



# The Apple IIc

***The Apple IIc  
Reference Manual  
Volume 2***



## **Customer Satisfaction**

If you discover physical defects in the manuals distributed with an Apple product or in the media on which a software product is distributed, Apple will replace the documentation or media at no charge to you during the 90-day period after you purchased the product.

In addition, if Apple releases a corrective update to a software product during the 90-day period after you purchased the software, Apple will replace the applicable disks and documentation with the revised version at no charge to you during the six months after the date of purchase.

In some countries the replacement period may be different; check with your authorized Apple dealer. Return any item to be replaced with proof of purchase to Apple or an authorized Apple dealer.

## **Limitation on Warranties and Liability**

Even though Apple has tested the software described in the manual and reviewed its contents, neither Apple nor its software suppliers make any warranty or representation, either express or implied, with respect to this manual or to the software described in this manual, their quality, performance, merchantability, or fitness for any particular purpose. As a result, this software and manual are sold "as is," and you the purchaser are assuming the entire risk as to their quality and performance. In no event will Apple or its software suppliers be liable for direct, indirect, incidental, or consequential damages resulting from any defect in the software or manual, even if they have been advised of the possibility of such damages. In particular, they shall have no liability for any programs or data stored in or used with Apple products, including the costs of recovering or reproducing these programs or data. Some states do not allow the exclusion or limitation of implied warranties or liability for incidental or consequential damages, so the above limitation or exclusion may not apply to you.

## **Copyright**

This manual and the software (computer programs) described in it are copyrighted by Apple or by Apple's software suppliers, with all rights reserved. Under the copyright laws, this manual or the programs may not be copied, in whole or part, without the written consent of Apple, except in the normal use of the software or to make a backup copy. This exception does not allow copies to be made for others, whether or not sold, but all of the material purchased (with all backup copies) may be sold, given, or lent to another person. Under the law, copying includes translating into another language.

You may use the software on any computer owned by you, but extra copies cannot be made for this purpose. For some products, a multi-use license may be purchased to allow the software to be used on more than one computer owned by the purchaser, including a shared-disk system. (Contact your authorized Apple dealer for information on multi-use licenses.)

## **Product Revisions**

Apple cannot guarantee that you will receive notice of a revision to the software described in the manual, even if you have returned a registration card received with the product. You should periodically check with your authorized Apple dealer.

© Apple Computer, Inc. 1984  
20525 Mariani Avenue  
Cupertino, California 95014

Apple, the Apple logo, and ProDOS are trademarks of Apple Computer, Inc.  
Simultaneously published in the United States and Canada. All rights reserved.

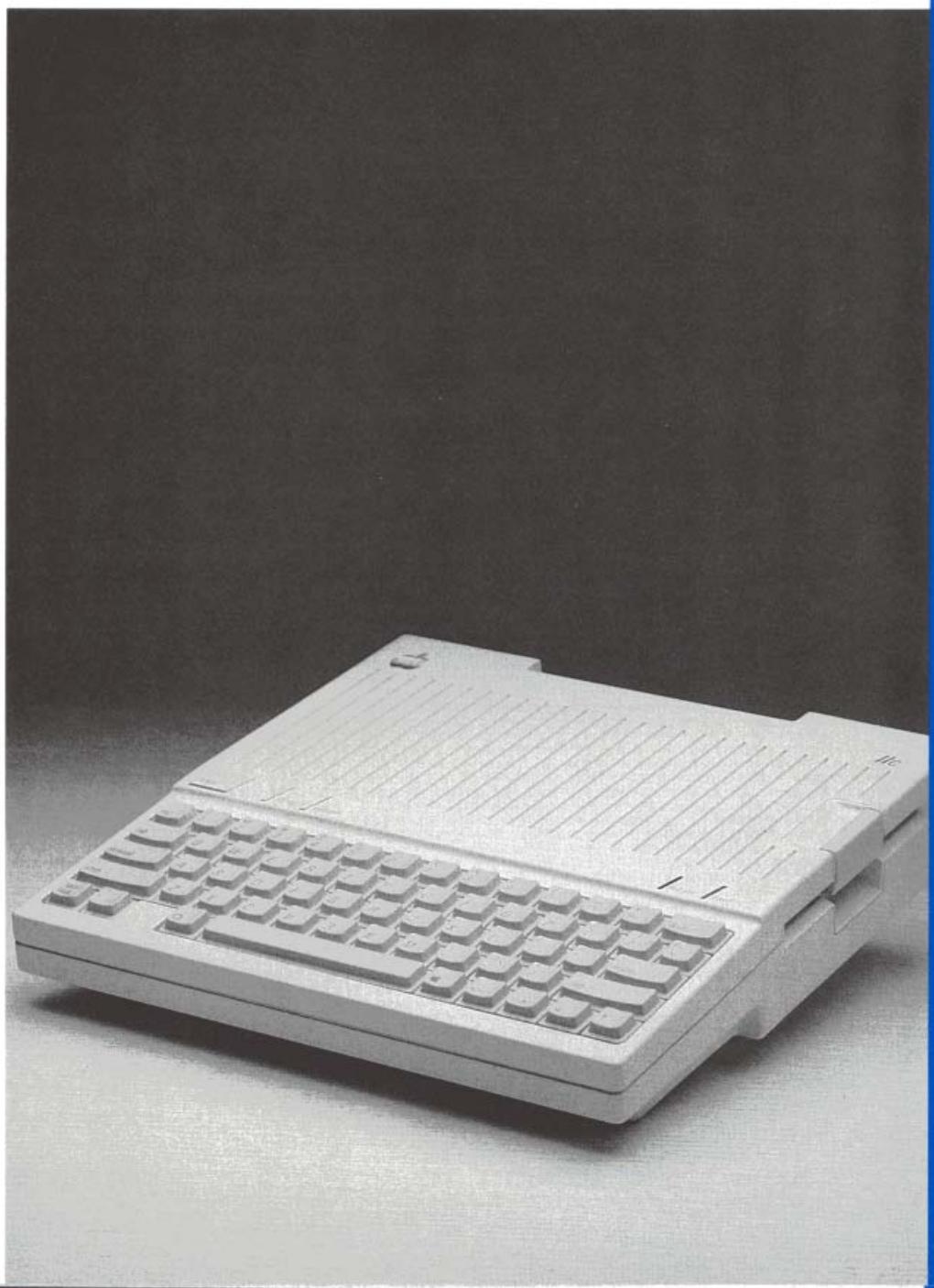
## **Warning**

This equipment has been certified to comply with the limits for a Class B computing device, pursuant to Subpart J of Part 15 of FCC Rules. Only peripherals (computer input/output devices, terminals, printers, etc.) certified to comply with the Class B limits may be attached to this computer. Operation with non-certified peripherals is likely to result in interference to radio and TV reception.



# The Apple IIc

***Apple IIc Reference Manual***  
**Volume 2**



# *Table of Contents*

---

<b>List of Figures and Tables</b>	<b>ix</b>	
<b>Preface</b>	<b>xiii</b>	
<b>Appendix A</b>	<b>The 65C02 Microprocessor</b>	<b>1</b>
2	A.1 Differences Between 6502 and 65C02	
2	A.1.1 Differing Cycle Times	
3	A.1.2 Differing Instruction Results	
4	A.2 Data Sheet	
<b>Appendix B</b>	<b>Memory Map</b>	<b>15</b>
15	B.1 Page Zero	
19	B.2 Page Three	
20	B.3 Screen Holes	
23	B.4 The Hardware Page	
<b>Appendix C</b>	<b>Important Firmware Locations</b>	<b>31</b>
31	C.1 The Tables	
32	C.2 Port Addresses	
34	C.3 Other Video and I/O Firmware Addresses	
34	C.4 Applesoft BASIC Interpreter Addresses	
34	C.5 Monitor Addresses	

**Appendix D*****Operating Systems and Languages***

37

- 37 D.1 Operating Systems
- 37 D.1.1 ProDOS
- 37 D.1.2 DOS
- 38 D.1.3 Pascal Operating System
- 38 D.1.4 CP/M
- 38 D.2 Languages
- 38 D.2.1 Applesoft BASIC
- 39 D.2.2 Integer BASIC
- 39 D.2.3 Pascal Language
- 39 D.2.4 FORTRAN

**Appendix E*****Interrupts***

41

- 41 E.1 Introduction
- 41 E.1.1 What Is an Interrupt?
- 42 E.1.2 Interrupts on Apple II Computers
- 43 E.1.3 Interrupt Handling on the 65C02
- 43 E.1.4 The Interrupt Vector at \$FFFE
- 44 E.2 The Built-in Interrupt Handler
- 46 E.2.1 Saving the Memory Configuration
- 46 E.2.2 Managing Main and Auxiliary Stacks
- 47 E.3 User's Interrupt Handler at \$3FE
- 48 E.4 Handling Break Instructions
- 49 E.5 Sources of Interrupts
- 50 E.6 Firmware Handling of Interrupts
- 50 E.6.1 Firmware for Mouse and VBL
- 52 E.6.2 Firmware for Keyboard Interrupts
- 53 Using Keyboard Buffering Firmware
- 53 Using Keyboard Interrupts  
Through Software
- 54 E.6.3 Using External Interrupts  
Through Firmware
- 55 E.6.4 Firmware for Serial Interrupts
- 55 Using Serial Buffering Transparently
- 56 Using Serial Interrupts Through Firmware
- 57 Transmitting Serial Data
- 57 A Loophole in the Firmware
- 58 E.7 Bypassing the Interrupt Firmware
- 58 E.7.1 Using Mouse Interrupts  
Without the Firmware
- 59 E.7.2 Using ACIA Interrupts  
Without the Firmware

61	F.1 Overview
63	F.1.1 Type of CPU
63	F.1.2 Machine Identification
64	F.2 Memory Structure
64	F.2.1 Amount and Address Ranges of RAM
65	F.2.2 Amount and Address Ranges of ROM
66	F.2.3 Peripheral-Card Memory Spaces
66	F.2.4 Hardware Addresses
67	\$C000 to \$C00F
67	\$C010 to \$C01F
68	\$C020 to \$C02F
68	\$C030 to \$C03F
68	\$C040 to \$C04F
68	\$C050 to \$C05F
69	\$C060 to \$C06F
70	\$C070 to \$C07F
70	\$C080 to \$C08F
70	\$C090 to \$C0FF
71	F.2.5 Monitors
72	F.3 I/O in General
72	F.3.1 DMA Transfers
72	F.3.2 Slots Versus Ports
72	F.3.3 Interrupts
73	F.4 Keyboard
73	F.4.1 Keys
74	F.4.2 Character Sets
75	F.5 Speaker
75	F.6 Video Display
75	F.6.1 Character Sets
76	F.6.2 MouseText
76	F.6.3 Vertical Blanking
76	F.6.4 Display Modes
77	F.7 Disk I/O
77	F.8 Serial I/O
77	F.8.1 Serial Ports Versus Serial Cards
78	F.8.2 Serial I/O Buffers
79	F.9 Mouse and Hand Controls
79	F.9.1 Mouse Input
79	F.9.2 Hand Control Input and Output
80	F.10 Cassette I/O
81	F.11 Hardware
81	F.11.1 Power
81	F.11.2 Custom Chips

**Appendix G*****USA and International Models***

83

- 83 G.1 Keyboard Layouts and Codes
- 85 G.1.1 USA Standard (Sholes) Keyboard
- 88 G.1.2 USA Simplified (Dvorak) Keyboard
- 89 G.1.3 ISO Layout of USA Keyboard
- 90 G.1.4 English Keyboard
- 91 G.1.5 French and Canadian Keyboards
- 93 G.1.6 German Keyboard
- 94 G.1.7 Italian Keyboard
- 96 G.1.8 Western Spanish Keyboard
- 97 G.2 ASCII Character Sets
- 99 G.3 Certifications
- 99 G.3.1 Radio Interference
- 99 G.3.2 Product Safety
- 99 G.3.3 Important Safety Instructions
- 100 G.4 Power Supply Specifications

**Appendix H*****Conversion Tables***

103

- 103 H.1 Bits and Bytes
- 106 H.2 Hexadecimal and Decimal
- 107 H.3 Hexadecimal and Negative Decimal
- 109 H.4 Graphics Bits and Pieces
- 112 H.5 Peripheral Identification Numbers
- 114 H.6 Eight-Bit Code Conversions

**Appendix I*****Firmware Listings***

125

Glossary	219
Bibliography	243
Index	247
Tell Apple Card	

# *List of Figures and Tables*

**Appendix A*****The 65C02 Microprocessor***

- 2 Table A-1 Cycle Time Differences

**Appendix B*****Memory Map***

- 16 Table B-1 Zero Page Use  
19 Table B-2 Page 3 Use  
20 Table B-3 Main Memory Screen Hole Allocations  
22 Table B-4 Auxiliary Memory Screen Hole Allocations  
24 Table B-5 Addresses \$C000 Through \$C03F  
25 Table B-6 Addresses \$C040 Through \$C05F  
26 Table B-7 Addresses \$C060 Through \$C07F  
27 Table B-8 Addresses \$C080 Through \$C0AF  
28 Table B-9 Addresses \$C0B0 Through \$C0FF

**Appendix C*****Important Firmware Locations***

- 32 Table C-1 Serial Port 1 Addresses  
32 Table C-2 Serial Port 2 Addresses  
33 Table C-3 Video Firmware Addresses  
33 Table C-4 Mouse Port Addresses  
34 Table C-5 Apple IIC Enhanced Video  
and Miscellaneous Firmware  
35 Table C-6 Apple IIC Monitor Entry Points  
and Vectors

## **Appendix E**

### **Interrupts**

- 45** Figure E-1 Interrupt-Handling Sequence
- 58** Table E-1 Activating Mouse Interrupts
- 58** Table E-2 Reading Mouse Interrupts

## **Appendix F**

### **Apple II Series Differences**

- 80** Figure F-1 Apple II, II Plus, and Ile Hand Control Signals

## **Appendix G**

### **USA and International Models**

- 85** Figure G-1 USA Standard or *Sholes* Keyboard (Keyboard Switch Up)
- 86** Table G-1 Keys and ASCII Codes
- 88** Figure G-2 USA Simplified or *Dvorak* Keyboard (Keyboard Switch Down)
- 89** Figure G-3 ISO Version of USA Standard Keyboard (Keyboard Switch Up)
- 90** Figure G-4 English Keyboard (Keyboard Switch Down)
- 90** Table G-2 English Keyboard Code Differences From Table G-1
- 91** Figure G-5 French Keyboard (Keyboard Switch Down)
- 92** Figure G-6 Canadian Keyboard (Keyboard Switch Down)
- 92** Table G-3 French and Canadian Keyboard Code Differences From Table G-1
- 93** Figure G-7 German Keyboard (Keyboard Switch Down)
- 93** Table G-4 German Keyboard Code Differences From Table G-1
- 94** Figure G-8 Italian Keyboard (Keyboard Switch Down)
- 95** Table G-5 Italian Keyboard Code Differences From Table G-1
- 96** Figure G-9 Western Spanish Keyboard (Keyboard Switch Down)
- 96** Table G-6 Western Spanish Keyboard Code Differences From Table G-1
- 98** Table G-7 ASCII Code Equivalents
- 100** Table G-8 50 Hz Power Supply Specifications

## **Appendix H**

### ***Conversion Tables***

- |                |   |
|----------------|---|
| 104 Table H-1  | What a Bit Can Represent                            |
| 105 Figure H-1 | Bits, Nibbles, and Bytes                            |
| 106 Table H-2  | Hexadecimal/Decimal Conversion                      |
| 108 Table H-3  | Decimal to Negative Decimal Conversion              |
| 109 Table H-4  | Hexadecimal Values for High-Resolution Dot Patterns |
| 113 Table H-5  | PIN Numbers   |
| 115 Table H-6  | Control Characters, High Bit Off                    |
| 116 Table H-7  | Special Characters, High Bit Off                    |
| 117 Table H-8  | Uppercase Characters, High Bit Off                  |
| 118 Table H-9  | Lowercase Characters, High Bit Off                  |
| 119 Table H-10 | Control Characters, High Bit On                     |
| 120 Table H-11 | Special Characters, High Bit On                     |
| 121 Table H-12 | Uppercase Characters, High Bit On                   |
| 122 Table H-13 | Lowercase Characters, High Bit On                   |

# *Preface*

W H E E L M A N

This volume, Volume 2 of the *Apple IIc Reference Manual*, contains nine appendixes, a bibliography, and a glossary.

Appendix A contains a description of the differences between the 6502 and the 65C02 microprocessors, plus a reprint of the manufacturer's data sheet for the 65C02 microprocessor.

Appendices B and C contain tables of the important RAM, ROM, and hardware addresses in the Apple IIc. The reader can use these tables to find locations by address, the index to find them by label, the firmware listings to find them as defined and used, and the chapters to find them described in the context of their function.

Appendix B is a memory map of the Apple IIc, including detailed tables of page zero, page three, the screen holes, and the hardware page.

Appendix C lists the *published* firmware entry points, arranged by address, and indicates where in the manual they are described. The list includes I/O firmware (pages \$C1 through \$CF) and Monitor firmware (pages \$F0 through \$FF). For Applesoft interpreter firmware (pages \$D0 through \$EF), refer to the *Applesoft BASIC Programmer's Reference Manual*, Volumes 1 and 2.

Appendix D discusses what operating systems and languages run on the Apple IIc, and what features they do and do not use.

Appendix E describes how to use the Apple IIc's interrupt handling capabilities.

Appendix F contains an overview of the differences among the Apple II series computers.

Appendix G contains the keyboard layouts, code conversion tables, and external power supply characteristics of USA and international models of the Apple IIc.

Appendix H contains reference tables for code and number base conversion.

Appendix I contains a listing of the source code for the Monitor, enhanced video firmware, and input/output firmware contained in the Apple IIc. The listings do not include the built-in Applesoft interpreter, which is discussed in the *Applesoft BASIC Programmer's Reference Manual*.

The Bibliography lists articles and books containing additional information about the Apple IIc and related products.

The Glossary defines many of the technical terms used in this manual.

1970-1971  
1971-1972  
1972-1973  
1973-1974  
1974-1975  
1975-1976  
1976-1977  
1977-1978  
1978-1979  
1979-1980  
1980-1981  
1981-1982  
1982-1983  
1983-1984  
1984-1985  
1985-1986  
1986-1987  
1987-1988  
1988-1989  
1989-1990  
1990-1991  
1991-1992  
1992-1993  
1993-1994  
1994-1995  
1995-1996  
1996-1997  
1997-1998  
1998-1999  
1999-2000  
2000-2001  
2001-2002  
2002-2003  
2003-2004  
2004-2005  
2005-2006  
2006-2007  
2007-2008  
2008-2009  
2009-2010  
2010-2011  
2011-2012  
2012-2013  
2013-2014  
2014-2015  
2015-2016  
2016-2017  
2017-2018  
2018-2019  
2019-2020  
2020-2021  
2021-2022



# *The 65C02 Microprocessor*

This appendix contains a description of the differences between the 6502 and the 65C02 microprocessor. It also contains the data sheet for the NCR 65C02 microprocessor.

In the data sheet tables, execution times are specified in number of cycles. One cycle time for the Apple IIc equals 0.978 microseconds.

If you want to write programs that execute on all computers in the Apple II series, make sure your code uses only the subset of instructions present on the 6502.

## A.1 Differences Between 6502 and 65C02

The data sheet lists the new instructions and addressing modes of the 65C02. This section supplements that information by listing the instructions whose execution times or results have changed.

### A.1.1 Differing Cycle Times

In general, differences in execution times are significant only in time-dependent code, such as precise wait loops. Fortunately, instructions with changed execution times are few.

Table A-1 lists the instructions whose number of instruction execution cycles on the 65C02 is different from the number on the 6502.

*Table A-1. Cycle Time Differences*

Instruction/Mode	Opcode	6502 Cycles	65C02 Cycles
ASL Absolute, X	1E	7	6
DEC Absolute, X	DE	7	6
INC Absolute, X	FE	7	6
JMP (Absolute)	6C	5	6
LSR Absolute, X	5E	7	6
ROL Absolute, X	3E	7	6
ROR Absolute, X	7E	7	6

---

### **A.1.2 Differing Instruction Results**

It is important to note that the BIT instruction when used in immediate mode (code \$89) leaves Processor Status Register bits 7 (N) and 6 (V) unchanged on the 65C02. On the 6502, all modes of the BIT instruction have the same effect on the Status Register: the value of memory bit 7 is placed in status bit 7, and memory bit 6 is placed in status bit 6. However, all BIT instructions on both versions of the processor set status bit 1 (Z) if the memory location contained a zero.

Also note that if the JMP indirect instruction (code \$6C) references an indirect address location that spans a page boundary, the 65C02 fetches the high-order byte of the effective address from the first byte of the next page, while the 6502 fetches it from the first byte of the current page. For example, JMP (\$2FF) gets ADL from location \$2FF on both processors. But on the 65C02, ADH comes from \$300; on the 6502, ADH comes from \$200.

## **A.2 Data Sheet**

The remaining pages of this appendix are copyright 1982, NCR Corporation, Dayton, Ohio, and are reprinted with their permission.



## NCR65C02

### ■ GENERAL DESCRIPTION

The NCR CMOS 6502 is an 8-bit microprocessor which is software compatible with the NMOS 6502. The NCR65C02 hardware interfaces with all 6500 peripherals. The enhancements include ten additional instructions, expanded operational codes and two new addressing modes. This microprocessor has all of the advantages of CMOS technology: low power consumption, increased noise immunity and higher reliability. The CMOS 6502 is a low power high performance microprocessor with applications in the consumer, business, automotive and communications market.

### ■ FEATURES

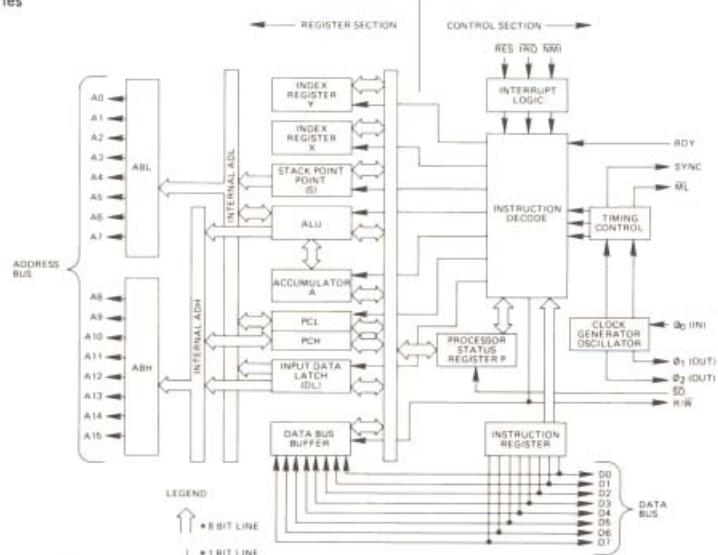
- Enhanced software performance including 27 additional OP codes encompassing ten new instructions and two additional addressing modes.
- 66 microprocessor instructions.
- 15 addressing modes.
- 178 operational codes.
- 1MHz, 2MHz operation.
- Operates at frequencies as low as 200 Hz for even lower power consumption (pseudo-static: stop during  $\Phi_2$  high).
- Compatible with NMOS 6500 series microprocessors.
- 64 K-byte addressable memory.
- Interrupt capability.
- Lower power consumption, 4mA @ 1MHz.
- +5 volt power supply.
- 8-bit bidirectional data bus.
- Bus Compatible with M6800.
- Non-maskable interrupt.
- 40 pin dual-in-line packaging.
- 8-bit parallel processing
- Decimal and binary arithmetic.
- Pipeline architecture.
- Programmable stack pointer.
- Variable length stack.
- Optional internal pullups for (RDY, IRQ, S<sub>O</sub>, NMI and RES)

\* Specifications are subject to change without notice.

### ■ PIN CONFIGURATION

VSS	1	40	RES
RDY	2	39	$\Phi_2$ (DUT)
$\Phi_1$ (DUT)	3	38	S <sub>O</sub>
IRQ	4	37	$\Phi_0$ (IN)
ML	5	36	NC
NMI	6	35	NC
SYNC	7	34	R/W
VDD	8	33	D0
A0	9	32	D1
A1	10	31	D2
A2	11	30	D3
A3	12	29	D4
A4	13	28	D5
A5	14	27	D6
A6	15	26	D7
A7	16	25	A15
AB	17	24	A14
A9	18	23	A13
A10	19	22	A12
A11	20	21	VSS

### ■ NCR65C02 BLOCK DIAGRAM



Copyright ©1982 by NCR Corporation, Dayton, Ohio, USA

**NCR65C02****■ ABSOLUTE MAXIMUM RATINGS:** ( $V_{DD} = 5.0 \text{ V} \pm 5\%$ ,  $V_{SS} = 0 \text{ V}$ ,  $T_A = 0^\circ \text{ to } +70^\circ \text{C}$ )

RATING	SYMBOL	VALUE	UNIT
SUPPLY VOLTAGE	$V_{DD}$	-0.3 to +7.0	V
INPUT VOLTAGE	$V_{IN}$	-0.3 to +7.0	V
OPERATING TEMP.	$T_A$	0 to +70	°C
STORAGE TEMP.	$T_{STG}$	-55 to +150	°C

**■ PIN FUNCTION**

PIN	FUNCTION
A0 - A15	Address Bus
D0 - D7	Data Bus
$\overline{IRQ}^*$	Interrupt Request
$\overline{RDY}^*$	Ready
$M_L$	Memory Lock
$\overline{NMI}^*$	Non-Maskable Interrupt
SYNC	Synchronize
$\overline{RES}^*$	Reset
$S_O^*$	Set Overflow
NC	No Connection
R/W	Read/Write
$V_{DD}$	Power Supply (+5V)
$V_{SS}$	Internal Logic Ground
$\overline{\theta}_0$	Clock Input
$\overline{\theta}_1, \overline{\theta}_2$	Clock Output

\*This pin has an optional internal pullup for a No Connect condition.

**■ DC CHARACTERISTICS**

	SYMBOL	MIN.	TYP.	MAX	UNIT
Input High Voltage $\overline{\theta}_0$ (IN)	$V_{IH}$	$V_{SS} + 2.4$	—	$V_{DD}$	V
Input High Voltage $\overline{RES}, \overline{NMI}, \overline{RDY}, \overline{IRQ}$ , Data, S.O.		$V_{SS} + 2.0$	—	—	V
Input Low Voltage $\overline{\theta}_0$ (IN) $\overline{RES}, \overline{NMI}, \overline{RDY}, \overline{IRQ}$ , Data, S.O.	$V_{IL}$	$V_{SS} - 0.3$ —	—	$V_{SS} + 0.4$ $V_{SS} + 0.8$	V V
Input Leakage Current ( $V_{IN} = 0$ to $5.25\text{V}$ , $V_{DD} = 5.25\text{V}$ ) With pullups Without pullups	$I_{IN}$	— —	-30 —	+30 +1.0	$\mu\text{A}$ $\mu\text{A}$
Three State (Off State) Input Current ( $V_{IN} = 0.4$ to $2.4\text{V}$ , $V_{CC} = 5.25\text{V}$ ) Data Lines	$I_{TSI}$	—	—	10	$\mu\text{A}$
Output High Voltage ( $I_{OH} = -100 \mu\text{A}_{dc}$ , $V_{DD} = 4.75\text{V}$ SYNC, Data, A0-A15, R/W)	$V_{OH}$	$V_{SS} + 2.4$	—	—	V
Out Low Voltage ( $I_{OL} = 1.6\text{mA}_{dc}$ , $V_{DD} = 4.75\text{V}$ SYNC, Data, A0-A15, R/W)	$V_{OL}$	—	—	$V_{SS} + 0.4$	V
Supply Current f = 1MHz Supply Current f = 2MHz	$I_{DD}$ $I_{D2}$	— —	— —	4 8	$\text{mA}$ $\text{mA}$
Capacitance ( $V_{IN} = 0$ , $T_A = 25^\circ\text{C}$ , f = 1MHz) Logic Data A0-A15, R/W, SYNC $\overline{\theta}_0$ (IN)	C $C_{IN}$ $C_{out}$ $C_{\overline{\theta}_0}$ (IN)	— — — —	— — — —	5 10 10 10	pF

## NCR65C02

### ■ AC CHARACTERISTICS $V_{DD} = 5.0V \pm 5\%$ , $T_A = 0^\circ C$ to $70^\circ C$ , Load = 1 TTL + 130 pF

Parameter	Symbol	1MHz		2MHz		3MHz		Unit
		Min	Max	Min	Max	Min	Max	
Delay Time, $\theta_0$ (IN) to $\theta_2$ (OUT)	$t_{DLY}$	—	60	—	60	20	60	nS
Delay Time, $\theta_1$ (OUT) to $\theta_2$ (OUT)	$t_{DLY1}$	-20	20	-20	20	-20	20	nS
Cycle Time	$t_{CYC}$	1.0	5000*	0.50	5000*	0.33	5000*	$\mu s$
Clock Pulse Width Low	$t_{PL}$	460	—	220	—	160	—	nS
Clock Pulse Width High	$t_{PH}$	460	—	220	—	160	—	nS
Fall Time, Rise Time	$t_F, t_R$	—	25	—	25	—	25	nS
Address Hold Time	$t_{AH}$	20	—	20	—	0	—	nS
Address Setup Time	$t_{ADS}$	—	225	—	140	—	110	nS
Access Time	$t_{ACC}$	650	—	310	—	170	—	nS
Read Data Hold Time	$t_{DHR}$	10	—	10	—	10	—	nS
Read Data Setup Time	$t_{DSU}$	100	—	60	—	60	—	nS
Write Data Delay Time	$t_{MDS}$	—	30	—	30	—	30	nS
Write Data Hold Time	$t_{DHW}$	20	—	20	—	15	—	nS
S0 Setup Time	$t_{SO}$	100	—	100	—	100	—	nS
Processor Control Setup Time**	$t_{PCS}$	200	—	150	—	150	—	nS
SYNC Setup Time	$t_{SYNC}$	—	225	—	140	—	100	nS
ML Setup Time	$t_{ML}$	—	225	—	140	—	100	nS
Input Clock Rise/Fall Time	$t_{F\theta_0, t_{R\theta_0}}$	—	25	—	25	—	25	nS

\*NCR65C02 can be held static with  $\theta_2$  high.

\*\*This parameter must only be met to guarantee that the signal will be recognized at the current clock cycle.

