PROGRAMMER'S AID #1

INSTALLATION AND OPERATING MANUAL

TM

Apple Utility Programs

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INTRODUCTION

FEATURES OF PROGRAMMER'S AID #1

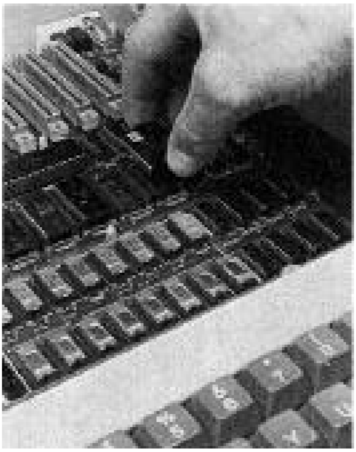
Programmer's Aid #l combines several APPLE II programs that Integer BASIC programmers need quite frequently. To avoid having to load them from a cassette tape or diskette each time they are used, these programs have been combined in a special read—only memory (ROM) integrated circuit (IC). When this circuit is plugged into one of the empty sockets left on the APPLE's printed—circuit board for this purpose, these programs become a built—in part of the computer the same way Integer BASIC and the Monitor routines are built in. Programmer's Aid #1 allows you to do the following, on your APPLE II:

Chapter 1.	Renumber an entire Integer BASIC program. or a portion of the program.
Chapter 2.	Load am Integer BASIC program from tape <u>without</u> erasing the Integer BASIC program that was already in memory, in order to combine the two programs.
Chapter 3.	verify that an Integer BASIC program has been saved correctly on tape, <u>before</u> the program is deleted from APPLE's memory.
Chapter 4.	Verify that a machine.-language program or data area has been saved correctly on tape from the Monitor.
Chapter 5,	Relocate 6502 machine—language programs.
Chapter 6.	Test the memory of the APPLE.
Chapter 7.	Generate musical notes of variable duration over four chromatic octaves, in five (slightly) different timbres, from Integer BASIC.
Chapter 8.	Do convenient High—Resolution graphics from Integer BASIC.

Note: if your APPLE has the firmware APPLESOFT card installed, its switch <u>must be down</u> (in the Integer BASIC position) for Programmer's Aid #1 to operate.

HOW TO INSTALL THE PROGRAMMER'S AID ROM

The Programmer's Aid ROM is an IC that has to be plugged into a socket on the inside of the APPLE II computer.



1. Turn off the power switch on the back of the APPLE II This is important to prevent damage to the computer.
.
2. Remove the cover from the APPLE II. This is done by pulling up on the cover at the rear edge until the two corner fasteners pop apart. Do not continue to lift the rear edge, but slide cover backward until it comes free.

3. Inside the APPLE. toward the right center of the main printed—circuit board, locate the large empty socket in Row F, marked "ROM—D0".

4. Make sure that the Programmer's Aid ROM IC is oriented correctly. The small semicircular notch should be toward the keyboard. The Programmer's Aid. ROM IC must match the orientation of the other ROM ICs that are already installed in that row.

5. Align all the pins on the Programmer's Aid ROM IC with the holes in socket D0, and gently press the IC into place. If a pin bends, remove the IC from its socket using an "IC puller' (or. less optimally, by prying up gently with a screwdriver). Do not attempt to pull the socket off the board. Straighten any bent pins with a needlenose pliers, and press the IC into its socket again, even more carefully.

6. Replace the cover of the APPLE, remembering to start by sliding the front edge of the cover into position. Press down on the two rear corners until they pop into place.

7. Programmer's Aid #1 is installed; the APPLE II may now he turned on.

CHAPTER 1
RENUMBER

RENUMBERING AN ENTIRE BASIC PROGRAM

After loading your program into the APPLE, type the

CLR

command. This clears the BASIC variable table, so that the Renumber feature's parameters will be the first variables in the table. The Renumber feature looks for its parameters by location in the variable table. For the parameters to appear in the table in their correct locations, they must be specified in the correct order and they must have names of the correct, length.

Now, choose the number you wish assigned to the first line in your renumbered program. Suppose you want your renumbered program to start at line number 1000. Type

START = 1000

Any valid variable name will do, but it must have the correct number of characters. Next choose the amount by which you want succeeding line numbers to increase. For example, to remumber in increments of 10, type

STEP = 10

Finally, type the this commands

CALL —10531

As each line of the program is renumbered, its old line number is displayed with an "arrow" pointing to the new line number. A possible example might appear like this on the APPLE's screen:

7—>1000
213—>1010
527—>1020
698—>1030
13000—>1040
13233—>1050

RENUMBERING PORTIONS OF A PROGRAM

You do not have to renumber your entire program. You can renumber just the lines numbered from, say, 300 to 500 by assigning values to four variables. Again, you must first type the command

CLR

to clear the BASIC variable table.

The first two variables for partial renumbering are the same as those for renumbering the-whole program. They specify that the program portion, after renumbering, will begin with line number 200. say, and that each line's number thereafter will be 20 greater than the previous line's:

```
START = 200
STEP  = 20
```

The next two variables specify the program portion's range of line numbers before renumbering.

```
FROM = 300
TO = 500
```

The final command is also different. For renumbering a portion of a program, use the command:

```
CALL —10521
```

If the program was previously numbered

```
 100
 120
 300
 310
 402
 500
2000
2022
```

then after the renumbering specified above, the APPLE will show this list of changes:

```
300—>200
310—>220
402—>240
500—>260
```

and the new program line numbers will be

```
 100
 120
 200
 220
 240
 260
2000
2022
```

You cannot renumber in such a way that the renumbered lines would replace, be inserted between or be intermixed with un—renumbered lines. Thus, you cannot change the order of the program lines. If you try, the message

*** RANGE ERR

is displayed after the list of~proposed line changes, and the line numbers themselves are left unchanged. If you type the commands in the wrong order, nothing happens, usually.

COMMENTS:

1. If you do not CLR before renumbering, unexpected line numbers may result. It may or may not be possible to renumber the program again and save your work.

.2. If you omit the START or STEP values, the computer will choose them unpredictably. This nay result in loss of the program.

3. If am arithmetic expression or variable is used in a GOTO or GOSUB, that GOTO or GOSUB will generally not be renumbered correctly. For example, GOTO TEST or GOSUB 10+20 will not be renumbered correctly.

4.Nonsense values for STEP, such as 0 or a negative number, can render your program unusable. A negative START value cam renumber your program with line numbers above 32767, for what it's worth. Such line numbers are difficult to deal with. For example, an attempt to LIST one of them will result in a >32767 error. Line numbers greater than 32767 cam be corrected by renumbering the entire program to lower line numbers.

5. The display of line number changes can appear correct even though the line numbers themselves have not been changed correctly. After the *** RANGE ERR message, for instance, the line numbers are left with their original numbering. LIST your program and check it before using it.

6. The Renumber feature applies only to Integer BASIC programs.

7 Occasionally, what seems to be a "reasonable" renumbering does not work. Try the renumbering again, with a different START and STEP value.

CHAPTER 2
APPEND

APPENDING ONE BASIC PROGRAM TO ANOTHER

If you have one program or program portion stored in your APPLE'S memory, and another saved on tape, it is possible to combine them into one program. This feature is especially useful when a subroutine has teen developed for one program, and you wish to use it in another program without retyping the subroutine.

For the Append feature to function correctly, all the line numbers of the program in memory must be greater than all the line numbers of the program to he appended from tape. In this discussion, we will call the program saved on tape "Program1," and the program in APPLE's memory "Program2."

If Program2 is not in APPLE's memory already, use the usual command

LOAD

to put Program2 (with high line numbers) into the APPLE. Using the Renumber feature, if necessary, make sure that all the line numbers in Program2 are greater than the highest line number in Program1.

Now place the tape for Program1 in the tape recorder. Use the usual loading procedure,. except that instead of the LOAD command use this command:

CALL —11076

This will give the normal beeps, and when the second beep has sounded, the two programs will both be in memory. If this step causes the message

***MEM FULL ERR

to appear, neither Program2 nor Program1 will be accessible In this case,. use the command

CALL —11059

to-recover Program2, the program which was already in APPLE's memory.

COMMENTS:

1. The Append feature operates only with APPLE II Integer BASIC programs.

2. If the line numbers of the, two programs are not as described, expect unpredictable results.

CHAPTER 3
TAPE VERIFY (BASIC)

VERIFYING A BASIC PROGRAM SAVED ON TAPE

Normally, it is impossible (unless you have two APPLES) to know whether or not you have successfully saved your current program on tape, in tine to do something about a defective recording. The reason is this: when you SAVE a program on tape the only way to discover whether it has been recorded correctly is to LOAD it back in to the APPLE. But, when you LOAD a program, the first thing the APPLE does is erase whatever current program is stored. So, if the tape is bad, you only find out after your current program-has been lost.

The Tape Verify feature solves this problem. Save your current program in the usual way:

SAVE

Rewind the tape, and (without modifying your current program in any way) type the. command

CALL -10955

Do not press the RETURN key until after you start the tape playing. If the tape reads in normally (with the usual two beeps), then it is correct. If there is any error on the tape, you will get a beep and the ERR message. If this happens, you will probably want to try re-recording the tape, although you don’t know for sure whether the Tape Verify error means that the tape wasn’t recorded right or if it just didn’t play back properly. In any case, if it does verify, you know that it is good.

COMMENTS:

1. This works only with Integer BASIC programs.

2. Amy change in the program, however slight, between the time the program is SAVEd on tape and the time the tape is verified, will cause the verification to fail.

CHAPTER 4
TAPE VERIFY (Machine Code or Data)

VERIFYING A PORTION OF MEMORY SAVED ON TAPE

Users of machine—language routine will find that this version of the Tape Verify feature meets their, needs. Save the desired portion of memory, from address1 to address2, in the usual way:

address1 . address2 W return

Note: the example instructions in this chapter often include spaces for easier reading; do <u>not</u> type these spaces.

Rewind the tape, and type (after the asterisk prompt)

D52EG return

This initializes the Tape Verify-feature by preparing locations $3F8 through $3FA for the ctrl Y vector. Now type (do not type the spaces)

address1 . address2 ctrl Y return

and re—play the tape. The first error encountered stops the program and is reported with a>beep and the word ERR. If it is not a checksum error, then the Tape Verify feature will print out the location where the tape and memory disagreed and the data that it expected on the tape.

Note: type “ctrl-Y” by typing Y while holding down the <u>CTRL</u> key; ctrl Y is not displayed on the TV screen. Type “return” by pressing the RETURN key.

COMMENTS:

Any change in the specified memory area, however slight, between the time the program is saved on tape and the tine the tape is verified, will cause the verification to fail.

CHAPTER 5
RELOCATE

PART A: THEORY OF OPERATION

LOCATING MACHINE-LANGUAGE CODE

Quite frequently. programmers encounter situations that call -for relocating machine-language (not BASIC) programs on the 6502-based APPLE II computer. Relocation implies creating a new version of the program, a version that runs properly in an area of memory different from that in which the original program ran.

If they rely on the relative branch instruction,- certain snail 6502 programs can simply be moved without alteration, using the existing Monitor Move commands. Other programs will require only minor hand-modification after Monitor Moving. These modifications are simplified on the APPLE II by the built-in dissembler, which pinpoints absolute memory-reference instructions such as JMP's and JSR's.

However, sometimes it is-necessary to relocate lengthy programs containing multiple data segments interspersed with code. Using this Machine-Code Relocation feature can save you hours of work on such a move, with improved reliability and accuracy.

The following situations call for program relocation:

1. No different programs. which were originally written to run in identical memory 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 a different set of addresses in RAM.

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 nay have to be performed on the smaller machine.

5. Because of memory- mapping differences, a program that ran on an APPLE I (or other 6502-based computer) falls- into unusable address space on an APPLE II.

6. Because different operating systems assign variables differently, either page-zero or non-page-zero variable allocation for a specific program may have to modified when moving the program from one make of computer to another.

7. A program, which exists as several chunks strewn about memory, 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” memory space.

9. A program insertion or deletion requires-a portion of the program to move a few bytes up or down.

10. On a whim, the user wishes to move a program.

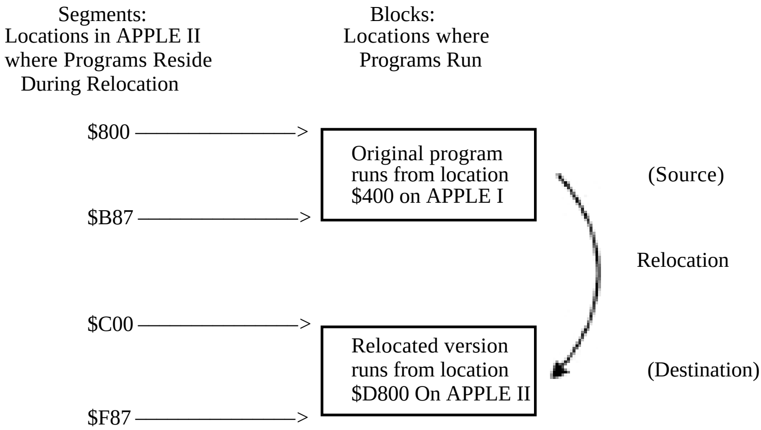
PROGRAM MODEL

Here is one simple way to visualize program relocation: starting with a program which resides and runs in a “Source Block” of memory, relocation creates a modified version of that program which resides and runs properly in a “Destination Block” of memory.

However, this model does not sufficiently describe situations where the “Source Block” and the “Destination Block” are the same locations in memory. For example, a program written to begin at location $400 on an APPLE I (the $ indicates a hexadecimal number) falls in the APPLE II screen-memory range. It must be loaded to some other area of memory in the APPLE II. But the program will not run properly in its new memory locations, because various absolute memory references, etc., are now wrong. This program can then be “relocated” right back into the sane new memory locations, a process which modifies it to run properly in its new location,

A more versatile program model is as follows. A program or section of a program written to run in a memory range termed the “Source Block” actually resides currently in a range termed the “Source Segments’. Thus a program written to run from location $400 may currently reside beginning at -location $800. After relocation, the new version of the program must be written to run correctly in a range termed the “Destination- Block” although it will actually reside currently in a range termed the “Destination Segments”. Thus a program may be relocated such that it will run correctly from location $D800 (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 RON). In some cases, the Source and Destination Segments may overlap.

BLOCKS AND SEGMENTS EXAMPLE

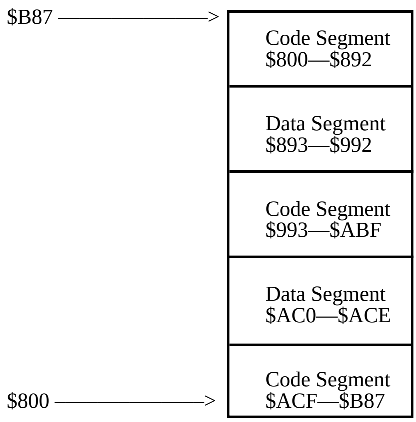


SOURCE BLOCK	$400-$787:	DESTINATION BLOCK: $D800—$DB87
SOURCE SEGMENTS.:	$800—$B87	DESTINATION SEGMENTS: $C00—$F87

DATA SEGMENTS

The problem with relocating a large program all at once is that blocks of data (tables, text, etc.) nay be interspersed throughout the code. During relocation, this date may be treated as if it were code, causing the data to be changed or causing code to be altered incorrectly because of boundary uncertainties introduced when the data takes on the multi—byte attribute of code. This problem is circumvented by dividing the program into code segments and data segments, and then treating the two types of segment differently.

CODE AND DATA SEGMENTS EXAMPLE



The Source Code Segments are relocated (using the 6502 Code—Relocation feature), while the Source Data Segments are moved (using the Monitor Move command).

HOW TO USE THE CODE-RELOCATION FEATURE

1. To initialize the 6502 Code-ReIocatIon feature, press the RESET key to invoke the Monitor, and then type

D4D5G return

The Monitor user function ctrl Y will now call the Code—Relocation feature as a subroutine at location $3F8.

Note: To type “ctrl Y”, type Y while holding down the CTRL key. To type “return”, press the RETURN key. In the remainder of this discussion, all instructions are typed to the right of the Monitor prompt character (*). The example instructions in this chapter often -include spaces for easier reading; do not type these spaces.

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 Destination and Source Block parameters. Remember that a Block refers to locations from which the program will run, not the locations at which the Source and Destination Segments actually reside 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 . SOURCE BLOCK END ctrl Y * return

Notes: the syntax of this command closely resembles that of the Monitor Move command. Type “ctrl Y” by pressing the Y key while holding down the CTRL key. Then type an asterisk (*); and finally, type “return” by pressing the RETURN key. Do not type, any spaces within the command.

4. Move all Data Segments and relocate all Code Segments in sequential (increasing address) order. It is wise to prepare a list of segments, specifying beginning and ending addresses, and>whether each segment is code or data.

<u>If First Segment is Code</u>:

DEST SEGMENT BEG < SOURCE SEGMENT BEG . SOURCE SEGMENT END ctrl Y return

<u>If First Segment is Data</u>:

DEST SEGMENT BEG < SOURCE SEGMENT BEG SOURCE SEGMENT END N return

After the first segment has been either relocated (if Code) or Moved (if data), subsequent segments can be relocated or Moved using a shortened. form of the command.

<u>Subsequent Code Segments</u>:

SOURCE SEGMENT END ctrl Y return (Relocation)

<u>Subsequent Data Segments</u>:

SOURCE SEGMENT END M return (Move)

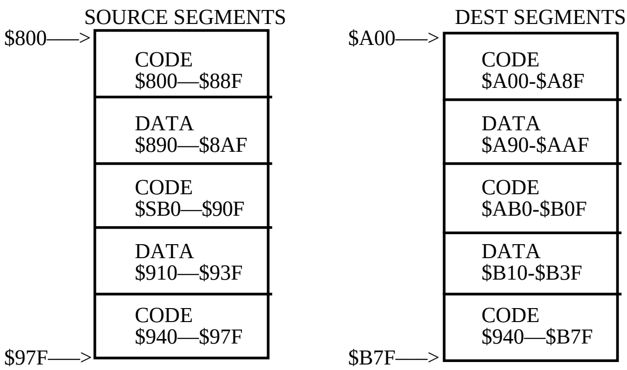
Note: the shortened form of the command cam only be used if each "subsequent" segment is <u>contiguous</u> to the segment previously relocated or Moved. If a "subsequent" segment is in a part of memory that does not begin exactly where the previous segment ended, it must be Moved or relocated using the full "First Segment" format.

If the relocation is performed "in place" (SOURCE and DEST SEGMENTs reside in identical locations) then the SOURCE SEGMENT BEG parameter may be omitted from the First Segment relocate or Move command.

PART B: CODE-RELOCATION EXAMPLES

EXAMPLE 1. Straightforward Relocation

Program A resides and runs in locations $800—$97F. The relocated version will reside and run in locations $A00—$B7F.



SOURCE BLOCK: $800—$97F	DEST BLOCK: $A00-$B7F
SOURCE SEGMENTS: $800—$97F	DEST SEGMENTS: $A00-$B7F

(a) Initialize Code—Relocation feature:

reset D4D5G return

(b) Specify Destination and Source Block parameters (locations from which the program will run)

A00 < 800 - 97F ctrl Y * return

(C.) Relocate first segment (code):

A00 < 800 .88F ctrl Y return

(d) Move subsequent Data Segments and relocate subsequent Code Segments, in ascending address sequence:

- 8AF M return (data)
- 90F ctrl Y return (code)
- 93F M return (data)
- 97F ctrl Y return (code)

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

A90 < 890 • 8AF M return (data)
AB0 < 8B0 • 90F ctrl Y return (code)
B10 < 910 • 93F M return (data)
B40 <940 • 97F ctrl Y return (code)

EXAMPLE 2. Index into Block

Suppose that the program of Example I uses an indexed reference into the Data Segment at $890 as follows:

LDA 7B0,X

where the X-REG is presumed to contain a number in the range $E0 to $FF. Because address $730 is outside the Source Block, it will not he relocated. This nay be handled in one of two ways.

(a) You. nay fix the exception by hand; or

(b) You nay begin the Block specifications one page lower than the addresses at which the original and relocated programs begin to use all such "early references." One lower page is enough, since FF (the number of bytes in one page) is the largest offset number that the X-REG can contain. In EXAMPLE 1, change step (b) to:

900 < 700 . 97F ctrl Y * return

Note: with this Block specification, <u>all</u> program references to the "prior page" (in this case the $700 page) will be relocated.

EXAMPLE 3. Immedlate Address References

Suppose 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.

EXAMPLE 4. Unusable Block Ranges

Suppose a program was written to run from locations $400-$78F on an APPLE 1. A version which will run in ROM locations SD800-SDB8F must be generated. The Source (and Destination) Segments will reside in locations $800—$B8F on the APPLE II during relocation.

