F0
0308: 85 F1         38            STA  $F1        SET THE SWITCH AT $F0
                    39  *
                    40  * INITIALIZE REGISTERS, ETC.
                    41  *
030A: 20 89 F6      42            JSR  SW16
030D: B0            43            SUB  R0         ZERO THE ACCUMULATOR
030E: 3A            44            ST   R10        ZERO MAX SIZE.
030F: E0            45            INR  R0
0310: 35            46            ST   R5         SET R5 TO 1.
0311: 13 04 00      47            SET  R3,4       SET R3 TO 4.
0314: 16 4A 00      48            SET  R6,LOMEM   GET ADDRESS OF LOMEM.
0317: 17 4C 00      49            SET  R7,HIMEM   HIMEM, TOO.
031A: 66            50            LDD  @R6
031B: 36            51            ST   R6         SET R6 TO LOMEM.
031C: 32            52            ST   R2         INITIALIZE SCAN PTR. THERE, TOO.
031D: 67            53            LDD  @R7
031E: 37            54            ST   R7         SET R7 TO HIMEM.
                    55  *
                    56  *  THE MAIN LOOP STARTS HERE.  WE
                    57  *  SCAN FOR AN END-OF-STATMENT TOKEN ($01).
                    58  *
031F: 22            59  MAINLOOP  LD   R2         TEST TO SEE IF WE'RE PAST
0320: D7            60            CPR  R7           HIMEM; IF WE ARE, WE ARE
0321: 03 59         61            BC   ALLDONE      FINALLY DONE.
0323: 42            62            LD   @R2        PICK UP THE NEXT BYTE.
```

WOZPAK II

```
0324: D5          64            CPR  R5        IS IT THE EOS TOKEN?
0325: 07 F8       65            BNZ  MAINLOOP  IF ITS NOT, CONTINUE THE SCAN.
0327: 22          66            LD   R2        INITIALIZE R8 & R9
0328: F0          67            DCR  R0          TO POINT TO THE
0329: 38          68            ST   R8          END-OF-STATMENT TOKEN.
032A: 39          69            ST   R9
                  70  *
                  71  *  AT THIS POINT A CANDIDATE FOR A STATMENT
                  72  *  HAS BEEN FOUND.  THE FOLLOWING LOOP PERFORMS
                  73  *  VALIDITY CHECKS ON SUCCESSIVE STATMENTS
                  74  *  UNTIL AN INVALID ONE IS FOUND OR HIMEM IS
                  75  *  REACHED.  R9 POINTS TO THE LAST BYTE OF
                  76  *  THE MOST RECENT VALID STATMENT.
                  77  *
032B: E8          78  CHKLOOP   INR  R8        BUMP R8 TO THE NEW LENGTH BYTE
032C: 48          79            LD   @R8       PICK UP THE LENGTH BYTE.
032D: D3          80            CPR  R3        MAKE SURE ITS GREATER THAN 4.
032E: 02 18       81            BNC  INVALID   IF ITS NOT, ITS INVALID.
0330: A9          82            ADD  R9
0331: 34          83            ST   R4        R4 NOW HOLDS THE END ADDRESS.
0332: 44          84            LD   @R4       PICK UP THE LAST BYTE OF STATMENT.
0333: D5          85            CPR  R5        IT BETTER BE AN EOS TOKEN.
0334: 07 12       86            BNZ  INVALID   IF ITS NOT, ITS INVALID.
                  87  *
                  88  *  AT THIS POINT, R8 POINTS ONE PAST THE BEGINNING OF A
                  89  *  VALID STATMENT AND R4 POINTS TO THE START OF THE NEXT,
                  90  *  POSSIBLY VALID ONE.  WE PERFORM LINE NO. VALIDITY CHECKS
                  91  *  AND TEST AGAINST HIMEM.
                  92  *
0336: 27          93            LD   R7        PICK UP HIMEM AND SEE IF
0337: D4          94            CPR  R4          WE'VE PASSED IT.
0338: 05 0E       95            BM   INVALID   IF WE HAVE, ITS INVALID.
033A: 24          96            LD   R4
033B: F0          97            DCR  R0        ITS VALID, SO MARK IT
033C: 39          98            ST   R9          IN R9.
033D: 68          99            LDD  @R8       PICK UP THE LINE NUMBER OF THE
033E: 31         100            ST   R1          OLD LINE AND SAVE IN R1.
033F: E4         101            INR  R4
0340: 64         102            LDD  @R4       PICK UP THE NEWER LINE NUMBER
0341: D1         103            CPR  R1          AND COMPARE IT WITH THE OLDER ONE.
0342: 05 04      104            BM   INVALID   IF NEW IS LESS THAN OLD, ITS NO GOOD.
0344: 29         105            LD   R9        THE STATMENT'S OK SO
0345: 38         106            ST   R8          UPDATE R8 WITH R9.
0346: 01 E3      107            BR   CHKLOOP   GO EXAMINE THE NEXT STATMENT.
                 108  *
                 109  * AT THIS POINT, WE HAVE REACHED THE END OF A VALID
                 110  * PROGRAM SEGMENT;
                 111  *  R9 POINTS TO THE LAST BYTE OF THE LAST VALID STATMENT
                 112  *  R2 POINTS ONE PAST THE LAST BYTE OF THE FIRST VALID STATMENT
                 113  *  IF R2=R9+1, WE DIDN'T FIND ANYTHING
                 114  *
0348: 22         115  INVALID   LD   R2        POINT R4 TO THE LAST BYTE OF
0349: F0         116            DCR  R0          OF THE LAST VALID STATMENT.
034A: 34         117            ST   R4
034B: D9         118            CPR  R9        IF R9=R4 THEN NOTHING WAS FOUND
034C: 06 D1      119            BZ   MAINLOOP    SO FORGET IT AND GO CONTINUE SCAN.
034E: F4         120            DCR  R4
034F: F4         121            DCR  R4        SUBTRACT 3 FROM R4 TO PREPARE
0350: F4         122            DCR  R4          FOR THE BACKWARD SCAN.
0351: 11 05 00   123            SET  R1,5      R1 WILL HOLD THE TENTATIVE LENGTH.
```

WOZPAK II

```
                        125  *
                        126  * IN THE FOLLOWING LOOP WE SCAN BACK, SEARCHING FOR THE
                        127  * BEGINNING OF THE SEGMENT'S INITIAL STATMENT.
                        128  *
0354: 84                129  SCANLOOP  POP   @R4        PICK UP THE NEXT BYTE.
0355: D1                130            CPR   R1         COMPARE WITH THE LENGTH COUNT.
0356: 06 0D             131            BZ    DONE       IF THEY'RE EQUAL, WE'RE DONE.
0358: E1                132            INR   R1         INCREMENT R1 FOR THE NEXT ITERATION.