### ■ MICROPROCESSOR OPERATIONAL ENHANCEMENTS

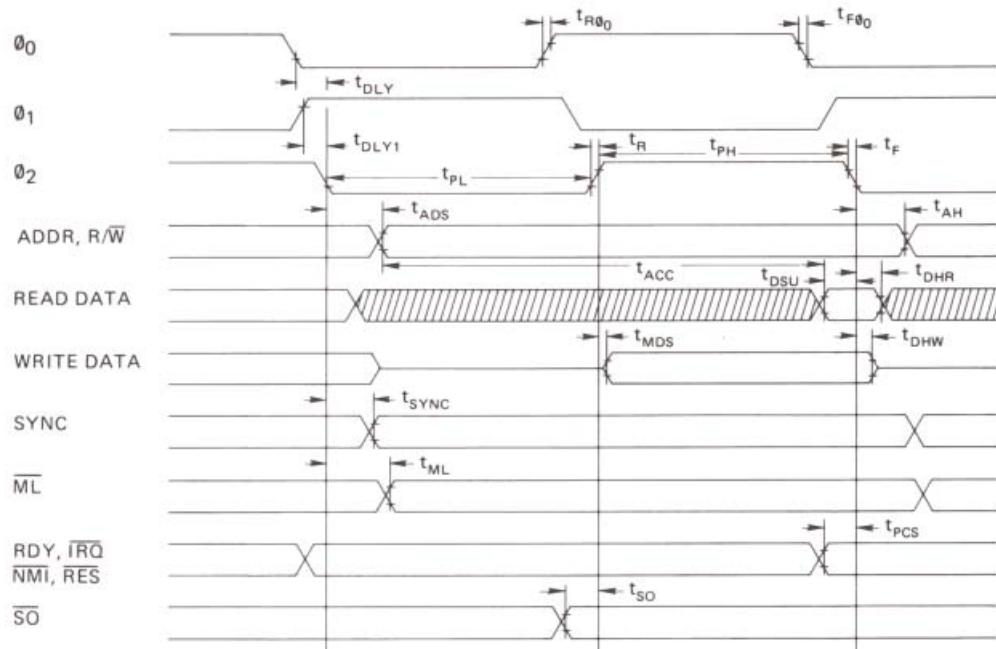
Function	NMOS 6502 Microprocessor	NCR65C02 Microprocessor
Indexed addressing across page boundary.	Extra read of invalid address.	Extra read of last instruction byte.
Execution of invalid op codes.	Some terminate only by reset. Results are undefined.	All are NOPs (reserved for future use). Op Code Bytes Cycles X2 2 2 X3, X7, XB, XF 1 1 44 2 3 54, D4, F4 2 4 5C 3 8 DC, FC 3 4
Jump indirect, operand = XXFF.	Page address does not increment.	Page address increments and adds one additional cycle.
Read/modify/write instructions at effective address.	One read and two write cycles.	Two read and one write cycle.
Decimal flag.	Indeterminate after reset.	Initialized to binary mode (D=0) after reset and interrupts.
Flags after decimal operation.	Invalid N, V and Z flags.	Valid flag adds one additional cycle.
Interrupt after fetch of BRK instruction.	Interrupt vector is loaded, BRK vector is ignored.	BRK is executed, then interrupt is executed.

### ■ MICROPROCESSOR HARDWARE ENHANCEMENTS

Function	NMOS 6502	NCR65C02
Assertion of Ready RDY during write operations.	Ignored.	Stops processor during $\theta_2$ .
Unused input-only pins ( $\bar{IRQ}$ , NMI, RDY, RES, SO).	Must be connected to low impedance signal to avoid noise problems.	Connected internally by a high-resistance to $V_{DD}$ (approximately 250 K ohm.)

## NCR65C02

### ■ TIMING DIAGRAM



Note: All timing is referenced from a high voltage of 2.0 volts and a low voltage of 0.8 volts.

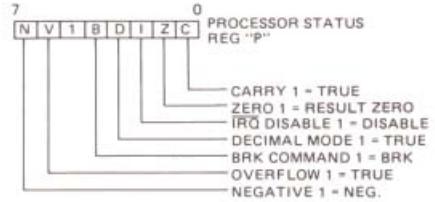
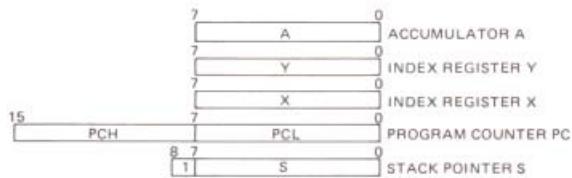
### ■ NEW INSTRUCTION MNEMONICS

HEX	MNEMONIC	DESCRIPTION
80	BRA	Branch relative always [Relative]
3A	DEA	Decrement accumulator [Accum]
1A	INA	Increment accumulator [Accum]
DA	PHX	Push X on stack [Implied]
5A	PHY	Push Y on stack [Implied]
FA	PLX	Pull X from stack [Implied]
7A	PLY	Pull Y from stack [Implied]
9C	STZ	Store zero [Absolute]
9E	STZ	Store zero [ABS, X]
64	STZ	Store zero [Zero page]
74	STZ	Store zero [ZPG,X]
1C	TRB	Test and reset memory bits with accumulator [Absolute]
14	TRB	Test and reset memory bits with accumulator [Zero page]
0C	TSB	Test and set memory bits with accumulator [Absolute]
04	TSB	Test and set memory bits with accumulator [Zero page]

### ■ ADDITIONAL INSTRUCTION ADDRESSING MODES

HEX	MNEMONIC	DESCRIPTION
72	ADC	Add memory to accumulator with carry [(ZPG)]
32	AND	"AND" memory with accumulator [(ZPG)]
3C	BIT	Test memory bits with accumulator [ABS, X]
34	BIT	Test memory bits with accumulator [ZPG, X]
D2	CMP	Compare memory and accumulator [(ZPG)]
52	EOR	"Exclusive Or" memory with accumulator [(ZPG)]
7C	JMP	Jump (New addressing mode) [ABS(IND,X)]
B2	LDA	Load accumulator with memory [(ZPG)]
12	ORA	"OR" memory with accumulator [(ZPG)]
F2	SBC	Subtract memory from accumulator with borrow [(ZPG)]
92	STA	Store accumulator in memory [(ZPG)]

## ■ MICROPROCESSOR PROGRAMMING MODEL



## ■ FUNCTIONAL DESCRIPTION

### Timing Control

The timing control unit keeps track of the instruction cycle being monitored. The unit is set to zero each time an instruction fetch is executed and is advanced at the beginning of each phase one clock pulse for as many cycles as is required to complete the instruction. Each data transfer which takes place between the registers depends upon decoding the contents of both the instruction register and the timing control unit.

### Program Counter

The 16-bit program counter provides the addresses which step the microprocessor through sequential instructions in a program.

Each time the microprocessor fetches an instruction from program memory, the lower byte of the program counter (PCL) is placed on the low-order bits of the address bus and the higher byte of the program counter (PCH) is placed on the high-order 8 bits. The counter is incremented each time an instruction or data is fetched from program memory.

### Instruction Register and Decode

Instructions fetched from memory are gated onto the internal data bus. These instructions are latched into the instruction register, then decoded, along with timing and interrupt signals, to generate control signals for the various registers.

### Arithmetic and Logic Unit (ALU)

All arithmetic and logic operations take place in the ALU including incrementing and decrementing internal registers (except the program counter). The ALU has no internal memory and is used only to perform logical and transient numerical operations.

### Accumulator

The accumulator is a general purpose 8-bit register that stores the results of most arithmetic and logic operations, and in addition, the accumulator usually contains one of the two data words used in these operations.

### Index Registers

There are two 8-bit index registers (X and Y), which may be used to count program steps or to provide an index value to be used in generating an effective address. When executing an instruction which specifies indexed addressing, the CPU fetches the op code and the base address, and modifies the address by adding the index register to it prior to performing the desired operation. Pre- or post-indexing of indirect addresses is possible (see addressing modes).

### Stack Pointer

The stack pointer is an 8-bit register used to control the addressing of the variable-length stack on page one. The stack pointer is automatically incremented and decremented under control of the microprocessor to perform stack manipulations under direction of either the program or interrupts (NMI and IRQ). The stack allows simple implementation of nested subroutines and multiple level interrupts. The stack pointer should be initialized before any interrupts or stack operations occur.

### Processor Status Register

The 8-bit processor status register contains seven status flags. Some of the flags are controlled by the program, others may be controlled both by the program and the CPU. The 6500 instruction set contains a number of conditional branch instructions which are designed to allow testing of these flags (see microprocessor programming model).

## NCR65C02

### ■ ADDRESSING MODES

Fifteen addressing modes are available to the user of the NCR65C02 microprocessor. The addressing modes are described in the following paragraphs:

#### Implied Addressing [Implied]

In the implied addressing mode, the address containing the operand is implicitly stated in the operation code of the instruction.

#### Accumulator Addressing [Accum]

This form of addressing is represented with a one byte instruction and implies an operation on the accumulator.

#### Immediate Addressing [Immediate]

With immediate addressing, the operand is contained in the second byte of the instruction; no further memory addressing is required.

#### Absolute Addressing [Absolute]

For absolute addressing, the second byte of the instruction specifies the eight low-order bits of the effective address, while the third byte specifies the eight high-order bits. Therefore, this addressing mode allows access to the total 64K bytes of addressable memory.

#### Zero Page Addressing [Zero Page]

Zero page addressing allows shorter code and execution times by only fetching the second byte of the instruction and assuming a zero high address byte. The careful use of zero page addressing can result in significant increase in code efficiency.

**Absolute Indexed Addressing [ABS, X or ABS, Y]**  
Absolute indexed addressing is used in conjunction with X or Y index register and is referred to as "Absolute, X," and "Absolute, Y." The effective address is formed by adding the contents of X or Y to the address contained in the second and third bytes of the instruction. This mode allows the index register to contain the index or count value and the instruction to contain the base address. This type of indexing allows any location referencing and the index to modify multiple fields, resulting in reduced coding and execution time.

**Zero Page Indexed Addressing [ZPG, X or ZPG, Y]**  
Zero page absolute addressing is used in conjunction with the index register and is referred to as "Zero Page, X" or "Zero Page, Y." The effective address is calculated by adding the second byte to the contents of the index register. Since this is a form of "Zero Page" addressing, the content of the second byte references a location in page zero. Additionally, due to the "Zero Page" addressing nature of this mode, no carry is added to the high-order eight bits of memory, and crossing of page boundaries does not occur.

#### Relative Addressing [Relative]

Relative addressing is used only with branch instructions;

it establishes a destination for the conditional branch. The second byte of the instruction becomes the operand which is an "Offset" added to the contents of the program counter when the counter is set at the next instruction. The range of the offset is -128 to +127 bytes from the next instruction.

#### Zero Page Indexed Indirect Addressing [(IND, X)]

With zero page indexed indirect addressing (usually referred to as indirect X) the second byte of the instruction is added to the contents of the X index register; the carry is discarded. The result of this addition points to a memory location on page zero whose contents is the low-order eight bits of the effective address. The next memory location in page zero contains the high-order eight bits of the effective address. Both memory locations specifying the high- and low-order bytes of the effective address must be in page zero.

#### \*Absolute Indexed Indirect Addressing [ABS(IND, X)] (Jump Instruction Only)

With absolute indexed indirect addressing the contents of the second and third instruction bytes are added to the X register. The result of this addition, points to a memory location containing the lower-order eight bits of the effective address. The next memory location contains the higher-order eight bits of the effective address.

#### Indirect Indexed Addressing [(IND), Y]

This form of addressing is usually referred to as Indirect, Y. The second byte of the instruction points to a memory location in page zero. The contents of this memory location are added to the contents of the Y index register, the result being the low-order eight bits of the effective address. The carry from this addition is added to the contents of the next page zero memory location, the result being the high-order eight bits of the effective address.

#### \*Zero Page Indirect Addressing [(ZPG)]

In the zero page indirect addressing mode, the second byte of the instruction points to a memory location on page zero containing the low-order byte of the effective address. The next location on page zero contains the high-order byte of the effective address.

#### Absolute Indirect Addressing [(ABS)] (Jump Instruction Only)

The second byte of the instruction contains the low-order eight bits of a memory location. The high-order eight bits of that memory location is contained in the third byte of the instruction. The contents of the fully specified memory location is the low-order byte of the effective address. The next memory location contains the high-order byte of the effective address which is loaded into the 16 bit program counter.

NOTE: \* = New Address Modes

## ■ SIGNAL DESCRIPTION

### **Address Bus (A0-A15)**

A0-A15 forms a 16-bit address bus for memory and I/O exchanges on the data bus. The output of each address line is TTL compatible, capable of driving one standard TTL load and 130pF.

### **Clocks ( $\theta_0$ , $\theta_1$ , and $\theta_2$ )**

$\theta_0$  is a TTL level input that is used to generate the internal clocks in the 6502. Two full level output clocks are generated by the 6502. The  $\theta_2$  clock output is in phase with  $\theta_0$ . The  $\theta_1$  output pin is 180° out of phase with  $\theta_0$ . (See timing diagram.)

### **Data Bus (D0-D7)**

The data lines (D0-D7) constitute an 8-bit bidirectional data bus used for data exchanges to and from the device and peripherals. The outputs are three-state buffers capable of driving one TTL load and 130 pF.

### **Interrupt Request (IRQ)**

This TTL compatible input requests that an interrupt sequence begin within the microprocessor. The IRQ is sampled during  $\theta_2$  operation; if the interrupt flag in the processor status register is zero, the current instruction is completed and the interrupt sequence begins during  $\theta_1$ . The program counter and processor status register are stored in the stack. The microprocessor will then set the interrupt mask flag high so that no further IRQs may occur. At the end of this cycle, the program counter low will be loaded from address FFFE, and program counter high from location FFFF, transferring program control to the memory vector located at these addresses. The RDY signal must be in the high state for any interrupt to be recognized. A 3K ohm external resistor should be used for proper wire OR operation.

### **Memory Lock (ML)**

In a multiprocessor system, the ML output indicates the need to defer the re arbitration of the next bus cycle to ensure the integrity of read-modify-write instructions. ML goes low during ASL, DEC, INC, LSR, ROL, ROR, TRB, TSB memory referencing instructions. This signal is low for the modify and write cycles.

### **Non-Maskable Interrupt (NMI)**

A negative-going edge on this input requests that a non-maskable interrupt sequence be generated within the microprocessor. The NMI is sampled during  $\theta_2$ ; the current instruction is completed and the interrupt sequence begins during  $\theta_1$ . The program counter is loaded with the interrupt vector from locations FFFA (low byte) and FFFB (high byte), thereby transferring program control to the non-maskable interrupt routine.

Note: Since this interrupt is non-maskable, another NMI can occur before the first is finished. Care should be taken when using NMI to avoid this.

### **Ready (RDY)**

This input allows the user to single-cycle the microprocessor on all cycles including write cycles. A negative transition to the low state, during or coincident with phase one ( $\theta_1$ ), will halt the microprocessor with the output address lines reflecting the current address being fetched. This condition will remain through a subsequent phase two ( $\theta_2$ ) in which the ready signal is low. This feature allows microprocessor interfacing with low-speed memory as well as direct memory access (DMA).

### **Reset (RES)**

This input is used to reset the microprocessor. Reset must be held low for at least two clock cycles after VDD reaches operating voltage from a power down. A positive transition on this pin will then cause an initialization sequence to begin. Likewise, after the system has been operating, a low on this line of at least two cycles will cease microprocessing activity, followed by initialization after the positive edge on RES.

When a positive edge is detected, there is an initialization sequence lasting six clock cycles. Then the interrupt mask flag is set, the decimal mode is cleared, and the program counter is loaded with the restart vector from locations FFFC (low byte) and FFFD (high byte). This is the start location for program control. This input should be high in normal operation.

### **Read/Write (R/W)**

This signal is normally in the high state indicating that the microprocessor is reading data from memory or I/O bus. In the low state the data bus has valid data from the microprocessor to be stored at the addressed memory location.

### **Set Overflow (SO)**

A negative transition on this line sets the overflow bit in the status code register. The signal is sampled on the trailing edge of  $\theta_1$ .

### **Synchronize (SYNC)**

This output line is provided to identify those cycles during which the microprocessor is doing an OP CODE fetch. The SYNC line goes high during  $\theta_1$  of an OP CODE fetch and stays high for the remainder of that cycle. If the RDY line is pulled low during the  $\theta_1$  clock pulse in which SYNC went high, the processor will stop in its current state and will remain in the state until the RDY line goes high. In this manner, the SYNC signal can be used to control RDY to cause single instruction execution.

## NCR65C02 ■ INSTRUCTION SET — ALPHABETICAL SEQUENCE

ADC	Add Memory to Accumulator with Carry	LDX	Load Index X with Memory
AND	"AND" Memory with Accumulator	LDY	Load Index Y with Memory
ASL	Shift One Bit Left	LSR	Shift One Bit Right
BCC	Branch on Carry Clear	NOP	No Operation
BCS	Branch on Carry Set	ORA	"OR" Memory with Accumulator
BEQ	Branch on Result Zero	PHA	Push Accumulator on Stack
BIT	Test Memory Bits with Accumulator	PHP	Push Processor Status on Stack
BMI	Branch on Result Minus	*PHX	Push Index X on Stack
BNE	Branch on Result not Zero	*PHY	Push Index Y on Stack
BPL	Branch on Result Plus	PLA	Pull Accumulator from Stack
*BRA	Branch Always	PLP	Pull Processor Status from Stack
BRK	Force Break	*PLX	Pull Index X from Stack
BVC	Branch on Overflow Clear	*PLY	Pull Index Y from Stack
BVS	Branch on Overflow Set	ROL	Rotate One Bit Left
CLC	Clear Carry Flag	ROR	Rotate One Bit Right
CLD	Clear Decimal Mode	RTI	Return from Interrupt
CLI	Clear Interrupt Disable Bit	RTS	Return from Subroutine
CLV	Clear Overflow Flag	SBC	Subtract Memory from Accumulator with Borrow
CMP	Compare Memory and Accumulator	SEC	Set Carry Flag
CPX	Compare Memory and Index X	SED	Set Decimal Mode
CPY	Compare Memory and Index Y	SEI	Set Interrupt Disable Bit
*DEA	Decrement Accumulator	STA	Store Accumulator in Memory
DEC	Decrement by One	STX	Store Index X in Memory
DEX	Decrement Index X by One	STY	Store Index Y in Memory
DEY	Decrement Index Y by One	*STZ	Store Zero in Memory
EOR	"Exclusive-or" Memory with Accumulator	TAX	Transfer Accumulator to Index X
*INA	Increment Accumulator	TAY	Transfer Accumulator to Index Y
INC	Increment by One	*TRB	Test and Reset Memory Bits with Accumulator
INX	Increment Index X by One	*TSB	Test and Set Memory Bits with Accumulator
INY	Increment Index Y by One	TSX	Transfer Stack Pointer to Index X
JMP	Jump to New Location	TXA	Transfer Index X to Accumulator
JSR	Jump to New Location Saving Return Address	TXS	Transfer Index X to Stack Pointer
LDA	Load Accumulator with Memory	TYA	Transfer Index Y to Accumulator

Note: \* = New Instruction

## ■ MICROPROCESSOR OP CODE TABLE

S	D	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	
0	BRK	ORA ind, X			TSB* zpg	ORA zpg	ASL zpg			PHP	ORA imm	ASL A		TSB* abs	ORA abs	ASL abs		0
1	BPL rel	ORA ind, Y	ORA*† (zpg)		TRB* zpg	ORA zpg, X	ASL zpg, X			CLC	ORA abs, Y	INA* A		TRB* abs	ORA abs, X	ASL abs, X		1
2	JSR abs	AND ind, X			BIT* zpg	AND zpg	ROL zpg			PLP	AND imm	ROL A		BIT* abs	AND abs	ROL abs		2
3	BMI rel	AND ind, Y	AND*† (zpg)		BIT* zpg, X	AND zpg, X	ROL zpg, X			SEC	AND abs, Y	DEA* A		BIT*† abs, X	AND abs, X	ROL abs, X		3
4	RTI	EOR ind, X				EOR zpg	LSR zpg			PHA	EOR imm	LSR A		JMP abs	EOR abs	LSR abs		4
5	BVC rel	EOR ind, Y	EOR*† (zpg)			EOR zpg, X	LSR zpg, X			CLI	EOR abs, Y	PHY*			EOR abs, X	LSR abs, X		5
6	RTS	ADC ind, X			STZ* zpg	ADC zpg	ROR zpg			PLA	ADC imm	ROR A		JMP (abs)	ADC abs	ROR abs		6
7	BVS rel	ADC ind, Y	ADC*† (zpg)		STZ* zpg, X	ADC zpg, X	ROR zpg, X			SEI	ADC abs, Y	PLY*		JMP*† abs (ind, X)	ADC abs, X	ROR abs, X		7
8	BRA*	STA ind, X			STY zpg	STA zpg	STX zpg			DEY	BIT* imm	TXA		STY abs	STA abs	STX abs		8
9	BCC rel	STA ind, Y	STA*† (zpg)		STY zpg, X	STA zpg, X	STX zpg, Y			TYA	STA abs, Y	TXS		STZ* abs	STA abs, X	STZ* abs, X		9
A	LDY imm	LDA ind, X	LDX imm		LDY zpg	LDA zpg	LDX zpg			TAY	LDA imm	TAX		LDY abs	LDA abs	LDX abs		A
B	BCS rel	LDA ind, Y	LDA*† (zpg)		LDY zpg, X	LDA zpg, X	LDX zpg, Y			CLV	LDA abs, Y	TSX		LDY abs, X	LDA abs, X	LDX abs, Y		B
C	CPY imm	CMP ind, X			CPY zpg	CMP zpg	DEC zpg			INY	CMP imm	DEX		CPY abs	CMP abs	DEC abs		C
D	BNE rel	CMP ind, Y	CMP*† (zpg)			CMP zpg, X	DEC zpg, X			CLD	CMP abs, Y	PHX*			CMP abs, X	DEC abs, X		D
E	CPX imm	SBC ind, X			CPX zpg	SBC zpg	INC zpg			INX	SBC imm	NOP		CPX abs	SBC abs	INC abs		E
F	BEQ rel	SBC ind, Y	SBC*† (zpg)			SBC zpg, X	INC zpg, X			SED	SBC abs, Y	PLX*			SBC abs, X	INC abs, X		F
	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F		

Note: \* = New OP Codes

Note: † = New Address Modes

## ■ OPERATIONAL CODES, EXECUTION TIME, AND MEMORY REQUIREMENTS

		IMMEDIATE	ABSO-LUTE	ZERO-PAGE	ACCUM-PLIED	IND., X	IND., Y	ZPG, X	ZPG, Y	ABS, X	ABS, Y	RELA-TIVE	(ABS)	ABS (IND., X)	(ZPG)	PROCESSOR STATUS CODES
MNE	OPERATION	OP n	#DP n	OP n	#OP n	OP n	#OP n	OP n	#OP n	OP n	#OP n	OP n	#OP n	OP n	#OP n	7 6 5 4 3 2 1 0 N V B D I Z C MNE
ADC A + M C + A	(1,3)	69 2 2 6D 4 3 65 3 2				61 6 2 71 5 2 75 4 2		7D 4 3 79 4 3								7 6 5 4 3 2 1 0 N V B D I Z C MNE
AND A $\wedge$ M $\wedge$ A	(1)	29 2 2 2D 4 3 25 3 2				21 6 2 31 5 2 35 4 2		3D 4 3 39 4 3								Z C ADC
ASL [S+D] $\leftarrow$ 0	(1)	OE 6 3 06 5 2 DA 2 1				1E 6 2										Z AND
BCC Branch if C=0	(2)															Z C ASL
BCS Branch if C=1	(2)															Z C BCC
BEQ Branch if Z=1	(2)															Z C BCS
BIT A $\wedge$ M	(4,5)	89 2 2 2C 4 3 24 3 2														Z C BEQ
BMI Branch if N=1	(2)															Z C BIT
BNE Branch if Z=0	(2)															Z C BMI
BPL Branch if N=0	(2)															Z C BNE
BRA Branch Always	(2)					00 7 1										Z C BPL
BRK Break																Z C BRA
BVC Branch if V=0	(2)															Z C BRK
BVS Branch if V=1	(2)															Z C BVC
CLC 0 $\wedge$ C						18 2 1										Z C BVS
CLD 0 $\wedge$ D																Z C CLC
CLI 0 $\wedge$ I																Z C CLI
CLV 0 $\wedge$ V																Z C CLV
CMP A - M	(1)	C9 2 2 CD 4 3 C5 3 2														Z C CMP
CPA X - M	(1)	E0 2 2 EC 4 3 E4 3 2														Z C CPA
CPY Y - M		C0 2 2 CC 4 3 C4 3 2														Z C CPY
DEA A - 1 $\wedge$ A																Z C DEA
DEC M - 1 $\wedge$ M	(1)	CE 6 3 06 5 2				3A 2 1										Z C DEC
DEX X - 1 $\wedge$ X																Z C DEX
DEY Y - 1 $\wedge$ Y																Z C DEY
EOR A $\vee$ M $\wedge$ A		49 2 2 4D 4 3 45 3 2														Z C EOR
INA A + 1 $\wedge$ A																Z C INA
INC M + 1 $\wedge$ M	(1)	EE 6 3 E6 5 2				1A 2 1										Z C INC
INX X + 1 $\wedge$ X																Z C INX
INY Y + 1 $\wedge$ Y																Z C INY
JMP Jump to New Icc		4C 3 3														Z C JMP
JSR Jump Subroutine		20 6 3														Z C JSR
LDA A $\wedge$ M $\wedge$ A	(1)	A9 2 2 AD 4 3 A5 3 2														Z C LDA
LDX M $\wedge$ X	(1)	A2 2 2 AE 4 3 AB 3 2														Z C LDX
LDY M $\wedge$ Y	(1)	A0 2 2 AC 4 3 AA 3 2														Z C LDY
LSR 0 $\rightarrow$ [S+Icc]	(1)	4E 6 3 46 5 2 4A 2 1														Z C LSR
NOP PC + 1 $\rightarrow$ PC																Z C NOP
DRA A V M $\wedge$ A	(1)	09 2 2 0D 4 3 05 3 2														Z C DRA
PHA A $\wedge$ M <sub>1</sub> S $\rightarrow$ S <sub>5</sub>																Z C PHA
PHP P $\wedge$ M <sub>1</sub> S $\rightarrow$ S <sub>5</sub>																Z C PHP
PHX X $\wedge$ M <sub>1</sub> S $\rightarrow$ S <sub>5</sub>																Z C PHX
PHY Y $\wedge$ M <sub>1</sub> S $\rightarrow$ S <sub>5</sub>																Z C PHY
PLA S + 1 $\rightarrow$ S <sub>5</sub> M <sub>1</sub> $\wedge$ A																Z C PLA
PLP S + 1 $\rightarrow$ S <sub>5</sub> M <sub>1</sub> $\wedge$ P																Z C PLP
PLX S + 1 $\rightarrow$ S <sub>5</sub> M <sub>1</sub> $\wedge$ X																Z C PLX
PLY S + 1 $\rightarrow$ S <sub>5</sub> M <sub>1</sub> $\wedge$ Y																Z C PLY
ROL 4 $\rightarrow$ [S+Icc]	(1)	2E 6 3 26 5 2 2A 2 1														Z C ROL
ROR 4 $\rightarrow$ [S+Icc]	(1)	6E 6 3 66 5 2 2A 2 1														Z C ROR
RTI Return from Inter.																Z C RTI
RTS Return from Subr.																Z C RTS
SBC A - M C + A	(1,3)	E9 2 2 ED 4 3 E5 3 2														Z C SBC
SEC A + C																Z C SEC
SED 1 $\wedge$ D																Z C SED
SEI 1 $\wedge$ I																Z C SEI
STA A $\wedge$ M																Z C STA
STX A $\wedge$ M																Z C STX
STY Y $\wedge$ M																Z C STY
STZ 00 $\wedge$ M																Z C STZ
TAX A $\wedge$ X																Z C TAX
TAY A $\wedge$ Y																Z C TAY
TRB A $\wedge$ M $\wedge$ M	(4)	1C 6 3 14 5 2														Z C TRB
TSB A V M $\wedge$ M	(4)	DC 6 3 04 5 2														Z C TSB
TSX S $\wedge$ X																Z C TSX
TXA X $\wedge$ A																Z C TXA
TXS X $\wedge$ S																Z C TXS
TYA Y $\wedge$ A																Z C TYA

## Notes:

- Add 1 to "n" if page boundary is crossed.
- Add 1 to "n" if branch occurs to same page.
- Add 2 to "n" if branch occurs to different page.
- Add 1 to "n" if decimal mode.
- V bit equals memory bit 6 prior to execution.
- N bit equals memory bit 7 prior to execution.
- The immediate addressing mode of the BIT instruction leaves bits 6 & 7 (V & N) in the Processor Status Code Register unchanged.

X Index X  
Y Index Y  
A Accumulator  
M Memory per effective address  
Ms Memory per stack pointer

+ Add  
- Subtract  
 $\wedge$  And  
V Or  
 $\vee$  Exclusive or  
n No. Cycles  
# No. Bytes  
M<sub>6</sub> Memory bit 6  
M<sub>7</sub> Memory bit 7

# *Memory Map*



Appendix H explains the general rules and tables for converting numbers from one of these forms to another. For memory map diagrams, refer to Chapter 2. Figure 2-2 is an overall memory map, Figure 2-3 is a map of bank-switched memory, and Figure 2-11 is a map of the 48K memory space.

This appendix lists all important RAM and hardware locations in address order and describes them briefly. It also provides cross-references to the section of the manual where they are described further. Appendix C contains a similar list for important firmware addresses.

The tables in this appendix list addresses in either two or three forms: the hexadecimal form (preceded by a dollar sign) for use in assembly language; the decimal form for use in Applesoft BASIC; and (for numbers greater than 32767) the complementary decimal value for use in Apple Integer BASIC.

## B.1 Page Zero

For Monitor zero page usage, refer to the firmware listings. For zero page use by the languages and operating systems, refer to the appropriate reference manuals.

Table B-1 lists the zero page addresses in hexadecimal and decimal form, followed by symbols denoting the firmware or system software that uses them.

- M denotes the Monitor.
- A denotes Applesoft BASIC.
- I denotes Integer BASIC.
- D denotes DOS.
- P denotes ProDOS. Locations whose contents ProDOS saves and restores afterward have a P in parentheses, indicating that ProDOS has no net effect on them.