Addresses during relocation	Source And Destination Segments	Source And Destination Blocks
$800———>	CODE $800—$97F	Rums from locations $400-$78F on an APPLE 1, but must be relocated to run from locations $D800-$DB8F on the APPLE II.
	DATA S980—$9FF	
$B8F ———>	CODE $A00—SB8F	

SOURCE BLOCK: $400-$78F: DEST BLOCK: $D800—$DB8F:
SOURCE SEGMENTS: $800-$B8F DEST SEGMENTS: $800—SB8F

(a) Initialize the Code-Relocation feature:

reset D4D5G return

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

800 . B8F R return

(c) Specify Destination and Source Block parameters (locations from which the original and relocated versions will run):

0800 < 400 . 78F ctrl Y return

(d) Move Data Segments and relocate Code Segments. in ascending address sequence:

800 < 800 . 97F ctrl Y return	(first segment, code)
. 9FF M return	(data)
. B8F ctrl Y return	(code)

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

800 < . 97F ctrl Y return

EXAMPLE 5. Changing the Page Zero Variable Allocation

Suppose the program of EXAMPLE 1 need not be relocated, but the page zero variable allocation is from $20 to $3F. Because these locations are reserved for the APPLE II system monitor, the allocation must be changed to locations $80—$9F. The Source and Destination Blocks are thus <u>not</u> the program but rather the variable area.

SOURCE BLOCK:	$20-$3F	DEST BLOCK:	$80-$9F
SOURCE SEGMENTS:	$S00-$97F	DEST SEGMENTS:	$800-$97F

(a) Initialize the Code-Relocation feature:

reset D4D5G return

(b) Specify Destination and Source Blocks:

80 < 20 . 3F ctrl Y * return

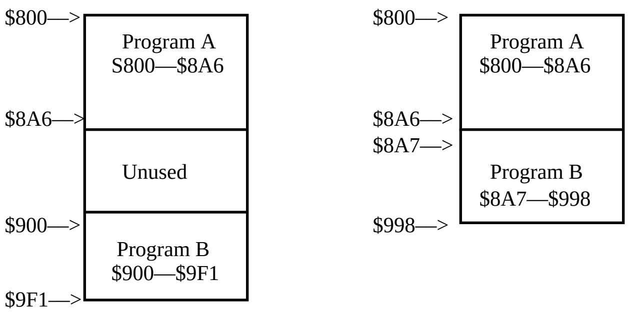
(c) Relocate Code Segments and Move Data Segments, in place:

800 < . 88F ctrl Y return	(first segment, code)
. 8AF M return	(data)
. 90F ctrl Y return	(code)
. 93F M return	(data)
. 97F ctrl Y return	(code)

EXAMPLE 6. 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 references to memory locations within the other. It is assumed that the programs contain no Data Segments.

SOURCE SEGMENTS DEST SEGMENTS



SOURCE BLOCK:	$900-$9F 1	DEST BLOCKS:	$8A7-$998
SOURCE SEGMENTS:	$800-$8A6 (A)	DEST SEGMENTS:	$800-$8A6 (A)
	$900-$9F1 (B)		$8A7-$998 (B)

(a) Initialize the Code-Relocation feature:

04B5G return

(b) Specify Destination and Source Blocks (Program B only):

8A7 < 900 . 9F1 ctrl Y * return

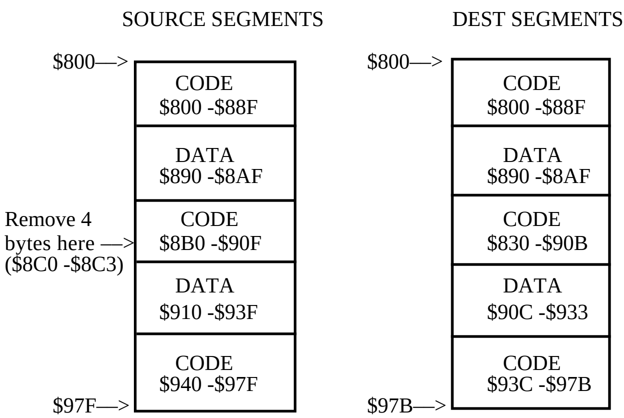
(c) Relocate each of the two programs individually. Program A must be relocated even though it does not move.

800 < . 8A6 ctrl Y return	(program A, “in place”)
8A7 < 900 . 9F1 ctrl Y return	(program B, not “in place”)

Note that any Data Segments within the two programs would necessitate additional relocation and Move commands,

EXAMPLE 7. Code Deletion

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



SOURCE BLOCK:	$8C4 -$97F	DEST BLOCK:	$8C0 -$97B
SOURCE SEGMENTS:	$800 -$88F (code)	DEST SEGMENTS:	$800 -$88F (code)
	$890 -$8AF (data)		$890 -$8AF (data)
	$8B0 -$8BF (code)		$8B0 -$8BF (code)
	$8C4 -$90F (code)		$8C0 -$90B (code)
	$910 -$93F (data)		$90C -$93B (data)
	$940 -$97F(code)		$93C -$97B(code)

(a) Initialize Code-Relocation feature:

reset D4D5G return

(b) Specify Destination and Source Blocks:

8C0 < 8C4 . 97F ctrl Y* return

(e) Relocate Code Segments and Move Data Segments, in ascending address Sequence

```
800 < .  88F   ctrl  Y  return              (first segment, code, "in place")
.  8AF   M   return                                 (data)
.  8BF   ctrl  Y   return                           (code)
8C0 < 8C4 .  90F   ctrl   Y   return        (first segment, code, not "in place")
.  93F   M   return                                 (data)
.  97F    ctrl   Y   return                         (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.

EXAMPLE 8. Relocating the APPLE II Monitor ($F800— $FFFF) to Run in RAM ($800—$FFF)

SOURCE BLOCK: $F700 -$FFFF   DEST BLOCK: $700 -$FFF
(see EXAMPLE 2)

SOURCE SEGMENTS:	$F800 -$F961 (code)	DEST SEGMENTS:	$800—$961 (code)
	$F962 -$FA42 (data)		$962 -$A42 (data)
	$FA43 -$FB18 (code)		$A43 -$B 18 (code)
	$FB19 -$FBlD (data)		$319 -$B1D (data)
	$FB1E -$FFCB (code)		$B1E -$FCB (code)
	$FFCC -$FFFF (data)		$FCC -$FFF (data)

IMMEDIATE ADDRESS REFERENCES (see EXAMPLE 3) $F FBF
$FEA8
(more if not relocating
to page boundary)

(a) Initialize the Code—Relocation feature:

reset D4D5G return

(b) Specify Destination and Source Block parameters:
700 < F700 . FFFF ctrl * return

(c) Relocate Code Segments and move Data Segments, in ascending address Sequence:

800 < F800 . F961 ctrl Y return	(first segment. code)
. FA42 M return	(data)
. FB18 ctrl Y return	(code)
. FB1D M return	(data)
. FFCB ctrl Y return	(code)
. FFFF M return	(data)

(d) Change immediate address references:

FBF : E return	(was $FE)
EA8 : E return	(was $FE)

PART C: PLOTTING POINTS AND LINES

TECHNICAL INFORMATION

The following details illustrate special technical features of the APPLE II which are used by the Code -Relocation feature.

1. The APPLE II Monitor command

Addr4 < Addrl . Addr2 ctrl Y return (Addr1, Addr2, and Addr4 are addresses)

vectors to location $3F8 with the value Addrl in locations $3C (low) and $3D (high), Addr2 in locations $3E (low) and $3F (high), and Addr4 in locations $42 (low) and $43 (high). Location $34 (YSAV) holds an Index to the next character of the command buffer (after the ctrl Y). The command buffer (IN) begins at $200.

2. If ctrl Y is followed by * , 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	ERMEND

3. If ctrl Y is not followed by * , then a segment relocation is initiated at RELOC2 ($3BB). Throughout, Addrl ($3C, $3D) is the Source Segment pointer and Addr4 ($42, $43) is the Destination Segment pointer.

4. INSDS2 is an APPLE II Monitor subroutine which determines the length of a 6502 instruction, given the opcode in the A-REG, and stores that opcode's instruction length in the variable LENGTH (location $2r)

Instruction Type in A-REG	LENGTH (in $2F)
Invalid	0
1 byte	0
2 byte	1
3 byte	2

5. The code from XLATE to SW16RT ($3D9-$3E6) uses the APPLE II 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 II Monitor subroutine which increments Addr1 (Source Segment index) and Addr4 (Destination Segment index). If Addr1 exceeds
- Addr2 (Source Segment end), then the carry is set; otherwise, it is cleared

ALGORITHM USED BY THE CODE-RELOCATION FEATURE

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 bytes).

4. If two-byte instruction with non-zero-page addressing mode (immediate or relative) them go to step 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 BEG + DEST BLOCK BEG

:7. Move “length” bytes from INST area to Destination Segment (using DEST PTR). Update SOURCE and DEST PTR’s by length.

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

COMMENTS:

Each Move or relocation carried Out sequentially, one byte at a time, beginning with the byte at the smallest source address. As. each source byte is Moved or relocated, it overwrites any information that was in the destination location. This is usually acceptable in these kinds of Moves and relocations:

1. Source Segments and Destination Segments do not share any common locations (no source location is overwritten).

2. Source Segments are in locations identical to the locations of the Destination Segments (each source byte overwrites itself).

3. Source Segments are in locations whose addresses are larger than the addresses of the Destination Segments' locations (any overwritten source bytes have already been Moved or relocated). This is a move toward smaller addresses.

If, however, the Source Segments and the Destination Segments share some common locations, and the Source Segments occupy locations whose addresses are smaller than the addresses of the Destination Segments' locations. then the source bytes occupying the common locations will be overwritten before they are Moved or relocated. If you attempt such a relocation, you will lose your program and data in the memory area common to both Source Segments and Destination Segments. To accomplish a small Move or relocation toward larger addresses, you must Move or relocate, to an area of memory well away from the Source Segments (no Address in common); then Move the entire relocated program back to its final resting place.

Note: the example instructions in this chapter often include spaces for easier reading; do not type these spaces.

CHAPTER 6
RAM TEST

TESTING THE APPLE'S MEMORY

With this program, you can easily discover any problems in the RAM (for Random Access Memory) chips in your APPLE. This is especially useful when adding new memory. While a failure is a rare occurrence, memory chips are both quite complex and relatively expensive. This program will point out the exact memory chip or chips, if any, that have malfunctioned.

Memory chips are made in two types~ one type can store 4K (4096) bits of information, the other can store 16K (16384) bits of information. Odd as it seems, the two types look alike, except for a code number printed on them.

The APPLE has provisions for inserting as many as 24 memory chips of either type into its main printed-circuit board, in three rows of eight sockets each. An eight-bit byte of information consists of one bit taken from each of the eight memory chips in a given, row. For this reason, memory can be added only in units of eight identical memory chips at a tine, filling an entire row. Eight 4K memory chips together in one row can store 4K bytes of information. Eight 16K memory chips in one row can store 16K bytes of information.

Inside the APPLE II, the three rows of sockets for memory chIps are row "C", row "D" and row "E". The rows are lettered along the left edge of the printed-circuit board, as viewed from the front of the-APPLE. The memory chips are installed in the third through the tenth sockets (counting from the left) of rows C, D and E. These sockets are labeled "RAM'. Row C must be filled; and row. E may be filled only if row D is filled. depending on the configuration of your APPLE's memory, the eight RAM sockets in a given row of memory must be filled entirely with 4K memory chips, entirely with 16K memory chips, or all eight RAM sockets may be empty.

To test the memory chips in your computer, you must first initialize the RAM Test program. Press the RESET key to invoke the Monitor, and then type

D5BCG return

Next, specify the hexadecimal, starting address for the portion of memory that you wish to test. You dust also specify the hexadecimal number of "pages" of memory that you wish tested, beginning at the given starting address. A page of memory is 256 bytes ($100 Hex). Representing the address by "a" and the number of pages by "p" (both in hexadecimal), start the RAM test by typing -

a .p ctrl Y return

Note 1: to type "ctrl Y", type Y while holding down the CTRL key; ctrl Y is not -displayed on the TV screen. Type "return" by pressing the RETURN key. The example instructions in this chapter often include spaces for easier reading; do not type these spaces.

Note 2: test length p*100 must not be greater than starting address a.

For example,

2000.10 ctrl Y return

tests hexadecimal 1000 bytes of memory (4096, or "4K" bytes, in decimal), starting at hexadecimal address 2000 (8192, or "8K". in decimal).

If the asterisk returns (after a delay that may be a half minute or so) without an error message (see ERROR MESSAGES discussion), then the specified portion of memory has tested successfully.

TABLE OF ADDRESS RANGES FOR STANDARD RAM CONFIGURATIONS

If the 3 Memory Configuration Blocks Look like this:	Then Row of Memory	Contains this Range of Hexadecimal RAM Addresses	And the total System Memory. If this is last Row filled, is
4K	C	0000—0FFF	4K
4K	D	1000—IFFF	8K
4K	E	2000—2FFF	12K
16K	C	0000—3FFF	16K
4K	D	4000—4FFF	20K
4K	E	5000—5FFF	24K
16K	C	0000—3FFF	16K
16K	D	4000—7FFF	32K
16K	E	8000—BFFF	48K

A 4K RAM Row contains 10 Hex pages (hex 1000 bytes, or decimal 4096 bytes).
A 16K RAM Row contains 40 Hex pages (hex 4000 bytes, or decimal 16384 bytes).

A complete test for a 48K system would be as follows:

400.4 ctrl Y return <——This tests the screen area of memory
800.8 ctrl Y return These first four tests examine
1000.10 ctrl Y return <—— the first 16K row of memory (Row C)
2000.20 ctrl Y return
4000.40 ctrl Y return <—— This tests the second 16K row of memory (Row D)
8000.40 ctrl Y return <—— This tests the third 16K row of memory (Row E)

Systems containing more than 16K of memory should also receive the following special test that looks for problems at the boundary between rows of memory:

3000.20 ctrl Y return

Systems containing more than 32K of memory should receive the previous special test, plus the following:

7000.20 ctrl Y return

:Tests may be run separately or they may be combined into one instruction.
For instance, for a 48K system you can type:

400.4 ctrl Y 800.8 ctrl Y 1000.10 ctrl Y 2000.20 ctrl Y 3000.20 ctrl Y
4000.40 ctrl Y 7000.20 ctrl Y 8000.40 ctrl Y return

Remember, ctrl Y will not print on the screen, but it must be typed. With the single exception noted in the section TESTING FOR INTERMITTENT FAILURE, spaces are shown for easier reading but should not be typed.

During a full test such as the one shown above, the computer will beep at the completion of each sub-test (each sub-test ends with a ctrl Y). At the end of the full test, if no errors have been found the APPLE will beep and the blinking cursor will return with the Monitor prompt character (*). It takes approximately 50 seconds for the computer to test the RAM memory in a 16K system; larger systems will take proportionately longer.

ERROR MESSAGES

TYPE I - Simple Error

During testing, each memory address in the test, range is checked by writing a particular number to it, then reading the. number actually stored at that address and comparing the two.

A simple error occurs when the number written to a particular memory address differs from the number which is then read back from that same address. Simple errors are reported in the following format:

xxxx yy zz ERR r-c

where	xxxx	is the hexadecimal address at which the error was detected;
	yy	is the hexadecimal data written to that address;
	z z	is the hexadecimal data read back from that address; and
	r-c	is the row and column where the defective memory chip was found. Count from the left, as viewed from the front of the APPLE: the leftmost memory chip is in column 3, the rightmost is in column 10.

Example:

201F 00 10 ERR D-I

TYPE II - Dynamic Error

This type of error occurs when the act of writing a number to one memory address causes the number read from a different address to change. If no simple error is detected at a tested address, all the addresses that differ from the tested address by one bit are read for changes indicating dynamic errors. Dynamic errors are reported in the following format:

xxxx yy zz vvvv qq ERR r-c

where	xxxx	is the hexadecimal address at which the error was detected;
	yy	is the hexadecimal data written earlier to address xxxx;
	zz	is the hexadecimal data now read back from address xxxx;
	vvvv	is the current hexadecimal address to which data qq was successfully written;
	qq	is the hexadecimal data successfully written to, and read back from, address vvvv; and
	r-c	is the row and column where the defective memory chip was found. Count from the left, as viewed from the front of the APPLE: the leftmost memory chip is in column 3, the rightmost is in column 10. In this type of error, the indicated row (but not the column) may he incorrect.

This is similar to Type I, except that the appearance of vvvv and qq indicates an error was detected at address xxxx after data was successfully written at address vvvv.

Example:

5051 00 08 5451 00 ERR E-6

After a dynamic error, the indicated row (but not the column) may he incorrect. Determine exactly which tests check each row of chips (according to the range of memory addresses corresponding to each row), and run those tests by themselves. Confirm your diagnosis by replacing the suspected memory chip with a known good memory chip (you can use either a 4K or a 16K memory chip, for this replacement). Remember to turn off the APPLE's power switch and to discharge yourself before handling the memory chips.

TESTING FOR INTERMITTENT FAILURE (Automatically Repeating Test)

This provides a way to test memory over and over again, indefinitely. You will type a complete series of tests, just as you did before, except that you will:

a. precede the complete test with the letter N
b. follow the complete test with 34:0
c. type at least one space before pressing the RETURN key.

Here is the format:

.N (memory test to be repeated) 34:0 (type one space) return

NOTE~ You must type at least one space at the end of the line, prior to pressing the RETURN-key. This is the only space that should be typed (all other spaces shown within instructions in this chapter are for easier reading only; they should not be typed).

Example (for a 48K system):

N 400.4 ctrl Y 800.8 ctrl Y 1000.10 ctrl Y 2000.20 ctrl Y 3000.20 ctrl Y 4000.40 ctrl Y 7000.20 ctrl Y 8000.40 ctrl Y 34:0 return

Run this test for at least one ho,~r (preferably overnight) with the APPLE's lid in place. This allows the system and the memory chips to reach maximum operating temperature.

Only if a failure occurs will, the APPLE display an error message and rapidly beep three tines; otherwise, the APPLE will beep once at the successful end of each sub-test To stop this repeating test, you must press the RESET. key.

COMMENTS:

1. You cannot test the APPLE's memory below the address of 400 (Hex), since various pointers and other system necessities are there. In any case, if that region of memory has problems, the APPLE won't function.

2. For any subtest, the number of pages tested cannot be greater than the starting address divided by 100 Hex. 2000.30 ctrl Y will not work, but 5000.30 ctrl Y will.

3. Before changing anything inside the APPLE, make sure the APPLE is plugged into a grounded, 3-wire power outlet, and that the power switch on the back of the computer is turned off. Always touch the outside metal bottom plate of the APPLE II, prior to handling any memory chips. This is done to -remove any static charge that you may have acquired.

EVEN A SMALL STATIC CHARGE CAN DESTROY MEMORY CHIPS

4. Besides the eight memory chips, some additions of memory require changing three other chip-like devices called Memory Configuration Blocks. The Memory Configuration Blocks tell the APPLE which type of memory chip (4K or 16K) is- to be plugged into each row of memory. A complete package for adding memory to your computer, containing all necessary parts and detailed instructions, can be purchased from APPLE Computer Inc. To add 4K of memory, order the Memory Expansion-Module (P/N A2M0014). To add 16K of memory, order the 16K Memory Expansion Module (P/N A2M0016).

CHAPTER 7
Music

GENERATING MUSICAL TONES

The Music feature is most easily used from within an Integer BASIC program. It greatly simplifies the task of making the APPLE II into a music-playing device.

There are three things the computer needs to know before playing a note: pItch (how high or low a note), duration (how long a time it is to sound), and timbre. Timbre is the quality of a sound that allows you to distinguish one instrument from another even if they are playing at the sane pitch and loudness. This Music feature does not permit control of loudness.

It is convenient to set up a few constants early in the program:

MUSIC =-10473
PITCH = 767
TIME = 766
TIMBRE = 765

There are 50 notes available, numbered from 1 to 50. The statement

POKE PITCH, 32

will set up the Music feature to produce (approximately) the note middle C. Increasing the pitch value by one increases the pitch by a semitone. Thus

POKE PITCH, 33

would set up the Music feature to produce the note C sharp. Just over four chromatic octaves are available. The note number 0 indicates a rest (a silence) rather than a pitch.

The duration of the note is set by

POKE TIME. t

Where t is a number from 1 to 255. The higher the number, the longer the note. A choice of t = 170 gives notes that are approximately one second long. To get notes at. a metronome marking of MM, use a duration of 10200/MM. For example, to get 204 notes per minute (approximately) use the command

POKE TIME, 10200/204

There are five timbres, coded by the numbers 2. 8, 16, 32 and 64. They are not very different from one another. With certain timbres, a few of the extremely low or high notes do not give the correct pitch. Timbre 32 does not have this problem.

POKE TIMBRE. 32

When the pitch, time, and timbre have been Set, the statement

CALL MUSIC

will cause the specified note to sound.

The following program plays a chromatic scale of four octaves~

```
10 MUSIC = -10473: PITCH = 767: TIME  = 766: TIMBRE = 765
20 POKE TINE, 40: POKE TIMBRE, 32
30 FOR I = 1 TO 49
40 POKE PITCH, I
50 CALL MUSIC
60 NEXT I: END
```

Where K is a number from 51 through 255.

POKE PITCH, X

will specify various notes, in odd sequences. In the program above, change line 40 to

40 POKE PITCH,. 86

for a demonstration.

COMMENTS:

Some extremely high or low notes will come out at the wrong pitch with certain timbres.

CHAPTER 8
HIGH-RESOLUTION GRAPHICS

PART A: SETTING UP PARAMETERS, SUBROUTINES, AND COLORS

Programmer's Aid If 1 provides your APPLE with the ability to do high-resolution color graphics from Integer BASIC. You may plot dots, lines and shapes in a wide variety of detailed forms, in 6 different colors (4 colors on systems below S/N 6000), displayed from two different "pages" of memory. The standard low-resolution graphics allowed you to plot 40 squares across the screen by 47 squares from top to bottom of the screen. This high-resolution graphics display node lets you plot in much smaller dots, 280 horizontally by 192 vertically. Because 8K bytes of memory (in locations from 8K to 16K, for Page 1) are dedicated solely to maintaining the high-resolution display, your APPLE must contain at least 16K bytes of memory. To use the Page 2 display (in locations from 16K to 24K). a system with at least 24K bytes of memory is needed. If your system is using the Disk Operating System (DOS), that occupies the top 10.5K of- memory: you will need a mInimum 32K system for Page 1, or 36K for Page 1 and Page 2. See the MEMORY MAP on page 63 for more details.

POSITIONING THE HIGH-RESOLUTION PARAMETERS

The first statement of an Integer BASIC program intending to use the Programmer's Aid High-Resolution subroutines should be:

```
0    X0 = Y0 = COLR = SHAPE = ROT = SCALE
```

The purpose of this statement is simply to place the six BASIC variable names used by the high-resolution feature (with space for their values) into APPLE's "variable table" in specific, known locations. When line 0 is executed, the six High-Resolution graphics parameters will be assigned storage space at the very beginning of the variable table, in the <u>exact</u> order specified in line 0. Your. BASIC program then uses those parameter names to change the six parameter values in the variable-table. However. the high-resolution subroutines ignore the parameter <u>names</u>, and look for the parameter <u>values</u> in specific variable-table <u>locations</u>. That is why the program's first line must place the six high-resolution graphics parameters in known variable—table locations. Different parameter names may be used, provided that they contain the same number of characters. Fixed parameter-name <u>lengths</u> are also necessary to insure that the parameter-value storage locations in the variable table do not change. For example, the name HI could be used in place of XO, but X or XCOORD could] not

The parameters SHAPE. ROT, and SCALE are used only by the subroutines that draw shapes (DRAW and DRAWl, see PART E). These parameters may be omitted from programs using only the PLOT and LINE features:

```
0    X0  =  Y0  =  COLR
```

Omitting unnecessary parameter definitions speeds up the program during execution. However, you can omit only those unused parameters to the right of the last parameter which is used. Each parameter that is used must be in its proper place. relative to the first parameter in. the definition list.

DEFINING SUBROUTINE NAMES

After the six parameters have been defined, the twelve High-Resolution subroutines should be given names, and these names should be assigned corresponding subroutine entry addresses as values. Once defined in this way, the various subroutines can be called by name each tine they are used, rather than by numeric address. When subroutines are called by name, the program is easier to type, more likely to be error-free, and easier to follow and to debug.