0359: 10 FF 00          133            SET   R0,FF      TEST IF WE'VE GONE 256 BYTES.
035C: D1                134            CPR   R1         IF WE HAVE, ITS TOO LONG
035D: 02 C0             135            BNC   MAINLOOP     SO GIVE UP THE SEGMENT.
035F: 24                136            LD    R4         MAKE SURE LOMEM ISN'T PASSED.
0360: D6                137            CPR   R6
0361: 05 BC             138            BM    MAINLOOP   IF IT HAS, GIVE UP.
0363: 01 EF             139            BR    SCANLOOP   GO CHECK THE NEXT BYTE.
                        140  *
                        141  *  AT THIS POINT, WE HAVE FOUND A VALID PROGRAM SEGMENT. R4
                        142  *  POINTS TO THE FIRST BYTE OF THE SEGMENT; R9 POINTS TO
                        143  *  THE LAST BYTE.
                        144  *
0365: 29                145  DONE      LD    R9         MAKE R2 POINT PAST THE RECENTLY
0366: 32                146            ST    R2           FOUND SEGMENT TO CONTINUE THE
0367: E2                147            INR   R2           SCAN IN THE MAIN LOOP.
0368: B4                148            SUB   R4         COMPUTE THE LENGTH OF THE SEGMENT
0369: 31                149            ST    R1           AND SAVE IT IN R1.
036A: 18 F0 00          150            SET   R8,F0      GET THE ADDRESS OF THE FLAG.
036D: 68                151            LDD   @R8        LOAD THE FLAG.
036E: 06 04             152            BZ    UPDATE     IF FLAG=0, ALWAYS DO IT.
0370: 21                153            LD    R1         RESTORE THE SIZE
0371: DA                154            CPR   R10          AND COMPARE WITH THE MAX SO FAR.
0372: 02 AB             155            BNC   MAINLOOP   IF ITS SMALLER, WE DON'T WANT IT.
0374: 21                156  UPDATE    LD    R1         RESTORE THE SIZE
0375: 3A                157            ST    R10          AND UPDATE THE MAX SIZE WITH IT.
0376: 24                158            LD    R4
0377: 3B                159            ST    R11        UPDATE THE MAX PP.
0378: 29                160            LD    R9
0379: 3C                161            ST    R12        UPDATE THE MAX HIMEM.
037A: 01 A3             162            BR    MAINLOOP   GO FIND THE NEXT SEGMENT.
                        163  *
                        164  *  WE REACH THIS POINT WHEN THE MAIN LOOP HAS RUN ITS COURSE
                        165  *  (I.E., THE MAIN SCAN POINTER HAS REACHED HIMEM).  SET PP AND
                        166  *  HIMEM APPROPRIATELY AND THEN RETURN TO THE BASIC
                        167  *  INTERPRETER.  PRINT "ERR" IF NOTHING FOUND.
                        168  *
037C: 2A                169  ALLDONE   LD    R10        GET THE SIZE OF WHAT WE FOUND.
037D: 06 12             170            BZ    ERROR      IF ITS ZERO, SIGNAL AN ERROR.
037F: 11 CA 00          171            SET   R1,PP      GET THE ADDRESS OF PP.
0382: 2B                172            LD    R11
0383: 71                173            STD   @R1        SET PP TO START OF PROGRAM.
0384: 11 4C 00          174            SET   R1,HIMEM   GET THE ADDRESS OF HIMEM.
0387: 2C                175            LD    R12
0388: E0                176            INR   R0         INCREMENT IT BY 1.
0389: 71                177            STD   @R1        SET HIMEM TO POINT ONE PAST PROGRAM.
038A: 00                178            RTN   RETURN     TO 6502 MODE.
038B: 20 3A FF          179            JSR   BELL       RING THE BELL TO WAKE UP USER.
038E: 4C 03 E0          180            JMP   BASIC+3    JUMP BACK TO INTERPRETER.
0391: 00                181  ERROR     RTN   RETURN     TO 6502 MODE.
0392: 20 2D FF          182            JSR   ERR        PRINT THE ERROR MESSAGE (& RING BELL)
0395: 4C 03 E0          183            JMP   BASIC+3    RETURN TO THE BASIC INTERPRETER.
```

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FLOATING POINT PACKAGE

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WOZPAK II

The mantissa-exponent, or 'floating point' numerical representation is widely used by computers to express values with a wide dynamic range. With floating point representation, the number 7.5 x 10^22 requires no more memory to store than the number 75 does. We have allowed for binary floating point arithmetic on the APPLE][computer by providing a useful subroutine package in ROM, which prforms the common arithmetic functions. Maximum precision is retained by these routines and overflow conditions such as 'divide by zero' are trapped for the user. The 4-byte floating point number representation is compatible with future APPLE products such as floating point BASIC.

A small amount of memory in Page Zero is dedicated to the floating point workspace, including the two floating-point accumulators, FP1 and FP2. After placing operands in these accumulators, the user calls subroutines in the ROM which perform the desired arithmetic operations, leaving results in FP1. Should an overflow condition occur, a jump to location $3F5 is executed, allowing a user routine to take appropriate action.

FLOATING POINT REPRESENTATION

1. Mantissa
The floating point mantissa is stored in two's complement representation with the sign at the most significant bit (MSB) position of the high-order mantissa byte. The mantissa provides 24 bits of precision, including sign, and can represent 24-bit integers precisely. Extending precision is simply a matter of adding bytes at the low order end of the mantissa.

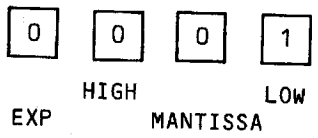
Except for magnitudes less than 2^-128 (which lose precision) mantissa are normalized by the floating point routines to retain maximum precision. That is, the numbers are adjusted so that the upper two high-order mantissa bits are unequal.

HIGH-ORDER MANTISSA BYTE
01.XXXXXX Positive mantissa.
10.XXXXXX Negative mantissa.
00.XXXXXX Unnormalized mantissa,
11.XXXXXX Exponent = -128.

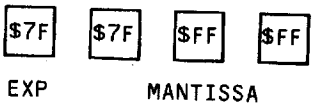
2. Exponent.
The exponent is a binary scaling factor (power of two) which is applied to the mantissa. Ranging from -128 to +127, the exponent is stored in standard two's complement representation except for the sign bit which is complemented. This representation allows direct comparison of exponents, since they are stored in increasing numerical sequence. The most negative exponent, corresponding to the smallest magnitude, -128, is stored as $00 ($ means hexidecimal) and the most positive, +127, is stored as $FF (all ones).

EXPONENT	STORED AS
+1	10000001 ($81)
+2	10000010 ($82)
+3	10000011 ($83)
-1	01111111 ($7F)
-2	01111110 ($7E)
-3	01111101 ($7D)

The smallest magnitude which can be represented is 2^-150.