*Table B-1. Zero Page Use*

Hex	Dec	Used by	Hex	Dec	Used by
\$00	0	A	\$30	48	M
\$01	1	A	\$31	49	M
\$02	2	A	\$32	50	M
\$03	3	A	\$33	51	M
\$04	4	A	\$34	52	M
\$05	5	A	\$35	53	M
\$06	6		\$36	54	M
\$07	7		\$37	55	M
\$08	8		\$38	56	M
\$09	9		\$39	57	M
\$0A	10	A	\$3A	58	M
\$0B	11	A	\$3B	59	M
\$0C	12	A	\$3C	60	M
\$0D	13	A	\$3D	61	M
\$0E	14	A	\$3E	62	M
\$0F	15	A	\$3F	63	M
\$10	16	A	\$40	64	M D (P)
\$11	17	A	\$41	65	M D (P)
\$12	18	A	\$42	66	M D (P)
\$13	19	A	\$43	67	M D (P)
\$14	20	A	\$44	68	M D (P)
\$15	21	A	\$45	69	M D (P)
\$16	22	A	\$46	70	M D (P)
\$17	23	A	\$47	71	M D (P)
\$18	24	A	\$48	72	M D (P)
\$19	25		\$49	73	M (P)
\$1A	26		\$4A	74	I D (P)
\$1B	27		\$4B	75	I D (P)
\$1C	28		\$4C	76	I D (P)
\$1D	29		\$4D	77	I D (P)
\$1E	30		\$4E	78	M (P)
\$1F	31		\$4F	79	M
\$20	32	M	\$50	80	M A
\$21	33	M	\$51	81	M A
\$22	34	M	\$52	82	M A
\$23	35	M	\$53	83	M A
\$24	36	M	\$54	84	M A
\$25	37	M	\$55	85	M A I
\$26	38	M	\$56	86	A I
\$27	39	M	\$57	87	A I
\$28	40	M	\$58	88	A I
\$29	41	M	\$59	89	A I
\$2A	42	M	\$5A	90	A I
\$2B	43	M	\$5B	91	A I
\$2C	44	M	\$5C	92	A I
\$2D	45	M	\$5D	93	A I
\$2E	46	M	\$5E	94	A I
\$2F	47	M	\$5F	95	A I

*Table B-1—Continued. Zero Page Use*

Hex	Dec	Used by	Hex	Dec	Used by
\$60	96	A I	\$90	144	A I
\$61	97	A I	\$91	145	A I
\$62	98	A I	\$92	146	A I
\$63	99	A I	\$93	147	A I
\$64	100	A I	\$94	148	A I
\$65	101	A I	\$95	149	A I
\$66	102	A I	\$96	150	A I
\$67	103	A I D	\$97	151	A I
\$68	104	A I D	\$98	152	A I
\$69	105	A I D	\$99	153	A I
\$6A	106	A I D	\$9A	154	A I
\$6B	107	A I	\$9B	155	A I
\$6C	108	A I	\$9C	156	A I
\$6D	109	A I	\$9D	157	A I
\$6E	110	A I	\$9E	158	A I
\$6F	111	A I D	\$9F	159	A I
\$70	112	A I D	\$A0	160	A I
\$71	113	A I	\$A1	161	A I
\$72	114	A I	\$A2	162	A I
\$73	115	A I	\$A3	163	A I
\$74	116	A I	\$A4	164	A I
\$75	117	A I	\$A5	165	A I
\$76	118	A I	\$A6	166	A I
\$77	119	A I	\$A7	167	A I
\$78	120	A I	\$A8	168	A I
\$79	121	A I	\$A9	169	A I
\$7A	122	A I	\$AA	170	A I
\$7B	123	A I	\$AB	171	A I
\$7C	124	A I	\$AC	172	A I
\$7D	125	A I	\$AD	173	A I
\$7E	126	A I	\$AE	174	A I
\$7F	127	A I	\$AF	175	A I D
\$80	128	A I	\$B0	176	A I D
\$81	129	A I	\$B1	177	A I
\$82	130	A I	\$B2	178	A I
\$83	131	A I	\$B3	179	A I
\$84	132	A I	\$B4	180	A I
\$85	133	A I	\$B5	181	A I
\$86	134	A I	\$B6	182	A I
\$87	135	A I	\$B7	183	A I
\$88	136	A I	\$B8	184	A I
\$89	137	A I	\$B9	185	A I
\$8A	138	A I	\$BA	186	A I
\$8B	139	A I	\$BB	187	A I
\$8C	140	A I	\$BC	188	A I
\$8D	141	A I	\$BD	189	A I
\$8E	142	A I	\$BE	190	A I
\$8F	143	A I	\$BF	191	A I

*Table B-1—Continued. Zero Page Use*

Hex	Dec	Used by	Hex	Dec	Used by
\$C0	192	A I	\$E0	224	A
\$C1	193	A I	\$E1	225	A
\$C2	194	A I	\$E2	226	A
\$C3	195	A I	\$E3	227	
\$C4	196	A I	\$E4	228	A
\$C5	197	A I	\$E5	229	A
\$C6	198	A I	\$E6	230	A
\$C7	199	A I	\$E7	231	A
\$C8	200	A I	\$E8	232	A
\$C9	201	A I	\$E9	233	A
\$CA	202	A I D	\$EA	234	A
\$CB	203	A I D	\$EB	235	
\$CC	204	A I D	\$EC	236	
\$CD	205	A I D	\$ED	237	
\$CE	206	I	\$EE	238	
\$CF	207	I	\$EF	239	
\$D0	208	A I	\$F0	240	A
\$D1	209	A I	\$F1	241	A
\$D2	210	A I	\$F2	242	A
\$D3	211	A I	\$F3	243	A
\$D4	212	A I	\$F4	244	A
\$D5	213	A I	\$F5	245	A
\$D6	214	I	\$F6	246	A
\$D7	215	I	\$F7	247	A
\$D8	216	A I D	\$F8	248	A
\$D9	217	A I	\$F9	249	
\$DA	218	A I	\$FA	250	
\$DB	219	A I	\$FB	251	
\$DC	220	A I	\$FC	252	
\$DD	221	A I	\$FD	253	
\$DE	222	A I	\$FE	254	
\$DF	223	A I	\$FF	255	

## B.2 Page Three

Most of page 3 is available for small machine-language programs or any other use your program might put it to. The built-in Monitor uses the top sixteen addresses of page 3, as shown in Table B-2; the XFER routine (section 2.5.3) uses locations \$3ED and \$3EE. If you are using DOS or ProDOS, it also uses the 32 locations \$3D0 through \$3EF.

*Table B-2. Page 3 Use*

Hex	Dec	Section	Use
\$3F0	1008	2.6.4	
\$3F1	1009		Address of BRK request handler (normally \$59, \$FA)
\$3F2	1010	2.6.4 &	Reset vector
\$3F3	1011	10.1	
\$3F4	1012	2.6.4	Power-up byte (see text)
\$3F5	1013		Jump instruction to Applesoft &-command handler (initially \$4C, \$58, \$FF)
\$3F6	1014		
\$3F7	1015		
\$3F8	1016	10.6.4	Jump instruction to user CONTROL-Y command handler
\$3F9	1017		
\$3FA	1018		
\$3FB	1019		Jump instruction to NMI interrupt handler (not used by Apple IIc)
\$3FC	1020		
\$3FD	1021		
\$3FE	1022	2.6.4	
\$3FF	1023		Address of user IRQ interrupt handler

### B.3 Screen Holes

One result of the way the Apple IIc hardware maps display memory on the screen is that groups of eight memory addresses are left over in sixteen areas of the text and low-resolution display pages—eight areas in main RAM and eight in auxiliary RAM. The firmware uses for these 128 bytes are shown in Tables B-3 and B-4, with cross-references to the section numbers where they are described.

*Table B-3. Main Memory Screen Hole Allocations*

Hex	Dec	Section	Description
\$478	1144	9.1.5	Mouse port: low byte of clamping minimum
\$479	1145	7.5	Reserved for serial port 1
\$47A	1146	8.5	Reserved for serial port 2
\$47B	1147		Reserved
\$47C	1148	9.1.5	Low byte of X coordinate
\$47D	1149		Reserved for mouse port
\$47E	1150		Reserved
\$47F	1151		Reserved
\$4F8	1272	9.1.5	Mouse port: low byte of clamping maximum
\$4F9	1273	7.5,E.6.3	Reserved for serial port 1
\$4FA	1274	8.5,E.6.2	Reserved for serial port 2
\$4FB	1275		Reserved
\$4FC	1276	9.1.5	Low byte of Y coordinate
\$4FD	1277		Reserved for mouse port
\$4FE	1278		Reserved
\$4FF	1279	E.6.4	Reserved
\$578	1400	9.1.5	Mouse port: high byte of clamping minimum
\$579	1401	7.5	Port 1 printer width (1-255; 0 = unlimited)
\$57A	1402	8.5	Port 2 line length (1-255; 0 = unlimited)
\$57B	1403		Cursor horizontal position (80-column display)
\$57C	1404	9.1.5	High byte of X coordinate
\$57D	1405		Reserved for mouse port
\$57E	1406		Reserved
\$57F	1407	E.6.4	Reserved
\$5F8	1528	9.1.5	Mouse port: high byte of clamping maximum
\$5F9	1529	7.5,E.6.3	Port 1 temporary storage location
\$5FA	1530	8.5,E.6.2	Port 2 temporary storage location
\$5FB	1531		Reserved
\$5FC	1532	9.1.5	High byte of Y coordinate
\$5FD	1533		Reserved for mouse port
\$5FE	1534		Reserved
\$5FF	1535	E.6.2	Reserved

**Table B-3—Continued.** Main Memory Screen Hole Allocations

Hex	Dec	Section	Description
\$678	1656		Reserved
\$679	1657	7.5	Indicates when port 1 firmware is parsing a command
\$67A	1658	8.5	Indicates when port 2 firmware is parsing a command
\$67B	1659		Reserved
\$67C	1660	9.1.5	Mouse port: reserved
\$67D	1661		Reserved for mouse port
\$67E	1662		Reserved
\$67F	1663	E.6.4	Reserved
\$6F8	1784		Reserved
\$6F9	1785	7.5	Current port 1 command character
\$6FA	1786	8.5	Current port 2 command character
\$6FB	1787		Reserved
\$6FC	1788	9.1.5	Mouse port: reserved
\$6FD	1789		Reserved for mouse port
\$6FE	1790		Reserved
\$6FF	1791	E.6.2	Reserved
\$778	1912		DEVNO: \$n0 = current active port number x 16
\$779	1913	7.5	Port 1 flags for echo and auto line feed
\$77A	1914	8.5	Port 2 flags for echo and auto line feed
\$77B	1915		Reserved
\$77C	1916	9.1.5,E.6.1	Mouse port status byte
\$77D	1917		Reserved for mouse port
\$77E	1918		Reserved
\$77F	1919		Reserved
\$7F8	2040		MSLOT: owner of \$C800-\$CFFF (\$C3, video)
\$7F9	2041	7.5	Port 1 current printer column
\$7FA	2042	8.5	Port 2 current line position
\$7FB	2043		Reserved
\$7FC	2044	9.1.5	Mouse port mode byte
\$7FD	2045		Reserved for mouse port
\$7FE	2046		Reserved
\$7FF	2047		Reserved

*Table B-4. Auxiliary Memory Screen Hole Allocations*

Hex	Dec	Section	Description
\$478	1144	7.5	Initial port 1 ACIA Control Register values (\$9E)
\$479	1145	7.5	Initial port 1 ACIA Command Register values (\$0B)
\$47A	1146	7.5	Initial port 1 characteristics flags (\$40)
\$47B	1147	7.5	Initial port 1 printer width (\$50)
\$47C	1148	8.5	Initial port 2 ACIA Control Register values (\$16)
\$47D	1149	8.5	Initial port 2 ACIA Command Register values (\$0B)
\$47E	1150	8.5	Initial port 2 characteristics flags (\$01)
\$47F	1151	8.5	Initial port 2 line length (\$00)
\$4F8 through \$4FF	1272 1279		Reserved
\$578 through \$57F	1400 1407		Reserved
\$5F8 through \$5FF	1528 1535		Reserved
\$678 through \$67F	1656 1663		Reserved
\$6F8 through \$6FF	1784 1791		Reserved
\$778 through \$77F	1912 1919		Reserved
\$7F8 through \$7FF	2040 2047		Reserved

## B.4 The Hardware Page

Tables B-5 through B-9 list all the hardware locations available for use in the Apple IIc. These tables have a column at the left that is not present in other tables. This column, labeled RW, indicates the action to take at a particular location.

- R means read.
- RR means read twice in succession.
- R7 means read the byte and then check bit 7; in the use column, "see if..." refers to the condition represented by bit 7 = 1, unless otherwise specified. Bit 7 has a value of \$80, so if the contents of the location are greater than or equal to \$80, the bit is on.

Another way to test bit 7 (the sign bit) is with a BIT instruction, followed by BPL (bit 7 was 0) or BMI (bit 7 was 1).

- R/W means to either read or write. For writing, the value is unimportant.
- W means to write only. The value is unimportant.
- N means not to read or write, because the location is reserved.

An address of the form \$C00x means the sixteen locations from \$C000 through \$C00F. Labels, when they are shown, are simply memory aids. Some of them correspond to the labels at those addresses in the firmware, others do not. Your program will have to assign a label for it anyway.

**Table B-5.** Addresses \$C000 Through \$C03F

RW	Hex	Dec	Neg Dec	Label	Section	Use
R	\$C00x	49152	-16384	KSTRB	4.1	Read keyboard data (bits 0-6) and strobe (bit 7)
W	\$C000	49153	-16383	80STORE	5.6†	Off: PAGE2 switches Page 1 and 2 On: PAGE2 switches Page 1 and 1X
W	\$C001	49154	-16382	RAMRD	2.5.2	Off: read main 48K RAM
W	\$C002	49155	-16381	RAMRD	2.5.2	On: read auxiliary 48K RAM
W	\$C003	49156	-16380	RAMWRT	2.5.2	Off: write in main 48K RAM
W	\$C004	49157	-16379	RAMWRT	2.5.2	On: write in auxiliary 48K RAM
W	\$C005	49158	-16378			Reserved
W	\$C006	49159	-16377			Reserved
W	\$C007	49160	-16376	ALTZP	2.4.2	Off: use main P0, P1, bank-switched RAM
W	\$C008	49161	-16375	ALTZP	2.4.2	On: use auxiliary P0, P1, bank-switched RAM
W	\$C009	49162	-16374			Reserved
W	\$C00A	49163	-16373			Reserved
W	\$C00B	49164	-16372	80COL	5.6	Off: 40-column display
W	\$C00C	49165	-16371	80COL	5.6	On: 80-column display
W	\$C00D	49166	-16270	ALTCHAR	5.6	Off: display primary character set
W	\$C00E	49167	-16369	ALTCHAR	5.6	On: display alternate character set
W	\$C00F					
W	\$C01x				4.1	Clear keyboard strobe (\$C00x bit 7)
R7	\$C010	49168	-16368	AKD	4.1	See if any key now down; clear strobe
R7	\$C011	49169	-16367	RDBNK2	2.4.2	See if using \$D000 bank 2 (or 1)
R7	\$C012	49170	-16366	RDLCRAM	2.4.2	See if reading RAM (or ROM).
R7	\$C013	49171	-16365	RDRAMRD	2.5.2	See if reading auxiliary 48K RAM (or main)
R7	\$C014	49172	-16364	RDRAMWRT	2.5.2	See if writing auxiliary 48K RAM (or main)
R	\$C015	49173	-16363	RSTXINT	9.1.3	Reset mouse X0 interrupt.
R7	\$C016	49174	-16362	RDALTZP	2.4.2	See if auxiliary P0, P1 and bank-switched RAM
R	\$C017	49175	-16361	RSTYINT	9.1.3	Reset mouse Y interrupt
R7	\$C018	49176	-16360	RD80STORE	5.6†	See if 80STORE on (or off)
R7	\$C019	49177	-16359	RSTVBL	9.1.3	See if VBLINT off (1); reset it
R7	\$C01A	49178	-16358	RDTEXT	5.6	See if text (or graphics)
R7	\$C01B	49179	-16357	RDMIX	5.6	See if mixed mode switch on
R7	\$C01C	49180	-16356	RDPAGE2	5.6†	See if page 2/1X selected (or 1)
R7	\$C01D	49181	-16355	RDHIRES	5.6†	See if high-resolution switch on
R7	\$C01E	49182	-16354	RDALTCHAR	5.6	See if alternate character set (or primary)
R7	\$C01F	49183	-16353	RD80COL	5.6	See if 80-column hardware on
N	\$C020 through \$C02F	49184	-16352			Reserved (read and write)
N		49199	-16337			
W	\$C030	49200	-16336		4.2.1	Reserved
R	\$C030	49200	-16336			Toggle speaker
N	\$C031 through \$C03F	49201	-16335			Reserved (read and write)
N		49215	-16321			

† Also section 2.5.4

**Table B-6.** Addresses \$C040 Through \$C05F

RW	Hex	Dec	Neg Dec	Label	Section	Use
R7	\$C040	49216	-16320	RDXYMSK	9.1.3	See if X0/Y0 mask set
R7	\$C041	49217	-16319	RDVBLMSK	9.1.3	See if VBL mask set
R7	\$C042	49218	-16318	RDX0EDGE	9.1.3	See if interrupt on falling X0 edge
R7	\$C043	49219	-16317	RDY0EDGE	9.1.3	See if interrupt on falling Y0 edge
N	\$C044	49220	-16316			Reserved
N	\$C045	49221	-16315			Reserved
N	\$C046	49222	-16314			Reserved
N	\$C047	49223	-16313			Reserved
R	\$C048	49224	-16312	RSTXY	9.1.3	Reset X0/Y0 interrupt flags
N	\$C049	49225	-16311			Reserved
N	\$C04A	49226	-16310			Reserved
N	\$C04B	49227	-16309			Reserved
N	\$C04C	49228	-16308			Reserved
N	\$C04D	49229	-16307			Reserved
N	\$C04E	49230	-16306			Reserved
N	\$C04F	49231	-16305			Reserved
R/W	\$C050	49232	-16304	TEXT	5.6	Off: graphics display
R/W	\$C051	49233	-16303	TEXT	5.6	On: text display
R/W	\$C052	49234	-16302	MIXED	5.6	Off: text or graphics only
R/W	\$C053	49235	-16301	MIXED	5.6	On: combination text and graphics
R/W	\$C054	49236	-16300	PAGE2	5.6†	Off: use page 1
R/W	\$C055	49237	-16299	PAGE2	5.6†	On: display page 2 (80STORE off); store to page 1X (80STORE on)
R/W	\$C056	49238	-16298	HIRES	5.6†	Off: low-resolution
R/W	\$C057	49239	-16297	HIRES	5.6†	On: high-resolution; double if 80COL and DHIRES on
N	\$C058	49240	-16296			Reserved if IOUDIS on (\$C07E bit 7=1)
R/W	\$C059	49241	-16295	DISXY	9.1.3	Disable (mask) mouse X0/Y0 interrupts
R/W	\$C05A	49242	-16294	ENBXY	9.1.3	Enable (allow) mouse X0/Y0 interrupts
R/W	\$C05B	49243	-16293	DISVBL	9.1.3	Disable (mask) VBL interrupts
R/W	\$C05C	49244	-16292	ENVBL	9.1.3	Reserved if IOUDIS on
R/W	\$C05D	49245	-16291	X0EDGE	9.1.3	Enable (allow) VBL interrupts
N	\$C05E	49246	-16290	X0EDGE	9.1.3	Interrupt on rising edge of X0
R/W	\$C05F	49247	-16289	DHIRES	5.6	Reserved if IOUDIS on
R/W				Y0EDGE	9.1.3	Interrupt on falling edge of X0
R/W				DHIRES	5.6	If IOUDIS on: set double-high-resolution
R/W				Y0EDGE	9.1.3	If IOUDIS off: interrupt on rising Y0
R/W				DHIRES	5.6	If IOUDIS on: clear double-high-resolution
R/W				Y0EDGE	9.1.3	If IOUDIS off: interrupt on falling Y0

† Also section 2.5.4.

**Table B-7. Addresses \$C060 Through \$C07F**

RW	Hex	Dec	Neg Dec	Label	Section	Use
W	\$C06x					Reserved (write)
R7	\$C060	49248	-16288	RD80SW	4.1	See if 80/40 switch down (= 40)
R7	\$C061	49249	-16287	RDBTN0	9.1.3†	See if switch 0 or (▲) pressed
R7	\$C062	49250	-16286	RDBTN1	9.2†	See if switch 1 or (▼) pressed
R7	\$C063	49251	-16285	RD63	9.1,9.2	See if mouse button not pressed
R7	\$C064	49252	-16284	PDL0	9.2	See if hand control button 0 pressed
R7	\$C065	49253	-16283	PDL1	9.2	See if hand control button 1 pressed
R7	\$C066	49254	-16282	MOUX1	9.1.3	See if mouse X1 (direction) is high
R7	\$C067	49255	-16281	MOUY1	9.1.3	See if mouse Y1 (direction) is high
N	\$C068 through \$C06F	49256	-16280			Reserved (write and read)
N		49263	-16273			
R/W	\$C07x					Trigger paddle timer; reset VBLINT; however, some \$C07x are reserved
R/W	\$C070	49264	-16272	PTRIG	9.2	Designated trigger or reset location
N	\$C071 through \$C07D	49265	-16271			Reserved
N		49277	-16259			
R7	\$C07E	49278	-16258	RDIUDIS		See if IOUDIS on; trigger paddle timer; reset VBLINT
W				IOUDIS	5.6,9.1.3	On: enable access to DHIRES switch; disable \$C058-\$C05F IOU access
R7	\$C07F	49279	-16257	RDDHIRESD IOUDIS	5.6,9.1.3 5.6	See if DHIRES on Off: disable access to DHIRES switch; enable \$C058-\$C05F IOU access

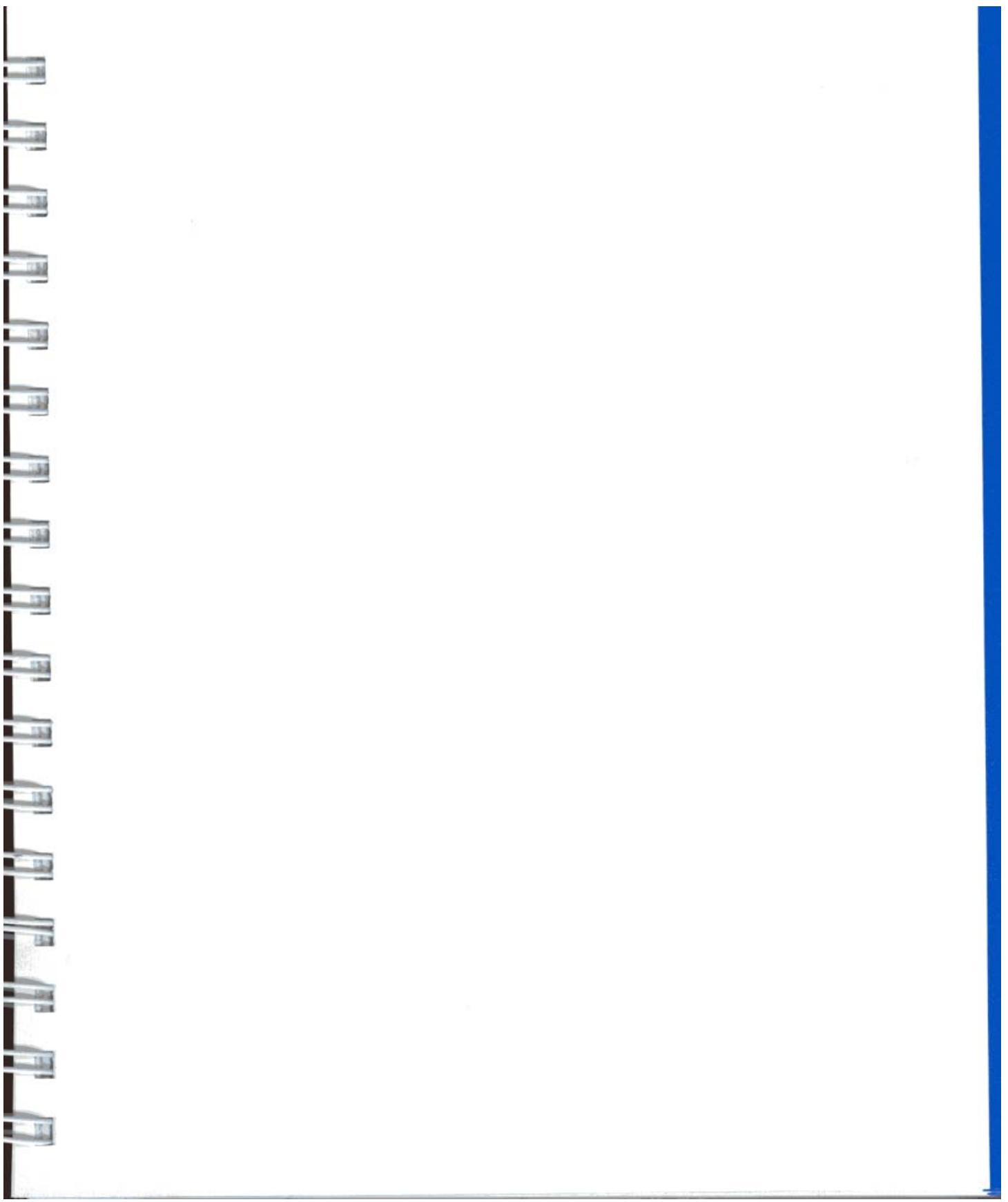
† Also section 4.1.

**Table B-8.** Addresses \$C080 Through \$C0AF

RW	Hex	Dec	Neg Dec	Label	Section	Use
R	\$C080	49280	-16256		2.4.2	Read RAM; no write; use \$D000 bank 2
RR	\$C081	49281	-16255		2.4.2	Read ROM, write RAM; use \$D000 bank 2
R	\$C082	49282	-16254		2.4.2	Read ROM; no write; use \$D000 bank 2
RR	\$C083	49283	-16253		2.4.2	Read and write RAM; use \$D000 bank 2
N	\$C084	49284	-16252			Reserved
N	\$C085	49285	-16251			Reserved
N	\$C086	49286	-16250			Reserved
N	\$C087	49287	-16249			Reserved
R	\$C088	49288	-16248		2.4.2	Read RAM; no write; use \$D000 bank 1
RR	\$C089	49289	-16247		2.4.2	Read ROM, write RAM; use \$D000 bank 1
R	\$C08A	49290	-16246		2.4.2	Read ROM; no write; use \$D000 bank 1
RR	\$C08B	49291	-16245		2.4.2	Read and write RAM; use \$D000 bank 1
N	\$C08C	49292	-16244			Reserved
N	\$C08D	49293	-16243			Reserved
N	\$C08E	49294	-16242			Reserved
N	\$C08F	49295	-16241			Reserved
N	\$C090 through \$C097	49296	-16240			Reserved
N	\$C097	49303	-16233			
R/W	\$C098	49304	-16232		7.3, 11.11	Port 1 ACIA Transmit/receive register
R/W	\$C099	49305	-16231		7.3, 11.11	Port 1 ACIA Status register
R/W	\$C09A	49306	-16230		7.3, 11.11, Appendix E	Port 1 ACIA Command register
R/W	\$C09B	49307	-16229		7.3, 11.11	Port 1 ACIA Control register
N	\$C09C through \$C09F	49308	-16228			Reserved
N	\$C09F	49311	-16225			
N	\$C0A0 through \$C0A7	49312	-16224			Reserved
N	\$C0A7	49319	-16217			
R/W	\$C0A8	49320	-16216		8.3, 11.11	Port 2 ACIA Transmit/receive register
R/W	\$C0A9	49321	-16215		8.3, 11.11	Port 2 ACIA Status register
R/W	\$C0AA	49322	-16214		8.3, 11.11, Appendix E	Port 2 ACIA Command register
R/W	\$C0AB	49323	-16213		8.3, 11.11	Port 2 ACIA Control register
N	\$C0AC through \$C0AF	49324	-16212			Reserved
N	\$C0AF	49327	-16209			

**Table B-9.** Addresses \$C0B0 Through \$COFF

RW	Hex	Dec	Neg Dec	Label	Section	Use
N	\$C0B0 through \$C0BF	49328	-16208			Reserved
N	\$C0C0 through \$C0CF	49343	-16193			
N	\$C0D0 through \$C0DF	49344	-16192			Reserved
N	\$C0E0 through \$C0EF	49359	-16177			
N	\$C0F0 through \$COFF	49360	-16176			Reserved
N	\$C0F0 through \$COFF	49375	-16161			
N	\$C0E0 through \$C0EF	49376	-16160			Reserved
N	\$C0F0 through \$COFF	49391	-16145			
N	\$C0F0 through \$COFF	49392	-16144			Reserved
N	\$C0F0 through \$COFF	49407	-16129			



# *Important Firmware Locations*

This appendix lists all significant firmware addresses: entry points, locations containing the addresses of entry points, and locations where machine and device identification bytes reside.

#### Warning

*The Monitor firmware entry points are the only published entry points in the sense that they are the only ones that will remain in the same locations in future Apple II series computers.*

*The firmware protocol identification bytes and offsets will work with other Apple II series computers only if used as directed (section 3.4.2).*

## C.1 The Tables

Appendix H contains tables and examples of the derivation of each form of address from either of the other forms.

This appendix supplements the chapter text by specifying three forms of each address: hexadecimal, decimal, and complementary (negative) decimal.

In these tables, some of the addresses are followed by a label of the location. These labels are listed only to assist you in finding the named location in the firmware listings, or in remembering the function found at the address. The Apple IIc contains no global label table: your program must assign its own labels to the addresses as required.

There are several types of information at these firmware addresses: actual entry points (labeled *entry*), the low-order byte of an entry point (labeled *offset*), a device or machine

identification byte (labeled *ident*), indicators (labeled *indic*) specifying whether there are optional routines, vector addresses (labeled *vector*), and an RTS instruction location.

The column labeled *Section* contains the number of the section that describes the item. If there is no description except in a table in this appendix, a section number is not listed.

Each input/output port has an associated protocol table, as shown in Tables C-1 through C-4. Many of the bytes (labeled *offset*) in the protocol tables are the low-order bytes of addresses of I/O routines for the ports; the high-order byte of these addresses must be \$Cn (where *n* is the port number). This structure is explained in Chapter 3. Although your program must perform some extra processing to use these tables, the benefit is simplified compatible port and slot I/O for all Apple II series machines.