```
5     INIT    = - 12288   :  CLEAR =- 12274 :  BKGND = - 11471
6     POSN  = - 11527   :  PLOT =- 11506      :  LINE = - 11500
7     DRAW = -11465   :  DRAWl = - 11462
8     FIND  = - 11780  :  SULOAD =- 11335
```

Any variable names of any length may be used to call these subroutines. If you want maximum speed, do not define names for subroutines that you will not use in your program.

DEFINING COLOR NAMES

Colors may also be specified by name, if a defining statement is added to the program. Note that GREEN is preceded by LET to avoid a SYNTAX ERROR, due to conflict with the GR command.

```
10    BLACK = 0 : LET GREEN = 42 : VIOLET = 85
11    WHITE = 127 : ORANGE = 170 : BLUE = 213
12    BLACK2 = 128 : WHITE2 = 255
```

Any integer from 0 through 255 may be used to specify a color, but most of the numbers not named above give rather unsatisfactory “colors”. On systems below S/N 6000, 170 will appear as green and 213 will appear as violet.

Once again, unnecessary variable definitions should be omitted, as they will slow some programs. Therefore, a program should not define VIOLET = 85 unless it uses the color VIOLET.

The following example illustrates condensed initialization for a program using only the INIT. PLOT, and DRAW subroutines, and the colors GREEN and WHITE.

```
0 X0 = YO = COLR = SHAPE = ROT = SCALE
5 INIT =- 12288k : PLOT = -11506 : DRAW = -11465
10  LET GREEN = 42 : WHITE = 127
```

(Body of program would go here)

SPEEDING UP YOUR PROGRAM

Where maximum speed of execution is necessary, any of the following techniques will help:

1. Omit the name definitions of colors and subroutines, and refer to colors and subroutines- by numeric value, not by name.

2. Define the most frequently used program variable names before defining the subroutine and color names (lines 5 through 12 in the previous examples). The example below illustrates how to speed up a program that makes very frequent use of program variables I, J, and K:

```
0  X0  =  Y0  =  COLR  =  SHAPE  =  ROT  =  SCALE
2  l = J = K
5  INIT =- 12288 : CLEAR  = - 12274
6  BKGND  =- 11471 : POSN  = - 11527
10  BLACK  =  0 : VIOLET = 85
```

3. Use the High-Resolution graphics parameter names as program variables when possible. Because they are defined first, these parameters are the BASIC variables which your program can find fastest.

PART B: PREPARING THE SCREEN FOR GRAPHICS

THE INITIALIZATION SUBROUTINE

In order to use CLEAR, BKCND, POS, PLOT, or any of the other high-resolution subroutine CALLs, the INITialization subroutine itself must first be CALLed:

CALL INIT

The INITialization subroutine turns on the high-resolution display and clears the high-resolution screen to black. INIT also Sets up certain variables necessary for using the other High-Resolution subroutines. The display consists of a graphics area that is 280 x-positions wide (X0=0 through X0=279) by 160 y-positions high (Y0=0 through Y0=l59), with an area for four lines of text at the bottom of the screen. Y0 values from 0 through 191 may be used, but values greater than 159 will not be displayed on the screen. The graphics origin (X0=0, Y0=0) is at the top left corner of the screen.

CHANGING THE GRAPHICS SCREEN

If you wish to devote the entire display to graphics (280 x-positions wide by 192 y-positions high), use

POKE -16302, 0

The split graphics-plus-text mode may be restored at any tine with

POKE -16301, 0

or another

CALL INIT

When the High-Resolution subroutines are first initialized, all graphics are done in Page 1 of memory ($2000-3FFF), and only that page of memory is displayed. If you wish to use memory Page 2 (S4000-5FFF), two POKEs allow you to do so:

POKE 806, 64

causes subsequent graphics instructions to be executed in Page 2, unless those instructions attempt to continue an instruction from Page 1 (for instance, a LINE is always drawn on the same memory page where the last previous point was plotted). After this POKE, the display will still show memory Page 1.

To see what you are plotting on Page 2,

POKE -16299, 0

will cause Page 2 to be displayed on the screen. You can switch the screen display back to memory Page 1 at amy time, with

POKE -16300, 0

while

POKE 806, 32

will return you to Page 1 plotting. This last POKE is executed automatically by INIT.

CLEARING THE SCREEN

If at any time during your program you wish to clear the current plotting page to black, use

CALL CLEAR

This immediately erases anything plotted on the <u>current</u> plotting page. INIT first resets the current plotting page to memory Page 1, and then clears <u>Page 1</u> to black.

The entire current plotting page can be set to any solid background color with the BKGND subroutine. After you have INITialized the High-Resolution subroutines, set corn to the background color you desire, and then

CALL BKGND

The following program turns the entire display violet:

```
0    X0  =  Y0  =  COLR : REM SET PARAMETERS
5    INIT =- 12288 : BKGND = -11471 : REM DEFINE SUBROUTINES
10   VIOLET = 85 : REM DEFINE COLOR
20   CALL INIT : REM INITIALIZE HIGH-RESOLUTION SUBROUTINES
30   COLR = VIOLET : REM ASSIGN COLOR VALUE
40   CALL BRGND : REM MAKE ALL OF DISPLAY VIOLET
50   END
```

PART C: PLOTTING POINTS AND LINES

Points can be plotted anywhere on the high-resolution display, in any valid color, with the use of the PLOT subroutine. The PLOT subroutine can only be used after a CALL INIT has been executed, and after you have assigned appropriate values to the parameters X~, Y0 and COLR. KO must in the range from 0 through 279, YO must be in the range from 0 through 191, and COLR must be in the range from 0 through 255, or a

*** RANGE ERR

message will be displayed and the program will halt.

The program below plots a white dot at K-coordinate 35, Y-coordinate 55, and a violet dot at K-coordinate 85, Y-coordinate 90:

```
0   X0 = COLR : REM SET PARAMETERS
5   INIT = —12288 : PLOT =- 11506 : REM DEFINE SUBROUTINES
10   WHITE = 127 : VIOLET = 85 : REM DEFINE COLORS
20   CALL INIT :  REM INITIALIZE SUBROUTINES
30   COLR = WHITE :REM ASSIGN PARAMETER VALUES
40   X0 = 35 : Y0 = 55
50   CALL PLOT : REM PLOT WITH ASSIGNED PARAMETER VALUES
60   COLR = VIOLET : REM ASSIGN NEW PARAMETER VALUES
70   X0  =  85 : Y0 = 90
80   CALL PLOT    REM PLOT WITH NEW PARAMETER VALUES
90   END
```

The subroutine POSN is exactly like PLOT, except that nothing is placed on the screen. COLE must be specified, however, and a subsequent DRAWl (see PART E) will take its color from the color used by POSN. This subroutine is often used when establishing the origin-point for a LINE.

Connecting any two points with a straight line is done with the LINE subroutine. As with the PLOT subroutine, a CALL INIT must be executed, and X0, Y0, and COLR must be specified. In addition, before the LINE subroutine can be CALLed, the line's point of origin must have been plotted with a CALL PLOT or as the end point of a previous line or shape. Do not attempt to use CALL LINE without first plotting a point for the line's origin, or the line may be drawn in random memory locations, not necessarily restricted to the current memory page. Once again, X0 and Y0 (the coordinates of the termination point for the line), and COLE must be assigned legitimate values, or an error nay occur, The following program draws a grid of green lines vertically and violet lines horizontally, on a white background:

```
0    X0 = Y0 = COLR : REM SET PARAMETERS. THEN DEFINE SUBROUTINES
5    INIT =- 12288 : BKGND  = - 11471 : PLOT =- 11506 : LINE = - 11500
10   LET GREEN = 42 : VIOLET = 85 : WHITE = 127 : REM DEFINE COLORS
20   CALL INIT : REM INITIALIZE HIGH-RESOLUTION SUBROUTINES
30   POKE - 16302, 0 : REM SET FULL-SCREEN GRAPHICS
40   COLR = WHITE : CALL BKGND : REM MAKE THE DISPLAY ALL WHITE
50   COLR = GREEN : REM ASSIGN PARAMETER VALUES
60   FOR X0 = 0 TO 270 STEP 10
70   Y0 = 0 : CALL PLOT : REM PLOT A STARTING-POINT AT TOP OF SCREEN
80   Y0 = 190 : CALL LINE : REM DRAW A VERTICAL LINE TO BOTTOM OF SCREEN
90   NEXT X0 : REM MOVE RIGHT AND DO IT AGAIN
100  COLR = VIOLET : REM ASSIGN NEW PARAMETER VALUES
110  FOR Y0 = 0 10 190 STEP 10
120  X0 = 0 : CALL PLOT : REM PLOT A STARTING-POINT AT LEFT EDGE OF SCREEN
130  X0 = 270 : CALL LINE : REM PLOT A HORIZONTAL LINE TO RIGHT EDGE
140  NEXT Y0 : REM MOVE DOWN AND DO IT AGAIN
150  END
```

PART D: CREATING, SAVING AND LOADING SHAPES

INTRODUCTION

The High-Resolution feature’s subroutines provide the ability to do a wide range of high-resolution graphics “shape” drawing. A “shape” is considered to be any figure or drawing (such as an outline of a rocket ship) that the user wishes to draw on the display many times, perhaps in different sizes, locations and orientations. Up to 255 different shapes nay be created, used, and saved in a “Shape Table”, through the use of the High-Resolution subroutines DRAW, DRAWl and SHLOAD, in conjunction with parameters SHAPE, ROT and SCALE.

In this section, PART D, you will be shown how to create, save and load a Shape Table. The following section, PART E, demonstrates the use of the shape-drawing subroutines with a predefined Shape Table.

HOW TO CREATE A SHAPE TABLE

Before the High-Resolution shape-drawing subroutines can be used, a shape must be defined by a "shape definition." This shape definition consists of a sequence of plotting vectors that are stored in a series of bytes in APPLE's memory. One or more such shape definitions, with their index, make up a "Shape Table" that can be created from the keyboard and saved on disk or cassette tape for future use.

Each byte in a shape definition is divided into three sections, and each section can specify a "plotting vector", whether or not to plot a point, and also a direction to move (up, down, left, or right). The shape-drawing subroutines DRAW and DRAWl (see PART E) step through each byte in the shape definition section by section. from the definition's first byte through its last byte. When a byte that contains all zeros is reached, the shape definition is complete.

This is how the three sections A, B and C are arranged within one of the bytes that make up a shape definition:

Section:	C		B			A		
Bit Number:	7	6	5	4	3	2	1	0
Specifies:	D	D	P	D	D	P	D	D

Each bit pair DD specifies a direction to move, and each bit P specifies whether or not to plot a point before moving, as follows:

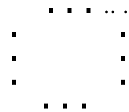
If DD	= 00	move up		
	= 01	move right	If P = 0	don't plot
	= 10	move down	=1	do plot
	= 11	move left		

Notice that the last section, C (the two most significant bits), does not have a P field (by default, P=0), so section C can only specify a move with<u>out</u> plotting.

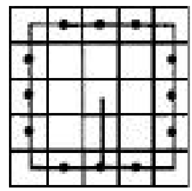
Each byte can represent up to three plotting vectors, one in section A, one in section B. and a third (a move only) in section C.

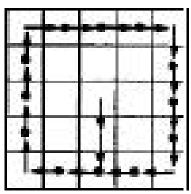
DRAW and DRAWl process the sections from right to left (least significant bit to most significant bit: section A, then B then C). At any section in the byte, IF ALL THE REMAINING SECTIONS OF THE BYTE CONTAIN ONLY ZEROS, THEN THOSE SECTIONS ARE IGNORED. Thus, the byte cannot end with a move in section C of 00 (a move up, without plotting) because that section, containing only zeros, will be ignored. Similarly, if section C is 00 (ignored), then section B cannot be a move of 000 as that will also be ignored. And a move of 000 in section A will <u>end</u> your shape definition unless there is a 1-bit somewhere in section II or C.

Suppose you want to draw a shape like this:



First, draw it on graph paper, one dot per square. Then decide where to start drawing the shape. Let's start this one at the center. Next, draw a path through each point in the shape, using only 90 degree angles on the turns:





Next, re-draw the shape as a series of plotting vectors, each one moving one place up, down, right, or left, and distinguish the vectors that plot a point before moving (a dot marks vectors that plot points).

Now "unwrap" those vectors and write them in a straight line:

Next draw a table like the one in Figure 1, below:

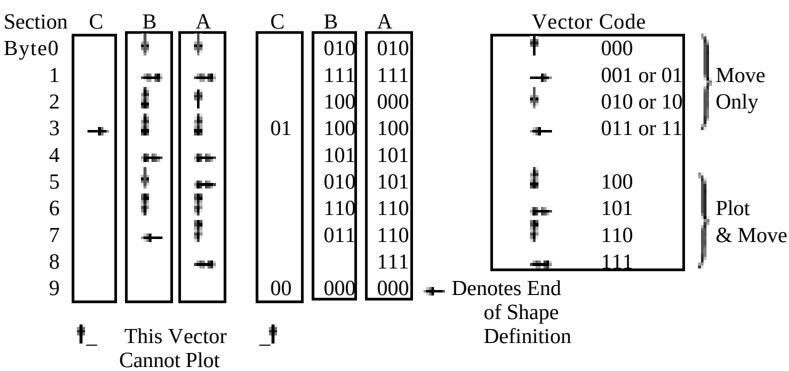


Figure 1

For each vector in the line, determine the bit code and place it in the next available section in the table. If the code will not fit (for example, the vector in section C can't plot a point), or is a 00 (or 000) at the end of a byte, then skip that section and go on to the next. When you have finished coding all your vectors, check your work to make sure it is accurate.

Now make another table, as shown in Figure 2, below, *and* re-copy the vector codes from the first table. Recode the vector, information into a series of hexadecimal bytes, using the hexadecimal codes from Figure 3.

Section:	C B	A		Bytes Recoded in Hex	
Byte 0	0 0 0 1	0 0 1 0	=	1 2	
1	0 0 1 1	1 1 1 1	=	3 F	
2	0 0 1 0	0 0 0 0	=	2 0	
3	0 1 1 0	0 1 0 0	=	6 4	
4	0 0 1 0	1 1 0 1	=	2 D	
5	0 0 0 1	0 1 0 1	=	1 5	
6	0 0 1 1	0 1 1 0	=	3 6	
7	0 0 0 1	1 1 1 0	=	l E	
8	0 0 0 0	0 1 1 1	=	0 7	
9	0 0 0 0	0 0 0 0	=	0 0	Denotes End of Shape Definition
Hex:	Digit 1	Digit 2			

Figure 2

Codes Binary		Hex
0000	=	0
0001	=	1
0010	=	2
0011	=	3
0100	=	4
0101	=	5
0110	=	6
0111	=	7
1000	=	8
1001	=	9
1010	=	A
1011	=	B
1100	=	C
1101	=	D
1110	=	E
1111	=	F

Figure 3

The series of hexadecimal bytes that you arrived at in Figure 2 is the shape definition. There is still a little more information you need to provide before you have a complete Shape Table. The form of the Shape Table, complete with its index, is shown in Figure 4 on the next page.

For this example, your index is easy: there is only one shape definition. The Shape Table's starting location, whose address we have called S. must contain the number of shape definitions (between 0 and 255) in hexadecimal. In this case, that number is just one. We will place our shape definition immediately below the index, for simplicity. That means, in this case, the shape definition will start in byte S+4: the address of shape definition #1, relative to S, is 4 (00 04, in hexadecimal). Therefore, index byte S+2 must contain the value 04 and index byte S+3 must contain the value 00. The completed Shape Table for this example is shown in Figure 5 on the next page.

Start=S	Byte S+0	n (0 to FF)	Total Number of Shape Definitions
	+1	Unused	
	+2	Lower 2 Digits	Dl: Index to First Byte of Shape Definition #1, Relative to S
	+3	Upper 2 Digits	
	+4	Lower 2 Digits	D2: Index to First Byte of Shape Definition #2, Relative to S
Index	+5	Upper 2 Digits	
	.	. . .	
	.	. . .	
	.	. . .	
	+2n	Lower 2 Digits	Dn: Index to First Byte of Shape Definition #n, Relative to S
	+2n+1	Upper 2 Digits	
	S+D1	First Byte	
	.	. .	Shape Definition #1
	.	Last Byte	
	S+D2	First Byte	
	.	. .	Shape Definition #2
	.	Last Byte	
Shape Definitions			
	.	. .	
	.	. .	
	.	. .	
	S+Dn	First Byte	
	.	. .	Shape Definition #n
	.	Last Byte+00	

Figure 4

Start (Store this address in $328 and $329)	Byte 0	01	Number of Shapes
	1	00	
	2	04	Index to Shape Definition #1, Relative to Start
	3	00	
	4	12	First Byte
	5	3F	
	6	20	
	7	64	
	8	2D	Shape Definition #1
	9	15	
	A	36	
	B	1E	
	C	07	
	D	00	Last Byte

Figure 5

You are now ready to type the Shape Table into APPLE's memory. First, choose a starting address. For this example, we'll use hexadecimal address 0800.

Note: this address must he less than the highest memory address available in your system (HIMEM), and not in an area that will be cleared when you use memory Page 1 (hexadecimal locations $2000 to $4000) or Page 2 (hexadecimal locations $4000 to $6000) for high-resolution graphics. Furthermore, it must not be in an area of memory used by your BASIC program. Hexadecimal 0800 (2048, in decimal) is the lowest memory address normally available to a BASIC program. This lowest address is called LOMEM. Later on, we will move the LOMEM. pointer higher, to the end of our Shape Table, in order to protect our table from BASIC program variables.

Press the RESET key to enter the Monitor program, and type the Starting address for your Shape Table:

If you press the RETURN key now, APPLE will show you the address and the contents of that address. That is how you examine an address to see if you have a put the correct number there. If instead you type a colon (:) followed by a two-digit hexadecimal number, that number will be stored at the specified address when you press the RETURN key. Try this:

0800 return

(type "return'~ by pressing the RETURN key). What does APPLE say the contents of location 0800 are? Now try this:

0800:01 return
0800 return
0800— 01

The APPLE now says that the value 01 (hexadecimal) is stored in the location whose address is 0800. To store more two-digit hexadecimal numbers in successive bytes in memory, just open the first address:

and then type the numbers, separated by spaces:

0800:01 00 04 00 12 3F 20 64 2D 15 36 IE 07 00 return

You. have just typed your first complete Shape Table...not so bad. was it? To check the information in your Shape Table, you can examine each byte separately or simply press the RETURN key repeatedly until all the bytes of interest (and a few extra, probably) have been displayed:

```
0800 return
0800-  01
return
00 04 00 12 3F 20 64
return
0808—           2D 15 36 1E 07 00 FF FF
```

If your Shape Table looks correct, all that remains is to store the starting address of the Shape Table where the shape-drawing subroutines cam find it (this is done automatically when you use the SHLOAD subroutine to get a table from cassette tape). Your APPLE looks for the four hexadecimal digits of the table's starting address in hexadecimal locations 328 (lower two digits) and 329 (upper two digits). For-our table's starting address of 08 00, this would do the trick:

```
328:00 08
```

To protect this Shape Table from being erased by the variables in your BASIC program, you must also set LOMEM (the lowest memory address available to your program) to the address that is one byte beyond the Shape Table's last, or largest, address.

It is best to set LOMEM from BASIC, as an immediate-execution command issued before the BASIC program is RUN. LOMEM is automatically set when you invoke BASIC (reset ctrl 3 return) to decimal 2048 (0800. im hexadecimal). You must then change LOMEM to 2048 plus the number of bytes in your Shape Table plus one. Our Shape Table was decimal 14 bytes long, so our immediate-execution BASIC command would be:

```
LOMEM:          2048 + 15
```

Fortunately, all of this (entering the Shape Table at LOMEM. resetting LOMEM to protect the table, and putting the table's starting address in $328—$329) is taken care of automatically when you use the High-Resolution feature's SHLOAD subroutine to get the table from cassette tape.

SAVING A SHAPE TABLE

Saving on Cassette Tape

To save your Shape Table on tape, you must be in the Monitor and you must know three hexadecimal numbers:

1) Starting Address of the table (0800. in our example)
2) Last Address of the table (080D, in our example)
3) Difference between 2) and 1) (000D, in our example)

Item 3, the difference between the last address and the first address of the table. must be stored in hexadecimal locations 0 (lower two digits) and 1 (upper two digits):

0:0D 00 return

Now you can "Write" (store on cassette) first the table length that is stored in locations 0 and 1, and then the Shape Table itself that is stored in locations Starting Address through Last Address:

0.1W 0800.080DW

Don't press the RETURN key until you have put a cassette in your tape recorder, rewound it. and started it recording (press PLAY and RECORD simultaneously). Now press the computer's RETURN key.

Saving on Disk

To save your Shape Table on disk, use a command of this format

BSAVE filename. A$ startingaddress, L$ tablelength

For our example, you might type

BSAVE MYSHAPE1, AS 0800. LS 000D

Note: the Disk Operating System (DOS) occupies the top 10.5K of memory (10752 bytes decimal, or $2A00 hex); make sure your Shape Table is not in that portion of memory when you "boot" the disk system.

LOADING A SHAPE TAIL!

Loading from-Cassette Tape

To- load a Shape Table from cassette tape, rewind the tape. start it playing (press PLAY), and (in BASIC. now) type

CALL —11335 return

or (if you have previously assigned the value —11335 to the variable SHLOAD)

CALL SHLOAD return

You should hear one “beep” when the table’s length has been read successfully, and another “beep” ‘when the table itself has been read. When loaded this way. your Shape Table will load into memory, beginning at hexadecimal address 0800. LOMEM is automatically changed to the address of the location immediately following the last Shape-Table byte. Hexadecimal locations 328 and 329 are automatically set to contain the starting address of the Shape Table.

Loading from Disk

To load a Shape Table from disk, use a command of the form

BLOAD filename

From our previously-saved example, you would type

BLOAD MYSHAPE1

This will load your Shape Table into memory, beginning at the address you specified after “A$” when-you BSAVEd the Shape Table earlier. In our example, MYSHAPEL would BLOAD beginning at address 0800. You must store the Shape Table’s starting address in hexadecimal locations 328 mmd 329, yourself, from the Monitor:

328:00 08 return

If your Shape Table is in an area of memory that may be used by your BASIC program (as our example is), you must protect the Shape Table from your program. Our example lies at the low end of memory, so we can protect it by raising LOMEM to just above the last byte of the Shape Table. This must be done after invoking BASIC (reset ctrl B return) and before RUNning our BASIC program. We could do this with the immediate-execution BASIC command

LOMEM: 2048 + 15

FIRST USE OF A SHAPE TABLE

You are now ready to write a BASIC program using Shape-Table subroutines such as DRAW and DRAW1. For a full discussion of these High-Resolution subroutines, see the following section, PART E.

Remember that Page 1 graphics uses memory locations 8192 through 16383 (8K to 16K). and Page 2 graphics uses memory locations 16384 through 24575 (16K to 24K). Integer BASIC puts your program right at the top of available memory; so if your APPLE contains less than 32K of memory, you should protect your program by setting HIMEM to 8192. This must be done after you invoke BASIC (reset ctrl B return) and before RUNning your program, with the immediate—execution command

HIMEM:8192

Here’s a sample program that assumes our Shape Table has already been loaded from tape, using CALL SHLOAD. This program will print our defined shape. rotate it 5.6 degrees if that rotation is recognized (see ROT discussion, next section) and then repeat, each repetition larger than the one before.

```
10   X0 = Y0 = COLE = SHAPE = ROT = SCALE REM SET PARAMETERS
20   INIT = -12288 : DRAW —11465 REM DEFINE SUBROUTINES
30   WRITE = 127 : BLACK = 0 : REM DEFINE COLORS
40   CALL INIT : REM INITIALIZE HIGH-RESOLIJTION SUBROUTINES
50   SHAPE = 1
60   X0 = 139 : Y0 = 79 : REM ASSIGN PARAMETER VALUES
70   FOR R = 1 TO 48
80   ROT =R
90   SCALE = R
100  COLR = WHITE
110  CALL DRAW : REM DRAW SHAPE 1 WITH ABOVE PARAMETERS
120  NEXT R : REM NEW PARAMETERS
130  END
```

To pause, and then erase each square after it is draw, add these lines:

```
114 FOR PAUSE - 1 TO 200 : NEXT PAUSE
116 COLR = BLACK : REM CHANGE COLOR
118 CALL DRAW : REM RE-DRAW SAME SHAPE, IN NEW COLOR
```

PART I: DRAWING SHAPES FROM A PREPARED SHAPE TABLE

before either of the two shape-drawing subroutines DRAW or DRAWl can be used, a “Shape Table” must be defined and stored in memory (see PART E: CREATING A SHAPE TABLE), the Shape Table’s starting address must be specified in hexadecimal locations 328 and 329 (808 and 809, im decimal), and the High-Resolution subroutines themselves must have been initialized by a CALL INIT.

ASSIGNING PARAMETER VALUES

The DRAW subroutine is used to display any of the shapes defined in the current Shape Table. The origin or beginning point’ for DRAWing the shape is specified by the values assigned to X0 and Y0. and the rest of the shape continues from that point. The color of the shape to be DRAWn is specified by the value of COLR.

The shape number (the Shape Table’s particular shape definition that you wish to have DRAWn) is specified by the value of SHAPE. For example,

SHAPE = 3

specifies that the next shape-drawing command will use the third shape definition in the Shape Table. SHAPE may be assigned any value (from 1 through 255) that corresponds to one of the shape definitions in the current Shape Table. An attempt to DRAW a shape that does not exist (by executing a shape-drawing command after setting SHAPE = 4, when there are only two shape. definitions in your Shape Table, for instance) will result in a *** RANGE ERR message being displayed, and the program will halt.

The relative size of the shape to be DRAWn is specified by the value assigned to SCALE. For example,

SCALE = 4

specifies that the next shape DRAWn will be four times the size that is described by the appropriate shape definition. That is, each “plotting vector” (either a plot and a move, or just a move) will be repeated four times. SCALE may be assigned any value from 0 through 255, but SCALE = 0 is interpreted as SCALE = 256, the largest size for a given shape definition.

You can also specify the orientation or angle of the shape to be DRAWn, by assigning the proper value to ROT. For example,

ROT = 0

will cause the next shape to be DRAWn oriented just as it was defined, while

ROT = 16

will cause the next shape to be DRAWn rotated 90 degrees clockwise. The value assigned to ROT must be within the range 0 to 255 (although ROT=64, specifying a rotation of 360 degrees clockwise, is the equivalent of ROT=0). For SCALE=1, only four of the 63 different rotations are recognized (0.16,32,48); for SCALE=2. eight different rotations are recognized; etc. ROT values specifying unrecognized rotations will usually cause the shape to be DRAWn with the next smaller recognized rotation.

ORIENTATIONS OF SHAPE DEFINITION

ROT = 0 (no rotation from shape definition)

ROT = 48 (270 degrees clockwise rotation)

ROT = 16 (90 degrees clockwise rotation)

ROT = 32 (180 degrees clockwise rotation)

DRAWING SHAPES

The following example program DRAWs shape definition number three. im white. at a 135 degree clockwise rotation. Its starting point, or origin, is at (140,80).

```
0  X0 = Y0 = COLR = SHAPE = ROT - SCALE : REM SET PARAMETERS
5  INIT=-12288 : DRAW = -11465 : REM DEFINE SUBROUTINES
10  WHITE = 127 : REM DEFINE COLOR
20  CALL INIT : REM INITIALIZE HIGH-RESOLUTION SUBROUTINES
30  X0 = 140 : Y0 = 80 : COLR = WHITE   REM ASSIGN PARAMETER VALUES
40  SHAPE = 3 : ROT =  24 : SCALE = 2
50  CALL DRAW : REM DRAM SHAPE 3, DOUBLE SIZE, TURNED 135 DEGREES
60  END
```

LINKING SHAPES

DRAWl is identical to DRAW, except that the last point previously DRAWn, PLOTted or POSNed determines the color and the starting point for the new shape. X0, TO. and COLE, need not be specified, as they will have no effect on DRAWl. However, some point must have been plotted before CALLing DRAW1, or this CALL will have no effect.

The following example program draws “squiggles” by DRAWing a small shape whose orientation is given by game control #0. then linking a new shape to the old one, each tine the game control gives a new orientation. To clear the screen of “squiggles,” press the game-control button.

```
10    X0 = Y0 = COLR = SHAPE = ROT = SCALE REM SET PARAMETERS
20    INIT = -12288 DRAW = -11465 DRAWl = -11462
22    CLEAR = -12274 UNITE = 127 REM NAME SUBROUTINES AND COLOR
30    FULLSCREEN = -16302 BUTN =-16287 REM NAME LOCATIONS
40    CALL INIT REM INITIALIZE HIGH-RESOLUTION SUBROUTINES
50    POKE FULLSCREEN, 0 REM SET FULL-SCREEN GRAPHICS
60    COLR = WHITE : SHAPE = 1 : SCALE = 5
70    X0 = 140 Y0 = 80 : REM ASSIGN PARAMETER VALUES
80    CALL CLEAR : ROT = PDL(0) : CALL DRAW : REM DRAW FIRST SHAPE
90    IF PEEK(BUTN) > 127 THEN GOTO 80 : REM PRESS BUTTON TO CLEAR SCREEN
100   R = PDL(0) : IF (R < ROT+2) AND (R >ROT+2) THEN GOTO 90 :
      REM WAIT FOR CHANGE IN GAME CONTROL
110 ROT = R : CALL DRAWl : REM ADD TO 'SQUIGGLE”
120 GOTO 90 : REM LOOK FOR ANOTHER CHANCE
```

After DRAWing a shape, you may wish to draw a LINE from the last plotted point of the shape to another fixed point on the screen. To do this, once the shape is DRAWS, you must first use

CALL FIND

prior to CALLing LINE. The FIND subroutine determines the X and Y coordinates of the final point in the shape that was DRAWn, and uses it as the beginning point for the subsequent CALL LINE.

The following example DRAWs a white shape, and then draws a violet LINE from the final plot position of the shape to the point (10, 25).

```
0  X0 = Y0 = COLR = SHAPE = ROT = SCALE : REM SET PARAMETERS
5  INIT = -12288 : LINE = -11500 : DRAW = -11402 : FIND = -11780
10   VIOLET = 85 : WHITE = 127 : REM DEFINE SUBROUTINES AND COLORS
20   X0 = 140 : Y0 = 80 : COLR = WHITE : REM ASSIGN PARAMETER VALUES
30   SHAPE = 3 : ROT = 0 : SCALE = 2
40   CALL DRAW : REM DRAW SHAPE WITH ABOVE PARAMETERS
50   CALL : FIND REM FIND COORDINATES OF LAST SHAPE POINT
60   X0 = 10 : Y0 = 25 :COLR = VIOLET REM NEW PARAMETER VALUES, FOR LINE
70   CALL LINE : REM DRAW LINE WITH ABOVE PARAMETERS
80   END
```

COLLISIONS

Any time two or more shapes intersect or overlap, the new shape has points in common with the previous shapes. These common points are called points of “collision.”

The DRAW and DRAWL subroutines return a “collision count” in the hexadecimal memory location $32A (810. in 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 value encountered while DRAWing a shape is a true collision counter. For example, the collision counter is useful for determining whether or not two constantly moving shapes ever touch each other.

```
110 CALL DRAW : REM DRAW THE SHAPE
120 COUNT = PEEK(810) : REM FIND THE COLLISION COUNT
```

PART F: TECHNICAL INFORMATION

LOCATIONS OF THE HIGH-RESOLUTION PARAMETERS

When the high-resolution parameters are entered (line 0, say), they are stored —— with space for their values —— in the BASIC variable table, just above LOMEM (the LOwest MEMory location used for BASIC variable storage). These parameters appear in the variable table in the exact order of their first mention in the BASIC program. That order must be as shown below. because the 111gb—Resolution subroutines look for the parameter values by location only. Each parameter value is two bytes in length. The low-order byte is stored in the lesser of the two locations assigned.

VARIABLE-TABLE PARAMETER LOCATIONS

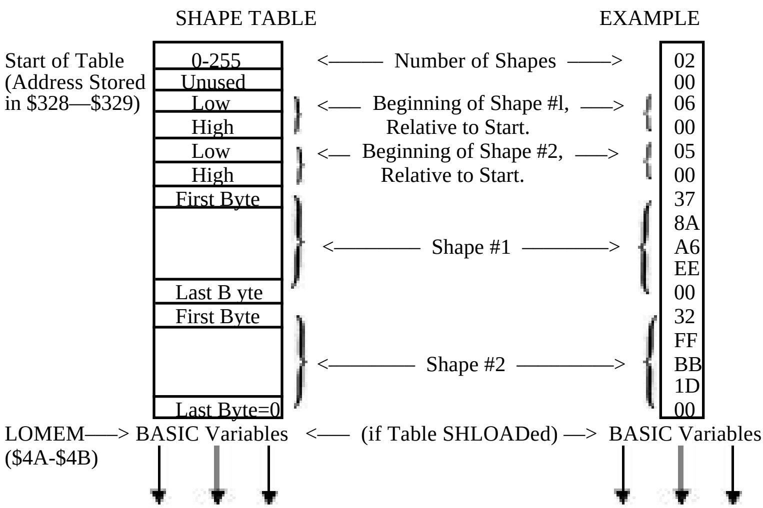
Parameter	Locations beyond LOMEM
X0	$05, $06
Y0	$0C, S0D
COLR	$15, $16
SHAPE	$IF, $20
ROT	$27, $28
SCALE	$31, $32

VARIABLES USED WITHIN THE HIGH-RESOLUTION SUBROUTINES

Variable Name	Hexadecimal Location	Description
SHAPEL, SHAPER	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.
X0L. X0R	320, 321	Most recent X-coordinate. Used for initial endpoint of LINE. Updated by PLOT. POSN, LINE and FIND, not DRAW.
Y0	322	Most recent y-coordinate (see X0L,
BXSAV	323	Saves 6502 K-register during high- resolution CALLs from BASIC.
BCOLOR	324	Color specification for PLOT. POSN.
HNDX	325	On-the-fly byte index from BASES ADDRESS
HPAG	326	Memory page for plotting graphics. Normally ~20 for plotting in Page 1 of high—resolution 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 from DRAW, DRAWl.

SHAPE TABLE INFORMATION

Shape Tape	Description
Record #1	A two—byte—long record that contains the length of record #2, Low—order first
Record Gap	Minumum of .7 seconds in length.
Record #2	The Shape Table (see below).

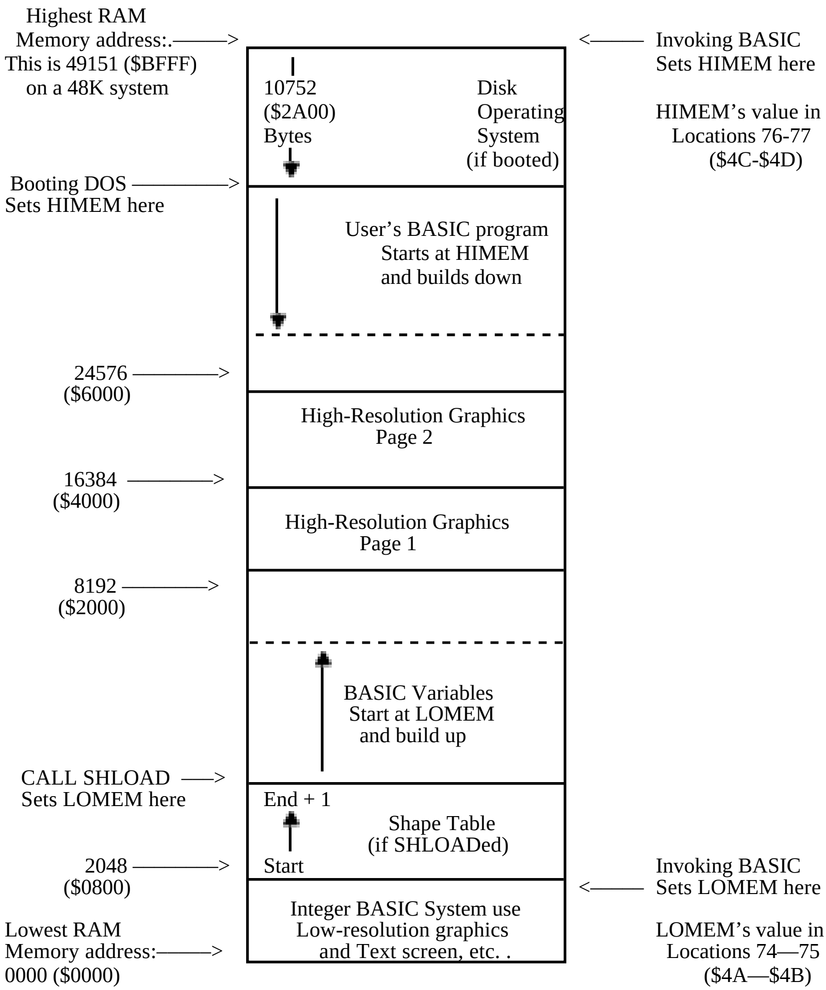


The address of the Shape Table's Start should be stored in locations $328 and $329. If the SHLOAD subroutineis used to load the table. start will be set to LOMEM(normally this is at $0800) and then LOMEM will be moved to one byte after the end of the Shape Table, automatically.

If you wish to load a Shape Table named MYSIIAPES2 from disk, beginning at decimal location 2048 (0800 hex) and ending at decimal location 2048 plus decimal 15 bytes (as in the example above), you may wish to begin your BASIC program as follows:

```
0  D$ = "" : REM QUOTES CONTAIN CTRL D (D$ WILL BE ERASED BY SHAPE TABLE)
1  PRINT D$; "BLOAD MYSHAPES2, A 2048" : REM LOADS SHAPE TABLE
2  POKE 808, 2048 MOD 256 POKE 809, 2048 / 256  :REM SETS TABLE START
3  POKE 74, (2048 + 15 + 1) MOD 256 POKE 75. (2048 + 15 + 1) / 256
4  POKE 204, PEEK(74) POKE 205, PEEK(75) : REM SETS LOMEM To TABLE END+l
5  X0 = Y0 = COLR = SHAPE = ROT = SCALE : REM SETS PAEM4ETERS
```

APPLE II MEMORY MAP FOR USING HIGH-RESOLUTION GRAPHICS WITH INTEGER BASIC



Unfortunately, there is no convention for napping memory. This map shows the highest (largest) address at the top, lowest (smallest) address at the bottom. The naps of Shape Tables that appear on other pages show the Starting address (lowest and smallest) at the top, the Ending address (highest end largest) at the bottom.

PART G: COMMENTS

1. Using memory Page 1 for high-resolution graphics erases everything in memory from location 8192 ($2000 hex) to location 16383 ($3FFF). If the top of your system's memory is in this range (as it will be, if you have a 16K system), integer BASIC will normally put your BASIC program exactly where it will be erased by INIT. You must protect your program by setting HIMEM below memory Page 1, after invoking BASIC (reset ctrl B return) and before RUNning your program: use this immediate-execution command:
HIMEM: 8192 return

2. Using memory Page 2 for high-resolution graphics erases memory from location 16384 ($4000) to location 24575 ($5FFF). If yours is a 24K system, this will erase your BASIC program unless you do one of the following:

a) never use Page 2 -for graphics; or
b) change HIMEM to 8192, as described above.

3. The picture is further confused if you are also using an APPLE disk with your system. The Disk Operating System (DOS). when booted, occupies the highest 10.5K ($2A00) bytes ~f memory. HIMEM is moved to just below the DOS. Therefore, if your system contains less than 32K of memory, the DOS will occupy memory Page 1 and Page 2. In that case, you cannot use the High-Resolution graphics with the DOS intact. An attempt to do so will erase all or part of the DOS. A 32K system can use only Page 1 for graphics without destroying the DOS, but HIMEM must be moved to location 8192 as described above. 48K systems cam usually use the DOS and both high-resolution memory pages without problems.

4. If you loaded your Shape ~able starting at LOMEM in location 2048 ($0800), from disk or from tape without using SHLOAD. Integer BASIC will erase the Shape Table when it stores the program variables. To protect your Shape Table, you must move LOMEM to one byte beyond the last byte of the Shape Table, after invoking BASIC and before using any variables. SHLOAD does this automatically, but you can use this immediate-execution command:

LOMEM: 2048 + tablelength + 1

where tablelength must be a number, not a variable name. Some programmers load their Shape Tables beginning in location 3048 ($0BE8). That leaves a safe margin of 1000 bytes for variables below the Shape Table, and at least 5000 bytes (if HIMEM: 8192) above the table for their BASIC program.

5, CALLing an undefined or accidentally misspelled variable name is usually a CALL to location zero (the default value of any undefined variable). This CALL may cause unpredictable and unwelcome results, depending on the contents of location zero. However, after you execute this BASIC command:

POKE 0, 96

an accidental CALL to location zero will cause a simple jump back to your BASIC program, with no damage.

APPENDIX I
SOURCE ASSEMBLY LISTINGS

```
 *****************************
 *                           *
 *  APPLE–II HI-RESOLUTION   *
 *  GRAPHICS SUBROUTINES     *
 *                           *
 *      by WOZ    9/13/77    *
 *                           *
 * AlL RIGHTS RESERVED       *
 *                           *
 ************t***************.