The largest positive magnitude which can be represented is +2^128-1.



FLOATING POINT REPRESENTATION EXAMPLES

DECIMAL NUMBER	HEX EXPONENT	HEX MANTISSA
+ 3	81	60 00 00
+ 4	82	40 00 00
+ 5	82	50 00 00
+ 7	82	70 00 00
+12	83	60 00 00
+15	83	78 00 00
+17	84	44 00 00
+20	84	50 00 00
+60	85	78 00 00

- 3	81	A0 00 00
- 4	81	80 00 00
- 5	82	B0 00 00
- 7	82	90 00 00
-12	83	A0 00 00
-15	83	88 00 00
-17	84	BC 00 00
-20	84	B0 00 00
-60	85	88 00 00

FLOATING POINT SUBROUTINE DESCRIPTIONS

FCOMPL subroutine (address $F4A4)

Purpose: FCOMPL is used to negate floating point numbers.

Entry: A normalized or unnormalized value is in FP1 (floating point accumulator 1).

Uses: NORM, RTLOG.

Exit: The value in FP1 is negated and then normalized to retain precision. The 3-byte FP1 extension, E, may also be altered but FP2 and SIGN are not disturbed. The 6502 A-REG is altered and the X-REG is cleared. The Y-REG is not disturbed.

Caution: Attempting to negate -2^128 will result in an overflow since +2^128 is not representable, and a jump to location $3F5 will be executed, with the following contents in FP1.

FP1:	0	$80	0	0	
	X1	M1			

Example: Prior to calling FCOMPL, FP1 contains +15.

FP1:	$83	$78	0	0	(+15)
	X1	M1			

After calling FCOMPL as a subroutine, FP1 contains -15.

FP1:	$83	$88	0	0	(-15)
	X1	M1			

FADD subroutine (address $F46E)

Purpose: To add two numbers in floating point form.

Entry: The two addends are in FP1 and FP2 respectively. For maximum precision, both should be normalized.

Uses: SWPALGN, ADD, NORM, RTLOG.

exit: The normalized sum is left in FP1. FP2 contains the addend of greatest magnitude. E is altered but sign is not. The A-REG is altered and the X-REG is cleared. The sum mantissa is truncated to 24 bits.

Caution: Overflow may result if the sum is less that -2^128 or greater than +2^128 -1. If so, a jump to location $3F5 is executed leaving 0 in X1, and twice the proper sum in the mantissa M1. The sign bit is left in the carry, 0 for positive, 1 for negative.

FP1:	0	X.YYY...
	X1	M1

(For carry=0, true sum=+X.YYY...x 2^128)

Example: Prior to calling FADD, FP1 contains +12 and FP2 contains -5.

FP1:	$83	$60	0	0	(+12)
	X1	M1			
FP2:	$82	$80	0	0	(-5)
	X2	M2			

After calling FADD, FP1 contains +7 (FP2 contains +12).

FP1	$82	$70	0	0	(+7)
	X1	M1			

FSUB subroutine (address $F468)

Purpose: To subtract two floating point numbers.

Entry: The minuend is in FP1 and the subtrahend is in FP2. Both should be normalized to retain maximum precision prior to calling FSUB.

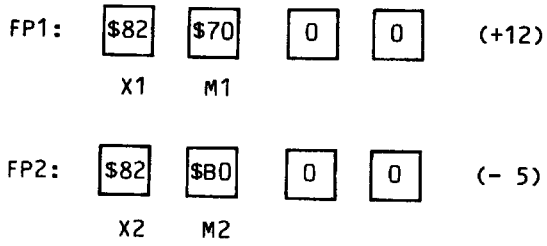
Uses: FCOMPL, ALGNSWP, FADD, ADD, NORM, RTLOG.

Exit: The normalized differnce is in FP1

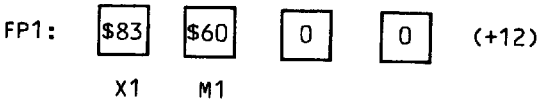
with the mantissa truncated to 24 bits. FP2 holds either the minued or the negated subtrahend, whichever is of greater magnitude. E is altered but SIGN and SCR are not. the A-REG is altered and the X-REG is cleared. The Y-REG is not disturbed.

Cautions: An exit to location $3F5 is taken if the result is less than -2^128 or greater than +2^128-1, or if the subtrahend is -2^128.

Example: Prior to calling FSUB, FP1 contains +7 (minuend) and FP2 contains -5 (subtrahend).



After calling FSUB, FP1 contains +12 and FP2 contains +7.



FMUL subroutine (address $F48C)

Purpose: To multiply floating point numbers.

Entry: The multiplicand and multiplier must reside in FP1 and FP2 respectively. Both should be normalized prior to calling FMUL to retain maximum precision.

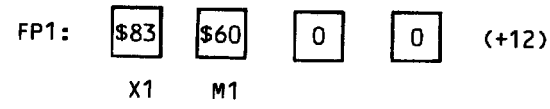
Uses: MD1, MD2, RTLOG1, ADD, MDEND.

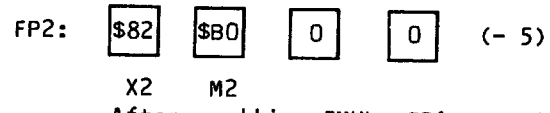
Exit: The signed normalized floating point product is left in FP1. M1 is truncated to contain the 24 most significant mantissa bits (including sign). The absolute value of the multiplier mantissa (M2) is left in FP2. E, SIGN, and SCR are altered. The A- and X-REGs are altered and the Y-REG contains $FF upon exit.

Cautions: An exit to location $3F5 is taken if the product is less than -2^128 or greater than +2^128-1.

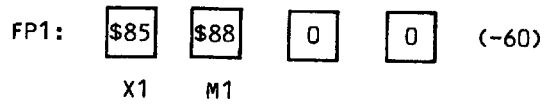
Notes: FMUL will run faster if the absolute value of the multiplier mantissa contains fewer '1's than the absolute value of the multiplicand mantissa.

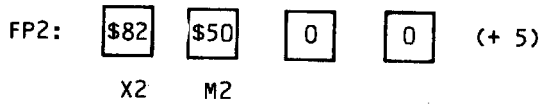
Example: Prior to calling FMUL, FP1 contains +12 and FP2 contains -5.





After calling FMUL, FP1 contains -60 and FP2 contains +5.





FDIV subroutine (address $F4B2)

Purpose: To perform division of floating point numbers.