## C.2 Port Addresses

**Table C-1. Serial Port 1 Addresses**

Hex	Dec	Neg Dec	Label	Type	Section	Description
\$C100	49408	-16128		entry	3.1.1	Main port 1 entry point
\$C105	49413	-16123		ident	3.4.2	ID byte (\$38)
\$C107	49415	-16121		ident	3.4.2	ID byte (\$18)
\$C10B	49419	-16117		ident	3.4.2	Firmware card signature (\$01)
\$C10C	49420	-16116		ident	3.4.2	Super Serial Card ID (\$31)
\$C10D	49421	-16115		offset	7.4	Low-order PINIT address
\$C10E	49422	-16114		offset	7.4	Low-order PREAD address
\$C10F	49423	-16113		offset	7.4	Low-order PWRITE address
\$C110	49424	-16112		offset	7.4	Low-order PSTATUS address
\$C111	49425	-16111		indic	3.4.2	Non-zero: no optional routines

**Table C-2. Serial Port 2 Addresses**

Hex	Dec	Neg Dec	Label	Type	Section	Description
\$C200	49664	-15872		entry	3.1.1	Main port 2 entry point
\$C205	49669	-15867		ident	3.4.2	ID byte (\$38)
\$C207	49671	-15865		ident	3.4.2	ID byte (\$18)
\$C20B	49675	-15861		ident	3.4.2	Firmware card ID (\$01)
\$C20C	49676	-15860		ident	3.4.2	Super Serial Card ID (\$31)
\$C20D	49677	-15859		offset	8.4	Low-order PINIT address
\$C20E	49678	-15858		offset	8.4	Low-order PREAD address
\$C20F	49679	-15857		offset	8.4	Low-order PWRITE address
\$C210	49680	-15856		offset	8.4	Low-order PSTATUS address
\$C211	49681	-15855		indic	3.4.2	Non-zero: no optional routines

**Table C-3.** Video Firmware Addresses

Hex	Dec	Neg Dec	Label	Type	Section	Description
\$C300	49920	-15616		entry	3.1.1	Main video entry point (output only)
\$C305	49925	-15611	C3KEYIN	ident	3.4.2	ID byte (\$38)
\$C307	49927	-15609	C3COUT1	ident	3.4.2	ID byte (\$18)
\$C30B	49931	-15605		ident	3.4.2	Firmware card signature (\$01)
\$C30C	49932	-15604		ident	3.4.2	80-column card ID (\$88)
\$C30D	49933	-15603		offset	5.9	Low-order PINIT address
\$C30E	49934	-15602		offset	5.9	Low-order PREAD address
\$C30F	49935	-15601		offset	5.9	Low-order PWRITE address
\$C310	49936	-15600		offset	5.9	Low-order PSTATUS address
\$C311	49937	-15599	MOVEAUX	entry	2.5.3	Routine for main/auxiliary control swapping (Also called AUXMOVE)

**Table C-4.** Mouse Port Addresses

Hex	Dec	Neg Dec	Label	Type	Section	Description
\$C400	50176	-15360		entry		Main mouse entry point
\$C405	50181	-15355		ident	3.4.2	ID byte (\$38)
\$C407	50183	-15353		ident	3.4.2	ID byte (\$18)
\$C40B	50187	-15349		ident	3.4.2	Firmware card signature (\$01)
\$C40C	50188	-15348		type	3.4.2	X-Y pointing device ID (\$20)
\$C40D	50189	-15347		offset	9.1.4	Low-order PINIT address
\$C40E	50190	-15346		offset	9.1.4	Low-order PREAD address
\$C40F	50191	-15345		offset	9.1.4	Low-order PWRITE address
\$C410	50192	-15344		offset	9.1.4	Low-order PSTATUS address
\$C411	50193	-15343		indic	3.4.2	Optional routines follow (\$00)
\$C412	50194	-15342	SETMOUSE	offset	9.1.4	Low-order SETMOUSE address
\$C413	50195	-15341	SERVEMOUSE	offset	9.1.4	Low-order SERVEMOUSE address
\$C414	50196	-15340	READMOUSE	offset	9.1.4	Low-order READMOUSE address
\$C415	50197	-15339	CLEARMOUSE	offset	9.1.4	Low-order CLEARMOUSE address
\$C416	50198	-15338	POSMOUSE	offset	9.1.4	Low-order POSMOUSE address
\$C417	50199	-15337	CLAMPMOUSE	offset	9.1.4	Low-order CLAMPMOUSE address
\$C418	50200	-15336	HOMEMOUSE	offset	9.1.4	Low-order HOMEMOUSE address
\$C419	50201	-15335	INITMOUSE	offset	9.1.4	Low-order INITMOUSE address

### C.3 Other Video and I/O Firmware Addresses

Miscellaneous firmware addresses are listed in Table C-5.

**Table C-5.** Apple IIc Enhanced Video and Miscellaneous Firmware

Hex	Dec	Neg Dec	Label	Type	Section	Description
\$C600	50688	-14848		entry	6.1	Disk drive firmware entry point
\$C700	50944	-14592		entry	6.2	External disk startup routine
\$C803	51203	-14333	NEWIRQ	entry	E.1	IRQ handling routine

### C.4 Applesoft BASIC Interpreter Addresses

The addresses of Applesoft BASIC entry points are listed in the *Applesoft BASIC Programmer's Reference Manual*. The Applesoft interpreter occupies ROM addresses from \$D000 through \$F7FF.

### C.5 Monitor Addresses

Table C-6 lists the Monitor entry points, machine identifier bytes, interrupt vectors, and the address of a known RTS instruction.

**Table C-6.** Apple IIc Monitor Entry Points and Vectors

Hex	Dec	Neg Dec	Label	Type	Section	Description
\$F800	63488	-2048	PLOT	entry	5.8	Plots a low-resolution block
\$F819	63513	-2023	HLINE	entry	5.8	Draws low-resolution horizontal line
\$F828	63528	-2008	VLINE	entry	5.8	Draws low-resolution vertical line
\$F832	63538	-1998	CLRSCR	entry	5.8	Clears low-resolution screen
\$F836	63542	-1994	CLRTOP	entry	5.8	Clears top 40 low-resolution lines
\$F864	63588	-1948	SETCOL	entry	5.8	Sets low-resolution color (Table 5-4)
\$F871	63601	-1935	SCRN	entry	5.8	Reads color of low-resolution block
\$F941	63809	-1727	PRNTAX	entry	5.8	Displays (A) and (X) in hex
\$F94A	63818	-1718	PRBL2	entry	5.8	Sends (X) blanks to output
\$FA47	63845	-1691	NEWBRK	entry	E.2	Apple IIc break handler
\$FA62	64098	-1438	RESET	entry	2.6	Hardware reset routine
\$FB1E	64286	-1250	PREAD	entry	9.2	Reads hand control position
\$FB6F	64367	-1169	SETPWRC	entry	2.6.4	Routine to create power-up byte
\$FBB3	64435	-1101		ident	F.1.2	Machine identification byte
\$FBC0	64448	-1088		ident	F.1.2	Machine identification byte
\$FBDD	64477	-1059	BELL1	entry	4.2.2	Sends 1 kHz beep to speaker
\$FC42	64578	-958	CLREOP	entry	5.8	Clears from cursor to bottom
\$FC58	64600	-936	HOME	entry	5.8	Clears; cursor to upper left
\$FC9C	64668	-868	CLREOL	entry	5.8	Clears from cursor to end of line
\$FC9E	64670	-866	CLEOLZ	entry	5.8	Clears from BASL to end of line
\$FCA8	64680	-856	WAIT	entry		Delays for time specified by (A)
\$FD0C	64780	-756	RDKEY	entry	3.2.1	Displays cursor, jumps to (KSW)
\$FD1B	64795	-741	KEYIN	entry	3.2.2	Waits for keypress, reads key
\$FD35	64821	-715	RDCHAR	entry	4.1.2	Gets input, interprets ESC codes
\$FD67	64871	-665	GETLNZ	entry	4.1.2	Sends CR to output, goes to GETLN
\$FD6A	64874	-662	GETLN	entry	3.2.3	Displays prompt, gets input line
\$FD6F	64879	-657	GETLN1	entry	4.1.2	No prompt; gets input line
\$FD8B	64907	-629	CROUT1	entry	5.8	Clears to end of line, calls CROUT
\$FD8E	64910	-626	CROUT	entry	5.8	Sends CR to output
\$FDDA	64986	-550	PRBYTE	entry	5.8	Sends (A) to output
\$FDE3	64995	-541	PRHEX	entry	5.8	Displays low nibble of (A) in hex
\$FDED	65005	-531	COUT	entry	3.3.1	Jumps to (CSW)
\$FDF0	65008	-528	COUT1	entry	3.3.2	Displays (A), advances cursor
\$FE2C	65068	-468	MOVE	entry		Copies (memory) elsewhere
\$FE36	65078	-458	VERIFY	entry		Compares two blocks of memory
\$FF2D	65325	-211	PRERR	entry	5.8	Sends ERR to output; beeps
\$FF3A	65338	-198	BELL	entry	4.2.2	Sends CONTROL-G to output
\$FF3F	65343	-193	IOREST	entry		Loads (\$45-\$49) into registers
\$FF4A	65354	-182	IOSAVE	entry		Stores (A,X,Y,P,S) at \$45-\$49
\$FF58	65368	-168	IORTS	RTS		Location of known RTS instruction
\$FF69	65385	-151	(Monitor)	entry	10.1	Standard Monitor entry point
\$FFFA	65530	-6		vector		Low-order NMI vector (unused)
\$FFFB	65531	-5		vector		High-order NMI vector (unused)
\$FFFC	65532	-4		vector		Low-order RESET vector (\$62)
\$FFFD	65533	-3		vector		High-order RESET vector (\$FA)
\$FFE	65534	-2	IRQVECT	vector		Low-order IRQ vector (\$03)
\$FFF	65535	-1		vector		High-order IRQ vector (\$CB)

# *Operating Systems and Languages*



This appendix is an overview of the characteristics of operating systems and languages when run on the Apple IIc. It is not intended to be a full account. For more information, refer to the manuals that are provided with each product.

## D.1 Operating Systems

This section discusses the operating systems that the Apple IIc does and does not work with.

### D.1.1 ProDOS

ProDOS is the preferred disk operating system for the Apple IIc. It supports startup from the external disk drive, interrupts, and all other hardware and firmware features of the Apple IIc.

### D.1.2 DOS

The Apple IIc works with DOS 3.3. Its disk drive support hardware and firmware can also access DOS 3.2 disks by using the *BASICs* disk. However, neither version of DOS takes full advantage of the features of the Apple IIc. DOS support is provided only for the sake of Apple II series compatibility.



---

### D.1.3 Pascal Operating System

Version 1.2 of the Pascal Operating System uses the 80/40 switch and the interrupt features of the Apple IIc, while remaining compatible with the other Apple II series computers.

While the Apple IIc works with Pascal 1.1, this version of the Pascal Operating System does not use the 80/40 switch or handle interrupts.

The Apple IIc does not work with Pascal 1.0, because the input/output firmware entry points are rigidly defined (rather than being accessed via a table), and the firmware does not support these entry points.

---

### D.1.4 CP/M

CP/M, and any other operating system that requires an interface card, will not work on the Apple IIc.

---

## D.2 Languages

For further information about these languages, refer to the manuals that came with them.

This section discusses special techniques to use, and characteristics to be aware of, when using Apple programming languages with the Apple IIc. It is also a guide to using this reference manual with these languages.

Use the appendixes to make or find decimal conversions. Appendix H has tables and examples to help you convert numbers between hexadecimal, decimal, and negative (complementary) decimal. All the addresses listed in Appendixes B and C—screen holes, hardware addresses, firmware entry points, and so on—are given in all three numeric forms.

---

### D.2.1 Applesoft BASIC

The focus of the chapters in this manual is assembly language, and so most addresses and values are given in hexadecimal notation.

Use a PEEK in BASIC (instead of LDA in assembly language) to read a location, and a POKE (instead of STA) to write to a location. If you read a hardware address from a BASIC program, you get a value between 0 and 255. Bit 7 has a value of 128, so if a soft switch is on, its value will be equal to or greater than 128; if the switch is off, the value will be less than 128.

---

### **D.2.2 Integer BASIC**

Unless you load a version of DOS into your Apple IIc, you will not have Integer BASIC available inside the machine. ProDOS does not support Integer BASIC.

---

### **D.2.3 Pascal Language**

The Pascal language works on the Apple IIc under versions 1.1 and 1.2 of the Pascal Operating System. However, for best performance, use Pascal version 1.2.

---

### **D.2.4 FORTRAN**

FORTRAN works under version 1.1 of the Pascal Operating System which, as explained in section D.1.3, does not detect or use certain Apple IIc features, such as the 80/40 switch or auxiliary memory. Therefore, FORTRAN does not take advantage of these features either.

# *Interrupts*

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

This appendix presents a unified account of the sources of interrupts on the Apple IIc, how the firmware handles the interrupts, and how to use interrupt-driven features directly in those rare cases when the firmware cannot meet your needs.

#### Warning

*If you use interrupt hardware directly, rather than using the built-in interrupt-handling firmware, compatibility with possible future Apple II series computers or revisions cannot be guaranteed.*

## E.1 Introduction

This section orients you to interrupts and their effects on the Apple IIc hardware.

### E.1.1 What Is an Interrupt?

On a computer, an interrupt is a signal that abruptly causes the computer to stop what it is currently doing and immediately attend to an important time-dependent task. For example, the Apple IIc mouse sends an interrupt to the computer every time it moves. This is necessary because unless the mouse is read shortly after it moves, the signal indicating its direction is lost.

When an interrupt occurs, control passes to an interrupt handler, which must record the exact state of the computer at the moment of the interrupt, determine the source of the interrupt, and take appropriate action. It is important that the

computer preserve a *snapshot* of its state when interrupted, so that when it continues later with what it had been doing, those conditions can be restored.

---

### **E.1.2 Interrupts on Apple II Computers**

Interrupts have not always been fully supported on the Apple II. All versions of Apple's DOS, as well as the Monitor program, rely on the integrity of location \$45, which the built-in interrupt handler has always destroyed by saving the accumulator in it. Most versions of Pascal simply do not work with interrupts enabled.

The Apple IIC built-in interrupt handler now saves the accumulator on the stack instead of in location \$45. Thus both DOS and the Monitor work with interrupts on the Apple IIC.

If, however, you want software that uses interrupts to work on the Apple IIe and the Apple II Plus, you must use either ProDOS, Apple's new enhanced disk operating system, or Pascal 1.2. Both operating systems have full interrupt support built in.

Interrupts are effective only if they are enabled most of the time. Interrupts that occur while interrupts are disabled cannot be detected. Due to the critical timing of disk read and write operations, Pascal, DOS, and ProDOS turn off interrupts while accessing the disk. Thus it is important to remember that while a disk drive is being accessed, all sources of interrupts discussed below are turned off.

On the Apple IIe only, interrupts are periodically turned off while 80-column screen operations are being performed. This is most noticeable while the screen is scrolling. Also, most peripheral cards used in the Apple IIe disable interrupts while reading and writing.

---

### **E.1.3 Interrupt Handling on the 65C02**

From the point of view of the 65C02, there are three possible causes of interrupts.

1. If 65C02 interrupts are not masked (that is, the CLI instruction has been used), the IRQ line on the microprocessor can be pulled low. This is the standard technique by which a device indicates that it needs immediate attention.
2. The processor executes a break (BRK, opcode \$00) instruction.
3. A non-maskable interrupt (NMI) occurs. Because the NMI line in the Apple IIc's 65C02 is not used, this never happens.

Options 1 and 2 cause the 65C02 to save the current program counter and status byte on the stack and then jump to the routine whose address is stored in \$FFFE and \$FFFF. The sequence performed by the 65C02 is:

1. If IRQ, finish executing the current instruction. (If BRK, current instruction is already finished.)
2. Push high byte of program counter onto stack.
3. Push low byte of program counter onto stack.
4. Push program status byte onto stack.
5. Jump to address stored in \$FFFE, \$FFFF, that is, JMP (\$FFFE).

The different sources of interrupt signals are discussed below.

---

### **E.1.4 The Interrupt Vector at \$FFFE**

In the Apple IIc computer there are three separate regions of memory that contain address \$FFFE: the built-in ROM, the bank-switched memory in main RAM, and the bank-switched memory in auxiliary RAM. The vector at \$FFFE in the ROM points to Apple IIc's built-in interrupt handling routine. Due to the complexity of interrupts in the Apple IIc, it is recommended that you use it rather than writing your own interrupt handling routine.

When you initialize the mouse or serial communication firmware, copies of the ROM's interrupt vector are placed in the interrupt vector addresses in both main and auxiliary bank-switched

memory. If you plan to use interrupts and the bank-switched memory without the mouse or communication firmware, you must copy the ROM's interrupt vector yourself.

## **E.2 The Built-in Interrupt Handler**

The built-in interrupt handler is responsible for determining whether a BRK or an IRQ interrupt occurred. If it was an IRQ interrupt, it decides whether the interrupt should be handled internally, handled by the user, or simply ignored.

The built-in interrupt handling routine records the current memory configuration, then sets up its own standard memory configuration so that a user's interrupt handler knows the precise memory configuration when it is called.

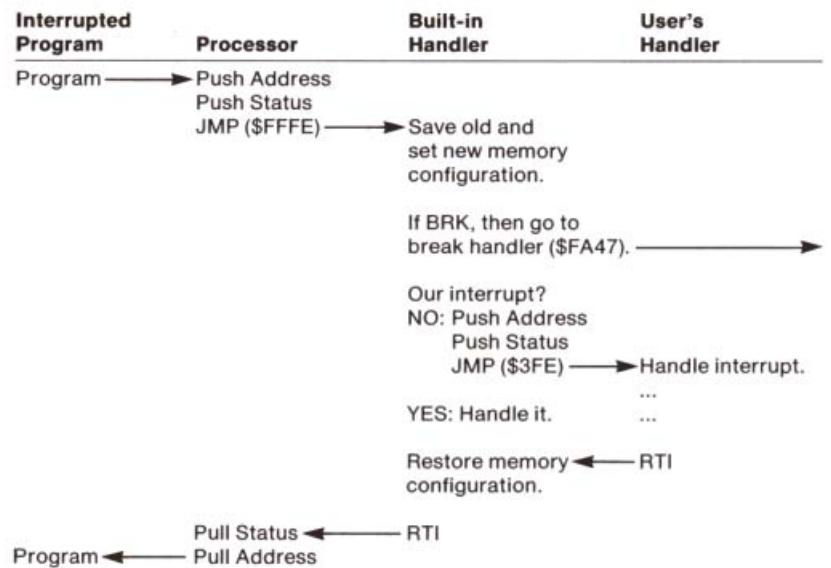
Next the handler checks to see if the interrupt was caused by a break instruction, and if it was, handles it as described in section E.4.

If the interrupt was not caused by a BRK, the handler checks for interrupts that it knows how to handle (for example, a properly initialized mouse) and handles them.

Depending on the state of the system, it either ignores other interrupts, or passes them to a user's interrupt handling routine whose address is stored at \$3FE and \$3FF of main memory.

After handling an interrupt itself, or after the user's handler returns (with an RTI), the built-in interrupt handler restores the memory configuration, and then does an RTI to restore processing to where it was when the interrupt occurred. Figure E-1 illustrates this whole process. Each of the steps is explained in detail in the sections that follow.

*Figure E-1. Interrupt-Handling Sequence*



---

### **E.2.1 Saving the Memory Configuration**

The built-in interrupt handler saves the state of the system, and sets it to a known state according to these rules:

- If 80STORE and PAGE2 are on, then it switches in Text Page 1 (PAGE2 off) so that main screen holes are accessible.
- It switches in main memory for reading (RAMRD off).
- It switches in main memory for writing (RAMWRT off).
- It switches in ROM addresses \$D000-\$FFFF for reading (RDLCRAM off).
- It switches in main stack and zero page (ALTZP off).
- It preserves the auxiliary stack pointer, and restores the main stack pointer (see section E.2.2).

**Note:** Because main memory is switched in, all memory addresses used later in this appendix are in main memory unless otherwise specified.

---

### **E.2.2 Managing Main and Auxiliary Stacks**

Because the Apple IIc has two stack pages, the firmware has established a convention that allows the system to be run with two separate stack pointers. Two bytes in the auxiliary stack page are to be used as storage for inactive stack pointers: \$100 for the main stack pointer when the auxiliary stack is active, and \$101 for the auxiliary stack pointer when the main stack is active.

When a program that uses interrupts switches in the auxiliary stack for the first time, it should place the value of the main stack pointer at auxiliary stack address \$100, and initialize the auxiliary stack pointer to \$FF (the top of the stack). When it subsequently switches from one stack to the other, it should save the current stack pointer before loading the pointer for the other stack.

When an interrupt occurs while the auxiliary stack is switched in, the current stack pointer is stored at \$101, and the main stack pointer is retrieved from \$100. Then the main stack is switched in for use. After the interrupt has been handled, the stack pointer is restored to its original value.

### **E.3 User's Interrupt Handler at \$3FE**

Screen hole locations can be set up to indicate that the user's interrupt handler should be called when certain interrupts occur. To use such a routine, place its address at \$3FE and \$3FF in main memory, low byte first.

The user's interrupt handler should do the following:

- Verify that the interrupt came from the expected source. The following sections describe how this should be done for each interrupt source.
- Handle the interrupt as desired.
- Clear the interrupt, if necessary. The following sections describe how to clear the interrupts.
- Return using an RTI instruction.

If your interrupt handler needs to know the memory configuration at the time of the interrupt, it can check the encoded byte stored four bytes down on the stack. This byte is explained in section E.4.

In general there is no guaranteed response time for interrupts. This is because the system may be doing a disk operation, which could last for several seconds.

Once the built-in interrupt handler has been called, it takes about 250 to 300 microseconds for it to call your interrupt handling routine. After your routine returns, it takes 40 to 140 microseconds to restore memory and return to the interrupted program.

If memory is in the standard state when the interrupt occurs, the total overhead for interrupt processing is about 150 microseconds less than if memory is in the worst possible state (80STORE and PAGE2 on, auxiliary memory switched in for reading and writing, auxiliary bank-switched memory page 2 switched in for reading and writing).

## E.4 Handling Break Instructions

After the interrupt handler has set the memory configuration, it checks to see if the interrupt was caused by a BRK (opcode \$00) instruction. (If it was, bit 4 of the processor status byte is a one). If so, it jumps to a break handling routine, which saves the state of the computer at the time of the break as follows.

Information	Location
Program counter (low byte)	\$3A
Program counter (high byte)	\$3B
Encoded memory state	\$44
Accumulator	\$45
X register	\$46
Y register	\$47
Status register	\$48

Finally the break routine jumps to the routine whose address is stored at \$3F0 and \$3F1.

The encoded memory state in location \$44 can be interpreted as follows:

Bit 7	=	0
Bit 6	=	1 if 80STORE and PAGE2 both on
Bit 5	=	1 if auxiliary RAM switched in for reading
Bit 4	=	1 if auxiliary RAM switched in for writing
Bit 3	=	1 if bank-switched RAM being read
Bit 2	=	1 if bank-switched \$D000 page 1 switched in
Bit 1	=	1 if bank-switched \$D000 page 2 switched in
Bit 0	=	0

## **E.5 Sources of Interrupts**

The Apple IIc can receive interrupts from many different sources. Each source is enabled and used slightly differently from the others. There are two basic classes of interrupt sources: those associated with use of the mouse, and those associated with the two 6551 ACIA circuits (the chips that control serial communication).

The interrupts that are associated with the mouse are these:

- An interrupt can be generated when the mouse is moved in the horizontal (X) direction.
- An interrupt can be generated when the mouse is moved in the vertical (Y) direction.
- An interrupt can be generated every 1/60 second. This is called the **vertical blanking** (VBL) interrupt, and is synchronized with a signal used for the video display.
- Using the firmware, interrupts can be generated when the mouse button is pressed.

The interrupts that are associated with the ACIAs are these:

- An interrupt can be generated when a key is pressed. The firmware can use this interrupt to buffer keystrokes, or it can pass the interrupt on to the user.
- An interrupt can be generated by a device attached to the external disk drive port. The firmware can pass this interrupt on to the user.
- An interrupt can be generated when either ACIA has received a byte of data from its port. The firmware can use this interrupt to buffer data or it can pass the interrupt on to the user.
- An interrupt can be generated when pin 5 of either serial port changes state (device ready/not ready to accept data). When the serial firmware is active, this interrupt is absorbed; however, the serial firmware uses the signal to decide whether or not to transmit the next byte of data.
- An interrupt can be generated when either ACIA is ready to accept another character to be transmitted. When the serial firmware is active, this interrupt is absorbed; however, the serial firmware uses the signal to decide whether or not to transmit the next byte of data.
- An interrupt is generated when the keyboard strobe is cleared. The firmware absorbs this interrupt.

## **E.6 Firmware Handling of Interrupts**

The following sections discuss the various sources of interrupts and how they should be used in conjunction with the built-in interrupt handler.

### **E.6.1 Firmware for Mouse and VBL**

As described in Chapter 9, the mouse can be initialized (by the SETMOUSE call) to nine different modes that enable one or more sources of interrupts. In transparent mode, the interrupts are entirely handled by the built-in interrupt handler; the other modes require a user-installed interrupt handler.

When the mouse is initialized, the interrupt vector is copied to addresses \$FFFE and \$FFFF in main and auxiliary bank-switched RAM. This permits mouse interrupts with any memory configuration.

When the mouse is active, possible sources of interrupts are:

- Mouse movement in the X direction
- Mouse movement in the Y direction
- Change of state of the button
- Rising edge of the vertical blanking signal.

When an interrupt occurs, the built-in interrupt handler determines whether that particular interrupt source was enabled (by the SETMOUSE call). If so, the user's interrupt handler, whose address is stored at \$3FE, is called.

The user's interrupt handler should first call SERVEMOUSE to determine the source of the interrupt. This call updates the mouse status byte at \$77C and returns with the carry bit clear if mouse movement, button, or vertical blanking was the source of the interrupt.

The values of this mouse status byte at \$77C are as follows:

Bit	1 means that
3	Interrupt was from vertical blanking
2	Interrupt was from button
1	Interrupt was from mouse movement

If the interrupt was due to mouse movement or button, the user's interrupt handler should then do a call to READMOUSE. This causes the mouse coordinates and status to be updated as follows:

\$47C	Low byte of X coordinate
\$4FC	Low byte of Y coordinate
\$57C	High byte of X coordinate
\$5FC	High byte of Y coordinate

---

\$77C	Button and movement status	
Bit	Means	
7	0	= button up; 1 = button down
6	0	= button up on last READMOUSE
	1	= button down on last READMOUSE
5	0	= no movement since last READMOUSE
	1	= movement since last READMOUSE
3-1	always set to 0 (interrupt cleared)	

After the interrupt has been handled, the routine should terminate with an RTI.

As already mentioned, interrupts may be missed during disk accesses.

If you turn on mouse interrupts without initializing the mouse, the built-in interrupt handler will absorb the interrupts. If you want to handle mouse interrupts yourself, you must write your own interrupt handler and place vectors to it at addresses \$FFFE and \$FFFF in bank-switched RAM. Interrupts will be ignored whenever the \$D000-\$FFFF ROM is switched in.

---

### **E.6.2 Firmware for Keyboard Interrupts**

The Apple IIc hardware is able to generate an interrupt when a key is pressed. The firmware is able to buffer up to 128 keystrokes, completely transparently, when properly enabled to do so. It saves them in the second half of page 8 of auxiliary memory. After the buffer is full, subsequent keystrokes are ignored. Because interrupts are only generated when keypresses occur, characters generated by the auto-repeat feature are not buffered. They can, however, be read when the buffer is empty.

Once keyboard buffering has been turned on, the next key should be read by calling RDKEY (\$FD0C).



#### **Warning**

*Do not call the buffer reading routine directly. Its entry address will not be the same in future versions of the computer.*

---

See Chapter 8.

- The special characters **(CONTROL)-S** (stop list) and **(CONTROL)-C** (stop Applesoft execution) do not work while keyboard buffering is turned on. A new keystroke, **Apple-(CONTROL)-X**, clears the buffer.

---

#### ***Using Keyboard Buffering Firmware***

Keyboard buffering is automatically turned on when the serial firmware is placed in terminal mode. Otherwise you must turn it on yourself.

1. Disable processor interrupts (SEI).
2. Set location \$5FA to \$80. This tells the firmware to buffer keystrokes without calling the user's interrupt handler.
3. Set locations \$5FF and \$6FF to \$80. These are pointers to where in the buffer the next keystroke will be stored and where the next will be read from, respectively.
4. Turn on the ACIA for port 2 by setting the low nibble of \$C0AA to the value \$F. For example:

```
LDA $C0AA      ;read port 2 ACIA command register  
ORA #$0F      ;set low nibble to $F  
STA $C0AA      ;set port 2 ACIA command register
```

If you are using the serial ports at the same time, just set the low bit of \$C0AA to 1. This prevents receiver interrupts from being turned off.

A PR#2 or IN#2 or the equivalent will shut off keyboard interrupts.

5. Enable processor interrupts (CLI).

---

#### ***Using Keyboard Interrupts Through Firmware***

Keyboard interrupts are received through the ACIA for port 2. They can be enabled as follows:

1. Disable processor interrupts (SEI).
2. Set location \$5FA to \$C0. This tells the firmware to identify a keystroke interrupt, and to call the user's interrupt handler.
3. Turn on the ACIA for port 2 by setting the low nibble of \$C0AA to the value \$F. For example:

---

```
LDA $C0AA ;read port 2 ACIA command register  
ORA #$0F ;set low nibble to $F  
STA $C0AA ;set port 2 ACIA command register
```

4. Enable processor interrupts (CLI).

When the user's interrupt handler is called, it can identify the keyboard as the interrupt source by reading location \$4FA. This is a copy of the ACIA status register at the time of the interrupt. If the interrupt was due to something on the ACIA for port 2, bit 7 is set. If the interrupt was caused by a keystroke, bit 6 is set and bit 5 is unchanged.

After servicing this interrupt, the interrupt handler should clear the interrupt by setting \$4FA to 0.

---

#### ***E.6.3 Using External Interrupts Through Firmware***

Pin 9 of the external disk drive connector (EXTINT) can be used to generate interrupts through the ACIA for port 1. It can be used as a source of interrupts (on a high-to-low transition) if enabled as follows:

1. Disable processor interrupts (SEI).
2. Set location \$5F9 to \$C0. This tells the firmware to identify an external interrupt, and to call the user's interrupt handler.
3. Turn on the ACIA for port 1 by setting the low nibble of \$C09A to the value \$F. For example:

```
LDA $C09A ;read port 1 ACIA command register  
ORA #$0F ;set low nibble to $F  
STA $C09A ;set port 1 ACIA command register
```

4. Enable processor interrupts (CLI).

When the user's interrupt handler is called, it can identify this interrupt by reading location \$4F9. This is a copy of the ACIA status register at the time of the interrupt. If the interrupt was due to something on the ACIA for port 1, bit 7 is set. If the interrupt was caused by the external interrupt line, bit 6 is clear and bit 5 is unchanged.

After servicing this interrupt, the interrupt handler should clear the interrupt by setting \$4F9 to 0.

#### **E.6.4 Firmware for Serial Interrupts**

The Apple IIc hardware is able to generate interrupts both when the ACIA receives data and when it is ready to send data. The built-in interrupt handler responds to incoming data only. The firmware is able to buffer up to 128 incoming bytes of serial data from either serial port. After the buffer is full, data is ignored. Only one port can be buffered at a time.

The following sections assume that the serial port to be buffered is already initialized, as explained in Chapter 8.