               * HI-RES EQUATES
               SHAPEL     EQU   $1A     POINTER TO
               SHAPEH     EQU   $1B     SHAPE LIST
               HCOLOR1    EQU   $1C     RUNNING COLOR MASK
               COUNTH     EQU   $1D
               HBASL      EQU   $26     BASE ADR FOR CURRENT
               HBASH      EQU   $27     HI-RES PLOT LINE. A
               HMASK      EQU   $30
               A1L        EQU   $SC     MONITOR Al.
               A1H        EQU   $3D
               A2L        EQU   $3E     MONITOR A2.
               A2H        EQU   $3F
               LOMEML     EQU   $4A.    BASIC ‘START CE VARS'.
               LOMEMH     EQU   $4B
               DXL,       EQO   $50     DELTA-X FOR HI IN, SHAPE.
               DXH.       EQU   $51
               SHAPEX     LQU   $51     SHAPE TEMP.
               DY         EQU   $52     DELTA-Y FOR HLIN. SHAPE.
               QDRNT      EQU   $53     ROT QUADRANT (SHAPE),
               EL         EQU   $54     ERROR FOR HLIN.
               EN         EQU   $55
               PPL        EQU   $CA     BASIC START OF PROG PTR.
               PPH        EQU   $CB
               PVL        EQU   $CC     BASIC END OF VARS PTR.
               PYH        EQU   $CD
               ACL        EQU   $CE     BASIC ACC.
               ACH        EQU   $CF
               X0L        EQU   $320    PRIOR X-COORD SAVE
               X0H        EQU   $321    AFTER HLIN OR HPLOT.
               Y0         EQU   $322    HLIN, HPLOT Y-COORD SAVE.
               BXSAV      EQU   $323    X-REG SAVE FOR SASIC.
               HCOLOR     EQU   $324    COLOR FOR HPLOT, HPOSN
               HNDX       EQU   $325    HORIZ OFFSET SAVE.
               HPAG       EQU   $326    HI—RES PAGE ($20 NORMAL)
               SCALE      EQU   $327    SCALE FOR SHAPE, MOVE.
               SWAP XL    EQU   $328    START OF
               SHAPXH     EQU   $329    -  SHAPE TABLE.
               COLLSN     EQU   $32A    COLLISION COUNT
               HIRES      EQU   $C057   SWITCH TO HI-RES VIDEO
               MIXSET     EQU   SC053   SELECT TEXT/GRAPHICS MIX
               TXTCLR     EQU   $C050   SELECT GRAPHICS MODE.
               MEMFUL     EQU   $E36B   BASIC MEM FULL ERROR.
               RNGERR     EQU   $EE68   BASIC RANGE ERROR.
               ACADR      EQU   $E11E   2-BYTE TAPE READ SETUP.
               RD2BIT     EQU   $FCFA TWO-EDGE TAPE SENSE
               READ       EQU   $FEFD   TAPE READ (A1, A2).
               READX1     EQU   $FF02   READ WITHOUT HEADER.

               * HIGH RESOLUTION GRAPHICS INITS
               *.
               * RUM VERSION $D000 TO $D3FF
               *
                          ORG   $D000
                          ODJ   $A000
D000 A9 20     SETHRL     LDA   #$20 INIT FOR $2000-3FFF
D002 8D 26 03             STA   HPAG HI-RES SCREEN MEMORY.
```

```
D005  AD  57  C0          LDA   HIRES SET HIRES DISPLAY MODE
D008  AD  53  C0          LDA   MIXSET WITH TEXT AT BOTTOM.
D00B  AD  50  C0          LDA   TXTCLR SET GRAPHICS DISPLAY MODE
D00E  A9  00      HCLR    LDA   #$0
D010  85  IC      BKGNDOSTA     HCOLOR1 SET FOR BLACK BKGND.
D012  AD  26  03  BKGND   LDA   HPAG
D015  85  18              STA   SHAPEH INIT HI-RES SCREEN MEM
D017  A0  00              LDY   #$0 FOR CURRENT PACE, NORMALLY
D019  84  IA              STY   SHAPEI. $2000-3FFF OR $4000-5FFF
D01B  A5  1C      BKGND1  LDA   HCOLOR1
D01D  91  1A              STA   (SHAPEL) Y
D01F  20  A2  D0          JER   CSHFT2 (SHAPEL,H) WILL. SPECIFY
D022  C8                  INY   32 SEPARATE PAGES.
D023  D0  F6              BNF   BKGND1 THROUGHOUT THE INIT.
D025  E6  18              INC   SHAPEH
D027  A5  lB              LDA   SHAPEH
D029  29  1F              AND   #$1F TEST FOR DONE.
D02B  D0  EE              BNE   BKGND1
D02D  60                  RTS

                  *  HI—RES GRAPHICS POSITION AND PLOT SUBRS
D02E  8D  22  03  HPOSN   STA   Y0 ENTER WITH Y IN A-REQ
D031  8E  20  03          STX   X0L XL IN X-REG,
D034  8C  21  03          STY   X0H AND XH IN Y-REG.
D037  48                  PHA
D038  29  C0              AND   #$C0
D03A  85  26              STA   HBASL FOR Y-COORD = 00ABCDEF
D03C  4A                  LSR   ;CALCULATES BASE ADDRESS
D030  4A                  LSR   ;IN HBASL, HBASH FOR
D03E  05  26              ORA   HBASL      ACCESSING SCREEN MEN
D040  85  24              STA   HBASL      VIA (HBASL),Y ADDRESSING MODE
D042  68                  PLA
D043  85  27              STA   HBASH
D045  0A                  ASL   ;CALCULATES
D046  0A                  ASL   ; HBASH = PPPFGHCD
D047  0A                  ASL   ; HBASL =EABAB000
D048  26  27              ROL   HBASH
D04A  0A                  ASL   WHERE PPP=001 FOR $2000-3FFF
D04B  26  27              ROL   HBASH SCREEN MEM RANGE AND
D04D  PA                  ASL   ; PPP=010 FOR $4000—7FFF
D04E  66  26              ROR   HBASL (GIVEN Y-COORD=ABCDEFGH)
D050  A5  27              LDA   HBASH
D052  29  1F              AND   #$1F
D054  0D  26  03          ORA   HPAG
D057  85  27              STA   HBASH
D059  8A                  TXA   DIVIDE X0 BY 7 FOR
D05A  C0  00              CPY   #$0 INDEX FROM BASE ADR
D05C  F0  05              BEG   HPOSN2 (QUOTIENT) AND BIT
D05E  A0  23              LDY   #$23 WITHIN SCREEN MEM BYTE
D060  69  04              AOC   ##4 (MASK SPEC'D BY REMAINDER)
D062  C8          HPOSN1  INY
D063  E9  07      HPOSN2  SBC   #$7 SUBTRACT OUT SEVENS.
D065  80  F8              BCS   HPOSN1
D067  8C  25  03          STY   MNDX WORKS FOR XO FROM
D06A  AA                  TAX   0 TO 279, LOW-ORDER
D06B  BD  EA  D0          LDA   MSKTBL-249, X BYTE IN X-REQ
D06E  85  30              STA   HMASK HIGH IN Y-REG ON ENTRY
D070  98                  TYA
D071  4A                  LSR   ; IF ON ODD BYTE (CARRY SET)
D072  AD  24  03          LDA   HCOLOR THEN ROTATE HCOLOR ONE
D075  85  1C      HPOSN3. STA   HCOLOR1 BIT FDR 180 DEGREE SHIFT
D077  80  29              BCS   CSHFT2 PRIOR TO COPYING TO HCOLOR1.
D079.60                   RTS
D07A  20  2E  D0  HPLOT   JSR   HPOSN
D07D  A5  IC      HPLOT1  LOA   HCOLOR1 CALC BIT POSN IN HBASL,H
D07F  51  24              EOR   (H8ASL),Y HNDX AND HMASK FROM
D031  25  30              AND   HMASK Y-COORD IN A-REQ.
D033  51  26              EOR   (HBASL), Y X-COORD IN X,Y-REGS.
D035  91  26              STA   (HBASL),Y FOR ANY ‘L’ BITS OF HMAS
D037  60                  RTS   SUBSTITUTE CORRESPONDING
                                           BIT OF HCOLOR1.
```

```
                          HI-RES GRAPHICS L, R, U, D SUBRS
D038  10  24              LFTRT    BPL   RIGHT USE SIGN FOR LFT/RT SELECT
D03A  A5  30              LEFT     LDA   HMASK
D03C  4A                           LSR   SHIFT LOW-ORDER
D03D  B0  05                       BCS   LEFT1 7 BITS OF HMASK
D03F  49  C0                       EOR   #$C0 ONE BIT TO LSB
DO91  85  30              LRI      STA   HMASK
D093  60                           RTS
D094  88                  LEFT1    DEY   DECR HORIZ INDEX.
D095  10  02                       SPL    LEFT2
D097  A0  27                       LDY   #$27 WRAP AROUND SCREEN
D099  A9  C0                       LOA    #$C0 NEW HMASK, RIGHTMOST
D09B  85  30                       STA   HMASK DOT OF BYTE
D0BD  SC  25  03                   STY   HNDX UPDATE HORIZ INDEX
D0A0  A5  IC              CSHIFT   LDA   HCOLOR1
D0A2  0A                  CSHFT2   ASL   ; ROTATE LOW-ORDER
D0A3  C9  C0                       CMP   #$C0 7 BITS OF HCOLDR1
D0A5  10  06                       SPL   RTSI ONE BIT POSN.
D0A7  A5  1C                       LDA   HCOLOR1
D0A9  49  7F                       EOR   #$7F ZXYXYXYX —> ZYXYXYXY
D048  85  IC                       STA   HCOLOR1
D0AD  60                           RTS
D0AE  A5  30                       LDA   HMASK
D090  0A                           ASL   ; SHIFT LOW—ORDER
D0B1  49  80                       EOR   #$80 7 BITS OF HMASK
D0B3  30  DC                       BMI   LR1 ONE SIT TO MSB.
D0B5  A9  81                       LDA   #$81
D0B7  C8                           INY   NEXT BYTE.
D0B8  C0  28                       OPY   #$28
D0B4  90  DF                       BCC   NEWNDX
D0BC  A0  00                       LDY   #$0 WRAP AROUND SCREEN IF > 279
D0BE  B0  DB                       BCS   NEWNDX ALWAYS TAKEN.

                          *L,R,U,D,      SUBROUTINES.
D0C0  18                  LRUDXI   CLC   NO 90 DEG ROT (X-0R).
D0C1  A5  51              LRUDX2   LOA   SHAPEX
D0C3  29  04                       AND   #$4 IF B2=0 THEN NO PLOT.
D0C5  F0  27                       BEG   LRUD4
D0C7  A9  7F                       LDA   #$7F FOR EX-OR INTO SCREEN MEM
D009  25  30                       AND   HMASK
D0CB  31  26                       AND   (HSASL),Y        SCREEN BIT SET?
D0CD  D0  1B                       BNE   LRUD3
D0CF  SE  24  03                   INC   COLLSN
D0D2  A9  7F                       LDA   #$7F
D0D4  25  30                       AND   HMASK
D0D6  10  12                       BPL   LRUD3 ALWAYS TAKEN.
D0D8  18                  LRUD1    CLC   NO 90 DEG ROT.
D0D9  AS  51              LRUD2    LDA   SHAPEX
D0DB  29  04                       AND   #$4 IF B2=0 TNSN NO PLOT.
D0DD  F0  0F                       BEQ   LRUD4
D0DF  B1  26                       LDA   (HBASL), V
D0EI  45  1C                       EOR   HCOLOR1 SET HI-RES SCREEN BIT
D0E3  25 `30                       AND   HMASK TO CORRESPONDING HCOLOR1

D0E5  D0  03                       BNE   LRUD3 IF BIT OF SCREEN CHANGES
D0E7  EE  2A  03                   INC   COLLSN THEN INCR COLLSN DETECT
D0ZA  51  26              LRUD3    EOR   (HBASL), Y
D0EC  91  26                       STA   (HBASL). Y
D0ZE  A5  51              LRUD4    LDA   SHAPEX ADD QDRNT TO
D0F0  65  53                       ADC   QDRNT SPECIFIED VECTOR
D0F2  29  03                       AND   #$3 AND MOVE LFT, RT,
                          EQS      EQU   *-I UP, OR DWN BASED
D0F4  09  02                       CMP   #$2 ON SIGN AND CARRY.
D0F6  6A                           ROR
D0F7  B0  8F              LRUD     BCS   LFTRT
D0F9  30  30              UPOWN    BM1   DOWN4 SIGN FOR UP/DWN SELECT
D0F8  18                  UP       CLC
D0FC  A5  27                       LDA   HBASH CALC BASE ADDRESS
D0FE  2C  EA  01                   BI1   EQ1C (ADR OF LEFTMOST BYTE)
D101  00  22                       ENS   UP4 FOR NEXT LINE UP
D103  06  24                       ASL   HBASL 1N (HEASL, HBASH)
```

```
D105  B0   1A                        DCS      UP2-WITH 192-LINE WRAPAROUND
D107  2C   F3  D0                    BIT      EG3
D10A F0   05                         BEQ      UP1
D10C 69   1F                         ADC      #$1F **** BIT MAP ****
D10E  38                             SEC
D10F  B0 12                          BCS      UP3 FOR ROW = ABCDEFGH,
D111  69   23           UP1          ADC       #$23
D113 48                              PHA
D114  A5   24                        LDA.     HBASL HDASL = EABAB000
D116 69    B0                        ADC      #$B0 HBASM = PPPFGHCD
D118 B0   02                         BCS      UP5
D11A  69   F0                        ADC      #$F0 WHERE PPP=001 FOR PRIMARY
D11C 85    26           UP5          STA      HBASL HI-RES PAGE {$2000—$3FFF)
D11E 68                              PLA
D11F  B0   02                        BCS      UP3
D121 69    1F           UP2          ADC      #$1F
D123 66    26           UP3          ROR      HBASL
D125 69    FC           UP4          AOC      #$FC
D127  85   27           UPDWN1       STA      HBASH
D129  60                             RT8
D12A 18                 DOWN         CLC
D12B A5   27            DOWN4        LDA      HBASH
D12D 69   04                         ADC      #$4 CALC BASE ADR FOR NEXT LINE
                        E04          EOU      *-1 DOWN TO (HBASL,HBASH)
D12F  2C   EA  D1                    BIT      EGIC
D132  D0   F3                        BNE      UPDWN1

D134  06   26                        ASL      HBASL WITH 192-LINE WRAPAROUND
D136 90    19                        BCC      DOWN1
D138 69    E0                        ADC      #$E0
D13A  18                             CLC
D13B 2C   2E  D1                     BIT      EG4
D13E F0   13                         BEG      DOWN2
D140  A5   26                        LDA      HBASL
D142 69    50                        ADC      #$50
D144 49    F0                        EOR      #$F0
D146  F0   02                        BEG      DOWN3
D148  49   F0                        EOR      #$F0
D14A  85   26           DOWN3        STA      HBASL
D14C  AD  26   03                    LDA      HPAG
D14F  90   02                        BCC      00WN2
D151  69   E0           DOWN1        ADC      #$E0
D153  66   26           DOWN2        ROR      HBASL
D155  90   D0                        BCC      UPDWN1

                        *HI-RES GRAPHICS LINE DRAW SUBRS
D157  48                HLINRL       PHA
D158  A9 00                          LDA      #$0 SET (X0L X0H) AND
D15A 8D   20   03                    STA      X0L Y0 TO ZERO FOR
D15D  8D   21 03                     STA      X0H REL LINE DRAW
D160 8D   22 03                      STA      Y0 (DX, DY).
D163  68                             PLA
D164  48                HLIN         PHA      ON ENTRY
D165  38                             SEC      XL: A-REG
D166  ED  20 03                      SBC      X0L XH; X-REG
D169  48                             PHA      Y: Y-REQ
D16A  8A                             TXA
D16B  ED  21 03                      SBC      X0H
D16E 85   53                         STA      QDRNT CALC ABS(X-X0)
D170  B0   0A                        BCS      HLIN2 IN (DXL.DXH)
```

```
D172  68                     PLA
D173  49  FE                 EOR  #$FF X DIR TO SIGN BIT
D175  69  01                 ADC  #$1 OF QDRNT.
D177  48                     PHA  0=RIGHT (DX P0S)
D178  A9  00                 LDA  #$0 1=LEFT (DX NEC)
D17A  E5  53                 SBC  QDRNT
D17C  85  51       HL1N2     STA  DXH
D17E  85  55                 STA  EH INIT (EL,EH) T0
D180  68                     PLA  ARS(X-X0)
D181. 85  50                 STA  DXL
D183  85  54                 STA  EL
D185  68                     PLA
D186  8D  20  03             STA  X0L
D189  8E  21  03             STX  X0H
D18C  98                     TYA
D18D  18                     CLC
D18E  ED  22  03             SBC  Y0 CALC -ABS(Y-0)-I
D191  90  04                 BCC  HL1N3 IN DY.
D193  49  FF                 EOR  #$FF
D195  69  FE                 ADO  #$FE
D197  85  52       HLIN3     STA  DY ROTATE Y DIR INTO
D199  BC  22  03             STY  V0 GDRNT SIGN BIT
D19C  66  53                 ROR  QDRNT (0=UP. l=DOWN)
D19E  38                     SEC
D19F  E5  50                 SBC  DXL INIT (COUNTL, COUNTH).
D1A1  AA                     TAX  TO -(DELTX+DELTY+1)
D1A2  A9  FE                 LDA  #$FF
D1A4  ES  51                 SBC  DXH
D1A6  65  1D                 STA  COUNTH
D1A8  AC  25  03             LDY  HNDX HORIZ INDEX
D1AB  80  05                 BCS  MOVEX2 ALWAYS TAKEN.
D1AD  0A           MOVEX     ASL  ; MOVE IN X-DIR. USE
D1AE  20                     JSR  LFTRT QDRNT 86 FOR LFT/RT SELECT
D1B1  38                     SEC
D1B2  A5  54       MOVEX2    LDA  EL ASSUME CARRY SET.
D1B4  65  52                 ADC  DY (EL, EH)-DELTY TO (EL,EH)
D1B6  65  54                 STA  EL NOTE: DY IS (-DELTY)-1
D1B8  AS  55                 LDA  EH CARRY CLR IF (EL,EX)
D1BA  E9  00                 SBC  #$0 GOES NEG
D1BC  85  S5       HCOUNT    STA  EH
D1BE  81  26                 LDA  (HRASL).Y SCREEN BYTE.
D1C0  45  1C                 EOR  HCOLOR1 PLOT DOT OF HCOLOR1.
D1C2  25  30                 AND  HMASK CURRENT BIT MASK.
D1C4  51  26                 EOR  (HRASL), Y
D1CS  91  26                 STA  (HSASL), Y
D1C8  E8                     INX  DONE (DELTX+DELTY)
D1C9  00  04                 BNE  XLIN4 DOTS?
D1CB  E6  10                 INC  COUNTH
D1CD  F0  68                 BEQ  RTS2 YES, RETURN.
D1CF  AS  53       HLIN4     LDA  GDRNT FOR DIRECTION TEST
D1D1  B0  DA                 BCS  MOVEX IF CLR SET. (EL, EH) POS
D1D3  20  F9  D0             JSR  UPDWN IF CLR, NEG, MOVE YDIR
D1D6  18                     CLC
D1D7  AS  54                 LDA  EL (EL., EH)+DELTX
D1D9  65  50                 ADC  DXL TO (EL,EH).
D1DB  65  54                 STA  EL
D1D0  A5  55                 LDA  EH CAR SET IF (EL,EH) GOES P0S
D1D6  65  51                 ADC  DXH
D1E1  50  09                 BVC  HCOUNT ALWAYS TAKEN.
D1E3  81           MSKTBL    HEX  81 LEFTMOST BIT OF BYTE
D1E4  82  84  89             HEX  82, 84, 86
D1E7  90  A0                 HEX  90, A0
D1E9  C0                     HEX  C0 RIGNTMOST BIT OF BYTE.
D1EA  1C           EG1C      HEX  IC
D1EB  FE  FE  FA   COS       HEX  FF, FE, FA, F4. EC, El, D4, DS, B4
D1F4  Al  8D  78             HEX  A1,8D, 78,61,49,31, 18.FF
```