Entry: The normalized dividend is in FP2 and the normalized divisor is in FP1.

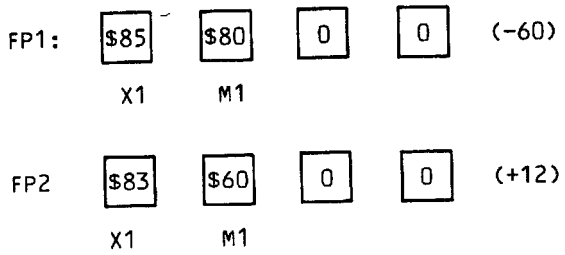
Exit: The signed normalized floating point quotient is left in FP1. The mantissa (M1) is truncated to 24 bits. The 3-bit M1 extension (E) contains the absolte value of the divisor mantissa. MD2, SIGN, and SCR are altered. The A- and X-REGs are altered and the Y-REG is cleared.

Uses: MD1, MD2, MDEND.

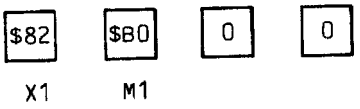
Cautions: An exit to location $3F5 is taken if the quotient is less than -2^128 or greater than +2^128-1

Notes: MD2 contains the remainder mantissa (equivalent to the MOD function). The remainder exponent is the same as the quotient exponent, or 1 less if the dividend mantissa magnitude is less than the divisor mantissa magnitude.

Example: Prior to calling FDIV, FP1 contains -60 (dividend), and FP2 contains +12 (divisor).



After calling FMUL,FP1 contains -5 and M2 contains 0.



FLOAT Subroutine (address $F451)

Purpose: To convert integers to floating point representation.

Entry: A signed (two's complement) 2-byte integer is stored in M1 (high-order byte) and M1+1 (low-order byte). M1+2 must be cleared by user prior to entry.

Uses: NORM1.

Exit: The normalized floating point equivalent is left in FP1. E, FP2, SIGN, and SCR are not disturbed. The A-REG contains a copy of the high-order mantissa byte upon exit but the X- and Y-REGs are not disturbed. The carry is cleared.

Notes: To float a 1-byte integer, place it in M1+1 and clear M1 as well as M1+2 prior to calling FLOAT.

FLOAT takes approximately 3 msec. longer to convert zero to floating point form than other arguments. The user may check for zero prior to calling FLOAT and increase throughput.

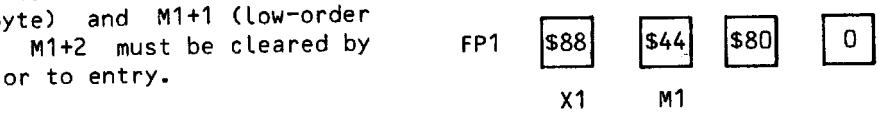
```
                *
                *  LOW-ORDER INT. BYTE IN A-REG
                * HIGH-ORDER BYTE IN Y-REG
                *
85 FA     XFLOAT  STA  M1+1
84 F9             STY  M1     INIT MANT1
A0 00             LDY  #$0
84 FB             STY  M1+2
05 D9             ORA  M1     CHK BOTH
                              BYTES FOR
D0 03             BNE  TOFLOAT  ZERO
85 F8             STA  X1     IF SO CLR X1
60                RTS         AND RETURN
4C 51 F4  TOFLOAT JMP  FLOAT  ELSE FLOAT
                              INTEGER
```

Example: Float +274 ($0112 hex)

CALLING SEQUENCE

```
A0 01             LDY  #$01   HIGH-ORDER
                              INTEGER BYTE
A9 12             LDA  #$12   LOW-ORDER
                              INTEGER BYTE
84 F9             STY  M1
85 FA             STA  M1+1
A9 00             LDA  #$00
85 F8             STA  M1+2
20 51 F4          JSR  FLOAT
```

Upon returning from FLOAT, FP1 contains the floating point representation of +274.



FIX subroutine (address $F640)

Purpose: To extract the integer portion of a floating point number with truncation (ENTIER function).

Entry: A floating point value is in FP1. It need not be normalized.

Uses: RTAR.

Exit: The two-byte signed two's complement representation of the integer portion is left in M1 (high-order byte) and M1+1 (low-order byte). The floating point values +24.63 and -61.2 are converted to the integers

+24 and -61 respectively. FP1 and E are altered but FP2, E, SIGN, and SCR are not. The A- and X-REGs are altered but the Y-REG is not.

Example: The floating point value +274 is in FP1 prior to calling FIX.

FP1: | $88 | $44 | $80 | 0 | (+274)

X1 M1

After calling FIX, M1 (high-order byte) and M1+1 (low-order byte) contain the integer representation of +274 ($0112).

FP1: | $8E | $01 | $12 | 0 |

X1 M1

Note: FP1 contains an unnormalized representation of +274 upon exit.

NORM Subroutine (address $F463)

Purpose: To normalize the value in FP1, thus insuring maximum precision.

Entry: A normalized or unnormalized value is in FP1.

Exit: The value in FP1 is normalized. A zero mantissa will exit with X1=0 (2 exponent). If the exponent on exit is -128 (X1=0) then the mantissa (M1) is not necessarily normalized (with the two high-order mantissa bits unequal). E, FP2, SIGN, AND SCR are not distubed. The A-REG is disturbed but the X- and Y-REGs are not. The carry is set.

Example: FP1 contains +12 in unnormalized form (as .0011 x 2).

FP1: | $86 | $0C | 0 | 0 | (+12)

x1 M1

Upon exit from NORM, FP1 contains +12 in normalized form (as 1.1 x 2).

FP1: | $83 | $60 | 0 | 0 | (+12)

X1 M1

NORM1 subroutine (address $F455)

Purpose: To normalize a floating point value in FP1 when it is known the exponent is not -128 (X1 =0) upon entry.

Entry: An unnormalized number is in FP1. The exponent byte should not be 0 for normal use.

Exit: The normalized value is in FP1. E, FP2, SIGN, and SCR are not not disturbed. The A-REG is altered but the X- and Y-REGs are not.

ADD Subroutine (address $F425)

Purpose: To add the two mantissas (M1 and M2) as 3-byte integers.

Entry: Two mantissas are in M1 (through M1+2) and M2 (through M2+2). They should be aligned, that is with identical exponents, for use in the FADD and FSUB subroutines.

Exit: the 24-bit integer sum is in M1 (high-order byte in M1, low-order byte in M1+2). FP2, X1, E, SIGN and SCR are not disturbed. The A-REG contains the high-order byte of the sum, the X-REG contains $FF and the Y-REG is not altered. The carry is the '25th' sum bit.