---

#### ***Using Serial Buffering Transparently***

Serial buffering is automatically turned on when the serial firmware is placed in terminal mode. Otherwise you must turn it on yourself, as follows:

1. Disable processor interrupts (SEI).
2. Set location \$4FF to \$C1 to buffer port 1, or to \$C2 to buffer port 2.
3. Set locations \$57F and \$67F to 0. These are pointers to the next byte in the buffer to be used and the next character to be read from the buffer, respectively.
4. Turn on the ACIA for the port by setting the low nibble of \$C09A for port 1 or \$C0AA for port 2 to \$D. For example:

```
LDA $C09A    ;read port 1 ACIA command register  
AND $F0      ;clear low nibble  
ORA #$0D    ;set low nibble to $D  
STA $C09A    ;set port 1 ACIA command register  
The 0 in bit 1 of the command register enables receiver  
interrupts, thus an interrupt is generated when a byte of data  
is received.
```

5. Enable processor interrupts (CLI).

See Chapter 8.

When serial port buffering is thus enabled, normal reads from the serial port firmware fetch data from the buffer rather than directly from the ACIA.

---

### ***Using Serial Interrupts Through Firmware***

It is also possible to use the firmware to call the user interrupt handler whenever a byte of data is read by the ACIA. In this mode buffering is not performed by the firmware.

1. Disable processor interrupts (SEI).
2. Set location \$4FF to a value other than \$C1 or \$C2.
3. Turn on the ACIA for the port by setting the low nibble of \$C09A for port 1 or \$C0AA for port 2 to \$D. For example:

```
LDA $C09A ;read port 1 ACIA command register  
AND $F0 ;clear low nibble  
ORA #$0D ;set low nibble to $D  
STA $C09A ;set port 1 ACIA command register
```

The 0 in bit 1 of the command register enables receiver interrupts, thus an interrupt is generated when a byte of data is received.

4. Enable processor interrupts (CLI).

When a serial port is thus enabled, the user's interrupt handler is called each time the port receives a byte of data. The status byte saved by the firmware (\$4F9 for port 1; \$4FA for port 2) has the high bit set if the interrupt occurred on that port. Bit 3 is set if the interrupt was due to a received byte of data.

The interrupt handler should clear the interrupt by clearing bits 7 and 3 of that port's status byte (\$4F9 for port 1; \$4FA for port 2).

---

### ***Transmitting Serial Data***

The serial firmware does not implement buffering for serial output. Instead it waits for two conditions to be true before transmitting a character:

- The ACIA's transmit register must be ready to accept a character. This is true if bit 4 of the ACIA's status register is 1.
- The device must signal that it is ready to accept data. This is true if bit 5 of the ACIA's status register is 0. Bit 5 is 0 if pin 5 of the port's connector is also 0.

When the serial firmware is active, a change of state on pin 5 of that port generates an interrupt. That interrupt is absorbed, but the data remains in bit 5 of the status register. Interrupts from the ACIA's transmit register are normally disabled.

---

### ***A Loophole in the Firmware***

So that programs can make use of interrupts on the ACIAs without affecting mouse interrupt handling, there is a tiny loophole purposely left in the built-in interrupt handler. If transmit interrupts are enabled on the ACIA—that is, if bits 3, 2, and 0 of the ACIA's command register have the values 0, 1, and 1, respectively—then control is passed to the user's interrupt handler if the interrupt is not intended for the mouse (movement, button, or VBL).

This means that you can write more sophisticated serial interrupt handling routines than the limited firmware space could provide (such as printer spooling). The firmware will still set memory to its standard state, handle mouse interrupts, and restore memory after your routine is finished.

When you receive the interrupt, neither ACIA's status register has been read. You are fully responsible for checking for interrupts on both ACIAs, determining which of the four interrupt sources on each ACIA caused the interrupt, and how to handle them. Refer to the 6551 specification for more details. The built-in firmware itself is an excellent example of how interrupts on the ACIA can be handled.

## **E.7 Bypassing the Interrupt Firmware**

The following sections give further details on using interrupts on the Apple IIc computer without using the built-in interrupt handler.

### **E.7.1 Using Mouse Interrupts Without the Firmware**

To use mouse interrupts without the firmware, as mentioned above, you must set your own interrupt vectors. If \$D000-\$FFFF ROM is ever switched in, the built-in interrupt handler will absorb the mouse interrupts. Tables E-1 and E-2 show how to activate and read mouse interrupts without using the firmware. Remember to disable interrupts (SEI) before enabling mouse interrupts, then turn them on when done (CLI).

**Table E-1. Activating Mouse Interrupts**

To Activate Interrupts On	Enable IOU Access	Select Source	Enable Source	Disable IOU Access
Mouse X (rising edge)	STA \$C079	STA \$C05C	STA \$C059	STA \$C078
Mouse X (falling edge)	STA \$C079	STA \$C05D	STA \$C059	STA \$C078
Mouse Y (rising edge)	STA \$C079	STA \$C05E	STA \$C059	STA \$C078
Mouse Y (falling edge)	STA \$C079	STA \$C05F	STA \$C059	STA \$C078
VBL	STA \$C079		STA \$C05B	STA \$C078

**Table E-2. Reading Mouse Interrupts**

To Read Interrupts From	Read Direction (A.S.A.P.)	Determine Source	Handle It	Return
Mouse X	LDA \$C066	LDA \$C015 (bit 7=1 if true)	...	RTI
Mouse Y	LDA \$C067	LDA \$C017 (bit 7=1 if true)	...	RTI
VBL		LDA \$C019 (bit 7=1 if true)	...	RTI

The mouse direction data read from \$C066 and \$C067 is guaranteed to be valid for at least 40 microseconds. Average duration is at least 200 microseconds. This means you should read the direction as soon as possible.

### **E.7.2 Using ACIA Interrupts Without the Firmware**

To use ACIA interrupts without the firmware, you must set your own interrupt vectors. If the \$D000-\$FFFF ROM is ever switched in, the built-in interrupt handler will handle the interrupt as determined by certain mode bytes (section E.6.1).

When writing your serial interrupt handler, refer to Figures 11.31 through 11-33 and to the Synertek 6551 ACIA specification. As shown in Chapter 11, the ACIA's have the following connections:

- |         |  |
|---------|--|
| Port 1: | DSR line connected to the EXTINT line on<br>the external disk port |
|         | DCD line connected to pin 5 of Port 1<br>connector                 |
| Port 2: | DSR line goes high when a key is<br>pressed                        |
|         | DCD line connected to pin 5 of Port 2<br>connector                 |

The ACIA registers have the following addresses:

Port 1:	Data Register = \$C098
	Status Register = \$C099
	Command Register = \$C09A
	Control Register = \$C09B
Port 2:	Data Register = \$C0A8
	Status Register = \$C0A9
	Command Register = \$C0AA
	Control Register = \$C0AB

# *Apple II Series Differences*



This appendix compares the Apple IIc to the Apple IIe, Apple II Plus, and Apple II.

## F.1 Overview

This appendix does not contain an exhaustive list of differences. However, it does include those differences most likely to affect the accuracy of programs, displays, and instructions created for end users of two or more models from the Apple II Series.

As an overview, the differences between the Apple II series computers can be expressed as a series of equations: this computer equals that one plus or minus certain features.

**Note:** The following *equations* are merely an overview of what each model of Apple II Series is with respect to its predecessor. These equations are in terms of functional equivalence, not strict equality. For example,

Apple IIe = Apple II Plus + Apple Language Card

does not mean there is an actual language card or slot—just that the one machine functions as if it were the other with such a card (with its connector) in a slot.

Apple II Plus	=	II	+ Autostart ROM + Applesoft firmware + 48K RAM standard - Old Monitor ROM - Integer BASIC firmware
Apple IIe	=	II Plus	+ Apple Language Card (with 16K of RAM) + 80-column (enhanced) video firmware + built-in diagnostics + full ASCII keyboard + internal power light + FCC approval + improved back panel + 9-pin back panel game connector + auxiliary slot (with possibility of 80-column text card) + extra 64K RAM) - slot 0
Apple IIc	=	IIe	+ extended 80-column text card + 80/40 switch + keyboard switch + disk light + disk controller port + disk drive + mouse port + serial printer port + serial communication port + built-in port firmware + video expansion connector - removable cover - slots 1 to 7 - auxiliary slot - internal power light - cassette I/O connectors - internal game I/O connector (hence no game <i>output</i> ) - auxiliary video pin - monitor cassette support

---

### **F.1.1 Type of CPU**

The CPU in the Apple II and II Plus is the 6502. The Apple Ile uses a 6502A. The Apple IIC uses the 65C02: this is a redesigned CMOS CPU that has 27 new instructions, new addressing modes, and for some instructions a differing execution scheme and machine cycle counts (see Appendix A). Programs written for the Apple IIC will run on the earlier machines only if they do not contain instructions unique to the 65C02, or depend on instruction cycle times that differ.

---

### **F.1.2 Machine Identification**

Identification of Apple II series computers is as follows:

Machine	\$FBB3	\$FB00	\$FB1E
Apple II	\$38		
Apple II Plus	\$EA		
Apple Ile	\$06	\$EA	
Apple IIC	\$06	\$00	
Apple III in Apple II Emulation Mode	\$EA		\$8A

Any future Apple II series computer or ROM release will have different values in these locations. Machine identification routines are available from Apple Vendor Technical Support.

With regard to ProDOS, its MACHID byte, at location \$BF98 on the global page, will have bit 3 set to 0 if the computer is an Apple II, II Plus, Ile, or III, and a 1 if the computer is not one of these machines. In addition, for an Apple IIC, bits 7 and 6 are set to binary 10.

Bits 7 and 6 set to binary 10 indicate that a computer is Apple Ile and IIC compatible, regardless of the value of bit 3.

## **F.2 Memory Structure**

This section compares the memory organization of the Apple IIc with that of the Apple II, II Plus, and IIe. These machines differ in RAM space, ROM space, slot or port address space, and hardware page use.

### **F.2.1 Amount and Address Ranges of RAM**

The Apple II could have as little as 4K of RAM at the time of purchase, and could be upgraded to as much as 48K of RAM, following a procedure described in the *Apple II Reference Manual*.

The Apple II Plus has 48K of RAM (\$0000 through \$BFFF) as a standard feature. With the addition of an Apple Language Card, a 48K Apple II or II Plus could be expanded to have 64K of RAM.

The Apple IIe has a full 64K of RAM. The top 12K addresses overlap with the ROM addresses \$D000 through \$FFFF. There is an additional **bank-switched** area of 4K from \$D000 through \$DFFF. This arrangement is equivalent to an Apple II Plus with an Apple Language Card installed. A program selects between the RAM and ROM address spaces and between the \$Dxxx banks by changing soft switches located in memory.

With an Extended 80-Column Text Card installed in its auxiliary slot, an Apple IIe has an additional 64K of RAM available, although no more than half of the 128K of RAM space is available at any given time. Soft switches located in memory control these address space selections.

The RAM in the Apple IIc is equivalent to the RAM in an Apple IIe with an Extended 80-column Card.

---

### **F.2.2 Amount and Address Ranges of ROM**

The Apple II has 8K of ROM (\$E000 through \$FFFF), and the Apple II Plus has 12K of ROM (\$D000 through \$FFFF). Users can plug their own ROMs into the sockets provided. The on-board (as opposed to slot) ROM address range is from \$D000 through \$FFFF.

The Apple IIe has 16K of ROM, of which it uses 15.75 K (addresses \$C100 through \$FFFF; page \$C0 addresses are for I/O hardware). ROM addresses \$C300 through \$C3FF (normally assigned to the ROM in a card in slot 3) and \$C800 through \$CFFF contain 80-column video firmware; ROM addresses \$C100 through \$C2FF and \$C400 through \$C7FF (normally assigned to the ROM on cards in slots 1, 2, 4, 5, 6 and 7) contain built-in self-test routines.

A soft switch in RAM controls whether the video firmware or slot 3 card ROM is active. Invoking the self-tests with **(Apple)-[CONTROL]-[RESET]** causes the self-test firmware to take over the slot ROM address spaces.

The Apple IIc ROM also uses the 15.75 K from \$C100 through \$FFFF, and its enhanced video firmware has the same entry point addresses as on the Apple IIe. However, there are only rudimentary built-in self-tests, and these do not pre-empt any port firmware space.

In the Apple IIc, addresses \$C100 through \$CFFF contain I/O and interrupt firmware, addresses \$D000 through \$F7FF contain the Applesoft BASIC Interpreter, and addresses \$F800 through \$FFFF contain the Monitor.

---

### **F.2.3 Peripheral-Card Memory Spaces**

Each Apple IIc port has up to sixteen peripheral-card I/O space locations in main memory on the hardware page (beginning at location \$C0s0 + \$80 for slot or port s), allocated in the standard Apple II series way (that is, beginning at location \$C0s0 + \$80 for each slot s).

The peripheral-card ROM space (page \$Cs for slot s in the Apple II, II Plus, and IIe) contains the starting and entry-point addresses for port s, but port routines are not limited to their allocated \$Cs pages.

The 2K-byte expansion ROM space from \$C800 to \$CFFF in the Apple IIc is used by the enhanced video firmware and miscellaneous I/O and memory-transfer routines.

The 128 bytes of peripheral-card RAM space or *scratch-pad RAM* (64 screen holes in main memory and their equivalent addresses in auxiliary memory) are reserved for use by the built-in firmware. It is extremely important for the correct operation of Apple IIc firmware that these locations not be altered by software except for the specific purposes described in Chapters 7, 8, and 9, and in Appendix E.

---

### **F.2.4 Hardware Addresses**

The hardware page (the addresses from \$C000 through \$C0FF) controls memory selection and input/output hardware characteristics. All input and output (except video output) takes place at one or more hardware page addresses. For the sake of simplicity, this section presents only a general comparison between the Apple IIc on the one hand, and the Apple II, II Plus, and IIe on the other, with respect to most hardware page uses. However, for many characteristics, the Apple IIe and IIc work one way, while the Apple II and II Plus work another.

---

#### ***\$C000 to \$C00F***

On all Apple II series computers, reading any one of these addresses reads the keyboard data and strobe. On the Apple IIe and IIc, writing to each of these addresses turns memory and display switches on and off. Writing to addresses \$C006, \$C007, \$C00A, and \$C00B performs ROM selection on the Apple IIe. Writing to these four addresses is reserved on the Apple IIc.

For reading the keyboard, use \$C000; reserve \$C001 through \$C00F.

---

#### ***\$C010 to \$C01F***

On all Apple II series computers, writing to any one of these addresses clears the keyboard strobe. On the Apple IIe and IIc, reading each of these addresses checks the status of a memory or display switch, or the any-key-down flag.

For clearing the keyboard strobe, use \$C010; reserve \$C011 through \$C01F.

Reading \$C015 checks the SLOTCXROM switch on the Apple IIe, but it resets the X-movement interrupt (XINT) on the Apple IIc. Similarly, reading \$C017 checks the SLOTC3ROM switch on the Apple IIe, but it resets the Y-movement interrupt (YINT) on the Apple IIc.

Reading \$C019 checks the current state of vertical blanking (VBL) on the Apple IIe, but it resets the latched vertical blanking interrupt (VBLINT) on the Apple IIc.

---

#### ***\$C020 to \$C02F***

On the Apple II, II Plus, and IIe, reading any address \$C02x toggles the cassette output signal. On the Apple IIc, both reading from and writing to these locations are reserved.

---

#### ***\$C030 to \$C03F***

On all Apple II series computers, reading an address of the form \$C03x toggles the speaker. For full Apple II series compatibility, toggle the speaker using \$C030, and reserve \$C031 through \$C03F.

On the Apple IIc, writing to these addresses is explicitly reserved.

---

#### ***\$C040 to \$C04F***

On the Apple II, II Plus, and IIe, reading any address of the form \$C04x triggers the Utility Strobe. The Apple IIc has no Utility Strobe.

On the Apple IIc, addresses \$C044 through \$C047 are explicitly reserved, and reading or writing any address from \$C048 through \$C04F resets both the X and Y interrupts (XINT and YINT).

---

#### ***\$C050 to \$C05F***

Addresses \$C050 through \$C057 work the same on the Apple IIc as on the Apple IIe: they turn the TEXT, MIXED, PAGE2 and HIRES switches on and off.

On the Apple IIe, addresses \$C058 through \$C05F turn the annunciator outputs on and off. On an Apple IIe with a revision B main logic board, an Apple Extended 80-Column Text Card, and a jumper installed on the card, reading locations \$C05E and \$C05F set and clear double-high-resolution display mode.

On the Apple IIc, if the IOUDIS switch is on, both reading from and writing to addresses \$C058 through \$C05D are reserved, and addresses \$C05E and \$C05F set and clear double-high-resolution display (as on the Apple IIe equipped as described in the preceding paragraph). If the IOUDIS switch is off, then addresses \$C058 through \$C05F control various characteristics of mouse and vertical blanking interrupts (Table 9-2).

---

#### **\$C060 to \$C06F**

On the Apple IIc, writing to any address of the form \$C06x is reserved, and reading addresses \$C068 through \$C06F is reserved.

Reading addresses \$C061 and \$C062 is the same as on the Apple IIe (switch inputs and Apple keys). Reading addresses \$C064 and \$C065 is the same as on all other Apple II series computers (analog inputs 0 and 1).

On the Apple IIc, address \$C063 bit 7 is 1 if the mouse switch is not pressed, and 0 if it is pressed, so that software looking for the *shift-key mod* (used on Apple II, II Plus, and IIe with some text cards) will *find* it and display lowercase correctly. If by chance the mouse button is pressed when the software checks location \$C063, it will appear that the shift-key mod is not present.

On the Apple IIc, address \$C060 is used for reading the state of the 80/40 switch; on the Apple II, II Plus, and IIe, this address is for reading cassette input.

The Apple IIc has two, rather than four, analog (*paddle*) inputs. Addresses \$C066 and \$C067 are used for reading the mouse X and Y direction bits.

---

#### **\$C070 to \$C07F**

On the Apple II, II Plus, and IIe, reading from or writing to any address of the form \$C07x triggered the (analog input) paddle timers.

On the Apple IIc, only address \$C070 is to be used for that one function. Addresses \$C071 through \$C07D are explicitly reserved. The results of reading from or writing to addresses \$C07E and \$C07F are described in Table 5-8.

---

#### **\$C080 to \$C08F**

On the Apple IIe and IIc, accessing addresses in this range selects different combinations of bank-switched memory banks. However, addresses \$C084 through \$C087 duplicate the functions of the four addresses preceding them, and addresses \$C08C through \$C08F do also. These eight addresses are explicitly reserved on the Apple IIc.

---

#### **\$C090 to \$C0FF**

On the Apple II, II Plus, and IIe, each group of 16 addresses of the form \$C080 + \$s0 is allocated to an interface card (if present) in slot s.

On the Apple IIc, addresses corresponding to slots 1, 2, 3, 4 and 6 are allocated to a serial interface card, communication interface card, 80-column text card, mouse interface card, and disk controller card, respectively. All other addresses in this range are reserved.

---

### **F.2.5 Monitors**

The older models of the Apple II and Apple II Plus included a different version of the System Monitor from the one built into more recent models (and the Apple IIe and IIc). The older version, called the Monitor ROM, had the same standard I/O subroutines as the newer Autostart ROM, but a few of their features were different; for example, there were no arrow keys for vertical cursor motion.

When you start the Apple IIc with a DOS or BASICS disk and it loads Integer BASIC into the bank-switched area in RAM, it loads the old Monitor along with it. When you type INT from Applesoft to activate Integer BASIC, you also activate this copy of the old Monitor, which remains active until you either type FP to switch back to Applesoft, which uses the new Monitor in ROM, or activate the 80-column firmware.

## **F.3 I/O in General**

Apple IIc I/O is different from I/O on the Apple II, II Plus, and IIe in three important respects: the possibility of direct memory access (DMA) transfers, the presence or absence of slots, and the presence or absence of built-in interrupt handling.

### **F.3.1 DMA Transfers**

The Apple II, II Plus, and IIe allow DMA transfers, because both the address and the data bus are available at the slots. No true DMA transfer is possible with the Apple IIc because neither bus is available at any of the back-panel connectors.

### **F.3.2 Slots Versus Ports**

The Apple II and II Plus have eight identical slots; the Apple IIe has seven identical slots plus a 60-pin auxiliary slot for video, add-on memory and test cards. The Apple IIc has no slots; instead, it has built-in hardware and firmware that are functional equivalents of slots with cards in them (and back-panel connectors). These are called **ports** on the Apple IIc.

### **F.3.3 Interrupts**

Interrupts on the Apple IIc are described in Appendix E.

The Apple IIc is the first computer in the Apple II Series to have built-in interrupt-handling capabilities.

## F.4 Keyboard

Both keyboard layout and character sets vary in the Apple II series computers. The major keyboard difference in the Apple II Series is that the Apple IIe and IIc have full ASCII keyboards, while the Apple II and II Plus do not.

### F.4.1 Keys

The Apple II and II Plus have identical 52-key keyboards. The Apple IIe and Apple IIc keyboards have the same 63-key full ASCII keyboard layout, with new and repositioned keys and characters as compared to the Apple II and II Plus. While the Apple II and II Plus have a **REPT** key, the IIe and IIc have an auto-repeat feature built into each character key.

Some Apple II and Apple II Plus machines have a slide switch inside the case, under the keyboard edge of the cover, for selecting whether or not **RESET** works without **CONTROL**. On the Apple IIe and Apple IIc, there is no choice: **CONTROL**-**RESET** works, and **RESET** alone does not.

The Apple IIc and IIe have an  and a  key; the Apple II and II Plus do not have these two keys.

The captions on several keys—**ESC**, **TAB**, **CONTROL**, **SHIFT**, **CAPS-LOCK**, **DELETE**, **RETURN**, and **RESET**—can vary: on the Apple II and II Plus some are abbreviated or missing; on the Apple IIc all keycaps are lowercase italic; on international models, some captions are replaced by symbols (Appendix G).

The Apple IIc has two switches that the other models do not have. One switch is for changing between 40-column and 80-column display, the other is for selecting keyboard layout (Sholes versus Dvorak on USA models), or both keyboard layout and character set (on international models).

The position of the power-on light differs on the Apple II and II Plus, Apple IIe, and Apple IIc. The Apple IIc has a disk-use light as well.

---

#### F.4.2 Character Sets

The Apple II and II Plus keyboard character sets are the same. They are described in the *Apple II Reference Manual*.

The Apple IIe and Apple IIc keyboard character sets are the same: full ASCII. The standard (Sholes) layout and key assignments are described in the *Apple IIe Reference Manual*. The Dvorak layout and key assignments are described in Chapter 4 and Appendix G of this manual.

To change between the two available keyboard layouts requires modification to the main logic board on the Apple IIe, but only toggling of the keyboard switch on the Apple IIc.

Apple Computer, Inc. manufactures fully localized models (power supply and character sets) of both the Apple IIe and the Apple IIc. However, there are minor variations in keyboard layout, even among early and late production models of the same machine. For further details, refer to Appendix G of this manual or to the *Apple IIe Supplement to the Owner's Manual*.

## **F.5 Speaker**

The Apple IIc has two speaker features that the three previous models do not have. They are a two-channel, but monaural, mini-phone jack for headphones—which disconnects the internal speaker when something is plugged into it—and a volume control.

## **F.6 Video Display**

This section discusses the general differences between Apple IIc video display capabilities and those of the other computers in the series. Note however that as new ROMs become available for the Apple IIe, many differences between these two machines will vanish.

### **F.6.1 Character Sets**

The Apple II and II Plus display only uppercase characters, but they display them in three ways: normal, inverse, and flashing. The Apple IIc and IIe can display uppercase characters in all three ways, and they can display lowercase characters in the normal way. This combination is called the **primary character set**.

The Apple IIc and IIe have another character set, called the **alternate character set**, that displays a full set of normal and inverse uppercase and lowercase characters, but can't display flashing characters. The primary and alternate character sets are described in Chapter 5. You can switch character sets at any time by means of the ALTCHAR soft switch, also described in Chapter 5.

Flashing display must not be used with the enhanced video firmware active. Use it in 40-column mode with the enhanced video firmware turned off; otherwise, strange displays may result, such as MouseText characters appearing in place of uppercase letters.

To be compatible with some software, you have to switch the Apple IIc keyboard to uppercase by pressing **CAPS LOCK**.

---

### **F.6.2 MouseText**

MouseText characters (Chapter 5) are available on every Apple IIc, and on any Apple IIe that has had its ROMs appropriately upgraded, if necessary.

---

### **F.6.3 Vertical Blanking**

A signal called **vertical blanking** indicates when a display device should stop projecting dots until the display mechanism returns from the bottom of the screen to the top to make another pass. During this interval, a program can make changes to display memory pages, and thus provide a smooth, flicker-free transition to a new display.

On the Apple IIe, vertical blanking (VBL) is a signal whose level must be polled. (VBL is not available to software on the Apple II or II Plus.) On the Apple IIc, vertical blanking is an interrupt (VBLINT) that occurs on the trailing edge of the active-low VBL signal. Programs intended to run on all Apple II series computers must take this difference into account.

---

### **F.6.4 Display Modes**

All models have 40-column text mode, low-resolution graphics mode, high-resolution graphics mode, and mixed graphics and text modes. The Apple IIe (revision B motherboard) with an Apple Extended 80-Column Text Card, and the Apple IIc have double-high-resolution graphics mode also.

## **F.7 Disk I/O**

The Apple II, II Plus, and IIe can support up to six (four is the recommended maximum) disk drives attached in controller cards plugged into slots 6, 5, and 4. The Apple IIc supports up to two disk drives: its built-in drive (treated as slot 6 drive 1), and one external disk drive (treated as slot 6 drive 2; also treated as slot 7 drive 1 under ProDOS) for external-drive startup purposes.

## **F.8 Serial I/O**

The Apple IIc serial ports (ports 1 and 2) are similar to Super Serial Cards installed in slots 1 and 2 of an Apple IIe. The serial port commands are a slightly modified subset of Super Serial Card commands. This subset includes all the commands supported by the earlier Apple Serial Interface Card and Communication Card.

### **F.8.1 Serial Ports Versus Serial Cards**

There are several important differences between Apple IIc serial ports and other Apple II series computers with serial cards installed in them.

Apple IIc serial ports have no switches. Instead, initial values are moved from firmware locations into auxiliary memory when the power is turned on. Changes made to these values in auxiliary memory remain in effect until the power is turned off. Pressing **(Ô)-(CONTROL)-(RESET)** does not change them.

When the port itself is turned on (with an IN or PR command), the initial values in auxiliary memory are placed in the main memory screen holes assigned to the port. These characteristics can be changed by the port commands. The changed characteristics remain in effect until the port is turned off and then on again (with PR and IN commands).

The command syntax for the Apple IIc ports also differs from the syntax for serial cards. A separate command character, **CONTROL-A** or **CONTROL-I**, must precede each individual port command, whereas several commands to a serial card can be strung together between the command character and a carriage return character.

The letters used for some of the commands have been changed from those used with the Super Serial Card (such as *S* instead of *B* for sending a BREAK signal). Each serial port command letter is unique to simplify command interpretation.

Changing the command character from CONTROL-A to CONTROL-I, or vice versa, makes the Super Serial Card change from communication mode to printer mode and back; this is not the case with Apple IIc serial ports. With the Apple IIc, use the *System Utilities Disk* to change modes.

Super Serial Card commands support several functions that Apple IIc serial port commands don't support: masking incoming line feed after carriage return; translating incoming characters, such as changing lowercase to uppercase (for the benefit of the Apple II or II Plus); delaying after sending carriage return, line feed, or form feed; ignoring keyboard input, and so on.

Following a CONTROL-I nnnN command, the Apple IIc automatically generates carriage return after nnn characters; with the Super Serial Card, you need to turn this on with CONTROL-I C.

---

### F.8.2 Serial I/O Buffers

The communication port firmware uses auxiliary memory page 8 as an input and output buffer. By doing so, the firmware can keep up with higher baud rates. It can also *hide* data from the Monitor, Applesoft, and other system software.

Programs written for the Apple IIe or IIc can, of course, store information in auxiliary memory page 8. However, such information will be destroyed when the communication port is activated.

## **F.9 Mouse and Hand Controls**

The DB-9 back-panel connector on the Apple IIc is used for both the mouse and hand controls. On the Apple IIc, the DB-9 connector supports hand controls only. On the Apple IIe, the mouse must use the connector on the interface card.

### **F.9.1 Mouse Input**

The Apple IIc provides built-in firmware support for a mouse connected to the DB-9 mouse and hand control connector. Apple IIc mouse support includes mouse movement and button interrupts (and vertical blanking interrupts for synchronization with the display); Apple IIe mouse support relies on polling VBL instead of vertical blanking interrupts.

As a result of how interrupts are handled on the two machines, the mouse firmware routine calls function somewhat differently for the Apple IIc and Apple IIe. However, using the calls in the manner described in Chapter 9 ensures mouse support compatibility between the two machines.

The ratio of mouse movement to cursor movement is different on the Apple IIc than it is on the Apple IIe.

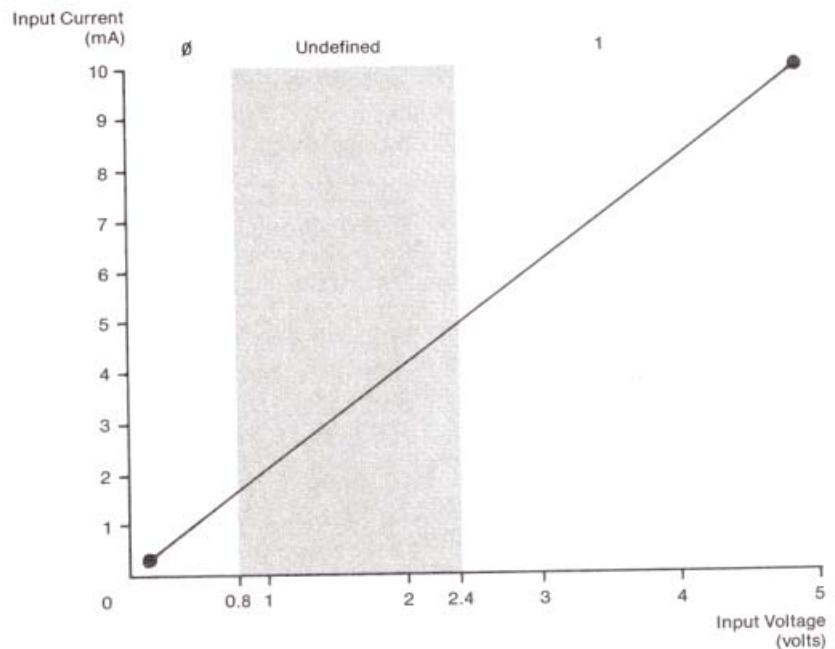
### **F.9.2 Hand Control Input and Output**

The Apple II, II Plus, and IIe have a 16-pin game I/O connector inside the case that supports three switch inputs, four analog (paddle) inputs, and four annunciator outputs. The Apple IIe and Apple IIc have a DB-9 back-panel connector that supports the three switch inputs and two paddle inputs (plus two more on the internal GAME I/O connector of the Apple II, II Plus, and IIe).