```
                     *  HI-RES GRAPHICS COORDINATE RESTORE SUSR
D1FC  A5  26         HFIND    LDA   HBASL
D1FE  0A                      ASL   CONVERTS BASE ADR
D1FF  A5  27                  LDA   HBASH TO Y-COORD.
D201  29  03                  AND   #$3
D203  2A                      ROL   ; FOR HBASL = EABASOOO
D204  05  26                  ORA   HBASL HBASH = PPPFGHCD
D206  0A                      ASL
D207  0A                      ASL   ; GENERATE
D208  0A                      ASL   ; Y-COORD = ABCDEFGH
D209  8D  22  03              STA   Y0
D20C  A5  27                  LDA   HBASH (PPP.SCREEN PAGE,
D20E  4A                      LSR   ; NORMALLY 001 FOR
D20F  4A                      LSR   ; $2000-$3FFF
D210  29  07                  AND   #$7 HI-RES SCREEN)
D212  0D  22  03              ORA   Y0
D215  8D  22  03              STA   Y0 CONVENTS HNDX (INDEX
D218  AD  25  03              LDA   HNDX FROM BASE ADR)
D21B  0A                      ASL   ; AND HMASK (BIT
D21C  6D  25  03              ADC   HNDX MASK TO X-COORD
D21F  0A                      ASL   ; IN (XOL,XOH)
D220  AA                      TAX   (RANGE $0—$133)
D221  CA                      DEX
D222  A5  30                  LDA   HMASK
D224  29  7F                  AND   #$7F
D226  E8             HFIND1   INX
D227  4A                      LSR
D228  D0  FC                  BNE   HFIND1
D22A  8D  21  03              STA   XOH
D22D  8A                      TXA
D22E  18                      CLC   CALC HNDX*7 +
D22F  6D  25  03              ADC   HNDX LOG (BASE 2) HMASK
D232  90  03                  BCC   HFIND2
D234  EE  21  03              INC   X0H
D237  8D  20  03     HFIND2   STA   X0L
D23A  60             RTS2     RTS
                     *  HI-RES GRAPHICS SHAPE DRAW SUBR
                     *
                     * SHAPE  DRAW
                     *  R = 0 TO 63
                     * SCALE  FACTOR USED (1=NORMAL)
                     *
D23B  86  1A         DRAW     STX   SHAPEL DRAW DEFINITION
D23D  84  1B                  STY   SHAPEH POINTER.
D23F  AA             DRAWl    TAX
D240  4A                      LSR   ; ROT ($0-$3F)
D241  4A                      LSR
D942  4A                      LSR   ; QDRNT  0=UP, 1=RT.
D243  4A                      LSR   ; 2=DWN, 3=LFT.
D244  85  53                  STA   QDRNT
D246  8A                      TXA
D247  29  0F                  AND   #$F
D249  AA                      TAX
D24A  BC  EB  Dl              LDY   COS, X SAVE COS AND SIN
D24D  84  50                  STY   DXL VALS IN DXL AND DY
D24F  49  0F                  E0R
D251  AA                      TAX
D252  BC  EB  Dl              LDY   CDS+1.X
D255  C8                      I NY
D256  84  52                  STY   DY
D258  AC  25  03     DRAW2    LDY   HNDX BYTE INDEX FROM
D25B  A2  00                  LDX   #$0 HI-RES BASE ADR.
D25D  8E  2A  03              STX   COLLSN CLEAR COLLISION COUNT,
D260  A1  1A                  LDA   (SHAPEL,X) 1ST SHAPE DEF BYTE.
```

```
D262   85  51      401  DRAWS   STA   SHAPEX
D264   A2  80      402          LDX   #$80
D266   86  54      403          STX   El, EL, EH FOR FRACTIONAL
D268   86  55      404          STX   EH L,R,IJ,D VECTORS.
D26A   AE 27 03    405          LDX   SCALE SCALE FACTOR.
D26D   A5  54      406  DRAW4   LDA   EL
D26F   38          407          SEC   IF FRAC COS 0VFL
D270   65  50      408          ADC   DXL THEN MOVE IN
D272   85  54      409          STA   EL SPECIFIED VECTOR
D274   90  04      410          BCC   DRAW5 DIRECTION.
D276   20  D8  D0  411          JSR   LRUD1
D279   18          412          CLC
D27A   A5 55       413  DRAW5   LDA   EH IF FRAC SIN OVFL
D27C   65  52      414          ADC   DY THEN MOVE IN
D27E   85  55      415          STA   EH SPECIFIED VECTOR
D280   90  03      416          SCC   DRAW6 DIRECTION +90 DEG.
D282   20  09  D0  417          JSR   LRUD2
D285   CA          418  DRAW6   DEX   LOOP ON SCALE
D286   D0  E5      419          BNE   DRAW4 FACTOR.
D288   A5  51      420          LDA   SHAPEX
D28A   4A          421          LSR   ; NEXT 3-BIT VECTOR
D28B   4A          422          LSR   ; OF SHAPE DEF
D28C   4A          423          LSR
D28D   00  03      424          BNE   DRAW3 NOT DONE THIS BYTE.
D28F   E6  lA      425          INC   SNAPEL
D291   00  02      426          BNE   DRAW3 NEXT BYTE OF
D293   56  12      427          INC   SHAPEH SHAPE DEFINITION.
D295   Al  1A      428  DRAW7   LDA   (SHAPEL, X)
D297   D0  C9      429          BNE   DRAW3 DONE IF ZERO.
D299   60          430          RTS

                   432  *  HI-RES GRAPHICS SHAPE EX-OR SUBR
                   433  *
                   434  *  EX-0R SHAPE INTO SCREEN.
                   435  *
                   436  *  ROT = 0 TO 3 (QUADRANT ONLY)
                   437  *  SCALE IS USED
                   438  *
D29A   86  1A      439  XDRAW   STX   SHAPEL SHAPE DEFINITION
D29C   84  15      440          STY   SHAPEH POINTER.
D29E   AA          441  XDRAW1  TAX
D29F   4A          442          LSR   ; ROT ($0-$3F)
D2A0   4A          443          LSR
D2A1   4A          444          LSR   ; QDRNT 0=UP, 1=RT,
D2A2   4A          445          LSR   ; 2=DWN, 3=LFT.
D2A3   85  53      446          STA   QDRNT
D2A5   8A          447          TXA
D2A6   29  0F      448          AND   #$F
D2A8   AA          449          TAX
D2A9   BCE8  D1    450          LDY   COS. X SAVE COS AND SIN
D2AC   84  50      451          STY   DXL VALS IN DXL AND DY,
D24E   49  0F      452          EOR   #$F
D280   AA          453          TAX
D2B1   SC  EC D1   454          LDY   COS+1, X
D2B4   C8          455          I NY
D2B5   84  52      456          STY   DY
D2B7   AC25  03    457  XDRAW2  LDY   HNDX INDEX FROM HI-RES
D2BA   A2  00      458          LDX   #$0 BADE ADR.
D2BC   8E  2A  03  459          STX   COLLSN CLEAR COLLISION DETECT
D2BF   A1  1A      460          LDA   (SHAPEL,X) 1ST SHAPE DEF BYTE.
```

```
D2C1  05  51      461  XDRAW3   STA     SHAPEX
D2C3  A2  80      462           LDX     #$80
D2C5  96  54      463           STX     EC EL,EH FOR FRACTIONAL
D2C7  86  55      464           STX     EH L, R,U,D, VECTORS
D2C9  AE  27  03  465           LDX     SCALE SCALE FACTOR
D2CC  A5  54      466           LDA     El
D2CE  38          467           SEC     IF FRAC COS OVFL
D2CF  65  50      468           A0C     DXL THEN MOVE IN
D2D1  85  54      469           STA     EL SPECIFIED VECTOR
D2D3  90  04      470           BCC     XDRAWS DIRECTION
D2D5  20  C0  D0  471           JSR     LRUDX 1
D2D8  18          472           CLC
D2D9  A5  55      473  XDRAW5   LDA     EH IF FRAC SIN OVFL
D2DB  65  52      474           ADC     DY THEN MOVE IN
D2DD  85  55      475           STA     EH SPECIFIED VECTOR
D2DF  90  03      476           BCC     XDRAW6 DIRECTION +90 DEC.
D2E1  20  D9  DO  477           JSR     LRIJD2
D2E4  CA          478  X0RAW6   DEX     LOOP ON SCALE
D2E5  D0  E5      479           BNE     XDRAW4 FACTOR.
D2E7  A5  51      480           LDA     SHAPEX
D2E9  4A          481           LSR     ; NEXT 3-BIT VECTOR.
D2EA  4A          482           LSR     ; OF SHAPE DEF
D2EB  4A          483           LSR
D2EC  DO  03      484           BNE     XDRAW3
D2EE  E6  IA      485           INC     SHAPEL
D2F0  D0  02      486           BNE     XDRAW7 NEXT BYTE OF
D2F2  E6  1B      487           INC     SHAPEH SHAPE DEF.
D2F4  Al  1A      488  XDARW7   LDA     (SHAPEL, X)
D2F6  DO  C9      489           BNE     XDRAW3 DONE IF ZERO.
D2F8  60          490           RTS

                  492  .*  ENTRY POINTS FROM APPLE—Il BASIC
D2F9  20  90  D3  493  BPOSN    JSR     PCOLR POSN CALL COLR FROM BASIC
D2FC  8D  24  03  494           STA     HCOLOR
D2FF  20  AF  D3  495           JSR     GETY0 Y0 FROM 8ASIC.
D302  48          496           PHA
D303  20  9A  D3  497           JSR     GETX0 X0 FROM BASIC.
D306  68          498           PLA
D307  20  2E  D0  499           JSR     HPOSN
D30A  AE  23  03  500           LDX     BXSAV
D30D  60          501           RTS
D30E  20  F9  02  502  BPLOT    JMP     BPOSN PLOT CALL (BASIC).
D311  4C  7D  D0  503           JMP     HPL0T1
D314  AD  25  03  504  BLIN1    LDA     HNDX
D317  4A          505           LSR     ; SET HCOLORI FROM
D318  20  90  D3  506           JSR     PCOLR BASIC VAR COLR.
D31B  20  75  D0  507           JSR     HPOSN3
D31E  20  9A  03  508  BLINE    JSR     GETX0 LINE CALL, GET X0 FROM BASIC
D321  8A          509           TXA
D322  48          510           PHA
D323  98          511           TYA
D324  AA          512           TAX
D325  20  AF  D3  513           JSR     GETY0 Y0 FROM BASIC
D328  A8          514           TAY
D329  68          515           PLA
D32A  20  64  D1  516           JSR     HL IN
D32D  AE  23  03  517           LDX     BXSAV
D330  60          518           RTS
D331  20  90  D3  519  BGND     JSR     PCOLR BACKGROUND CALL
D334  4C  10  D0  520           JMP     BKGNDO
```

```
                    522  * DRAW ROUTINES
D337 20 F9 D2       523 DORAWI .   JSR    BPOSN
D33A 20 51 D3       524 BDRAW      TSR    BDRAWX DRAW CALL FROM BASIC.
D33D 20 3B D2       525            JSR    DRAW
D340 AE 23 D3       526            LDX    DXSAV
D343 60             527            RTS
D344 20 F9 D2       528 BXDRW1     JSR    BPOSN
D347 20 51 D3       529 BXDRAW     JSR    BDRAWX EX-OR DRAW
D34A 20 9A D2       530            JSR    XDRAW FROM BASIC.
D34D AE 23 03       531            LDX    BXSAV
D350 60             532            RTS
D351 8E 23 03       533 BDRAWX     STX    BXSAV SAVE FROM BASIC
D354 AO 32          534            LDY    #$32
D356 20 92 D3       535            JSR    PBYTE SCALE FROM BASIC
D359 8D 27 03       536            STA    SCALE
D35C A0 28          537            LDY    #$28
D35E 20 92 D3       538            JSR    PBYTE ROT PROM BASIC.
D361 48             539            PHA    SAVE ON STACK.
D362 AD 28 03       540            LDA    SHAPEXL
D365 85 lA          541            STA    SHAPEL START OF
D367 AD 29 03       542            LDA    SHAPXH SHAPE TABLE.
D36A 85 18          543            STA    SHAPEH
D36C AG 20          544            LDY    #$20
D36E 20 92 03       545            JSR    PBYTE SHAPE FROM BASIC.
D371 F0 39          546            BEQ    RERR1
D373 A2 00          547            LDX    #$0
D375 C1 1A          548            CMP    (SHAPEL. X) > NUM OF SHAPES?
D377 F0 02          549            BEQ    BDRWX1
D379 B0 31          550            BCS    RERR1 YES, RANGE ERR.
D37B 0A             551            ASL
D37C 90 03          552            BCC    BDRWX2
D37E E6 1B          553            INC    SNAPEH
D380 18             554            CLC
D381 AB             555 BDRWX2     TAY    SHAPE NO. * 2.
D382 B1 1A          556            LDA.   (SHAPEL), Y
D384 65 1A          557            ADC    SHAPEL
D386 AA             558            TAX    ADD 2-BYTE INDEX
D387 C8             559            INY    TO SHAPE TABLE
D388 B1 1A          560            LDA    (SHAPEL)Y START ADR
D38A 60 29 03       561            ADC    SHAPXH (X LOW. Y HI)
D38B A8             562            TAY
D38E 68             563            PLA    ROT FROM STACK.
D38F 60             564            RTS

D390 A0 16          566 * BASIC PARAM FETCH SUBR'S
D392 B1 4A          567 PCOLR      LDY    #$16
D394 D0 16          568 PBYTE      LDA    (LOMEML), Y
D396 88             569            BNE    RERRI GET BASIC PARAM.
D397 Bl 4A          570            DEY    (ERR IF >255)
D399 60             571            LDA    (LOMEML). V
D39A 8E 23 03       572 RTSB.      RTS
D39D A0 05          573 GETYO      STX    BXSAV SAVE FOR BASIC.
D39F B1 4A          574            LDY    #$5
D3A1 AA             575            LDA    (LOMEML),Y X0 LOW-ORDER BYTE.
D3A2 C8             576            TAX
D3A3 B1 4A          577            INY    .
D3A5 A8             578            LDA    (LOMEML),Y HI—ORDER BYTE
D3A6 E0 18          579            TAY
D3A8 E9 01          580            CPX    #$18
D3AA 90 ED          581            SBC    #$1 RANGE ERR IF >279
D34C 4C 68 EE       582            BCC    RTSB
D3AF A0 0D          583 RERR1      JMP    RNGERR
D3BI 20 92 D3       584 GETYO      LDY    #$D OFFSET TO Y0 FROM LOMEM
D3B4 C9 C0          585            JSR    PBYTE GET BASIC PARAM YO
D3B6 80 F4          586            CMP    #$C0 (ERR IF >191)
D3B8 60             587            BCS    RERR1
                    588            RTS
```

```
                         *SHAPE TAPE LOAD SUSROUTINE
D3B9   8E  23  03        SHLOAD   STX   SXSAV SAVE FOR SASIC.
D3BC   20  1E  F1                 JSR   ACAOR READ 2-BYTE LENGTH INTO
D3BF   20  FD  FE                 JSR   READ BASIC ACC
D3C2   A9  00                     LDA   #$00 START OF SHAPE TABLE IS $0800
D3C4   85  3C                     STA   A1L
D3C6   8D  28  03                 STA   SHAPXL
D3C9   18                         CLC
D3CA   65  CE                     ADC   ACL
D3CC   A8                         TAY
D3CD   A9  08                     LDA   #$08 HIGH BYTE OF SHAPE TABLE POINTER
D3CF   85  3D                     STA   A1H
D3D1   8D  29  03                 STA   SHAPXL
D3D4   65  CF                     ADC   ACH
D3D6   B0  25                     BCS   MFULL1 NOT ENOUGH MEMORY.
D3D8   C4  CA                     CPY   PPL
D3DA   48                         PHA
D3DB   E5  CE                     SEC   PPH
D3DD   68                         PLA
D3DE   B0  1D                     BCS   MFULL1
D3E0   54  3E                     STY   A2L
D3E2   55  SF                     STA   A2H
D3E4   CS                         INY
D3E5   00  02                     BNE   SHLOD1
D3E7   69  01                     ADC   #$1
D3E9   54  4A            SHLOD1   STY   LOMEML
D3EB   55  4B                     STA   LOMENH
D3ED   54  CC                     STY   PVL
D3EF   55  CD                     STA   PVH
D3F1   20  FA  FC                 JSR   RD2BIT
D3F4   A9  03                     LDA   #$3 . 5 SECOND HEADER
D3F6   20  02  FF                 JSR   READX1
D3F9   AE  23  03                 LDX   BXSAY
D3FC   60                         RTS
D3FD   4C  6B  E3        MFULL1   JMP   MEM FUL

--- END ASSEMBLY ---

TOTAL ERRORS: 00
```

```
*****************************************************
*                                                   *
* APPLE-][ BASIC RENUMBER/ APPEND SUBROUTINES       *
*                                                   *
*                 VERSION    TWO                    *
*                   RENUMBER                        *
*                  >CLR                             *
*                  >START=                          *
*                  >STEP=                           *
*                  >CALL-10531                      *
*                                                   *
*                   OPTIONAL                        *
*                  >FROM=                           *
*                  >T0=                             *
*                  >CALL -10521                     *
*                                                   *
*                  USE RENX ENTRY                   *
*                  FOR  RENUMEER  ALL               *
*                                                   *
*           WOZ         APRIL  12,   1978           *
*           APPLE   COMPUTER   INC.                 *
*****************************************************

*
*           6502 EQUATES
*
ROL         EQU     $0       LOW-OROER SW16 RO BYTE..
ROH         EQU     $1       HI-ORDER
ONE         EQU     $01
R11L        EQU     $16      LOW-ORDER SW16 R11 BYTE.
R11H        EQU     $17      HI-ORDER.
HIMEM       EQU     $4C      BASIC HIMEM POINTER.
PPL         EQU     $CA      BASIC PROG POINTER
PVL         EQU     $CC      BASIC VAR POINTER
MEMEULL     EQU     $E36B    BASIC MEM FULL ERROR
PRDEC       EQU     $E51B    BASIC DECIMAL PRINT SUBR.
RANGERR     EQU     $EE68    BASIC RANGE ERROR
LOAD        EQU     $F0DF    BASIC LOAD SUBR
SW16        EQU     $F689    SWEET 16 ENTRY
CROUT       EQU     $FD8E    CAR RET SUBR.
COUT        EQU     $FDED    CHAR OUT SUBR.

*
*             SWEET 16 EQUATES
*
ACC.        EQU     $0       SWEET 16 ACCUMULATOR.
NEULOW      EQU     $1       NEW INITIAL LNO.
NEWINCR     EQU     $2       NEW LNO INOR.
LNLOW       EQU     $3       LOW LNO OF RENUM RANGE.
LNHI        EQU     $4       HI LNO OF RENUM RANGE
TBLSTRT     EQU     $5       LNO TABLE START.
TBLNDX1     EQU     $6       PASS 1 LNO TBL INDEX.
TBLIM       EQU     $7       LNO TABLE LIMIT.
SCRB        EQU     $8       SCRATCH REG.
HMEM        EQU     $8       HIMEM (END OF PRGM).
SCR9        EQU     $9       SCRATCH REQ.
PRGNDX      EQU     $9       PASS 1 PROC INDEX.
PRONDXI     EQU     $A        ALSO PROC INDEX,
NEWLN       EQU     $B       NEXT “NEW UND”.
NEWLN1      EQU     $C       PRIOR “NEW LNO” ASSIGN.
TBLND       EQU     $6       PASS 2 LNO TABLE END,
PRGNDX2     EQU     $7        PASS 2 PROG INDEX.
CHRO        EQU     $9       ASCII “0”
CHRA        EQU     $A       ASCII “A”.
```

```
                   MODE      EQU    $C          CONST/LNO MODE.
                   TBLNDX2   EQU    $B            LNO. TBL IDX FOR UPDATE
                   OLDLN     EQU    $D          OLD LNO F03 UPDATE.
                   STRCON    EQU    $B          BASIC STR CON TOKEN.
                   REM       EQU    $C          BASIC REM TOKEN.
                   R13       EQU    $D          SWEET 16 REG 13 (CPR NEC).
                   THEN      EQU    $D          BASIC THEN TOKEN
                   LIST      EQU    $D          BASIC LIST TOKEN
                   DEL       EQU    $D
                   SCRC      EQU    $C          SCRATCH REQ FOR APPEND.