Example: FP1 contains +5 and FP2 contains +7 prior to calling ADD.

FP1: | $82 | $50 | 0 | 0 | (+5)

X1 M1

FP2: | $82 | $70 | 0 | 0 | (+7)

Upon exit, M1 contains the overflow value for +12. Note that the sign bit is incorrect. This is taken care of with a call to the right shift routine.

FP: | $82 | $C0 | 0 | 0 | (+12)

ABSWAP Subroutine (address $F437)

Purpose: To take the absolute value of FP1 and then swap FP1 with FP2.

Note that two sequential calls to ABSWAP will take the absolute values of both FP1 and FP2 in preparation for a multiply or divide.

Entry: FP1 and FP2 contain floating point values.

Exit: The absolute value of the original FP1 contents are in FP2 and the original FP2 contents are in FP1. The least significant bit of SIGN is complemented if a negation takes place (if the original FP1 contents are negative) by means of an increment. SCR and E are used. The A-REG contains a copy of X2, the X-REG is cleared, and the Y-REG is not altered.

RTAR Subroutine (address $F47D)

Purpose: To shift M1 right one bit position while incrementing X1 to compensate for scale. This is roughly the opposite of the NORM subroutine.

Entry: A normalized or unnormalized floating point value is in FP1.

Exit: The 6-byte field MANT1 and E is shifted right one bit arithmetically and X1 is incremented by 1 to retain proper scale. The sign bit of MANT1 (MSB of M1) is unchanged. FP2, SIGN, and SCR are not disturbed. The A-REG contains the least significant byte of E (E+2), the X-REG is cleared, and the Y-REG is not disturbed.

Caution: If X1 increments of 0 (overflow) then an exit to location $3F5 is taken, the A-REG contains the high-order MANT1 byte, M1 and X1 is cleared. FP2, SIGN, SCR, and the X- and Y-REGs are not disturbed.

Uses: RTLOG

Example: Prior to calling RTAR, FP1 contains the normalized value -7.

FP1	$83	$A0	0	0	(-7)
	X1	M1			

After calling RTAR, FP1 contains the unnormalized value -7 (note that precision is lost off the low-order end of M1).

FP1	$84	$D0	0	0	(-7)
	X1	M1			

Note: M1 sign bit is unchanged.

RTLOG subroutine (address $F480)

Purpose: To shift the 6-byte field MANT1 and E one bit to the right (toward the least significant bit). The 6502 carry bit is shifted into the high-order M1 bit. This is useful in correcting binary sum overflows.

Entry: A normalized or unnormalized floating point value is in FP1. The carry must be cleared or set by the user since it is shifted into the sign bit of M1.

Exit: Same as RTAR except that the sign of M1 is not preserved (it is set to the value of the carry bit on entry)

Caution: Same as RTAR.

Example: Prior to calling RTLOG, FP1 contains the normalized value -12 and the carry is clear.

FP1:	$83	$A0	0	0	(-12)
	X1	M1			

After calling RTLOG, M1 is shifted one bit to the right and the sign bit is clear. X1 is incremented by 1.

FP1:	$84	$50	0	0	(+20)
	X1	M1			

Note: The bit shifted off the end of MANT1 is rotated into the high-order bit of the 3-byte extension E. The 3-byte E field is also shifted one bit to the right.

Exit: The 3 bytes of M1 are cleared (or all set to the contents of the X-REG on Entry) and the Y-REG is loaded with $17. The sign bit of the A-REG is complemented and a copy of the A-REG is stored in X1. FP2, SIGN, SCR, and the X-REG are not disturbed.

Uses: NORM.

Caution: Exponent overflow results in an exit to location $3F5. Exponent underflow results in an early return from the calling subroutine (FDIV or FMUL) with a floating point zero in FP1. Because MD2 pops a return address off the stack, it may only be called by another subroutine.

RTLOG1 subroutine (address $F484)

Purpose: To shift MANT1 and E right one bit without adjusting X1. This is used by the multiply loop. The carry is shifted into the sign bit of MANT1.

Entry: M1 and E contain a 6-byte unsigned field. E is the 3-byte low-order extension of MANT1.

Exit: Same as RTLOG except that X1 is not altered and an overflow exit cannot occur.

MD2 subroutine (address $F4E2)

Purpose: To clear the 3-byte MANT1 field for FMUL and FDIV, check for inital result exponent overflow (and underflow), and initialize the X-REG to $17 for loop counting.

Entry: the X-REG is cleared by the user since it is placed in the 3 bytes of MANT1. The A-REG contains the result of an exponent addition (FMUL) or subtraction (FDIV). The carry and sign status bits should be set according to this addition or subtraction for overflow and underflow determination.

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AUTO-REPEAT FOR
APPLE][MONITOR COMMANDS

It is occasionally desirable to automatically repeat a MONITOR command or command sequence on the APPLE][computer. For example, intermittently bad RAM bits in the $800-$FFF address range ($ stands for hex) may be detected by verifying those locations with themselves using the MONITOR verify command:

*800<800.FFFV[r] ([r] is RETURN)

Because this type of problem may be intermittent, multiple verifications may be necessary before the problem is detected. Typing the verify command over and over is a tedious chore which may not even catch the bug, since the RAMs are not fully exercised while the user is typing.

The APPLE][MONITOR command input buffer begins at location $200 and is scanned from beginning to end after the user finishes typing a line by typing a carriage return. An index to the next executable character of the buffer resides in location $34 while any function is being executed. By adding the command '34:0' to the end of a MONITOR command sequence, the user causes scanning to resume at the beginning. Because the '34:0' command leaves the MONITOR in a 'store' mode, an 'N' command should begin the line. The following is an example of a command sequence which verifies the locations $800-$FFF with themselves, automatically repeating:

*N800<800.FFFV 34:0 [r]
(Note that the space between the final command and [return] is necessary for this feature to work properly)

Multiple command sequences accepted by the APPLE][MONITOR may also be automatically repeated. For example, the following command sequence clears all bits in the address range $400-$5FF, verifies all of these locations with themselves, sets them all to ones, verifies them again, and repeats:

*N400:0 N401<400.5FEM 400<400.5FFV 400:FF
N401<400.5FEM 400<400.5FFV 34:0 [r]

Because this example uses screen memory locations, it is observable on the display. The repeating command may be halted by hitting RESET. Since the cursor is only generated for keyboard entry, it will disappear while the example repeats.