The Apple IIc does not support the four annunciator outputs.

The voltage-current curve for hand controls differs for the Apple IIc compared with that of the Apple II, II Plus, and IIe. Compare Figure F-1 with Figure 11-42. This was done so the hardware would support identifiable mouse and hand control signals using the same circuits.

**Figure F-1.** Apple II, II Plus, and Ile Hand Control Signals



The paddle timing circuit on the Apple II Plus is slightly different than the one on the Apple Ile and IIC. On the Apple Ile and IIC the 100 ohm fixed resistor is between the NE556 discharge lead and the capacitor; the variable resistor in the paddle is connected directly to the capacitor. On the Apple II Plus, the capacitor is connected directly to the discharge lead, and the fixed resistor is in series with the paddle resistor.

## F.10 Cassette I/O

The Apple II, II Plus, and Ile all have cassette input and output jacks, memory locations, and monitor support. The Apple IIC does not.

## **F.11 Hardware**

---

Besides the different microprocessors used in various models in the Apple II series (section F.1.1), there are important differences in power specifications and custom chips.

---

### **F.11.1 Power**

The power supplies for the Apple II, II Plus, and IIe are essentially the same. The floor transformer and voltage converter for the Apple IIC have smaller capacity for current and heat dissipation. Therefore, it is important to observe the load limits specified in each of the reference manuals.

---

### **F.11.2 Custom Chips**

The Apple IIe custom chips (Memory Management Unit and Input/Output Unit) replaced dozens of Apple II Plus chips, and added the functionality of dozens more. The Apple IIC has custom MMU and IOU chips, too, but they represent different *bonding options*, and so their pin assignments are not compatible.

In addition, the Apple IIC has a custom General Logic Unit (GLU), Timing Generator (TMG), and Disk Controller Unit (IWM). The Apple IIC has two hybrid units (AUD and VID) for audio and video amplification.

# *USA and International Models*



This appendix repeats some of the keyboard information given in Chapter 4 for the two USA keyboard layouts for easy comparison with the other layouts available. Following these there is a composite table of the ASCII codes and the characters associated with them on all the models discussed.

## G.1 Keyboard Layouts and Codes

Each of the following subsections has a keyboard illustration and a table of the codes that result from the possible keystrokes. Note, however, that Table G-1 is the basic table of keystrokes and their codes. For simplicity, subsequent tables (up to Table G-6) list only the keystrokes and codes that differ from those in Table G-1.

For example, pressing the **A** key produces *a* (hexadecimal 61); pressing **[SHIFT]-A** produces uppercase *A* (hexadecimal 41); pressing **[CONTROL]-A** or **[CONTROL]-[SHIFT]-A** produces *SOH* (the ASCII Start Of Header control character, hexadecimal 01). You can tell that this key has the same effect on all keyboards, from the fact that nothing appears in Tables G-2 through G-7 for that key.

A quick way to find out which characters in the ASCII set change on international keyboards is to check Table G-7. In fact, only a few of them change. The pairing of characters on keys varies more.

**Note:** On all but the French and Italian keyboards, **CAPS-LOCK** affects only keys that can produce both lowercase letters (with or without an accent) and their uppercase equivalents. With these keys, **CAPS-LOCK** down is equivalent to holding down **SHIFT**, resulting in uppercase instead of lowercase. If a key produces only a lowercase version of an accented letter, then **CAPS-LOCK** does not affect it.

On the French and Italian keyboards, **CAPS-LOCK** shifts all the keys. Furthermore, on the French keyboard, when **CAPS-LOCK** is down, the **SHIFT** key undoes the shifting.

**Note:** The shapes and arrangement of keys in Figures G-1 and G-2 follow the ANSI (American National Standards Institute) standard, which is used mainly in North and South America. The shapes and arrangement of keys in Figure G-3 follows the ISO (International Standards Organization) standard used in Europe and elsewhere.

The only differences between the ANSI and ISO versions of the USA keyboard are

- The shapes of three keys: the left **SHIFT** key, **CAPS-LOCK**, and **RETURN**.
- The resulting repositioning of two keys (**①** and **□**) in Figures G-1 and G-3.
- For some countries, there are arrow symbols on **TAB**, **CAPS-LOCK**, **RETURN**, and the two **SHIFT** keys (as shown in Figure G-3).

---

### G.1.1 USA Standard (Sholes) Keyboard

Figure G-1 shows the Standard (Sholes) keyboard as it is laid out for USA models of the Apple IIc with the keyboard switch up. Table G-1 lists the ASCII codes resulting from all simple and combination keystrokes on this keyboard.

Figure G-1. USA Standard or Sholes Keyboard (Keyboard Switch Up)



**Table G-1.** Keys and ASCII Codes. Codes are shown here in hexadecimal; to find the decimal equivalents, use Table G-7.

Key	Key Alone Hex	Char	CONTROL + Key Hex	Char	SHIFT + Key Hex	Char	Both + Key Hex	Char
DELETE	7F	DEL	7F	DEL	7F	DEL	7F	DEL
-	08	BS	08	BS	08	BS	08	BS
TAB	09	HT	09	HT	09	HT	09	HT
0	0A	LF	0A	LF	0A	LF	0A	LF
0	0B	VT	0B	VT	0B	VT	0B	VT
RETURN	0D	CR	0D	CR	0D	CR	0D	CR
0	15	NAK	15	NAK	15	NAK	15	NAK
ESC	1B	ESC	1B	ESC	1B	ESC	1B	ESC
SPACE	20	SP	20	SP	20	SP	20	SP
"	27	'	27	'	22	"	22	"
,<	2C	,	2C	,	3C	<	3C	<
-	2D	-	1F	US	5F	-	1F	US
:>	2E	.	2E	.	3E	>	3E	>
/?	2F	/	2F	/	3F	?	3F	?
0)	30	0	30	0	29	)	29	)
1!	31	1	31	1	21	!	21	!
2@	32	2	00	NUL	40	@	00	NUL
3#	33	3	33	3	23	#	23	#
4\$	34	4	34	4	24	\$	24	\$
5%	35	5	35	5	25	%	25	%
6^	36	6	1E	RS	5E	,	1E	RS
7&	37	7	37	7	26	&	26	&
8*	38	8	38	8	2A	*	2A	*
9(	39	9	39	9	28	(	28	(
::	3B	:	3B	:	3A	:	3A	:
=+	3D	=	3D	=	2B	+	2B	+
[	5B	[	1B	ESC	7B	-	1B	ESC
\	5C	\	1C	FS	7C	-	1C	FS
]	5D	]	1D	GS	7D	-	1D	GS
	60		60		7E		7E	

**Table G-1—Continued.** Keys and ASCII Codes. Codes are shown here in hexadecimal; to find the decimal equivalents, use Table G-7.

Key	Key Alone Hex	Char	CONTROL + Key Hex	Char	SHIFT + Key Hex	Char	Both + Key Hex	Char
A	61	a	01	SOH	41	A	01	SOH
B	62	b	02	STX	42	B	02	STX
C	63	c	03	ETX	43	C	03	ETX
D	64	d	04	EOT	44	D	04	EOT
E	65	e	05	ENQ	45	E	05	ENQ
F	66	f	06	ACK	46	F	06	ACK
G	67	g	07	BEL	47	G	07	BEL
H	68	h	08	BS	48	H	08	BS
I	69	i	09	HT	49	I	09	HT
J	6A	j	0A	LF	4A	J	0A	LF
K	6B	k	0B	VT	4B	K	0B	VT
L	6C	l	0C	FF	4C	L	0C	FF
M	6D	m	0D	CR	4D	M	0D	CR
N	6E	n	0E	SO	4E	N	0E	SO
O	6F	o	0F	SI	4F	O	0F	SI
P	70	p	10	DLE	50	P	10	DLE
Q	71	q	11	DC1	51	Q	11	DC1
R	72	r	12	DC2	52	R	12	DC2
S	73	s	13	DC3	53	S	13	DC3
T	74	t	14	DC4	54	T	14	DC4
U	75	u	15	NAK	55	U	15	NAK
V	76	v	16	SYN	56	V	16	SYN
W	77	w	17	ETB	57	W	17	ETB
X	78	x	18	CAN	58	X	18	CAN
Y	79	y	19	EM	59	Y	19	EM
Z	7A	z	1A	SUB	5A	Z	1A	SUB

### G.1.2 USA Simplified (Dvorak) Keyboard

Figure G-2 shows the Dvorak layout of the USA keyboard. Characters are paired up on keys in exactly the same way as on the USA Standard keyboard; only individual key positions are changed. In fact, you can change the keycap arrangement to match Figure G-2, lock the keyboard switch in its down position, and have a working Dvorak keyboard. All keystrokes produce the same ASCII codes as those shown in Table G-1.

Figure G.2. USA Simplified or Dvorak Keyboard (Keyboard Switch Down)



### G.1.3 ISO Layout of USA Keyboard

Figure G-3 shows the layout of the keyboard of all ISO European keyboards (except the Italian keyboard) when the keyboard switch is up. All keystrokes produce the same ASCII codes as those shown in Table G-1.

Figure G-3. ISO Version of USA Standard Keyboard (Keyboard Switch Up)



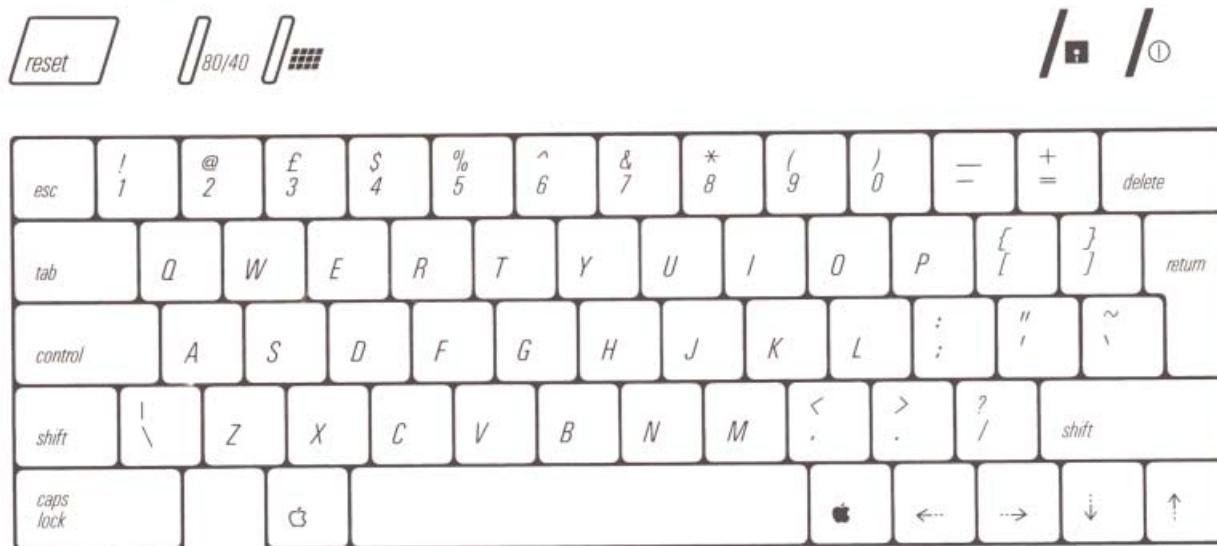
### G.1.4 English Keyboard

With the keyboard switch up, the English model of the Apple IIc keyboard layout is as shown in Figure G-3, and keystrokes produce the ASCII codes shown in Table G-1.

With the keyboard switch down, the English model keyboard layout is as shown in Figure G-4. The change in ASCII code production (from that in Table G-1) is shown in Table G-2.

The only changed character is the substitution of the British pound-sterling symbol (£) for the cross-hatch symbol (#) on the shifted 3-key.

**Figure G-4.** English Keyboard (Keyboard Switch Down)



**Table G-2.** English Keyboard Code Differences From Table G-1

Key	Key Alone Hex	Char	CONTROL Hex	+ Key Char	SHIFT + Key Hex	Char	Both + Key Hex	Char
3£	33	3	33	3	23	£	23	#

### G.1.5 French and Canadian Keyboards

With the keyboard switch up, the French model of the Apple IIc keyboard layout is as shown in Figure G-3, and the Canadian is as shown in Figure G-1. On both models, keystrokes produce the ASCII codes shown in Table G-1.

**Note:** On the French keyboard, (CAPS-LOCK) shifts to the upper characters on all keys. With (CAPS-LOCK) on, (SHIFT) "unshifts" to the lower character on any key pressed with it.

With the keyboard switch down, the French model keyboard layout is as shown in Figure G-5, and the Canadian model keyboard layout is as shown in Figure G-6. The changes in ASCII code production (from that in Table G-1) are shown in Table G-3.

Figure G-5. French Keyboard (Keyboard Switch Down)



**Figure G-6.** Canadian Keyboard (Keyboard Switch Down)



**Table G-3.** French and Canadian Keyboard Code Differences From Table G-1

Key	Key Alone Hex	Char	CONTROL Hex	+ Key Char	SHIFT + Key Hex	Char	Both + Key Hex	Char
&1	26	&	26	&	31	1	31	1
é2	7B	é	7B	é	32	2	32	2
"3	22	"	22	"	33	3	33	3
'4	27	'	27	'	34	4	34	4
(5	28	(	28	(	35	5	35	5
§6	5D	§	1D	GS	36	6	1D	GS
è7	7D	è	7D	è	37	7	37	7
!8	21	!	21	!	38	8	38	8
ç9	5C	ç	1C	FS	39	9	1C	FS
à0	40	à	00	NUL	30	0	00	NUL
)°	29	)	1B	ESC	5B	°	1B	ESC
-	5E	-	1E	RS	7E	-	1E	RS
\$*	24	\$	24	\$	2A	*	2A	*
ú%	7C	ú	7C	ú	25	%	25	%
£	60	,	60	,	23	£	23	£
<>	3C	<	3C	<	3E	>	3E	>
,?	2C	,	2C	,	3F	?	3F	?
;	3B	;	3B	;	2E	,	2E	,
:/	3A	:	3A	:	2F	/	2F	/

### G.1.6 German Keyboard

With the keyboard switch up, the German model of the Apple IIc keyboard layout is as shown in Figure G-3, and keystrokes produce the ASCII codes shown in Table G-1.

With the keyboard switch down, the German model keyboard layout is as shown in Figure G-7. The change in ASCII code production (from that in Table G-1) is shown in Table G-4.

Figure G-7. German Keyboard (Keyboard Switch Down)

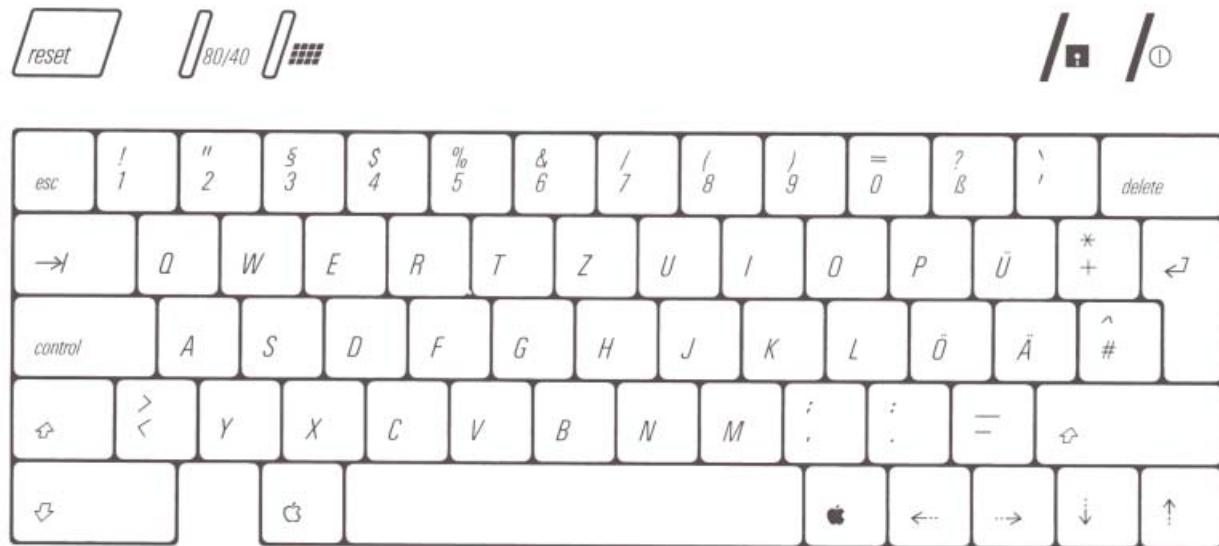


Table G-4. German Keyboard Code Differences From Table G-1

Key	Key Alone Hex	Char	CONTROL + Key Hex	Char	SHIFT + Key Hex	Char	Both + Key Hex	Char
2"	32	2	32	2	22	"	22	"
3§	33	3	00	NUL	40	§	00	NUL
6&	36	6	36	6	26	&	26	&
7/	37	7	37	7	2F	/	2F	/
8(	38	8	38	8	28	(	28	(
9)	39	9	39	9	29	)	29	)
0=	30	0	30	0	3D	=	3D	=
ß?	7E	ß	7E	ß	3F	?	3F	?
Ü	7D	Ü	1D	GS	5D	Ü	1D	GS
+	2B	+	2B	+	2A	*	2A	*
Ö	7C	ö	1C	FS	5C	ö	1C	FS
Ä	7B	ä	1B	ESC	5B	ä	1B	ESC
#*	23	#	1E	RS	5E	*	1E	RS
<>	3C	<	3C	<	3E	>	3E	>
:	2C	:	2C	:	3B	:	3B	:
::	2E	::	2E	::	3A	::	3A	::

### G.1.7 Italian Keyboard

With the keyboard switch down, the Italian model keyboard layout is as shown in Figure G-8. The change in ASCII code production (from that in Table G-1) is shown in Table G-5.

With the keyboard switch up, the Italian model keyboard produces exactly the same ASCII codes for each key, but what is displayed differs for the ten characters shown in Table G-5 or Table G-7.

Figure G-8. Italian Keyboard (Keyboard Switch Down)



**Table G-5.** Italian Keyboard Code Differences From Table G-1

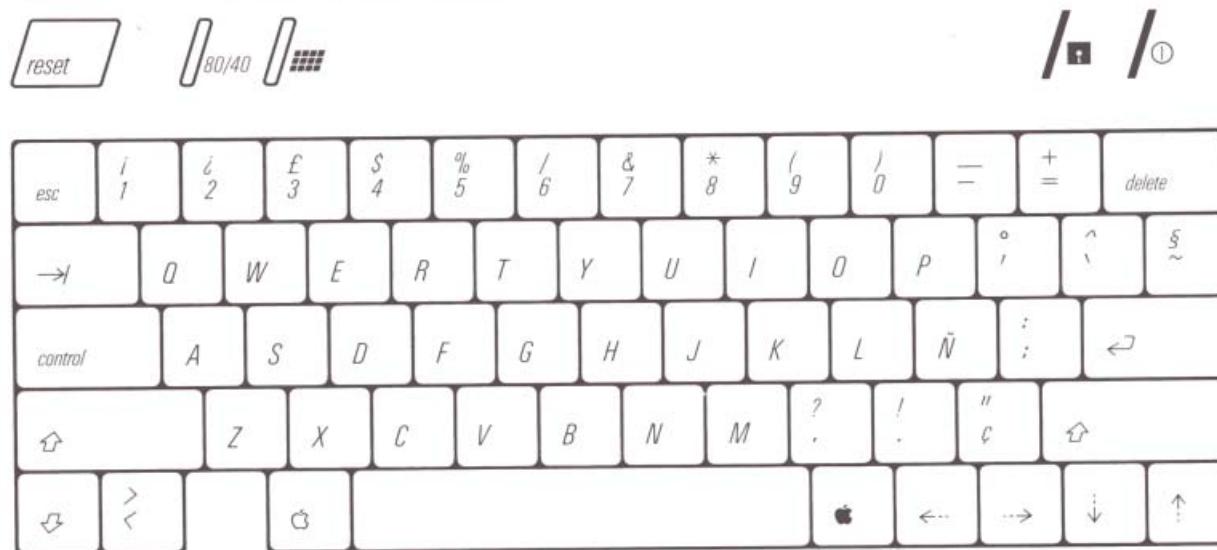
Key	Key Alone Hex	Char	CONTROL + Key Hex	Char	SHIFT + Key Hex	Char	Both + Key Hex	Char
&1	26	&	26	&	31	1	31	1
"2	22	"	22	"	32	2	32	2
'3	27	'	27	'	33	3	33	3
(4	28	(	28	(	34	4	34	4
ç5	5C	ç	1C	FS	35	5	1C	FS
è6	7D	è	7D	è	36	6	36	6
)7	29	)	29	)	37	7	37	7
£8	23	£	23	£	38	8	38	8
à9	7B	à	7B	à	39	9	39	9
é0	5D	é	1D	GS	30	0	1D	GS
í^	7E	í	1E	RS	5E	^	1E	RS
\$*	24	\$	24	\$	2A	*	2A	*
ù%	60	ù	60	ù	25	%	25	%
§°	40	§	00	NUL	5B	°	1B	ESC
<>	3C	<	3C	<	3E	>	3E	>
,?	2C	,	2C	,	3F	?	3F	?
;	3B	;	3B	;	2E	-	2E	-
:/	3A	:	3A	:	2F	/	2F	/
ò!	7C	ò	7C	ò	21	!	21	!

### G.1.8 Western Spanish Keyboard

With the keyboard switch up, the Western (that is, American) Spanish model of the IIc keyboard layout is as shown in Figure G-1, and keystrokes produce the ASCII codes shown in Table G-1.

With the keyboard switch down, the Western Spanish model keyboard layout is as shown in Figure G-9. The change in ASCII code production (from that in Table G-1) is shown in Table G-6.

**Figure G-9. Western Spanish Keyboard (Keyboard Switch Down)**



**Table G-6. Western Spanish Keyboard Code Differences From Table G-1**

Key	Key Alone Hex	Char	CONTROL Hex	Key Char	SHIFT + Key Hex	Char	Both + Key Hex	Char
2"	32	2	32	2	22	"	22	"
3£	33	3	33	3	23	£	23	£
6&	36	6	00	NUL	26	&	00	NUL
7/	37	7	37	7	2F	/	2F	/
8(	38	8	38	8	28	(	28	(
9)	39	9	39	9	29	)	29	)
0=	30	0	30	0	3D	=	3D	=
'?	27	'	27	'	3F	?	3F	?
'£	60	'	60	'	5D	£	5D	£
-'	7E	-	1E	RS	5E	^	1E	RS
+'*	2B	+	1B	ESC	2A	*	1B	ESC
Ñ	7C	Ñ	1C	FS	5C	Ñ	1C	FS
çí	7D	ç	7D	ç	5B	í	5B	í
°§	7B	°	00	NUL	40	§	00	NUL
<>	3C	<	1E	RS	3E	>	1E	RS
:	2C	:	2C	:	3B	:	3B	:
::	2E	::	2E	::	3A	::	3A	::

## **G.2 ASCII Character Sets**

Table G-7 lists the ASCII (American National Standard Code for Information Interchange) codes that the Apple IIc uses, as well as the decimal and hexadecimal equivalents. Where there are differences between character sets, a circled number in the main table refers to a column in the lower part of the table.

*Table G-7. ASCII Code Equivalents*

ASCII	DEC	HEX									
NUL	00	00	SP	32	20	•②	64	40	•⑦	96	60
SOH	01	01	!	33	21	A	65	41	a	97	61
STX	02	02	"	34	22	B	66	42	b	98	62
ETX	03	03	•⑧	35	23	C	67	43	c	99	63
EOT	04	04	•①	36	24	D	68	44	d	100	64
ENQ	05	05	%	37	25	E	69	45	e	101	65
ACK	06	06	&	38	26	F	70	46	f	102	66
BEL	07	07	'	39	27	G	71	47	g	103	67
BS	08	08	(	40	28	H	72	48	h	104	68
HT	09	09	)	41	29	I	73	49	i	105	69
LF	10	0A	*	42	2A	J	74	4A	j	106	6A
VT	11	0B	+	43	2B	K	75	4B	k	107	6B
FF	12	0C	,	44	2C	L	76	4C	l	108	6C
CR	13	0D	-	45	2D	M	77	4D	m	109	6D
SO	14	0E	.	46	2E	N	78	4E	n	110	6E
SI	15	0F	/	47	2F	O	79	4F	o	111	6F
DLE	16	10	0	48	30	P	80	50	p	112	70
DC1	17	11	1	49	31	Q	81	51	q	113	71
DC2	18	12	2	50	32	R	82	52	r	114	72
DC3	19	13	3	51	33	S	83	53	s	115	73
DC4	20	14	4	52	34	T	84	54	t	116	74
NAK	21	15	5	53	35	U	85	55	u	117	75
SYN	22	16	6	54	36	V	86	56	v	118	76
ETB	23	17	7	55	37	W	87	57	w	119	77
CAN	24	18	8	56	38	X	88	58	x	120	78
EM	25	19	9	57	39	Y	89	59	y	121	79
SUB	26	1A	:	58	3A	Z	90	5A	z	122	7A
ESC	27	1B	;	59	3B	•③	91	5B	•⑧	123	7B
FS	28	1C	<	60	3C	•④	92	5C	•⑨	124	7C
GS	29	1D	=	61	3D	•⑤	93	5D	•⑩	125	7D
RS	30	1E	>	62	3E	•⑥	94	5E	•⑪	126	7E
US	31	1F	?	63	3F	—	95	5F	DEL	127	7F

	•	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪
Hexadecimal	23	24	40	5B	5C	5D	5E	60	7B	7C	7D	7E
English (USA)	#	\$	@	[	\	]	^	~	{		}	-
English (UK)	£	\$	@	[	\	]	^	~	{		}	-
Deutsch	#	\$	§	Ä	Ö	Ü	“	”	ä	ö	ü	ß
Français	£	\$	à	°	ç	§	“	”	é	ù	è	”
Italiano	£	\$	§	°	ç	é	“	”	ù	à	ò	è
Españolo	£	\$	§	í	Ñ	¿	“	”	º	ñ	ç	”

## **G.3 Certifications**

In the countries where they are applicable, these certifications replace the USA FCC Class B notice printed on the inside front cover of this manual. The safety instructions apply to all countries.

### ***G.3.1 Radio Interference***

This product is designed to comply with specification VDE 0871/6.78, Radio Frequency Interference Suppression of Radio Frequency Equipment, Level B.

### ***G.3.2 Product Safety***

This product is designed to meet the requirements of safety standard IEC 380, Safety of Electrically Energized Office Machines.

### ***G.3.3 Important Safety Instructions***

This equipment is intended to be electrically grounded. This product is equipped with a plug having a third (grounding) pin. This plug will fit only into a grounding-type alternating current outlet. This is a safety feature.

If you are unable to insert the plug into the outlet, contact a licensed electrician to replace the outlet and, if necessary, install a grounding conductor.

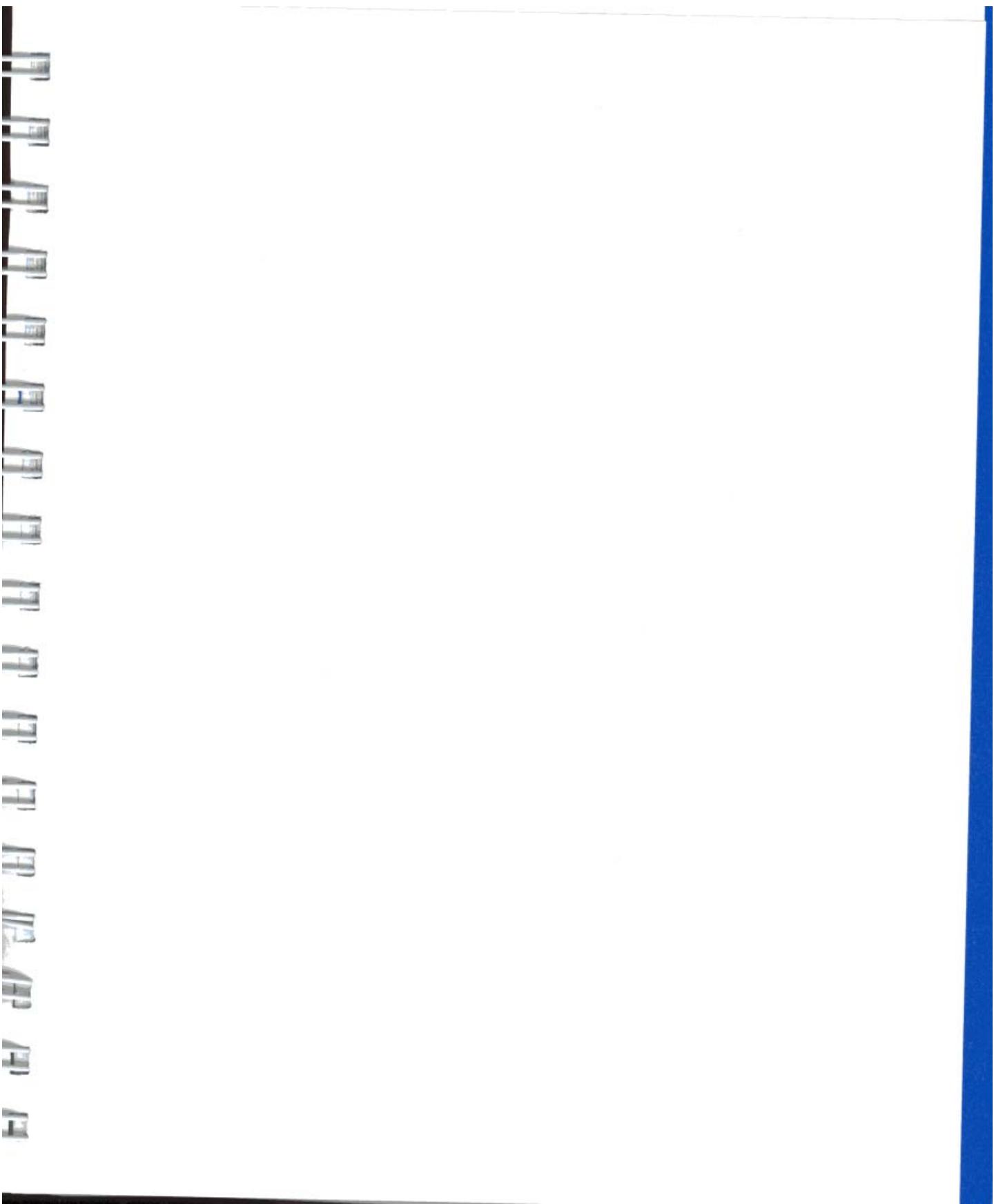
Do not defeat the purpose of the grounding-type plug.

## G.4 Power Supply Specifications

The basic specifications of the power supply furnished with the Apple IIc for use in Europe and other countries having 50 Hz alternating current are shown in Table G-8.