                   *
                   *            APPLE - 11 BASIC RENUMBER SUBROUTINE - PASS 1
                             ORG    $D400
                             OBJ    $A400
D400   20  89  F6  RENX      ,JSR   SW16        OPTIONAL RANGE ENTRY.
D403   B0                    SUB    ACC
D404   33                    ST     LNLOW       SET LNLOW=0, LNHI=0.
D405   34                    ST     LNH I
D406   F4                    DCR    LNH I
D407   00                    RTN
D408   20  39  F6  RENUM     JSR    SW16
D40B  18  4C  00             SET    HMEM, HIMEM
D40E   68                    LDD    @HMEM
D40W       38                ST     HMEM
D410   19  CE  00  RNUM3     SET    SCR9, PVL+2
D413   C9.                   POP D  @SCR9       BASIC VAR PNT TO
D414   35                    ST     TBLSTRT     TBLSTRT AND TBLNDX1
D415   36                    ST     TBLNDX1
D416   21                    LD     NEWLOW      COPY NEWLOW (INITIAL)
D417   3B                    ST     NEWLN       TO NEWLN,
D418   3C                    ST     NEWLN1
D419   C9                    POPD   @SCR9       BASIC PROG PNTR
D41A  37                     ST     TBLIM        TO TOLIM AND PRGNDX.
D41B  39                     ST     PRGNDX
D41C  29                     LD     PRGNDX
D41D  D8                     CPR    HMEM        IF PRGNDX > =HMEM
D41E   03  46                BC     PASS2        THEN DONE PASS 1.
D420   3A                    ST     PRGNDX1
D421   26                    LD     TBLNDX1
D422   E0                    INR    ACC         IF < TWO BYTES AVAIL IN
D423   D7                    CPR    TBLIM        LNO TABLE THEN RETURN
D424   03  38                BC     MERR         WITH "MEM FULL" MESSAGE
D426   4A                    LD     @PRGNDX1
D427   A9                    ADD    PRGNDX      ADD LENTH BYTE TO PROG INDEX.
D428   39                    ST     PRGNDX
D429   6A                    LDD    @PRGNDX1    LINE ‘lUMBER.
D42A  D3                     CPR    LNLOW        IF < LNLOW THEN OOTO P1B
D42B  02  2A                 BNC    P1B
D42D  D4                     CPR    LNHI        IF > LNHI THEN GOTO P1C
D42E   02  02                BNC    P1A
D430   07   30               BNZ    P1C
D432   76          P1A       STD    @TBLNDX1    ADD TO LNO TABLE.
D433   00                    RTN
D434   A5  01                LDA    R0H         **** 6502 CODE ****
D436   46  00                LDX    R0L
D438   20  1B  E5            JSR    PRDEC       PRINT OLD LNO "—>" NEW LNO
D43B  A9  AD                 LDA    #$AD         (R0 R11) IN DECIMAL.
D43D  20   ED  FD            JSR    COUT
D440   A9  BE                LDA    #$BE
D442   20   ED  FD           JSR    C OUT
D445   A5  17                LDA    R11H
D447   A6  16                LDX    R11L
D449   20  1B   E5           JSR    PRDEC
D44C  20   8E  FD            JSR    CROUT
                   *
D44F 20 BC F6                JSR    SW16+3      **** END 6502 CODE ****
```

```
                 *
D452  2B                  LD     NEWLN
D453  3C                  ST     NEWLNI     COPY NEWLN ro NEWLMI AND INCR
D454  A2                  ADD    NEWINCR  UEWLN flY NEWINOR
D455  3B                  ST     NEWLN
D456  0D                  HEX    .00          'NUL' (WELL SKIP NEXT INSTRUCTION)
D457  D1           P1B    CPR    NEWLOW .IF LOW LNO< NEW LOW THEN RANGE ERR
D45B  02 C2               BNC    PASS1
D45A  00           RERR   RTN    PRINT "RANGE ERR" MESSAGE AND RETURN.
D450  4C 68 EE            JMP    RANGERR
D45E  00           KERR   RTN    PRINT "MEM FULL" MESSAGE AND RETURN
D45F  4C 6B E3            JMP    MEMFULL
D462  EC           PlC    INR    NEWLN1     IF HI LNO <= MOST RECENT HEWLN THEN
D463  DC                  CRR    NEWLN1               RANGE ERROR.
D464  02   F4             BNC    RERR

                 *
                 *          APPLE ][ BASIC RENUMBER / APPEND SUBROUTINE -- PASS 2
                 *
D466  19 B0 00     PASS2  SET    CHRO, $00B0       ASCII "0"
D469  1A CO 00            SET    CHRA, $00C0       ASCII "A"
D46C  27           P2A    LD     PRGNDX2
D46D  D8                  CPR    HMEM       IP PROG INDEX = HIMEN THEN DONE PASS 2.
D46E  03   63             BC     DONE
D470  E7                  INR    PRONDX2 SKIP LENIN BYTE
D471  67                  LDD    @PRGNDX2 LINE NUMBER
D472  3D           UPDATE ST     OLDLN      SAVE OLD LUD.
D473  25                  LD     TBLSTRT
D474  3B                  ST     TBLNDX2   INIT LNO TABLE INDEX
D475  21                  LD     NEWLOW    INIT NEWLN TO NEWLOW
D476  1C                  HEX    1C         (WILL SKIP NEXT INSTR)
D477  2C           UD2    LD     NEWLN1
D478  A2                  AD0    NEWINCR ADD INCR TO NEWLN1.
D479  3C                  ST     NFWLN1
D47A  28                  LD     TBLNDX2   IF LNO TBL lDX = TBLND THEN DONE
D47B  B6                  SUB    TELND      SCANNING LNO TABLE
D47C  03   07             BC     UD3
D47E  6B                  LDD    @TBLNDX2NEXT LNO FROM TABLE.
D47F  8D                  SUB    OLDLN      LOOP TO UD2 IF NOT SAME AS OLDLN.
D480  07   F5             BNZ    UD2
D482  C7                  POPD   @PRGNDX2 REPLACE OLD LNO WITH CORRESPONDING
D483  2C                  LD     NEWLN1     NEW LINE.
D484  77                  STD    @PRGNDX2
D485  1B  2800     UD3    SET    STRCON, #$028            STR CON TOKEN.
D488  1C                  HEX    IC         (SKIP-S NEXT TWO INSTRUCTIONS)
D489  67           GOTCON LDD    @PRGNDX2
D48A  FC                  DCR    MODE       IF MODE = 0 THEN UPDATE LNO REF.
D48B  08   E5             BM1    UPDATE
D48C  47           ITEM   LD     @PRGNDXBASIC TOKEN.2
D48E  D9                  CPR    CHRO
D4SF  02   09             BNC    CHKTOK     CHECK.TOKEN FOR SPECIAL.
D491  DA                  CPR    CHRA       IF >= "0" AND < "A" THEN SKIP CONST
D492  02  F5              BNC    GOTCON     OR UPDATE.
D494  F7           SKPASC DCR    PRGNDX2
D495  67                  LDD    @PRGNDX2`   SKIP ALL. NEG. BYTES OF STR CON, REM,
D496  05  FC              BM     SKPASC     OR NAME.
D496  F7                  DCR    PRGNDX2
D499  47                  LD     @PRGNDX2
```

```
D49A  DB           191  CHKTOK CPR     STRCON    SW CON TOKEN?
D49B  06    F7     192         BZ      SKPASC    YES, SKIP SUBSEOUENT BYTES.
D49D  1C    5D  00 193         SET     REM, $0050
D4A0  DC           194         CPR     REM       REM TOKEN?
D4A1  06F1         195         BZ      SKPASC    YES, SKIP SUBSEQUENT LINE
D4A3  08    13     196         BM1     CONTST    GOSUB, LOOK FOR LINE NUMBER.
D4A5  FD           197         DCR     R13
D4A6  FD           198         DCR     R13       (TOKEN $5F IS GOTO)
D4A7  06    0F     199         BZ      CONTST
D4A9  10    24  00 200         SET     THEN, $0024
04AC  DD           201         CR9     THEN
D4AD06      09     202         BZ      CONTST    ‘THEN’ LNO, LOOK FOR LNO.
D4AF  F0           203         DCR     ACC
D4B0  06    116    204         BZ      P2A       E0L (TOKEN 01)?
D4B2  10    74  00 205         SET     LIST, $0074
D4B5  20           206         SUB     LIST      SET MODEIF LIST OR LIST COMMA.
D4B6  09    01     207         BNM1    CONTS2    (TOKENS $74, $75)
D4B8  20           208  CONTST SUB     ACC       CLEAR MODE FOR LNO
D4B9  3C           209  CONTS2 ST      MODE      UPDATE CHECK
D4BA01      01     210         BR      ITEM

                   212 *
                   213 *               .
                   214 *               APPLE ][ BASIC APPEND SUBROUTINE
                   215 *
D4BC20      89  F6 216  APPEND JSR     SW1 6
D4BF  1C    4E  00 217         SET     SCRC, HIMEM+2
D4C2  CC           218         POPD    @SCRC     SAVE HIMEM.
D4C0  88           219         ST      HMEM
D4C4  19    CA00   220         SET     SCR9, PPL
D4C7  69           221         L0D     @SCR9
D4C8  7C           222         ST D    @SCRC     SET HIMEM TO PRESERVE PROGRAM.
D4C9  00           220         RTN
D4CA20      DF  F0 224         JSR     LOAD      LOAD FROM TAPE
D4CD20      89  F6 225         JSR     SW16
D4.00CC            226         P0PD    @SCRC     RESTORE HIMEM TO SHOW BOTH PROGRAMS
D4Ot  28           227         LD      HMEM      (OLD AND NEW)
D402  7C           228         STD     RETURN
D403  00           229 DONE    RTN
D404  60           230         RTS

                               .
 - - -  END ASSEMBLY - - -

 TOTAL ERRORS:   00
```

ASM

```
********************************
*                              *
*     6502 RELOCATION          *
*       SUBROUTINE             *
*                              *
*     1. DEFINE BLOCKS         *
*        *A4<A1.A2 ^Y          *
*        (^Y IS CTRL-Y)        *
*                              *
*     2. FIRST SEGMENT         *
*        *A4<A1.A2 ^Y          *
*          (IF CODE)           *
*                              *
*        *A4<A1.A2M            *
*          (IF MOVE)           *
*                              *
*     3. SUBSEQUENT SEGMENTS   *
*        *.A2 ^Y OR *.A2M      *
*                              *
*        WOZ 11-10-77          *
*       APPLE COMPUTER INC.    *
*                              *
********************************

*
*     RELOCATION SUBROUTINE EQUATES
*
ROL.       EQU        $02 SWEET 16 REG 1.
INST       EQU        $0B 3-BYTE INST FIELD.
LENGTH     EQU        $2F LENGTH CODE
YSAV       EQU        $34 CMND BUF POINTER
A1L        EQU        $3C APPLE-II MON PARAM AREA.
A4L        EQU        $42 APPLE-II MON PARAM REG 4
IN         EQU        $0200
SW16       EQU        $F689 ;SWEET 16 ENTRY
INSDS2     EQU        $F88E DISASSEMILER ENTRY
NXTA4      EQU        $FCB4 POINTER INCR SUBR
FRMBEG     EQU        $01 SOURCE BLOCK BEGIN
FRMEND     EQU        $02 SOURCE BLOCK END
TOBEG      EQU        $04 DEST BLOCK BEGIN
ADR        EQU        $06 ADR PART OF INST.
```

```
                    *
                    *    6502 RELOCATION SUBROUTINE
                    *
                                 ORG   $D4DC
                                 OBJ   $A4DC
D4DC  A4  34        RELOC        LDY   YSAV CMND BUF POINTER
D4DE  B9  00  02                 LDA   IN, Y NEXT CMD CHAR
D4E1  C9  AA                     CMP   #$AA '4'?
D4E3  D0  0C                     BNE   RELOC2 NO, RELOC CODE SEQ.
D4E5  E6  34                     INC   YSAV ADVANCE POINTER
D4E7  A2  07                     LDX   .#$07
D4E9  B5  3C        INIT         LDA   A1L, X MOVE BLOCK PARAMS
D4EB  95  02                     STA   R1L,X FROM APPLE-II MON
D4ED  CA                         DEX   AREA TO SW16 AREA
D4EE  10  F9                     BPL   INIT  R1=SOURCE  BEG, R2=
D4FO  60                         RTS   SOURCE END, R4=DEST BEG.
D4F1  A0  02        RELOC2       LDY   #$02
D4F3  B1  3C        GETINS       LDA   (A1L),Y COPY 3 BYTES TO
D4F5  99  0B  00                 STA   INST, Y SW16 AREA
D4F8  88                         DEY
D4F9  10  F8                     BPL   GETINS
D4FB  20  8E  F8                 JSR   INSDS2 CALCULATE LENGTH OF
D4FE  A6  2F                     LDX   LENGTH   INST FROM OPCODE.
D500  CA                         DEX   0=1 BYTE, 1=2 BYTES,
D501  D0  0C                     BNE   XLATE 2=3 BYTES
D503  A5  0B                     LDA   INST
D505  29  0D                     AND   #$0D WEED OUT NON-ZERO-PAGE
D507  F0  14                     BEG   STINST 2 BYTE INSTS (IMM).
D509  29  08                     AND   #$08         IF ZERO PAGE ADR
D50B  D0  10                     BNE   STINST       THEN CLEAR HIGH BYTE
D50D  85  0D                     STA   INST+.2
D50F  20  99  F6    XLATE        JSR   SW16 IF ADR OF ZERO PAGE
D512  22                         LD    FRMEND OR ABS IS IN SOURCE
D513  06                         CPR   ADR (FRM) BLOCK THEN
D514  02  06                     BNC   SW16RT SUBSTITUTE
D516  26                         LD    ADR ADR-SOURCE SEG+DEST BEG
D517  B1                         SUB   FRMBEG
D518  02  02                     BNC   SW16RT
D5lA  A4                         ADD   TOBEG
D51B  36                         ST    ADR
D51C  00            SW16RT       RTN
D51D  A2  00        STINST       LDX   #$00
D51F  B5  0B        STINS2       LDA   INST. X
D521  91  42                     STA   (A4L) -Y COPY LENGTH BYTES
D523  E8                         INX   OF INST FROM SW16 AREA TO
D524  20  B4  FC                 JSR   NXTA4
D527  06  2F                     DEC   LENGTH DEST SEGMENT. UPDATE
D529  10  F4                     BPL   STINS2 SOURCE, DEST SEGMENT
D52B  90  C4                     DCC   RELOC2 POINTERS. LOOP IF NOT
D52D  60                         RTS   BEYOND SOURCE SEQ END.
                                             END ASSEMBLY
```

- - -END ASSEMBLY - - -

TOlAL ERRORS: 00

```
                  ********************************
                  *                              *
                  *          TAPE VERIFY         *
                  *                              *
                  *            JAN 78            *
                  *            BY WOZ            *
                  *                              *
                  *                              *
                  ********************************
                  *
                  *          TAPE VERIFY EGUATES
                  *
                   CHKSOM EQU   $2E
                  A1      EQU   $3C
                  HIMEM   EQU   $4C ;BASIC HIMEM POINTER
                  PP      EQU   $CA ;BASIC BEGIN OF PROGRAM
                  PRLEN   EQU   $CE ;BASIC PROGRAM LENGTH
                  XSAVE   EQU   $D8 ;PRESERVE X-REG FOR BASIC
                  HDRSET  EQU   $F11E ;SETS TAPE POINTERS TO $CE.CF
                  PRGSET  EQU   $F12C ;SETS TAPE POINTERS FOR PROGRAM
                  NXTA1   EQU   $FCBA ;INCREMENTS (A1) AND COMPARES TO (A2)
                  HEADR   EQU   $FCC9
                  RDBYTE  EQU   $FCEC
                  RD2BIT  EQU   $FCFA
                  RDBIT   EQU   $FCFD
                  PRA1    EQU   $F092 ;PRINT (A1)-
                  PRBYTE  EQU   $FDDA
                  COUT    EQU   $FDED
                  FINISH  EQU   $FF26 ;CHECK CHECKSUM,  RING SELL
                  PRERR   EQU   $FF2D
                  *
                  *           TAPE VERIFY ROUTINE
                  *
                          0RG   $D535
                          0BJ   $A535
                  VFYBSC  STX   XSAVE ;PRESERVE X-REG FOR BASIC
0535  86  D8              SEC
0537  38                  LDX   #$FF
0538  A2  FF      GET LEN LDA   HIMEM+1 CALCULATE PROGRAM LENGTH
053A  A5  4D              SBC   PP+1,X INTO PRLEN
053C  FS  CB              STA   PRLEN+1, X
D53E  95  CF              INX
0540  E8                  BEQ   GETLEN
0541  F0  F7              JSR   HDRSET ;SET UP POINTERS
0543  20  1E  F1          JSR   TAPEVFY ;DO A VERIFY ON HEADER
0546  20  54  D5          LDX   #$01 ;PREPARE FOR PRGSET
0549  A2  01              JSR   PRGSET SET POINTERS FOR PROGRAM VERIFY
054B  20  2C  F1          JSR   TAPEVFY
DS4E  20  54  D5          LDX   XSAVE ;RESTORE X-REG
0551  A6  D8              RTS
0553  60
```

```
                     *
                     * TAPE VERIPY RAM IMAGE (A1.A2)
                     *
D554  20  FA  FC     TAPEVPY  JBR  RD2BIT
D557  A9  16                  LDA  #$16
D559  20  C9  FC              JSR  HEADR ;SYNCHRONIZE ON HEADER
D55C  85  2E                  STA  CHKSUM INITIALIZE CHKSUM
DS5E  20  FA  FC              JSR  RD2B1T
D561  A0  24         VRPY2    LDY  #$24
D563  20  PD  PC              JSR  RDBIT
D566  20  P9                  BCS  VRFY2 CARRY SET IF READ A '1' BIT
D568  20  FD  FC              JSR  RDBIT
D56B  A0  3B                  LDY  #$3B
D56D  20  EC  FC     VRFY3    JSR  RDBYTE READ A BYTE
D570  F0  0E                  SEQ  EXTDEL ALWAYS TAKEN
D572  45  2E         VFYLOOP  EOR  CHKSUM UPDATE CHECKSUM
D574  85  2E                  STA  CHKSUM
D576  20  BA  FC              JSR  NXTA1 INCREMENT A1, SET CARRY IF A1>A2
D579  A0  34                  LDY  #$34 ONE LESS THAN USED IN READ FOR EXTRA 12
D57B  90  F0                  BCC  VRPY3 ;LOOP UNTIL A1>A2
D57D  4C  26  FF              JMP  FINISH ;VERIPY CHECKSUMSCRING BELL
D580  EA             EXTDEL   NOP  ;EXTRA DELAY TO EQUALIZE TIMING
D581  EA                      NOP  ;    ( +12 USEC )
D582  EA                      NOP
D583  C1  3C                  CMP  (AI,X) BYTE THE SAME?
D585  F0  EB                  BEQ  VFYLOOP IT MATCHES, LOOP BACK
D587  48                      PHA  ;SAVE WRONG BYTE FROM TAPE
D598  20  2D  FF              JSR  PRERR ;PRINT "ERR"
D58B  20  92  FD              JSR  PRA1 ;OUTPUT (A1)"-"
D58E  B1  3C                  LDA  (A1),Y
D590  20  DA  FD              JSR  PRBYTE OUTPUT CONTENTS OP A1
D593  A9  A0                  LDA  #$A0 PRINT A BLANK
D595  20  ED  FD              JSR  COUT
D598  A9  A8                  LDA  #$AB ; '('
D59A  20  ED  FD              JSR  COUT
D59D  68                      PLA  ;OUTPUT BAD BYTE FROM TAPE
D59E  20  DA  FD              JSR  PRBYTE
D5A1  A9  A9                  LDA  #$A9 ;   '('
D5A3  20  ED  FD              JSR  COUT
D5A6  A9  FD                  LDA  #$8D;CARRIAGE RETURN, AND RETURN TO CALLER
D5A8  4C  ED  FD              JMP  COUT

- - - END ASSEMBLY - - -

TOTAL ERRORS: 00
```

:ASM

```
**************************
*                        *
*        RAMTEST         *
*                        *
*         BY WOZ         *
*          6/77          *
*                        *
*   COPYRIGHT 1978 BY:   *
*   APPLE COMPUTER INC   *
*                        *
**************************