DIRECT CALLS TO APPLE][
INTEGER BASIC FUNCTIONS

WOZPAK II

The following APPLE][Integer BASIC entry points are directly callable:

LIST -- JSR $E04B CALL -8117

RUN -- JSR $EFEC CALL -4116

RUN* -- JSR $E836 CALL -6090

SAVE -- JSR $F140 CALL -3776

LOAD -- JSR $F0DF CALL -3873

The random number function may be accessed directly as follows:

1. Place the modulus (RND argument) in locations $CE (low) and $CF (high).
2. LDX #$20 (may use other values--X-REG used as BASIC stack pointer.)
3. JSR $EF51
4. X-REG will now be one less and the random value returned is in locations $6F (low) and $BF (high).

NOTE: If X were less (or greater) than $20, then the correspondingly lower (or higher) locations.

* This RUN entry does NOT delete the BASIC Variables.

PRINT DECIMAL

(2-byte integer 0 to 65535)

1. Specify leading character option in location $FA.
   0 = no leading characters (normal BASIC mode)
   "0" = leading zeros, 5-char. field
   "blank" = leading blanks
   "(char)" = leading (char)
2. LDX low byte
3. LDA high byte
4. JSR $E51B

CAUTIONS:

a. Location $F8 should be positive when PRINT DEC is called, or the printed characters will also be added to the BASIC input buffer ($200-$2FF) using the Y-REG as an index (as in AUTO LINE NUMBER mode).
b. Locations $C9, $F2, $F3, $F9 are used as temporaries.
c. Exit conditions:
   A-REG contains last char printed.
   X-REG contains $FF.
   Y-REG undisturbed (unless caution (a) ignored)
   Negative flag is set.

APPLE][TREK

By Wendell Sander

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WOZPAK II

APPLE][TREK is a sophisticated space war game in which the player, as Captain of the Starship ENTERPRISE is sent on a search and destroy mission against the KLINGON Empire Fleet. The APPLE][computer creates the game environment, operates the KLINGON Cruisers in combat and transforms the APPLE][keyboard and display into a spaceship command console.

THE GALAXY

APPLE][TREK is played in a galaxy which is represented by a grid of 64 quadrants charted as an 8 by 8 array. Each quadrant contains 64 sectors, again in an 8 by 8 array. The sector is the elemental location in the universe and may be occupied by only one of a star, a KLINGON, or the ENTERPRISE. The galaxy is a closed space in which the opposite edges are actually adjacent to each other. Moving to Galactic East of the Eastmost quadrant, the ENTERPRISE will enter the Westmost quadrant. At the start of a mission, the APPLE places all stars, Klingons, bases, and your ship at random.

THE STARSHIP ENTERPRISE

The ENTERPRISE is a powerful craft with somewhat more firepower and energy capacity than the battle cruisers of the Klingon fleet. However, the ENTERPRISE is usually heavily outnumbered and is easily destroyed unless good maneuvering and firing strategies are used.

The ENTERPRISE has two forms of weaponry; Photon Torpedoes (PH TORPS) and Phasers. The ENTERPRISE normally carries 10 PH TORPS which may be restocked through energy conversion or by visiting a base.

The ENTERPRISE carries energy in three forms; available energy, shield energy, and PH TORPS. The available energy is used for Phasers, propulsion, and to operate the ship's sensory and display subsystems.

Shield energy is carried in ship's shields to absorb hits from attacking Klingons. If the ENTERPRISE receives an enemy hit that reduces its shield energy too low, then the ENTERPRISE may sustain damage to its subsystems (see damage report).

PH TORPS are considered as energy in determining the maximum allowable energy aboard the ENTERPRISE. Also, PH TORPS can be converted directly into energy or formed from energy. The transformation consumes energy.

The ENTERPRISE receives new energy from contact with restocking bases and from on-board Dilithium Crystals. In addition, energy reallocation between available energy, shield energy, and PH TORPS may be directed by the captain. Rendezvous with a restocking base brings the ENTERPRISE back to maximum and repairs all sub-systems. The restocking base is depleted by this action and can not be used again. The on-board Dilithium Crystals generate energy at a rate of 50 units per 0.1 stardate.

KLINGON BATTLE CRUISERS

The Klingon Battle Cruiser is somewhat less powerful than the ENTERPRISE but usually runs in squadrons of several ships at a time and therefore may have greater joint firepower than the ENTERPRISE in a battle. Each Klingon has 800 units of energy and 3 Photon Torpedoes (PH TORPS) at the beginning of a battle. The Klingon energy may be used for Phasor fire, movement, or to absorb hits from the ENTERPRISE. When the Klingon energy is reduced to zero, the Klingon is destroyed.

The Klingons have both Phasors and PH TORPS which operate the same as the ENTERPRISE (see below) except that the Klingons cannot lock PH TORPS, or convert between PH TORPS and ENERGY.

Klingon's can move one sector distance per turn during a battle. They may retreat into adjacent quadrants and become restocked at that time.

CONSOLE DISPLAY

The console display for the APPLE TREK mission is presented in four display segments. The top third of the screen displays the Galactic Record, the lower left of the screen contains a detailed display of the current quadrant, the lower right of the screen is a status display, and the center of the screen is reserved for command I/O.

THE GALACTIC RECORD

The Galactic Record is displayed at the beginning of the game or whenever any navigation command is entered. The Galactic Record is an 8 by 8 array of numbers representing a summary of the number of Klingons, Bases, and stars in each quadrant of the galaxy that have been observed during the game. Figure 1 shows a typical Galactic Record. The number shown in a square of the Galactic Record should be interpreted digit by digit. The ones digit is the number of stars in that quadrant, the tens digit is the number of bases, and the hundreds digit is the number of Klingons. Some examples would be:

305	3 Klingons, no bases, 5 stars
13	1 base, 3 stars
4	4 stars

The Galactic Record contains data for each quadrant that the ENTERPRISE has occupied. In addition, the data for the 8 surrounding quadrants are presented if the Long Range Sensor is operational.

The Galactic Record display area is also used for several other utility displays such as the Probe and Damage Report.

THE QUADRANT DISPLAY

The Quadrant Display presents a detailed picture of the quadrant currently occupied by the ENTERPRISE. Figure 2 illustrates a typical Quadrant Display. The display is in inverse video. The locataion of the ENTERPRISE is indicated an "E", Klingons are shown as "K", stars as "*", and bases as "B".

THE STATUS DISPLAY

The Status Display presents a brief summary of the current status of the ENTERPRISE. The display includes current sector location, years remaining in the mission, current stardate, conditior code (green = no problems, yellow = low on energy, and red = Klingons present), shields (percentage of total energy that will go to shields), shield energy, available energy, number of PH TORPS, number of Klingons, and number of bases. The last line of the Status Display indicates the course coordinates set by the on-board computer to permit fire and move sequences.

The Status Display area is also used to display the list of possible commands whenever a non-legal command is entered.