*Table G-8. 50 Hz Power Supply Specifications*

<b>Line voltage</b>	199 to 255 VAC, 50 Hz
<b>Maximum input power consumption</b>	25 W
<b>Supply voltage</b>	+15 V DC (nominal)
<b>Supply current</b>	1.2 A (nominal)



# *Conversion Tables*

This appendix briefly discusses bits and bytes and what they can represent. It also contains conversion tables for hexadecimal to decimal and negative decimal, for low-resolution display dot patterns, display color values, and a number of 8-bit codes.

These tables are intended for convenient reference. This appendix is not intended as a tutorial for the materials discussed. The brief section introductions are for orientation only.

## H.1 Bits and Bytes

This section discusses the relationships between bit values and their position within a byte. The following are some rules of thumb regarding the 65C02.

- A bit is a binary digit; it can be either a 0 or a 1.
- A bit can be used to represent any two-way choice. Some choices that a bit can represent in the Apple IIc are listed in Table H-1.

**Table H-1. What a Bit Can Represent**

Context	Representing	0 =	1 =
Binary number Logic	Place value Condition	0 False	1 x that power of 2 True
Any switch	Position	Off	On
Any switch	Position	Clear†	Set
Serial transfer	Beginning	Start	Carrier (no information yet)
Serial transfer	Data	0 value	1 value
Serial transfer	Parity	SPACE	MARK
Serial transfer	End		Stop bit(s)
Serial transfer	Communication state	BREAK	Carrier
P reg. bit N	Neg. result?	No	Yes
P reg. bit V	Overflow?	No	Yes
P reg. bit B	BRK command?	No	Yes
P reg. bit D	Decimal mode?	No	Yes
P reg. bit I	IRQ interrupts	Enabled	Disabled (masked out)
P reg. bit Z	Zero result?	No	Yes
P reg. bit C	Carry required?	No	Yes

† Sometimes ambiguously termed *reset*.

- Bits can also be combined in groups of any size to represent numbers. Most of the commonly used sizes are multiples of four bits.
- Four bits comprise a nibble (sometimes spelled *nybble*).
- One nibble can represent any of 16 values. Each of these values is assigned a number from 0 through 9 and (because our decimal system has only ten of the sixteen digits we need) A through F.
- Eight bits (two nibbles) make a byte (Figure H-1).

Figure H-1. Bits, Nibbles, and Bytes

	High Nibble				Low Nibble				
	MSB 7	6	5	4	3	2	1	LSB 0	
Hexadecimal	\$80	\$40	\$20	\$10	\$08	\$04	\$02	\$01	
Decimal	128	64	32	16	8	4	2	1	
Binary									
0000					\$0				0
0001					\$1				1
0010					\$2				2
0011					\$3				3
0100					\$4				4
0101					\$5				5
0110					\$6				6
0111					\$7				7
1000					\$8				8
1001					\$9				9
1010					\$A				10
1011					\$B				11
1100					\$C				12
1101					\$D				13
1110					\$E				14
1111					\$F				15

- One byte can represent any of  $16 \times 16$  or 256 values. The value can be specified by exactly two hexadecimal digits.
- Bits within a byte are numbered from bit 0 on the right to bit 7 on the left.
- The bit number is the same as the power of 2 that it represents, in a manner completely analogous to the digits in a decimal number.
- One memory position in the Apple IIc contains one eight-bit byte of data.
- How byte values are interpreted depends on whether the byte is an instruction in a language, part or all of an address, an ASCII code, or some other form of data. Tables H-6 through H-13 list some of the ways bytes are commonly interpreted.

- Two bytes make a word. The sixteen bits of a word can represent any one of  $256 \times 256$  or 65536 different values.
- The 65C02 uses a 16-bit word to represent memory locations. It can therefore distinguish among 65536 (64K) locations at any given time.
- A memory location is one byte of a 256-byte page. The low-order byte of an address specifies this byte. The high-order byte specifies the memory page the byte is on.

## H.2 Hexadecimal and Decimal

Use Table H-2 for conversion of hexadecimal and decimal numbers.

*Table H-2. Hexadecimal/Decimal Conversion*

Digit	\$x000	\$0x00	\$00x0	\$000x
F	61440	3840	240	15
E	57344	3584	224	14
D	53248	3328	208	13
C	49152	3072	192	12
B	45056	2816	176	11
A	40960	2560	160	10
9	36864	2304	144	9
8	32768	2048	128	8
7	28672	1792	112	7
6	24576	1536	96	6
5	20480	1280	80	5
4	16384	1024	64	4
3	12288	768	48	3
2	8192	512	32	2
1	4096	256	16	1

To convert a hexadecimal number to a decimal number, find the decimal numbers corresponding to the positions of each hexadecimal digit. Write them down and add them up.

**Examples:**

\$3C = ?	\$FD47 = ?
\$30 = 48	\$F000 = 61440
\$0C = 12	\$D00 = 3328
-----	\$40 = 64
\$3C = 60	\$7 = 7
	-----
	\$FD47 = 64839

To convert a decimal number to hexadecimal, subtract from the decimal number the largest decimal entry in the table that is less than it. Write down the hexadecimal digit (noting its place value) also. Now subtract the largest decimal number in the table that is less than the decimal remainder, and write down the next hexadecimal digit. Continue until you have zero left. Add up the hexadecimal numbers.

**Example:**

16215	=	\$	?				
16215	-	12288	=	3927	12288	=	\$7000
3927	-	3840	=	87	3840	=	\$F00
87	-	80	=	7	80	=	\$50
				7			7
-----							
				16215	=	\$7F57	

---

### **H.3 Hexadecimal and Negative Decimal**

If a number is larger than decimal 32767, Applesoft BASIC allows and Integer BASIC requires that you use the negative-decimal equivalent of the number. Table H-3 is set up to make it easy for you to convert a hexadecimal number directly to a negative decimal number.

*Table H-3. Decimal to Negative Decimal Conversion*

Digit	\$x000	\$\$0x00	\$\$00x0	\$\$000x
F	0	0	0	-1
E	-4096	-256	-16	-2
D	-8192	-512	-32	-3
C	-12288	-768	-48	-4
B	-16384	-1024	-64	-5
A	-20480	-1280	-80	-6
9	-24576	-1536	-96	-7
8	-28672	-1792	-112	-8
7		-2048	-128	-9
6		-2304	-144	-10
5		-2560	-160	-11
4		-2816	-176	-12
3		-3072	-192	-13
2		-3328	-208	-14
1		-3584	-224	-15
0		-3840	-240	-16

To perform this conversion, write down the four decimal numbers corresponding to the four hexadecimal digits (zeros included). Then add their values (ignoring their signs for a moment). The resulting number, with a minus sign in front of it, is the desired negative decimal number.

**Example:**

```
$C010 = - ?
$C000: -12288
$ 000: - 3840
$   10: -  224
$     0: -   16
-----
$C010 -16368
```

To convert a negative-decimal number directly to a positive decimal number, add it to 65536. (This addition ends up looking like subtraction.)

**Example:**

```
-151 = + ?
65536 + (-151) = 65536 - 151 = 65385
```

To convert a negative-decimal number to a hexadecimal number, first convert it to a positive decimal number, then use Table H-2.

## H.4 Graphics Bits and Pieces

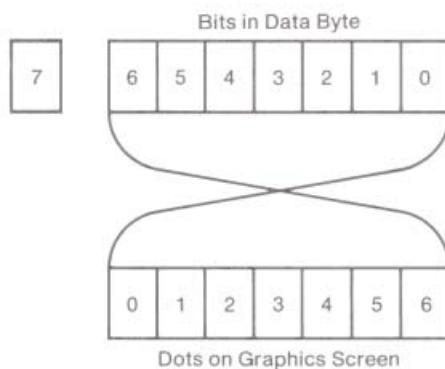
Table H-4 is a quick guide to the hexadecimal values corresponding to 7-bit high-resolution patterns on the display screen. Since the bits are displayed in reverse order, it takes some calculation to determine these values. Table H-4 should make it easy.

The  $x$  represents bit 7. Zeros represent bits that are off; ones bits that are on. Use the first hexadecimal value if bit 7 is to be off, and the second if it is to be on.

For example, to get bit pattern 00101110, use \$3A; for 10101110, use \$BA.

**Table H-4.** Hexadecimal Values for High-Resolution Dot Patterns

Bit pattern	(x=0)	(x=1)
x0000000	\$00	\$80
x0000001	\$40	\$C0
x0000010	\$20	\$A0
x0000011	\$60	\$E0
x0000100	\$10	\$90
x0000101	\$50	\$D0
x0000110	\$30	\$B0
x0000111	\$70	\$F0
x0001000	\$08	\$88
x0001001	\$48	\$C8
x0001010	\$28	\$A8
x0001011	\$68	\$E8
x0001100	\$18	\$98
x0001101	\$58	\$D8
x0001110	\$38	\$B8
x0001111	\$78	\$F8
x0010000	\$04	\$84
x0010001	\$44	\$C4
x0010010	\$24	\$A4
x0010011	\$64	\$E4
x0010100	\$14	\$94
x0010101	\$54	\$D4
x0010110	\$34	\$B4
x0010111	\$74	\$F4
x0011000	\$0C	\$8C
x0011001	\$4C	\$CC
x0011010	\$2C	\$AC
x0011011	\$6C	\$EC
x0011100	\$1C	\$9C
x0011101	\$5C	\$DC
x0011110	\$3C	\$BC
x0011111	\$7C	\$FC



*Table H-4—Continued. Hexadecimal Values for High-Resolution Dot Patterns*

Bit pattern	(x=0)	(x=1)
x0100000	\$02	\$82
x0100001	\$42	\$C2
x0100010	\$22	\$A2
x0100011	\$62	\$E2
x0100100	\$12	\$92
x0100101	\$52	\$D2
x0100110	\$32	\$B2
x0100111	\$72	\$F2
x0101000	\$0A	\$8A
x0101001	\$4A	\$CA
x0101010	\$2A	\$AA
x0101011	\$6A	\$EA
x0101100	\$1A	\$9A
x0101101	\$5A	\$DA
x0101110	\$3A	\$BA
x0101111	\$7A	\$FA
x0110000	\$06	\$86
x0110001	\$46	\$C6
x0110010	\$26	\$A6
x0110011	\$66	\$E6
x0110100	\$16	\$96
x0110101	\$56	\$D6
x0110110	\$36	\$B6
x0110111	\$76	\$F6
x0111000	\$0E	\$8E
x0111001	\$4E	\$CE
x0111010	\$2E	\$AE
x0111011	\$6E	\$EE
x0111100	\$1E	\$9E
x0111101	\$5E	\$DE
x0111110	\$3E	\$BE
x0111111	\$7E	\$FE
x1000000	\$01	\$81
x1000001	\$41	\$C1
x1000010	\$21	\$A1
x1000011	\$61	\$E1
x1000100	\$11	\$91
x1000101	\$51	\$D1
x1000110	\$31	\$B1
x1000111	\$71	\$F1
x1001000	\$09	\$89
x1001001	\$49	\$C9
x1001010	\$29	\$A9
x1001011	\$69	\$E9
x1001100	\$19	\$99
x1001101	\$59	\$D9
x1001110	\$39	\$B9
x1001111	\$79	\$F9

*Table H-4—Continued. Hexadecimal Values for High-Resolution Dot Patterns*

Bit pattern	(x=0)	(x=1)
x1010000	\$05	\$85
x1010001	\$45	\$C5
x1010010	\$25	\$A5
x1010011	\$65	\$E5
x1010100	\$15	\$95
x1010101	\$55	\$D5
x1010110	\$35	\$B5
x1010111	\$75	\$F5
x1011000	\$0D	\$8D
x1011001	\$4D	\$CD
x1011010	\$2D	\$AD
x1011011	\$6D	\$ED
x1011100	\$1D	\$9D
x1011101	\$5D	\$DD
x1011110	\$3D	\$BD
x1011111	\$7D	\$FD
x1100000	\$03	\$83
x1100001	\$43	\$C3
x1100010	\$23	\$A3
x1100011	\$63	\$E3
x1100100	\$13	\$93
x1100101	\$53	\$D3
x1100110	\$33	\$B3
x1100111	\$73	\$F3
x1101000	\$0B	\$8B
x1101001	\$4B	\$CB
x1101010	\$2B	\$AB
x1101011	\$6B	\$EB
x1101100	\$1B	\$9B
x1101101	\$5B	\$DB
x1101110	\$3B	\$BB
x1101111	\$7B	\$FB
x1110000	\$07	\$87
x1110001	\$47	\$C7
x1110010	\$27	\$A7
x1110011	\$67	\$E7
x1110100	\$17	\$97
x1110101	\$57	\$D7
x1110110	\$37	\$B7
x1110111	\$77	\$F7
x1111000	\$0F	\$8F
x1111001	\$4F	\$CF
x1111010	\$2F	\$AF
x1111011	\$6F	\$EF
x1111100	\$1F	\$9F
x1111101	\$5F	\$DF
x1111110	\$3F	\$BF
x1111111	\$7F	\$FF

## H.5 Peripheral Identification Numbers

Many Apple products now use Peripheral Identification Numbers (called **PIN numbers**) as shorthand for serial device characteristics. The Apple II Series *System Utilities Disk* presents a menu from which to select the characteristics of, say, a printer or modem. From the selections made, it generates a PIN for the user. Other products have a ready-made PIN that the user can simply type in.

Table H-5 is a definition of the PIN number digits. When communication mode is selected, the seventh digit is ignored.

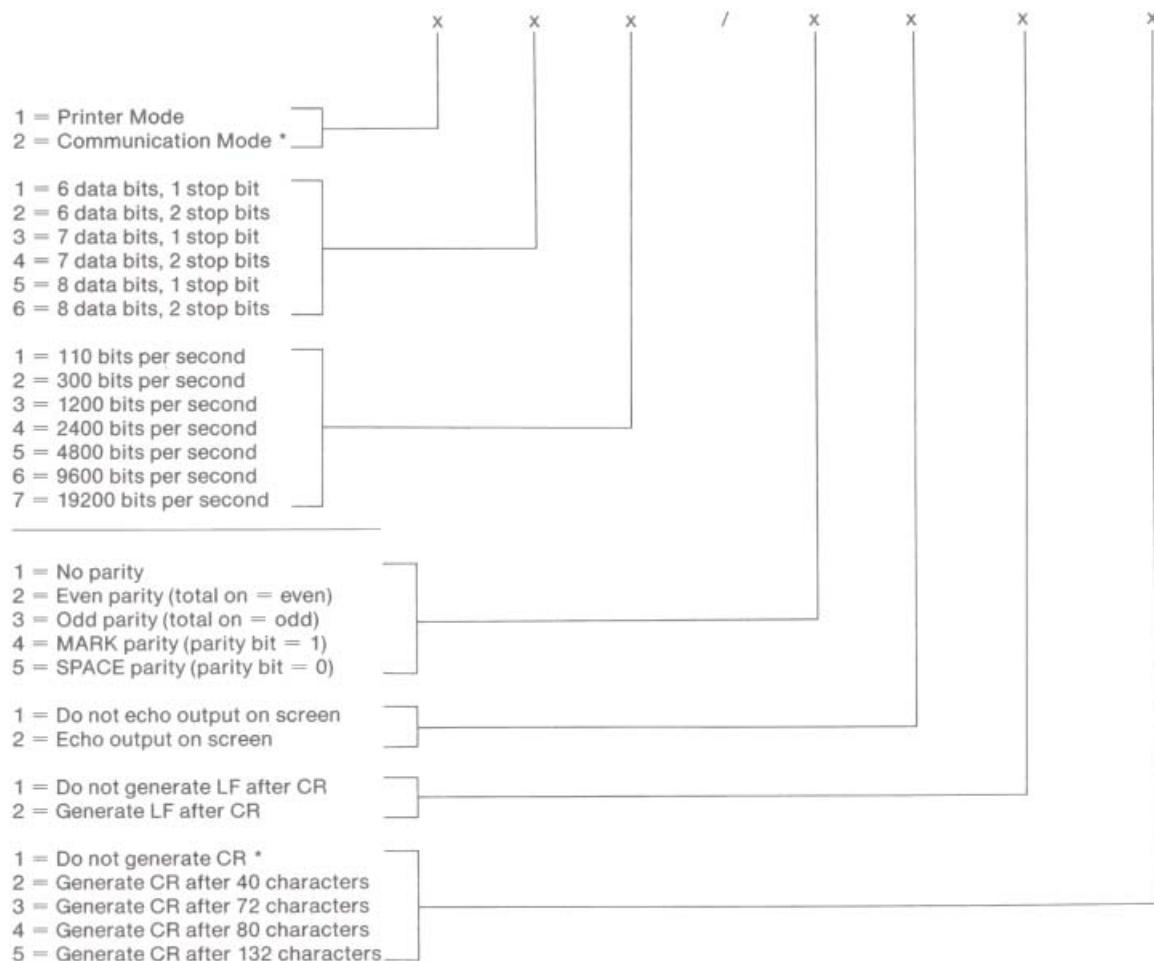
### Example:

252/1111 means:

Communication mode  
8 data bits, 1 stop bit  
300 baud (bits per second)

No parity  
Do not echo output to display  
No linefeed after carriage return  
Do not generate carriage returns

*Table H-5. PIN Numbers*



\* If you select Communication Mode, then seventh digit must equal 1. This value is supplied automatically when you use the UUD.

## H.6 Eight-Bit Code Conversions

Tables H-6 through H-13 show the entire ASCII character set twice: once with the high bit off, and once with it on. Here is how to interpret these tables.

- The **Binary** column has the 8-bit code for each ASCII character.
- The first 128 ASCII entries represent 7-bit ASCII codes plus a high-order bit of 0 (SPACE parity or Pascal)—for example, 01001000 for the letter *H*.
- The last 128 ASCII entries (from 128 through 255) represent 7-bit ASCII codes plus a high-order bit of 1 (MARK parity or BASIC)—for example, 11001000 for the letter *H*.
- A transmitted or received ASCII character will take whichever form (in the communication register) is appropriate if odd or even parity is selected—for example, 11001000 for an odd-parity *H*, 01001000 for an even-parity *H*.
- The **ASCII Char** column gives the ASCII character name.
- The **Interpretation** column spells out the meaning of special symbols and abbreviations, where necessary.
- The **What to Type** column indicates what keystrokes generate the ASCII character (where it is not obvious). The numbers between columns refer to footnotes.
- The columns marked **Pri** and **Alt** indicate what displayed character results from each code when using the primary or alternate display character set, respectively. Boldface is used for inverse characters; italic is used for flashing characters.

Note that the values \$40 through \$5F (and \$C0 through \$DF) in the alternate character set are displayed as MouseText characters (Figure 5-1) if the firmware is set to do so (section 5.2.2), or if the firmware is bypassed.

**Note:** The primary and alternate displayed character sets in Tables H-6 through H-13 are the result of firmware mapping. The CHARGEN ROM actually contains only one character set. The firmware mapping procedure is described in section 3.36.

**Table H-6. Control Characters, High Bit Off**

Binary	Dec	Hex	ASCII Char	Interpretation	What to Type	Pri	Alt
0000000	0	\$00	NUL	Blank (null)	(CONTROL-@)	@	@
0000001	1	\$01	SOH	Start of Header	(CONTROL-A)	A	A
0000010	2	\$02	STX	Start of Text	(CONTROL-B)	B	B
0000011	3	\$03	ETX	End of Text	(CONTROL-C)	C	C
0000100	4	\$04	EOT	End of Transm.	(CONTROL-D)	D	D
0000101	5	\$05	ENQ	Enquiry	(CONTROL-E)	E	E
0000110	6	\$06	ACK	Acknowledge	(CONTROL-F)	F	F
0000111	7	\$07	BEL	Bell	(CONTROL-G)	G	G
0001000	8	\$08	BS	Backspace	(CONTROL-H)	H	H
				or -			
0001001	9	\$09	HT	Horizontal Tab	(CONTROL-I)	I	I
				or TAB			
0001010	10	\$0A	LF	Line Feed	(CONTROL-J)	J	J
				or ¶			
0001011	11	\$0B	VT	Vertical Tab	(CONTROL-K)	K	K
				or ¶			
0001100	12	\$0C	FF	Form Feed	(CONTROL-L)	L	L
0001101	13	\$0D	CR	Carriage Return	(CONTROL-M)	M	M
				or RETURN			
0001110	14	\$0E	SO	Shift Out	(CONTROL-N)	N	N
0001111	15	\$0F	SI	Shift In	(CONTROL-O)	O	O
0010000	16	\$10	DLE	Data Link Escape	(CONTROL-P)	P	P
0010001	17	\$11	DC1	Device Control 1	(CONTROL-Q)	Q	Q
0010010	18	\$12	DC2	Device Control 2	(CONTROL-R)	R	R
0010011	19	\$13	DC3	Device Control 3	(CONTROL-S)	S	S
0010100	20	\$14	DC4	Device Control 4	(CONTROL-T)	T	T
0010101	21	\$15	NAK	Neg. Acknowledge	(CONTROL-U)	U	U
				or -			
0010110	22	\$16	SYN	Synchronization	(CONTROL-V)	V	V
0010111	23	\$17	ETB	End of Text Blk.	(CONTROL-W)	W	W
0011000	24	\$18	CAN	Cancel	(CONTROL-X)	X	X
0011001	25	\$19	EM	End of Medium	(CONTROL-Y)	Y	Y
0011010	26	\$1A	SUB	Substitute	(CONTROL-Z)	Z	Z
0011011	27	\$1B	ESC	Escape	(CONTROL-[)	[	[
				or ESC			
0011100	28	\$1C	FS	File Separator	(CONTROL-\)	\	\
0011101	29	\$1D	GS	Group Separator	(CONTROL-])	]	]
0011110	30	\$1E	RS	Record Separator	(CONTROL-^)	^	^
0011111	31	\$1F	US	Unit Separator	(CONTROL-_)	-	-

*Table H-7. Special Characters, High Bit Off*

Binary	Dec	Hex	ASCII Char	Interpretation	What to Type	Pri	Alt
0100000	32	\$20	SP	Space	SPACE bar	!	!"
0100001	33	\$21	!			"	"
0100010	34	\$22	"			#	#
0100011	35	\$23	#			\$	\$
0100100	36	\$24	\$			%	%
0100101	37	\$25	%			&	&
0100110	38	\$26	&			,	,
0100111	39	\$27	'	Closing Quote		(	(
0101000	40	\$28	(			)	)
0101001	41	\$29	)			*	*
0101010	42	\$2A	*			+	+
0101011	43	\$2B	+			,	,
0101100	44	\$2C	.	Comma		-	-
0101101	45	\$2D	-	Hyphen		.	.
0101110	46	\$2E	.	Period		/	/
0101111	47	\$2F	/			0	0
0110000	48	\$30	0			1	1
0110001	49	\$31	1			2	2
0110010	50	\$32	2			3	3
0110011	51	\$33	3			4	4
0110100	52	\$34	4			5	5
0110101	53	\$35	5			6	6
0110110	54	\$36	6			7	7
0110111	55	\$37	7			8	8
0111000	56	\$38	8			9	9
0111001	57	\$39	9			:	:
0111010	58	\$3A	:			;	;
0111011	59	\$3B	:			<	<
0111100	60	\$3C	=			=	=
0111101	61	\$3D	>			>	>
0111110	62	\$3E	>			?	?
0111111	63	\$3F	?				

*Table H-8. Uppercase Characters, High Bit Off*

Binary	Dec	Hex	ASCII Char	Interpretation	What to Type	Pri	Alt
1000000	64	\$40	@			@	
1000001	65	\$41	A			A	
1000010	66	\$42	B			B	
1000011	67	\$43	C			C	
1000100	68	\$44	D			D	
1000101	69	\$45	E			E	
1000110	70	\$46	F			F	
1000111	71	\$47	G			G	
1001000	72	\$48	H			H	
1001001	73	\$49	I			I	
1001010	74	\$4A	J			J	
1001011	75	\$4B	K			K	
1001100	76	\$4C	L			L	
1001101	77	\$4D	M			M	
1001110	78	\$4E	N			N	
1001111	79	\$4F	O			O	
1010000	80	\$50	P			P	
1010001	81	\$51	Q			Q	
1010010	82	\$52	R			R	
1010011	83	\$53	S			S	
1010100	84	\$54	T			T	
1010101	85	\$55	U			U	
1010110	86	\$56	V			V	
1010111	87	\$57	W			W	
1011000	88	\$58	X			X	
1011001	89	\$59	Y			Y	
1011010	90	\$5A	Z			Z	
1011011	91	\$5B		Opening Bracket			
1011100	92	\$5C	\	Reverse Slant	\		
1011101	93	\$5D	]	Closing Bracket	]		
1011110	94	\$5E	,	Caret	,		
1011111	95	\$5F	-	Underline	-		

**Table H-9. Lowercase Characters, High Bit Off**

Binary	Dec	Hex	ASCII Char	Interpretation	What to Type	Pri	Alt
1100000	96	\$60	'	Opening Quote		.	.
1100001	97	\$61	a		!	a	
1100010	98	\$62	b		"	b	
1100011	99	\$63	c		#	c	
1100100	100	\$64	d		\$	d	
1100101	101	\$65	e		%	e	
1100110	102	\$66	f		&	f	
1100111	103	\$67	g		,	g	
1101000	104	\$68	h		(	h	
1101001	105	\$69	i		)	i	
1101010	106	\$6A	j		*	j	
1101011	107	\$6B	k		+	k	
1101100	108	\$6C	l		-	l	
1101101	109	\$6D	m		.	m	
1101110	110	\$6E	n		/	n	
1101111	111	\$6F	o		0	o	
1110000	112	\$70	p		1	p	
1110001	113	\$71	q		2	q	
1110010	114	\$72	r		3	r	
1110011	115	\$73	s		4	s	
1110100	116	\$74	t		5	t	
1110101	117	\$75	u		6	u	
1110110	118	\$76	v		7	v	
1110111	119	\$77	w		8	w	
1111000	120	\$78	x		9	x	
1111001	121	\$79	y		:	y	
1111010	122	\$7A	z		;	z	
1111011	123	\$7B	—	Opening Brace	<		
1111100	124	\$7C		Vertical Line	=		
1111101	125	\$7D	—	Closing Brace	>		
1111110	126	\$7E	—	Overline (Tilde)	?		
1111111	127	\$7F	DEL	Delete/Rubout			DEL

**Table H-10. Control Characters, High Bit On**

Binary	Dec	Hex	ASCII Char	Interpretation	What to Type	Pri	Alt
10000000	128	\$80	NUL	Blank (null)	(CONTROL-@)	@	@
10000001	129	\$81	SOH	Start of Header	(CONTROL-A)	A	A
10000010	130	\$82	STX	Start of Text	(CONTROL-B)	B	B
10000011	131	\$83	ETX	End of Text	(CONTROL-C)	C	C
100000100	132	\$84	EOT	End of Transm.	(CONTROL-D)	D	D
10000101	133	\$85	ENQ	Enquiry	(CONTROL-E)	E	E
10000110	134	\$86	ACK	Acknowledge	(CONTROL-F)	F	F
10000111	135	\$87	BEL	Bell	(CONTROL-G)	G	G
10001000	136	\$88	BS	Backspace	(CONTROL-H)	H	H
				OR →			
10001001	137	\$89	HT	Horizontal Tab	(CONTROL-I)	I	I
				OR TAB			
10001010	138	\$8A	LF	Line Feed	(CONTROL-J)	J	J
				OR ↴			
10001011	139	\$8B	VT	Vertical Tab	(CONTROL-K)	K	K
				OR ↑			
10001100	140	\$8C	FF	Form Feed	(CONTROL-L)	L	L
10001101	141	\$8D	CR	Carriage Return	(CONTROL-M)	M	M
				OR RETURN			
10001110	142	\$8E	SO	Shift Out	(CONTROL-N)	N	N
10001111	143	\$8F	SI	Shift In	(CONTROL-O)	O	O
10010000	144	\$90	DLE	Data Link Escape	(CONTROL-P)	P	P
10010001	145	\$91	DC1	Device Control 1	(CONTROL-Q)	Q	Q
10010010	146	\$92	DC2	Device Control 2	(CONTROL-R)	R	R
10010011	147	\$93	DC3	Device Control 3	(CONTROL-S)	S	S
10010100	148	\$94	DC4	Device Control 4	(CONTROL-T)	T	T
10010101	149	\$95	NAK	Neg. Acknowledge	(CONTROL-U)	U	U
				OR →			
10010110	150	\$96	SYN	Synchronization	(CONTROL-V)	V	V
10010111	151	\$97	ETB	End of Text Blk.	(CONTROL-W)	W	W
10011000	152	\$98	CAN	Cancel	(CONTROL-X)	X	X
10011001	153	\$99	EM	End of Medium	(CONTROL-Y)	Y	Y
10011010	154	\$9A	SUB	Substitute	(CONTROL-Z)	Z	Z
10011011	155	\$9B	ESC	Escape	(CONTROL-[)	[	[
				OR [ESC]			
10011100	156	\$9C	FS	File Separator	(CONTROL-\)	\	\
10011101	157	\$9D	GS	Group Separator	(CONTROL-])	]	]
10011110	158	\$9E	RS	Record Separator	(CONTROL-^)	^	^
10011111	159	\$9F	US	Unit Separator	(CONTROL-_)	_	_

*Table H-11. Special Characters, High Bit On*

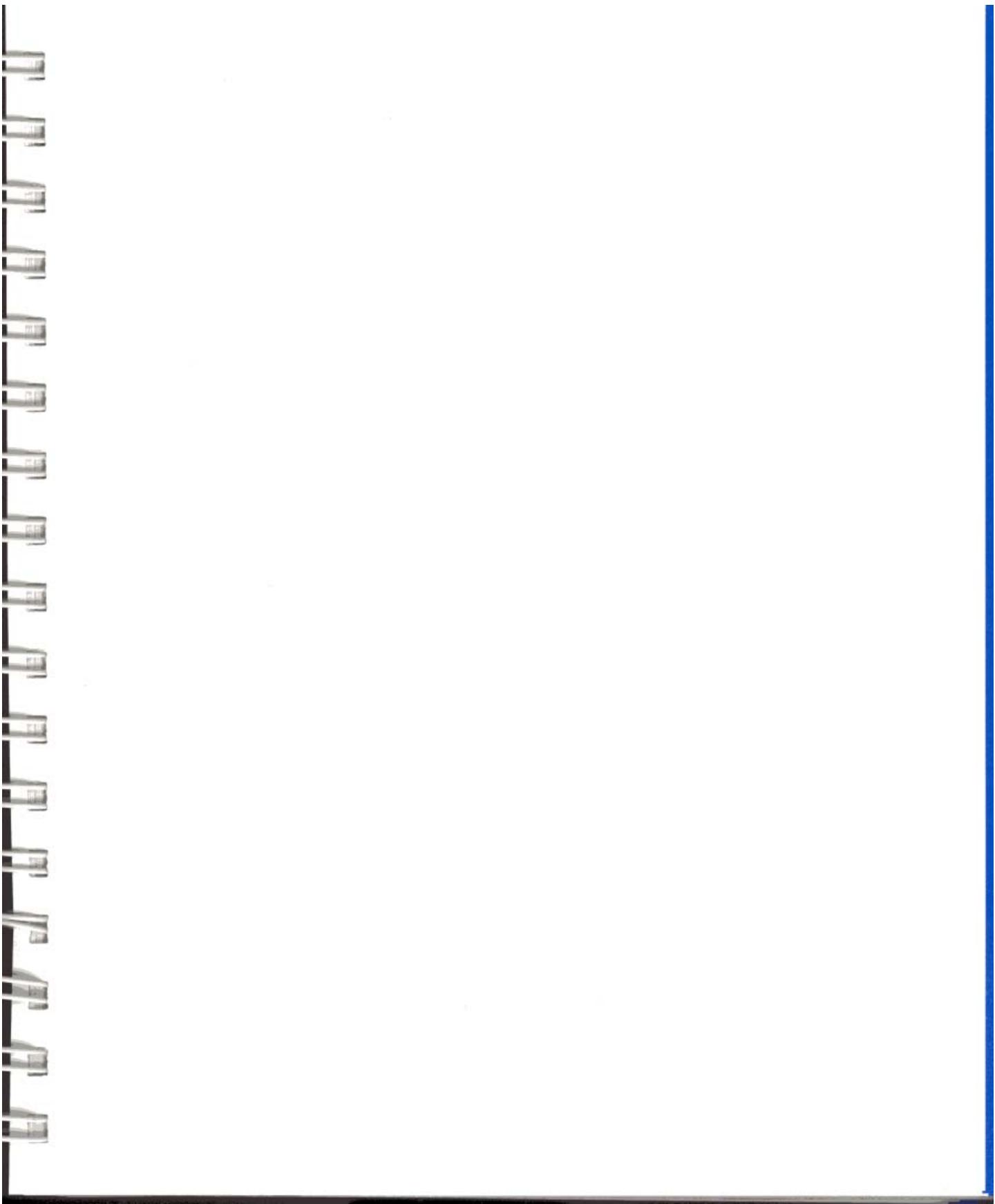
Binary	Dec	Hex	ASCII Char	Interpretation	What to Type	Pri	Alt
10100000	160	\$A0	SP	Space	SPACE bar	!	!
10100001	161	\$A1	!"			"	"
10100010	162	\$A2	"			#	#
10100011	163	\$A3	#			\$	\$
10100100	164	\$A4	\$			%	%
10100101	165	\$A5	%			&	&
10100110	166	\$A6	&			,	,
10100111	167	\$A7	'	Closed Quote (acute accent)		(	(
10101000	168	\$A8	(			)	)
10101001	169	\$A9	)			*	*
10101010	170	\$AA	*			+	+
10101011	171	\$AB	+			,	,
10101100	172	\$AC	,	Comma		-	-
10101101	173	\$AD	-	Hyphen		.	.
10101110	174	\$AE	.	Period		/	/
10101111	175	\$AF	/			0	0
10110000	176	\$B0	0			1	1
10110001	177	\$B1	1			2	2
10110010	178	\$B2	2			3	3
10110011	179	\$B3	3			4	4
10110100	180	\$B4	4			5	5
10110101	181	\$B5	5			6	6
10110110	182	\$B6	6			7	7
10110111	183	\$B7	7			8	8
10111000	184	\$B8	8			9	9
10111001	185	\$B9	9			:	:
10111010	186	\$BA	:			:	:
10111011	187	\$BB	:			<	<
10111100	188	\$BC	<			=	=
10111101	189	\$BD	=			>	>
10111110	190	\$BE	>			?	?
10111111	191	\$BF	?				