*
*           EQUATES:
*
DATA      EQU   $0      TEST DATA $00 OR $FF
NDATA     EQU   $1      INVERSE TEST DATA.
TESTD     EQU   $2      GALLOP DATA
R3L       EQU   $6      AUX ADR POINTER
R3H       EQU   $7
R4L       EQU   $8      AUX ADR POINTER.
R4H       EQU   $9
R5L       EQU   $A      AUX ADR POINTER.
R5H       EQU   $D
R6L.      EQU   $C      GALLOP BIT MASK.
R6H       EQU   $D      ($0001 TO 2^N)
YSAV      EQU   $34     MONITOR SCAN INDEX.
A1H       EQU   $3D     BEGIN TEST BLOCK ADR.
A2L       EQU   $3E     LEN (PAGES) FROM MON.
SETCTLY   EQU     $D5B0   ;SET UP CNTRL - Y LOCATION
PRBYTE    EQU   $FDDA   BYTE PRINT SUSR.
COOT      EQU   $FDED   Cl-fAR OUT SUEBR
PRERR     EQU   $FF2D  PRINTS 'ERR - BELL'
BELL      EQU   $FF3A
```

```
                         •
                         *          RAMTEST
                         *
                                    ORG        $D5BC
                                    OBJ        $A5BC
D5BC  A9  C3             SETUP      LDA        #$C3 ;SET UP CNTRL-V LOCATION
D5BE  A0  D5                        LDY        #$D5
D5CO  4C  B0  D5                    JMP        SETCTLY
D5C3  A9  00             RAMTST     LDA        #$0 TEST FOR $00.
DSC5  20  D0  05                    JSR        TEST
D508  A9  FF                        LDA        #$FF THEN $FF.
D5CA  20  D0  D5                    JSR        TEST
D500  4C  3A  FF                    JMP        BELL
D500  85  00             TEST       STA        DATA
D502  49  FF                        E0R        #$FF
D504  85  01                        STA        NDATA
D506  A5  3D                        LDA        A1H
D508  85  07                        STA        R3H INIT (R3L, R3H)
DSDA  85  09                        STA        R4H   (R4L, R4H),  (R5L, R5H)
D500  85  0B                        STA        A4H   TO TEST BLOCK BEGIN
D50E  A0  00                        LDY        #$0     ADDRESS.
D5E0  84  06                        STY        R3L
D5E2  84  08                        STY        R4L
D5E4  84  0A                        STY        R5L
D5E6  A6  3E                        LDX        A2L  LENGTH (PAGES).
D5EB  A5  00                        LDA        DATA
D5EA  91  08             TEST0I     STA        (R4L), Y SET ENTIRE TEST
D5EC  C8                            INY        BLOCK TO DATA.
D5ED  D0  FB                        BNE        TEST01
D5EF  E6  09                        INC        R4H
D5FI  CA                            DEX
D5F2  D0  F6                        BNE        TEST01
D5F4  A6  3E                        LDX        A2L
D5F6  B1  06             TEST02     LDA        (R3L).Y VERIFY ENTIRE
D5P9  C5  00                        CMP        DATA TEST BLOCK.
D5FA  F0  13                        BEQ        TEST03
D5FC  48                            PHA        PRESERVE BAD DATA.
D5FD  A5  07                        LDA        R3H
D5FF  20  DA  FD                    JSR        PRBYTE PRINT ADDRESS,
D602  98                            TYA
D603  20  8A  D6                    JSR        PRBYSP
D606  A5  00                        LDA        DATA THEN EXPECTED DATA,
D606  20  8A  D6                    JSR        PRBYSP
D606  68                            PLA        THEN BAD DATA,
D60C  20  7F  D6                    JSR        PRBYCR THEN ‘ERR-BELL’.
D60F  C8                 TEST03     INY
D610  D0  E4                        BNE        TEST02
D612  E6  07                        INC        R3H
D614  CA                            DEX
D615  D0  DF                        BNE        TEST02
D617  A6  3E                        LDX        A2L LENGTH.
D619  A5  01             TEST04     LDA        NDATA
D618  91  0A                        STA        (R5L),Y SET TEST CELL TO
D610  84  0D                        STY        R6H       NDATA AND R6
D61F  64  0C                        STY        R6L       (GALLOP BIT MASK)
D621  E6  0C                        INC        R6L       TO $0001.
D623  A5  01             TEST05     LDA        NDATA
D625  20  45  D6                    JSR        TEST6 GALLOP WITH NDATA
D628  A5  00                        LDA        DATA
D62A  20  45  D6                    JSR        TEST6 THEN WITH DATA.
D620  06  0C                        ASL        R6L
D62F  26  0D                        ROL        R6H SHIFT GALLOP BIT
D631  A5  0D                        LDA        R6H MASK FOR NEXT
```

```
D633  C5  3E             CMP   A2L      NEIGHBOR. DONE
D635  90  EC             BCC   TEST05  IF > LENGTH.
D637  A5  00             LDA   DATA
D639  91  0A             STA   (R5L),Y RESTORE TEST CELL.
D63B  E6  0A             IPNC  R5L
D63D  D0  DA             BNE   TEST04
D63F  E6  0B             INC   R5H INCR TEST CELL
D641  CA                 DEX   POINTER AND DECR
D642  D0  D5             BNE   TEST04 LENGTH COUNT.
D644  60         RTSI    RTS
D645  85  02     TEST 6  STA   TESTD SAVE GALLOP DATA.
D647  A5  0A             LDA   R5L
D649  45  0C             EOR   R6L     SETR4 TO R5
D64B  85  08             STA   R4L     EX - OR R6
D64D  A5  0B             LDA   R5N     FOR NEIGHBOR
D64F  45  0D             EUR   R6H     ADDRESS (1 BIT
D651  85  09             STA   R4H     DIFFERENCE)
D653  A5  02             LDA   TESTD
D655  91  08             STA   (R4L) Y GALLOP TEST. DATA.
D657  B1  0A             LDA   (R5L),Y CHECK TEST CELL
D659  C5  01             CMP   NDATA FOR CHANGE.
D65B  F0  E7             BEG   RTSI  (OK).
D65D  48                 PHA   PRESERVE FAIL DATA.
D65E  A5  0B             LDA   R5N
D660  20  0A  FD         JSR   PRBYTE PRINT TEST CELL
D663  A5  0A             LDA   R5L   ADDRESS,
D665  20  8A  D6         JSR   PRBYSP
D668  A5  01             LDA   NDATA
D66A  91  0A             STA   (R5L),Y (REPLACE CORRECT DATA)
D66C  20  8A  D6         JSR   PRBYSP THEN TEST DATA BYTE.
D66F  68                 PLA
D670  20  8A  D6         JSR   PRBYSP THEN FAIL DATA,
D673  A5  09             LDA   R4H
D675  20  DA  FD         JSR   PRBYTE
D678  A5  08             LDA   R4L THEN NEIGHBOR ADR,
D67A  20  8A  D6         JSR   PRBYSP
D67D  A5  02             LDA   TESTD THEN GALLOP DATA.
D67F  20  8A  D6 PRBYCR  JSR   PRBYSP OUTPUT BYTE, SPACE.
D682  20  2D  FF         JSR   PRERR THEN ‘ERR-BELL’.
D685  A9  8D             LDA   #$8D ASCII CAR. RETURN.
D687  4C  ED  FD         JMP   COUT
D69A  20  DA  FD PRBYSP  JSR   PRBYTE
D63D  A9  A0             LDA   #$A0 OUTPUT BYTE. THEN
D6SF  4C  ED  FD         JMP   COUT   SPACE.
                         ORG   $3F8
03F8  4C  C3  D5 USRLOC  JMP   RAMTST  ENTRY PROM MON (CTRL—Y)

- - - END ASSEMSLY - - -

TOTAL ERRORS: 00
```

```
                     *********************************
                     *
                     * MUSIC SUBROUTINE
                     *
                     *  GARY J. SHANNON
                     *
                     *********************************
                                   ORG    $D717
                     *
                     * ZERO PAGE WORK AREAS
                     * PARAMETER PASSING AREAS

                     DOWNTIME EQU   $0
                     UPTIME    EQU   $1
                     LENGTH    EQU   $2
                     VOICE     EQU  $2FD
                     LONG      EQU  $2FE
                     NOTE      EQU  $2FF
                     SPEAKER   EQU   $C030
D717  4C  4E  D7     ENTRY   JMP    LOOKUP
                     *
                     * PLAY ONE NOTE
                     *
                     *  DUTY CYCLE DATA IN 'UPTIME' AND
                     * 'DOWNTIME', DURATION IN LENGTH'
                     *
                     *
                     * CYCLE IS DIVIDED INTO 'UP' HALF
                     * AND 'DOWN' HALF
                     *
D71A  A4  01         PLAY    LDY    UPTIME ; GET POSITIVE PULSE WIDTH
D71C  AD  30  C0             LDA    SPEAKER ; TOGGLE SPEARER
D71F  E6  02         PLAY2   INC    LENGTH ; DURATION
D721  D0  05                 BNE    PATH1 ; NOT EXPIPED
D723  E6  03                 INC    LENGTH=1
D725  D0  05                 BNE    PATH2
D727  60                     RTS    ; DURATION EXPIRED
D728  EA             PATH1   NOP    ; DUMMY
D729  4C  2C  D7             JMP    PATH2 ; TIME ADJUSTMENTS
D72C  88             PATH2   DEY    ; DECREMENT WIDTH
D72D  f0  05                 BEG    DOWN ; WIDTH EXPIRED
D72F  4C  32  D7             JMP    PATH3 ; IF NOT, USE UP
                     *
                     * DOWN HALF OF CYCLE

D732  D0  EB         PATH3   BNE    PLAY2 ; SAME # CYCLES
D34   A4  00         DOWN    LDY    DOWNTIME ; GET NEGATIVE PULSE WIDTH
D736  AD  30  C0             LDA    SPEAKER : TOGGLE SPEAKER
D739  E6  02         PLAY3   INC    LENGTH ; DURATION
D73B  D0  05                 BNE    PATH4 ; NOT EXPIRED
D73D  E6  03                 INC    LENGTH+1
D7SF  D0  05                 BNE    PATH5
D741  60                     RTS    ; DURATION EXPIRED
D742  EA             PATH4   NOP    ; DUMMY
D743  4C  46  D7             JMP    PATH5 ; TIME ADJUSTMENTS
D746  88             PATH5   DEY    ; DECREMENT WIDTH
D747  F0  D1                 BEQ    PLAY ; BACK TO UP-SIDE
D749  4C  4C  D7             JMP    PATH6 ; USE UP SOME CYCLES
D74C  D0  EB         PATH6   BNE    PLAY3 ; REPEAT
```

```
                                *
                                * NOTE TASLE L00~SUP SUDROUTINE
                                *
                                * GIVEN NOTE NUMBER IN 'NOTE'
                                * DURATION COUNT IN 'LONG'
                                * FIND 'UPTIME' AND 'DOWNTIME'
                                *       ACCORDING TO DUTY CYCLE CALLED
                                *       FOR BY 'VOICE'
                                *
D74E  AD  FF  02                LOOKUP  LDA   NOTE GET NOTE NUMOER
D751  0A                                ASL   ; DOUBLE IT
D752  A8                                TAY
D753  B9  96  D7                        LDA   NOTES, Y ; GET UPTIME
D756  85  00                            STA   DOWNTIME ; SAVE IT
D758  AD  FD  02                .       LDA   VOICE ; GET DUTY CYCLE
D752  4A                        SHIFT   LSR
D75C  F0  04                            BEQ   DONE ; SHIFT WIDTH COUNT
D75E  46  00                            LSR   DOWNTIME ; ACCORDING TO VOICE
D760  D0  P9                            BNE   SHIFT
D762  B9  96  D7                DONE    LDA   NOTES, Y ; GET ORIGINAL
D765  38                                SEC
D766  E5  00                            SBC   DOWNTIME ; COMPUTE DIFFERENCE
D768  85  01                            STA   UPTIME ; SAVE IT
D76A  C8                                INY   ; NEXT ENTRY
D762  B9  96  D7                        LDA   NOTES,Y ;  GET DOWNTIME
D76E  65  00                            ADC   DOWNTIME ; ADD DIFFERENCE
D770  85  00                            STA   DOWNTIME
D772  A9  00                            LDA   #0
D774  38                                SEC
D775  ED  FE  02                        SBC   LONG ; GET COMPLIMENT OF DURATION
D778  85  03                    .       STA   LENGTH+1 MOST SIGNIFICANT BYTE
D77A  A9  00                            LDA   #0
D77C  85  02                            STA   LENGTH.
D77E  A5  01                            LDA   UPTIME
D780  D0  98                            BNE   PLAY IF NOT NOTE #0, PLAY IT

                                * 'REST' SUBROUTINE' PLAYS NOTE #0
                                *  SILENTLY, FOR SAME DURATION AS
                                *  A REGULAR NOTE
D782  EA                        *
D783  EA                        REST    NOP   ; DUMMY
D784  4C  87  07                        NOP   ; CYCLE USERS
D787  E6  02                            JMP   REST2 ; TO ADJUST TIME
D789  D0  05                    REST2 . INC   LENGTH
D788  E6  03                            BNE   REST3
D780  D0  05                            INC   LENGTH+ 1
D78F  60                                BNE   REST4
D790  EA                                RTS   ; IF DURATION EXPIRED
D791  4C  94  D7                RESTS   NOP   ; USE UP 'INC' CYCLES
D794  D0  EC                            JMP   REST4
                                REST4   BNE   REST ; ALWAYS TAKEN
```

```
                              113 *
                              114 *  NOTE TABLES
D796   00   00   F6           115 *
D79E   CF   CF   C3           116              HEX       00, 00, F6, F6,E8, E8, DB,DB
D7A6   A4   A4   9B           117              HEX       CF, CF,C3,C3,B8, B8,AE, AE
D7AE   82   82   7B           118              HEX       A4, A4,9B,9B,92, 92, 8A, 8A
D7B6   67   68   61           119              HEX       82, 82, 7B,7B,74, 74, 6D, 6E
D7BE   52   52   4D           120              HEX       67, 68, 61, 62,5C, 5C,57, 57
D7C6   41   41   3D           121              HEX       52, 52, 4D,4E,49, 49, 45, 45
D7CE   33   34   30           122              HEX       41, 41, 3D,3E,3A, 3A,36, 37
D7D6   29   29   26           123              HEX       33, 34, 30, 31,2E, 2E, 2B, 2C
D7DE   20   21   1E           124              HEX       29, 29, 26, 27,24, 25, 22, 23
D7E6   1A   1A   18           125              HEX       20, 21, 1E, 1F,1D, 1D,1B, 1C
D7EE   14   15   13           126              HEX       1A, 1A,18, 19,17, 17, 15, 16
D7F6   10   10   0F           127              HEX       14, 15, 13, 14,12, 12, 11, 11
                              128              HEX       10, 10, 0F, 10,0E, 0F

 - - - END ASSEMBLY   - - -

TOTAL ERR0RS: 00
```

APPENDIX II
SUMMARY OF PROGRAMMER'S AID COMMANDS

Chapter 1: RENUMBER

(a) To renumber an entire BASIC program:

```
CLR
START  = 1000
STEP  = 10
CALL —10531
```

(b) To renumber a program portion:

```
CLR
START = 200
STEP = 20

FROM = 300          (program portion
TO = 500             to be renumbered)

CALL —10521
```

Chapter 2: APPEND

(a) Load the second BASIC program, with high line numbers:

```
LOAD
```

(b) Load and append the first BASIC program, with low line numbers:

```
CALL —11076
```

Chapter 3: TAPE VERIFY (BASIC)

(a) Save current BASIC program on tape:

```
SAVE
```

(b) Replay the tape, after:

```
CALL —10955
```

Chapter 4: TAPE VERIFY (Machine Code and Data)

(a) From the Monitor, save the portion of memory on tape:

address1 . address2 W return

(b) Initialize Tape Verify feature:

D52EG return

(c) Replay the tape, after:
address1 . address2 ctrl Y return

Note: spaces show within the above commands are for easier reading only; they should <u>not</u> be typed.

Chapter 5: RELOCATE (Machine Code and Data)

(a) From the Monitor, initialize Code-Relocation feature:

D4D5G return

(b) Blocks are memory locations from, which program <u>runs</u>.
Specify Destination and Source Block parameters:

Dest Blk Beg < Source Blk Beg . Source Blk End ctrl Y * return

(c) Segments are memory locations where parts of program <u>reside</u>. If first program Segment is code, Relocate:

Dest Seg Beg < Source Seg Beg Source Seg End ctrl Y return
If first program Segment is data. Move:

Dest Seg Beg < Source Seg Beg . Source Seg End return

(4) In order of increasing address, Move subsequent contiguous data Segments:

- Source Segment End ctrl Y return

and Relocate subsequent contiguous code Segments:

- Source Segment End M return

Note: spaces show within the above commands are for easier reading only; they should <u>not</u> be typed.

Chapter 6: RAM TEST

(a) From the Monitor, initialize RAM Test program:

D5BCG return

(b) To test a portion of memory:

address • pages ctrl Y return (test begins at address, continues for length pages.

Note: test length. pages*l00, must <u>not</u> be greater than starting address. One page = 256 bytes ($100 bytes, in Hex).

(c) To test more memory, do individual tests or concatenate:

addr1.pagesl ctrl Y addr2.pages2 ctrl Y Addr3.pages3 ctrl Y return

Example, for a 48K system:

400.4 ctrl Y 800.8 ctrl Y 1000.10 ctrl Y 2000.20 ctrl Y
3000.20 ctrl Y 4000.40 ctrl Y 7000.20 ctrl Y 8000.40
ctrl Y return

(d) To repeat test indefinitely:

N complete test 34:0 type one space return

Note: except where specified in step (d), spaces shown within the above commands are for easier reading only; they should <u>not</u> be typed.

Chapter 7: MUSIC

(a) Assign appropriate variable names to CALL and POKE locations (optional):

MUSIC = -10473
PITCH = 767
TIME = 766
TIMBRE = 765

(b) Set parameters for next note:

POKE PITCH, p	(p =1 to 50; 32 = middle C)
POKE TIME, m	(m = 1 to 255; 170 = 1 second)
POKE TIMBRE, t	(t = 2, 8, 16, 32 or 64)

(c) Sound the note:

CALL MUSIC

Chapter 8: HIGH-RESOLUTION GRAPHICS

(a) Set order of parameters (first lines of progratn):

```
1 X0 = Y0 = COLR
2 SHAPE = ROT = SCALE        (if shapes are used)
```

(b) Assign appropriate variable names to subroutine calling addresses (optional; omit any subroutines not used in program):

```
10  INIT   =  —12288   CLEAR =  —12274   BKGND = —11471
11  POSN  =  —11527    PLOT  =  —11506   LINE = —11500
12  DRAW =  —11465     DRAWl =  —11462
13  FIND   =  —11780   SHLOAD =—11335
```

(c) Assign appropriate variable names to color values (optional; omit any colors not used in progran):

```
20 BLACK = 0 : LET GREEN = 42 : VIOLET = 85
21 WHITE = 127 : ORANGE = 170 : BLIJE  213
22 BLACK2 = 128 : WHITE2 = 255
```

(d) Initialize:

```
30 CALL INIT
```

(e) Change screen conditions, if desired. Set appropriates parameter values, and CALL desired subroutines by name.

Example:

```
40 COLR = VIOLET : CALL BKCND : REM : TURN BACKGROUND VIOLET
50 FOR I = 0 TO 279 STEP 5
60 X0 = 140 : V0 = 150 : COLR = WHITE : REM SET PARAMETERS
70 CALL POSN : REM MARK THE ‘CENTER’
80 X0 = 1 : Y0 = 0 : REM SET NEW PARAMETERS
90 CALL LINE : REM DRAW LINE TO EDGE
100 NEXT I : END
```

QUICK REFERENCE TO HIGH-RESOLUTION INFORMATION

Subroutine Name	CALLing Address	Patameters Needed
INIT	—12288	
CLEAR	—12274	
BKGND	—11471	COLR
POSN	—11527	X0, Y0. COLR X0,
PLOT	—11506	Y0, COLR
LINE	—11300	X0, Y0, COLR
DRAW	—11463	X0, Y0, COLR, SHAPE, ROT. SCALE
DRAW1	—11462	SHAPE, ROT, SCALE
FIND	—11780	
SHLOAD	—11335	

Color Name	COLR Value	Color Name	COLR Value
BLACK	0	BLACK2	128
GREEN	42	ORANGE	170
VIOLET	85	BLUE	213
WHITE	127	WHITE2	255

(Note: on systems below S/N 6000. colors in the second column appear identical to those in the first column)

CHANGING THE High-Resolution GRAPHICS DISPLAY

Full—Screen Graphics	POKE —16302, 0
Mixed Graphics—Plus—Text (Default)	POKE —16301, 0
Page 2 Display	POKE —16299, 0
Page 1 Display (Normal)	POKE —16300, 0
Page 2 Plotting	POKE 806, 64
Page 1 Plotting (Default)	POKE 806, 32

(Note: CALL INIT sets mixed graphics—plus—text, and Page 1 plotting, but does not reset to Page 1 display.)

Collision Count for Shapes PEEK (810)

(Note: the change in PEEKed value indicates collision.)