FIGURE 1
SAMPLE GALACTIC RECORD

```
:   :   :   :   :   :   :   :   :
:   :   :3  :104:4  :   :   :   :
:   :   :12 :8  :21 :   :   :   :
:   :   :3  :312:104:4  :   :   :
:   :   :11 :2  :3  :16 :   :   :
:   :   :1  :202:4  :5  :   :   :
:   :   :   :   :   :   :   :   :
:   :   :   :   :   :   :   :   :
```

Note: The quadrant that the ENTERPRISE is in will appear in inverse video.

FIGURE 2
SAMPLE QUADRANT DISPLAY

```
                1
                2
    *       *   3
  K             4
K         E     5
        *       6
    *         * 7
        B       8
1 2 3 4 5 6 7 8
```

Note: Display is in inverse video.

COMMANDS

The ENTERPRISE is controlled by entering the following commands from the keyboard:

1 - Navigation
2 - Set Shield Energy
3 - Damage Report
4 - Phasers
5 - Ph Torps
6 - Load Ph Torps
7 - Computer
8 - Probe
9 - Self Destruct

The request for a command appears in the left center display area. The commands operate as described below.

1-NAVIGATION

The Navigation command is used to move the ENTERPRISE to different sectors within a quadrant, or to different quadrants within the galaxy. After pressing "1", the Galactic Record is displayed. If Warp Drive is not damaged, the question WARP OR ION (W OR I)? will appear. Warp Drive is used for movement between quadrants. A warp factor will be requested. Movement will occur to a quadrant that is that many units distant. Similarly, with Ion Drive, duration will be requested and will specify the number of sectors to move within the quadrant. With both warp and ion drive, a course is also requested. This is simply the angle or direction that you wish the ENTERPRISE to travel in. Galactic North (up on your screen) is 0 degrees, East (to the right) is 90 degrees, etc. Any number between 0 and 359 may be entered.

2 - SET SHIELD ENERGY

The ENTERPRISE maintains a certain portion of its available energy in the shields to absorb blows from Klingon fire. If the shield energy goes below 10 units, damage may be sustained to the operating systems of the ENTERPRISE. The Set Shield parameter sets the percentage of total energy that goes to shields. This value is initially 50%.

3 - DAMAGE REPORT

Command 3 will cause the top portion of the screen to display the current status of all of the ENTERPRISE systems such as Phasers, PH TORPS, Computer, etc. If the subsystem is operational, the display will indicate OK. If damage has occurred, the display will indicate the estimated time required to repair the subsystem.

4 - PHASERS

Firing the Phasers will cause a blast of energy to be shot at all targets within the quadrant. The energy is equally divided among the targets and is diminished by the distance between the ENTERPRISE and the target. The available energy of the ENTERPRISE is decreased by the amount of Phaser fire. Hits on the Klingons will decrease their energy by a like amount. Phasers can be locked on to one or more targets using the computer (see below). In that case, the energy is spread evenly between the selected targets. Phaser fire is not

blocked by stars or Klingons.

5 - PH TORPS

Photon Torpedoes may be fired under manual or automatic control. Under manual control, only a single TORP may be fired. A trajectory must be input (angle is similar to course discussed above). Under automatic control, you can use the computer to lock-on to any number of targets (see computer section). The computer then directs the PH TORPS to their targets. The only disadvantage to automatic fire is that the Klingons then get to shoot first.

Photon Torpedoes will cause 500 energy units of damage if a hit is made. The torpedo will hit the first object that it encounters on the given trajectory, be that a Klingon, a star, or a base.

6 - LOAD PH TORPS

Photon Torpedoes can be converted to or from energy using this command. You will be asked how many TORPS to load. A positive number response will convert energy to PH TORPS at a rate of 500 units of energy each. A negative input will convert PH TORPS to energy at the same rate.

7 - COMPUTER

The captain of the ENTERPRISE has an APPLE-81 computer at his disposal, giving him a major advantage over his Klingon opponents. The computer has 7 command options which will be displayed whenever a non-legal input is made (such as 0 or 8). These options allow you to compute a course angle to any given set of sector or quadrant coordinates, compute a trajectory to a Klingon, lock Phasers or PH TORPS to any number of targets, lock in a course, or display ship's status. Control can be returned to command mode by entering the return command (option 7 while in Computer mode).

8 - PROBE

The Probe command is used to assess the strength of Klingons that are in the same quadrant as the ENTERPRISE. The command will display the coordinates, energy levels, number of PH TORPS, and "lock" status of all Klingons in the current quadrant. The "lock" status specifies whether or not the Klingon's Phasers or PH TORPS are locked-on to the ENTERPRISE or not. The Probe infor-

mation is displayed in the Galactic Record display area.

9 - SELF DESTRUCT

The Self Destruct command should be reserved until there is no hope of the survival of the ENTERPRISE. It will cause the ENTERPRISE to explode, hopefully taking any nearby Klingons with it.

END OF A MISSION

A mission will end when one of three events occurs. If all Klingons are destroyed, the ENTERPRISE has successfully completed its mission. If the time allotted for the mission runs out, the mission ends with the Klingons still threatening the empire. Finally, if the ENTERPRISE is destroyed, the mission is considered a failure. Your performance will be rated under each of these circumstances and an appropriate dispatch from Star Fleet Command will be sent. Your rating will depend on the overall success of your mission, on the number of bases used up, the amount of time required, and the amount of energy and PH TORPS used.

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APPLE][
HI-RES COLOR MODIFICATION

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WOZPAK II

The High Resolution Color Graphics capability of the APPLE][computer is one of its features that set it apart from most other personal computers. Early versions of the APPLE][had the ability to display four colors: Black, White, Green, and Violet. A production change was made, and the ability to display Blue and Orange was added. The modification presented here allows those early APPLEs to be updated to 6 color capability.

PLEASE NOTE: This modification will VOID the warranty (if still in effect) on the APPLE][.

(1) Remove the ten screws securing the plastic top piece to the metal bottom plate. Six of these are flat-head screws around the perimeter of the bottom plate, and four are round head screws located at the front lip of the computer. All are Phillips screws. Do not remove the screws securing the power supply or the nylon PC board standoffs.
(2) Lift the plastic top piece from the bottom plate, taking care not to damage the ribbon cable connecting the keyboard to the main PC board. This cable must be disconnected from one end or the other.
(3) Disconnect the power supply from the PC board.
(4) Remove the #8 nut and lockwasher that secures the center of the PC board. This may not be found on the earlier APPLE][computers.
(5) Carefully disengage each of the 6 nylon insulating standoffs from the PC board. (7 on earlier versions)
(6) Carefully lift the PC board from the bottom plate.

Now that your APPLE][is in pieces, there are two wiring methods for this modification. It is HIGHLY recommended that you choose the second (below the board method), since the final result will have a much more professional appearance. It will not be visible when the APPLE][is reassembled. (Now that's professional!) The wiring itself is much easier to keep track of if you use small pieces of tape (with the Integrated Circuit numbers written on them) on the bottom of the board.

In the following instructions, the connections required are designated by:
(<chip number> - <pin number>)
See the APPLE Red Manual for IC number designations.

ABOVE THE BOARD WIRING METHOD

(1) Lift the following IC pins from their sockets. This requires bending the pins (careful!).

(A8-1)	(A8-6)	(A8-13)
(A9-1)	(A9-2)	(A9-9)

(2) Mount a 74LS74 (dual C-D flip-flop) and a 74LS02 (quad NOR gate) in the APPLE][breadboard area (A11 to A14 region).
(3) Wire the circuit as shown if Fig. 1. (* indicates a connection to a pin which is out of its socket)

WOZPAK II

BELOW THE BOARD WIRING METHOD

(1) Remove IC# A8 (74LS257). Desolder socket A8. Lift the socket from the board taking care not to damage it. In most cases, it is possible to remove the plastic part of the socket without desoldering the pins. This is the easier way to do it if you can. Cut the trace between pins 6 and 13 of A8 on the top side of the board, using a small, sharp knife. Also cut the trace between pins 13 and 15 of A8. Reinsert socket A8 and the 74LS257. BE CAREFUL!

(2) Cut the foil traces to the following IC pins on the bottom of the APPLE][board. Each pin should have a single trace going to it.

(A8-1) (A8-6) (A9-1)
(A9-2) (A9-9)

(3) Connect (A8-15) to ground; (A7-8) on the keyboard socket is a close ground.

(4) Mount the 74LS74 and 74LS02 as per step 2 of the above the board method.

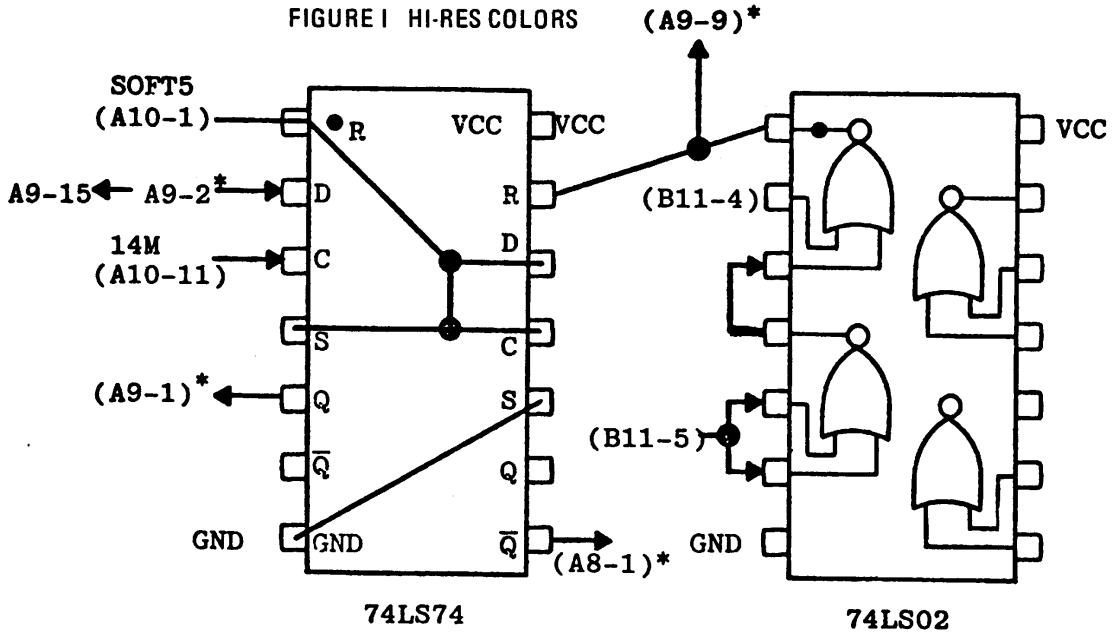
(5) Wire the circuit as shown in Fig.1. All wires are on the bottom of the APPLE][board and no IC pins need be removed from their sockets. Don't forget to hook up VCC (+5Volts), and ground, to the ICs that you added. Be sure to double and triple check your work at this point.

Reassemble the APPLE][, remembering to connect the keyboard, power supply, and speaker connectors. Check to see if it still works. If not, take it apart again and recheck the added wiring VERY CAREFULLY. It is easy to get the ICs mixed up when looking at the bottom of the board. Make sure the chips are properly oriented in their sockets.

The following color values are now applicable to the HI-RES subroutines.

BLACK2=128 ORANGE=170
WHITE2=255 BLUE=213

FIGURE I HI-RES COLORS



(B8-14) → (A8-6)*

(B8-7) → (A8-13)*

APPLE][
COLOR KILLER MODIFICATION

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WOZPAK II

The APPLE][+'s color graphics are great, but there are times when color is not needed. Printing a page of text on the screen is a situation when it is not desirable to have color on the screen. The early APPLEs did not disable the burst signal (the signal that tells the color television to turn on the color circuits), so the color was on all the time.

This simple modification will provide this 'color on/color off' switching in the APPLE to make the screen display color or black & white as necessary.

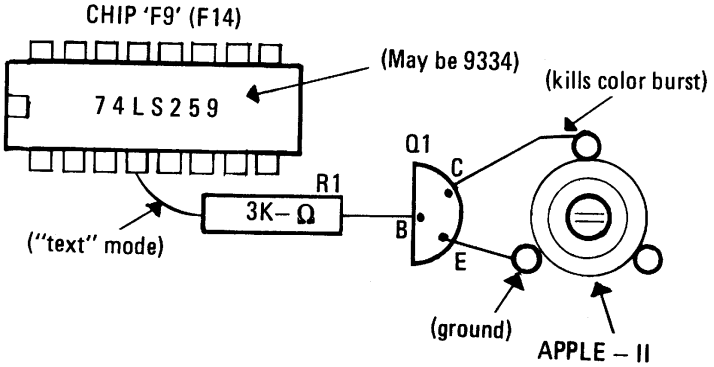
PARTS NEEDED:

3K to 5K 1/4 watt resistor
NPN transistor (2N222 or equavilent)

Wire the circuit as shown in figure 1. Be sure to unplug your APPLE][whenever making ANY connections or modifications.

PLEASE NOTE: This, or any other, modfication will VOID the warranty on your APPLE][, if it is still in effect.

APPLE – II COLOR KILLER MOD



Add R1 and Q1 as shown pictorially