*Table H-12. Uppercase Characters, High Bit On*

Binary	Dec	Hex	ASCII Char	Interpretation	What to Type	Pri	Alt
11000000	192	\$C0	@			@	
11000001	193	\$C1	A			A	
11000010	194	\$C2	B			B	
11000011	195	\$C3	C			C	
11000100	196	\$C4	D			D	
11000101	197	\$C5	E			E	
11000110	198	\$C6	F			F	
11000111	199	\$C7	G			G	
11001000	200	\$C8	H			H	
11001001	201	\$C9	I			I	
11001010	202	\$CA	J			J	
11001011	203	\$CB	K			K	
11001100	204	\$CC	L			L	
11001101	205	\$CD	M			M	
11001110	206	\$CE	N			N	
11001111	207	\$CF	O			O	
11010000	208	\$D0	P			P	
11010001	209	\$D1	Q			Q	
11010010	210	\$D2	R			R	
11010011	211	\$D3	S			S	
11010100	212	\$D4	T			T	
11010101	213	\$D5	U			U	
11010110	214	\$D6	V			V	
11010111	215	\$D7	W			W	
11011000	216	\$D8	X			X	
11011001	217	\$D9	Y			Y	
11011010	218	\$DA	Z			Z	
11011011	219	\$DB	[	Opening Bracket		[	
11011100	220	\$DC	\	Reverse Slant		\	
11011101	221	\$DD	]	Closing Bracket		]	
11011110	222	\$DE	,	Caret		,	
11011111	223	\$DF	_	Underline		_	

**Table H-13. Lowercase Characters, High Bit On**

Binary	Dec	Hex	ASCII Char	Interpretation	What to Type	Pri	Alt
11100000	224	\$E0	'	Open Quote	'	'	'
11100001	225	\$E1	a		a	a	a
11100010	226	\$E2	b		b	b	b
11100011	227	\$E3	c		c	c	c
11100100	228	\$E4	d		d	d	d
11100101	229	\$E5	e		e	e	e
11100110	230	\$E6	f		f	f	f
11100111	231	\$E7	g		g	g	g
11101000	232	\$E8	h		h	h	h
11101001	233	\$E9	i		i	i	i
11101010	234	\$EA	j		j	j	j
11101011	235	\$EB	k		k	k	k
11101100	236	\$EC	l		l	m	m
11101101	237	\$ED	m		m	n	n
11101110	238	\$EE	n		n	o	o
11101111	239	\$EF	o		o	p	p
11110000	240	\$F0	p		p	q	q
11110001	241	\$F1	q		q	r	r
11110010	242	\$F2	r		r	s	s
11110011	243	\$F3	s		s	t	t
11110100	244	\$F4	t		t	u	u
11110101	245	\$F5	u		u	v	v
11110110	246	\$F6	v		v	w	w
11110111	247	\$F7	w		w	x	x
11111000	248	\$F8	x		x	y	y
11111001	249	\$F9	y		y	z	z
11111010	250	\$FA	z		z	-	-
11111011	251	\$FB	-	Opening Brace	-	-	-
11111100	252	\$FC	-	Vertical Line	-	-	-
11111101	253	\$FD	-	Closing Brace	-	-	-
11111110	254	\$FE	-	Overline (Tilde)	DELETE	DEL	DEL
11111111	255	\$FF	DEL	Delete (Rubout)			



# *Firmware Listings*



Appendix I comprises a listing of the source code for the Monitor, enhanced video firmware, and input/output firmware contained in the Apple IIc.

```

C100:      2 ****
C100:      3 *
C100:      4 * Apple //c
C100:      5 * Video Firmware and
C100:      6 * Monitor ROM Source
C100:      7 *
C100:      8 * COPYRIGHT 1977-1983 BY
C100:      9 * APPLE COMPUTER, INC.
C100:     10 *
C100:     11 * ALL RIGHTS RESERVED
C100:     12 *
C100:     13 * S. WOZNIAK      1977
C100:     14 * A. BAUM        1977
C100:     15 * JOHN A          NOV 1978
C100:     16 * R. AURICCHIO    SEP 1981
C100:     17 * E. BEERNINK     1983
C100:     18 *
C100:     19 ****
C100:     20 *
C100:     21 * ZERO PAGE EQUATES
C100:     22 *
C100: 0000 23 LOCO    EQU $00      ;vector for autostart from disk
C100: 0001 24 LOC1    EQU $01
C100: 0020 25 WNDLFT   EQU $20      ;left edge of text window
C100: 0021 26 WNDWDTH  EQU $21      ;width of text window
C100: 0022 27 WNDTOP   EQU $22      ;top of text window
C100: 0023 28 WNDBTM   EQU $23      ;bottom+1 of text window
C100: 0024 29 CH       EQU $24      ;cursor horizontal position
C100: 0025 30 CV       EQU $25      ;cursor vertical position
C100: 0026 31 GBASL   EQU $26      ;lo-res graphics base addr.
C100: 0027 32 GBASH   EQU $27
C100: 0028 33 BASL    EQU $28      ;text base address
C100: 0029 34 BASH    EQU $29
C100: 002A 35 BAS2L   EQU $2A      ;temp base for scrolling
C100: 002B 36 BAS2H   EQU $2B
C100: 002C 37 H2       EQU $2C      ;temp for lo-res graphics
C100: 002C 38 LMNEM   EQU $2C      ;temp for mnemonic decoding
C100: 002D 39 V2       EQU $2D      ;temp for lo-res graphics
C100: 002D 40 RMNEM   EQU $2D      ;temp for mnemonic decoding
C100: 002E 41 MASK    EQU $2E      ;color mask for lo-res gr.
C100: 002E 42 FORMAT   EQU $2E      ;temp for opcode decode
C100: 002F 43 LENGTH   EQU $2F      ;temp for opcode decode
C100: 0030 44 COLOR    EQU $30      ;color for lo-res graphics
C100: 0031 45 MODE     EQU $31      ;Monitor mode
C100: 0032 46 INVFLG   EQU $32      ;normal/inverse(/flash)
C100: 0033 47 PROMPT   EQU $33      ;prompt character
C100: 0034 48 YSAV    EQU $34      ;position in Monitor command
C100: 0035 49 YSAV1   EQU $35      ;temp for Y register
C100: 0036 50 CSWL    EQU $36      ;character output hook
C100: 0037 51 CSWH    EQU $37
C100: 0038 52 KSWL    EQU $38      ;character input hook
C100: 0039 53 KSWH    EQU $39
C100: 003A 54 PCL     EQU $3A      ;temp for program counter
C100: 003B 55 PCH     EQU $3B
C100: 003C 56 A1L    EQU $3C      ;Monitor temp
C100: 003D 57 A1H    EQU $3D      ;Monitor temp
C100: 003E 58 A2L    EQU $3E      ;Monitor temp
C100: 003F 59 A2H    EQU $3F      ;Monitor temp

```

```

C100:    0040  60 A3L     EQU   $40      ;Monitor temp
C100:    0041  61 A3H     EQU   $41      ;Monitor temp
C100:    0042  62 A4L     EQU   $42      ;Monitor temp
C100:    0043  63 A4H     EQU   $43      ;Monitor temp
C100:    0044  64 A5L     EQU   $44      ;Monitor temp
C100:    0045  65 A5H     EQU   $45      ;Monitor temp
C100:    66 *
C100:    67 * Note: In Apple II, //e, both interrupts and BRK destroyed
C100:    68 * location $45. Now only BRK destroys $45 (ACC) and it
C100:    69 * also destroys $44 (MACSTAT).
C100:    70 *
C100:    0044  71 MACSTAT  EQU   $44      ;Machine state after BRK
C100:    0045  72 ACC     EQU   $45      ;Acc after BRK
C100:    73 *
C100:    0046  74 XREG    EQU   $46      ;X reg after break
C100:    0047  75 YREG    EQU   $47      ;Y reg after break
C100:    0048  76 STATUS   EQU   $48      ;P reg after break
C100:    0049  77 SPNT    EQU   $49      ;SP after break
C100:    004E  78 RNDL    EQU   $4E      ;random counter low
C100:    004F  79 RNDH    EQU   $4F      ;random counter high
C100:    80 *
C100:    81 * Value equates
C100:    82 *
C100:    0006  83 GOODF8  EQU   $06      ;value of //e, lolly ID byte
C100:    0095  84 PICK    EQU   $95      ;CONTROL-U character
C100:    009B  85 ESC     EQU   $9B      ;what ESC generates
C100:    86 *
C100:    87 * Characters read by GETLN are placed in
C100:    88 * IN, terminated by a carriage return.
C100:    89 *
C100:    0200  90 IN      EQU   $0200    ;input buffer for GETLN
C100:    91 *
C100:    92 * Page 3 vectors
C100:    93 *
C100:    03F0  94 BRKV    EQU   $03F0    ;vectors here after break
C100:    03F2  95 SOFTEV   EQU   $03F2    ;vector for warm start
C100:    03F4  96 PWREDUP  EQU   $03F4    ;THIS MUST = EOR #$A5 OF SOFTEV+1
C100:    03F5  97 AMPERV   EQU   $03F5    ;APPLESOFT & EXIT VECTOR
C100:    03F8  98 USRADR   EQU   $03F8    ;APPLESOFT USR function vector
C100:    03FB  99 NMI     EQU   $03FB    ;NMI vector
C100:    03FE  100 IRQLOC  EQU   $03FE    ;Maskable interrupt vector
C100:    0400  101 LINE1   EQU   $0400    ;first line of text screen
C100:    07F8  102 MSLOT   EQU   $07F8    ;owner of $C8 space
C100:    103 *
C100:    104 * HARDWARE EQUATES
C100:    105 *
C100:    C000  106 IOADR   EQU   $C000    ;for IN#, PR# vector
C100:    C000  107 KBD     EQU   $C000    ;>127 if keystroke
C100:    C000  108 CLR80COL EQU   $C000    ;disable 80 column store
C100:    C001  109 SET80COL EQU   $C001    ;enable 80 column store
C100:    C002  110 RDMAINRAM EQU   $C002    ;read from main 48K RAM
C100:    C003  111 RDCARDRAM EQU   $C003    ;read from alt. 48K RAM
C100:    C004  112 WRMAINRAM EQU   $C004    ;write to main 48K RAM
C100:    C005  113 WRCARDRAM EQU   $C005    ;write to alt. 48K RAM
C100:    C008  114 SETSTDZP  EQU   $C008    ;use main zero page/stack
C100:    C009  115 SETALTZP  EQU   $C009    ;use alt. zero page/stack
C100:    C00C  116 CLR80VID  EQU   $C00C    ;disable 80 column hardware
C100:    C00D  117 SET80VID  EQU   $C00D    ;enable 80 column hardware

```

```

C100:      C00E  118 CLRALTCHAR EQU  $C00E ;normal LC, flashing UC
C100:      C00F  119 SETALTCHAR EQU  $C00F ;normal inverse, LC; no flash
C100:      C010  120 KBDSTRB   EQU  $C010 ;turn off key pressed flag
C100:      C011  121 RDLCBNK2 EQU  $C011 ;>127 if LC bank 2 is in
C100:      C012  122 RDLCRAM   EQU  $C012 ;>127 if LC RAM read enabled
C100:      C013  123 RDRAMRD   EQU  $C013 ;>127 if reading main 48K
C100:      C014  124 RDRAMWRT  EQU  $C014 ;>127 if writing main 48K
C100:      C016  125 RDALTZP   EQU  $C016 ;>127 if Alt ZP and LC switched in
C100:      C018  126 RD80COL   EQU  $C018 ;>127 if 80 column store
C100:      C019  127 RDVBLBAR  EQU  $C019 ;>127 if not VBL
C100:      C01A  128 RDTEXT    EQU  $C01A ;>127 if text (not graphics)
C100:      C01B  129 RDMIX     EQU  $C01B ;>127 if mixed mode on
C100:      C01C  130 RDPAGE2   EQU  $C01C ;>127 if TXTPAGE2 switched in
C100:      C01D  131 RDHIRES   EQU  $C01D ;>127 if HIRES is on
C100:      C01E  132 ALTCHARSET EQU  $C01E ;>127 if alternate char set in use
C100:      C01F  133 RD80VID   EQU  $C01F ;>127 if 80 column hardware in
C100:      C020  134 TAPEOUT   EQU  $C020 ;what is this??
C100:      C030  135 SPKR      EQU  $C030 ;clicks the speaker
C100:      C050  136 TXTCLR    EQU  $C050 ;switch in graphics (not text)
C100:      C051  137 TXTSET    EQU  $C051 ;switch in text (not graphics)
C100:      C052  138 MIXCLR   EQU  $C052 ;clear mixed-mode
C100:      C053  139 MIXSET   EQU  $C053 ;set mixed-mode (4 lines text)
C100:      C054  140 TXTPAGE1  EQU  $C054 ;switch in text page 1
C100:      C055  141 TXTPAGE2  EQU  $C055 ;switch in text page 2
C100:      C056  142 LORES    EQU  $C056 ;low-resolution graphics
C100:      C057  143 HIRES    EQU  $C057 ;high-resolution graphics
C100:      C058  144 CLRANO   EQU  $C058
C100:      C059  145 SETANO   EQU  $C059
C100:      C05A  146 CLRAN1   EQU  $C05A
C100:      C05B  147 SETAN1   EQU  $C05B
C100:      C05C  148 CLRAN2   EQU  $C05C
C100:      C05D  149 SETAN2   EQU  $C05D
C100:      C05E  150 CLRAN3   EQU  $C05E
C100:      C05F  151 SETAN3   EQU  $C05F
C100:      C060  152 RD40SW   EQU  $C060 ;>127 if 40/80 switch in 40 pos
C100:      C061  153 BUTNO    EQU  $C061 ;open apple key
C100:      C062  154 BUTN1    EQU  $C062 ;closed apple key
C100:      C064  155 PADDLO   EQU  $C064 ;read paddle 0
C100:      C070  156 PTRIG    EQU  $C070 ;trigger the paddles
C100:      C081  157 ROMIN    EQU  $C081 ;switch in $D000-$FFFF ROM
C100:      C083  158 LCBANK2  EQU  $C083 ;switch in LC bank 2
C100:      C08B  159 LCBANK1  EQU  $C08B ;switch in LC bank 1
C100:      CFFF  160 CLRROM   EQU  $CFFF ;switch out $C8 ROMs
C100:      E000  161 BASIC    EQU  $E000 ;BASIC entry point
C100:      E003  162 BASIC2   EQU  $E003 ;BASIC warm entry point
C100:      163 *
C100:      04FB  164 VMODE    EQU  $4F8+3 ;OPERATING MODE
C100:      165 *
C100:      166 * BASIC VMODE BITS
C100:      167 *
C100:      168 * 1..... - BASIC active
C100:      169 * 0..... - Pascal active
C100:      170 * .0.....
C100:      171 * .1.....
C100:      172 * ..0.... - Print control characters
C100:      173 * ..1.... - Don't print ctrl chars
C100:      174 * ..0.... -
C100:      175 * ..1.... -

```

```

C100:      176 * ....0... - Print control characters
C100:      177 * ....1... - Don't print ctrl chars.
C100:      178 * .....0.. -
C100:      179 * .....1.. -
C100:      180 * .....0.. -
C100:      181 * .....1.. -
C100:      182 * .....0 - Print mouse characters
C100:      183 * .....1 - Don't print mouse characters
C100:      184 *
C100:      0040 185 M.40     EQU   $40
C100:      0020 186 M.CTL2    EQU   $20           ;Don't print controls
C100:      0008 187 M.CTL     EQU   $08           ;Don't print controls
C100:      0001 188 M.MOUSE    EQU   $01           ;Don't print mouse chars
C100:      189 *
C100:      190 * Pascal Mode Bits
C100:      191 *
C100:      192 * 1..... - BASIC active
C100:      193 * 0..... - Pascal active
C100:      194 * .0.....
C100:      195 * .1.....
C100:      196 * ..0.....
C100:      197 * ..1.....
C100:      198 * ...0.... - Cursor always on
C100:      199 * ...1.... - Cursor always off
C100:      200 * ....0... - GOTOXY n/a
C100:      201 * ....1... - GOTOXY in progress
C100:      202 * .....0.. - Normal Video
C100:      203 * .....1.. - Inverse Video
C100:      204 * .....0.. -
C100:      205 * .....1.. -
C100:      206 * .....0 - Print mouse chars
C100:      207 * .....1 - Don't print mouse chars
C100:      208 *
C100:      0080 209 M.PASCAL  EQU   $80           ;Pascal active
C100:      0010 210 M.CURSOR  EQU   $10           ;Don't print cursor
C100:      0008 211 M.GOXY    EQU   $08           ;GOTOXY IN PROGRESS
C100:      0004 212 M.VMODE   EQU   $04
C100:      213 *
C100:      0478 214 ROMSTATE  EQU   $478          ;temp store of ROM state
C100:      04F8 215 TEMP1    EQU   $4F8          ;used by CTLCHAR
C100:      0578 216 TEMPA    EQU   $578          ;used by scroll
C100:      05F8 217 TEMPY    EQU   $5F8          ;used by scroll
C100:      218 *
C100:      047B 219 OLDCH    EQU   $478+3        ;last value of CH
C100:      057B 220 OURCH    EQU   $578+3        ;80-COL CH
C100:      05FB 221 OURCV    EQU   $5F8+3        ;CURSOR VERTICAL
C100:      067B 222 VFACTV   EQU   $678+3        ;Bit7=video firmware inactive
C100:      06FB 223 XCOORD   EQU   $6F8+3        ;X-COORD (GOTOXY)
C100:      077B 224 NXTCUR   EQU   $778+3        ;next cursor to display
C100:      07FB 225 CURSOR   EQU   $7F8+3        ;the current cursor char
C100:      17      INCLUDE SERIAL           ;Equates for serial code

```

```

C100:      3 ****
C100:      4 *
C100:      5 * Apple Lolly communications driver
C100:      6 *
C100:      7 * By
C100:      8 * Rich Williams
C100:      9 * August 1983
C100:     10 * November 5 - j.r.huston
C100:     11 *
C100:     12 ****
C100:     13 *
C100:     14 * Command codes
C100:     15 *
C100:     16 * Default command char is ctrl-A (^A)
C100:     17 *
C100:     18 *      ^AnnB: Set baud rate to nn
C100:     19 *      ^AnnD: Set data format bits to nn
C100:     20 *      ^AI:   Enable video echo
C100:     21 *      ^AK:   Disable CRLF
C100:     22 *      ^AL:   Enable CRLF
C100:     23 *      ^AnnN: Disable video echo & set printer width
C100:     24 *      ^AnnP: Set parity bits to nn
C100:     25 *      ^AQ:   Quit terminal mode
C100:     26 *      ^AR:   Reset the ACIA, IN#0 PR#0
C100:     27 *      ^AS:   Send a 233 ms break character
C100:     28 *      ^AT:   Enter terminal mode
C100:     29 *      ^AZ:   Zap control commands
C100:     30 *      ^Ax:   Set command char to ^x
C100:     31 *      ^AnnCR: Set printer width (CR = carriage return)
C100:     32 *
C100:     33 ****
C100:     C100 34 serslot equ $C100
C100:     C200 35 comslot equ $C200
C100:     36          MSB ON
C100:     00BF 37 cmdcur equ '?'           ;Cursor while on command mode
C100:     00DF 38 termcur equ ' '           ;Cursor while in terminal mode
C100:     39          MSB OFF
C100:     0091 40 xon equ $91              ;XON character
C100:     03B8 41 sermode equ $3B8           ;D7=1 if in cmd; D6=1 if term 479 & 47A
C100:     0438 42 astat equ $438             ;Acia status from int 4F9 & 4FA
C100:     04B8 43 pwdth equ $4B8              ;Printer width 579 & 57A
C100:     0538 44 extint equ $538             ;extint & typded enable 5F9 & 5FA
C100:     05F9 45 extint2 equ $5F9
C100:     05FA 46 typded equ $5FA
C100:     0679 47 oldcur equ $679             ;Saves cursor while in command
C100:     067A 48 oldcur2 equ $67A            ;Saves cursor while in terminal mode
C100:     0638 49 eschar equ $638             ;Current escape character 6F9 & 6FA
C100:     06B8 50 flags equ $6B8              ;D7 = Video echo D6 = CRLF 779 & 77A
C100:     0738 51 col equ $738               ;Current printer column 7F9 & 7FA
C100:     047F 52 number equ $47F              ;Number accumulated in command
C100:     04FF 53 aciabuf equ $4FF             ;Owner of serial buffer
C100:     057F 54 twser equ $57F              ;Storage pointer for serial buffer
C100:     05FF 55 twkey equ $5FF              ;Storage pointer for type ahead buffer
C100:     067F 56 trser equ $67F              ;Retrieve pointer for serial buffer
C100:     06FF 57 trkey equ $6FF              ;Retrieve buffer for type ahead buffer
C100:     0800 58 thbuf equ $800              ;Buffer in alt ram space
C100:     06F8 59 temp equ $6F8               ;Temp storage
C100:     BFF8 60 sdata equ $BFF8             ;+$N0+$90 is output port

```

```
C100:      BFF9    61 sstat    equ   $BFF9      ;ACIA status register
C100:      BFFA    62 scomd   equ   $BFFA      ;ACIA command register
C100:      BFFB    63 scntl    equ   $BFFB      ;ACIA control register
C100:      FF58    64 iorts   equ   $FF58      ;RTS opcode
C100:          18           INCLUDE SER      ;Printer port @ $C100
```

```

C100:          3 *org serslot
C100:2C 58 FF 4      bit   iorts      ;Set V to indicate initial entry
C103:70 0C C111 5      bvs   entrl     ;Always taken
C105:38          6      sec
C106:90          7      dfb   $90       ;BCC opcode
C107:18          8      clc
C108:B8          9      clv
C109:50 06 C111 10    bvc   entrl     ;V = 0 since not initial entry
                                         ;Always taken

C10B:01          12     dfb   $01       ;pascal signature byte
C10C:31          13     dfb   $31       ;device signature
C10D:E4          14     dfb   >plinit
C10E:EE          15     dfb   >plread
C10F:F6          16     dfb   >plwrite
C110:FB          17     dfb   >plstatus

C111:DA          19     entrl    phx      ;Save the reg
C112:A2 C1        20     idx   #<serslot ;X = Cn
C114:4C 33 C2        jmp   setup      ;Set mslot, etc
C117:90 05 C11E 22 serport bcc   serisout ;Only output allowed
C119:20 4D CE        23     jsr   zzquit    ;Reset the hooks
C11C:80 6A C188 24    bra   done
C11E:0A          25     serisout asl   A        ;A = flags
C11F:7A          26     ply
C120:5A          27     phy
C121:BD B8 04 28    lda   pwdth,x  ;Formatting enabled?
C124:F0 42 C168 29    beq   prnow
C126:A5 24        30     lda   ch       ;Get current horiz position
C128:80 1C C146 31    bcs   servid    ;Branch if video echo
C12A:DD B8 04 32    cmp   pwdth,x  ;If CH >= PWIDTH, then CH = COL
C12D:90 03 C132 33    bcc   chok
C12F:BD 38 07 34    lda   col,x   ;Must be > col for valid tab
C132:DD 38 07 35 chok  cmp   col,x   ;Branch if ok
C135:80 0B C142 36    bcs   fixch    ;8 or 16?
C137:C9 11        37     cmp   #$11    ;If > forget it
C139:80 11 C14C 38    bcs   prnt     ;Find next comma cheaply
C13B:09 F0        39     ora   #$FO    ;Don't blame me it's Dick's trick
C13D:3D 38 07 40    and   col,x
C140:65 24        41     adc   ch       ;Save the new position
C142:85 24        42     fixch
C144:80 06 C14C 43    bra   prnt
C146:C5 21        44     servid    cmp   wndwdth ;If ch>= wndwdth go back to start of line
C148:90 02 C14C 45    blt   prnt
C14A:64 24        46     stz   ch       ;Go back to left edge

```

```

C14C:          48 * We have a char to print
C14C:7A          49 prnt    ply
C14D:5A          50 phy
C14E:BD 38 07 51    lda   col,x   ;Have we exceeded width?
C151:DD B8 04 52    cmp   pwdth,x
C154:80 08 C15E 53    bge   toofar
C156:C5 24        54     cmp   ch     ;Are we tabbing?
C158:80 0E C168 55    bge   prnow
C15A:A9 40        56     lda   #$40    ;Space * 2
C15C:80 02 C160 57    bra   tab
C15E:A9 1A        58 toofar lda   #$1A    ;CR * 2

```

```

C160:C0 80      59 tab      cpy    #$80      ;C = High bit
C162:6A          60 ror      A       ;Shift it into char
C163:20 9D C1    61 jsr      serout3   ;Out it goes
C166:80 E4      C14C      bra      prnt
C168:98          62          tya
C169:20 8C C1    63 prnow
C16C:BD B8 04    64          jsr      serout
C16F:F0 17      C188      lda      pwdth,x ;Formatting enabled
C171:3C B8 06    65          beq      done
C174:30 12      C188      bmi      flags,x ;In video echo?
C176:BD 38 07    66          lda      col,x   ;Check if within 8 chars of right edge
C179:FD B8 04    67          sbc      pwdth,x ;So BASIC can format output
C17C:C9 F8      68          cmp      #$F8
C17E:90 04      C184      bcc      setch
C180:18          69          adc      wndwdth
C181:65 21      70          dfb      $AC      ;Dummy LDY to skip next two bytes
C183:AC          71          lda      #0      ;Keep cursor at 0 if video off
C184:A9 00      72          sta      ch
C186:85 24      73          clc
C188:68          74          adc      wndwdth
C189:7A          75          dfb      $AC      ;Restore regs
C18A:FA          76 setch
C18B:60          77          lda      #0
C18B:68          78 done     pla
C18B:7A          79          ply
C18B:80          80          plx
C18B:81 socmd
C18B:82          81 rts

C18C:           C18C      83 serout
C18C:20 EB C9    84          equ      *
C18F:90 FA      C18B      85          jsr      command
C191:           C191      86 serout2
C191:3C B8 06    87          bcc      socmd
C194:10 07      C19D      88          equ      *
C196:C9 91      89          bit      flags,x ;N=1 iff video on
C198:F0 03      C19D      90          bpl      serout3
C19A:20 F0 FD    91          cmp      #xon   ;Don't echo ^Q
C19D:           C19D      92 serout3
C19D:BC 85 C8    93          jsr      coutl
C1A0:48          94          equ      *
C1A1:2C 58 FF    95          ldy      devno,x ;Y points to ACIA
C1A4:F0 03      CIA9      96          pha      ;Save the char
C1A6:FE 38 07    97          bit      iorts
C1A9:08          98 sordy
C1AA:78          99          inc      sordy
C1AB:B9 BF      100         lda      col,x   ;Control char?
C1AE:10 11      C1C1      101         bpl      sordy2
C1B0:48          102         pha      ;Don't inc column if so
C1B1:5A          103         phy
C1B2:2C 14 CO    104         bit      rdramwrt ;Save state of aux ram
C1B5:08          105         php
C1B6:20 1C C9    106         jsr      aitst2
C1B9:28          107         plp
C1BA:10 03      C1BF      108         bpl      somain
C1BC:8D 05 CO    109         sta      wrcardram ;Branch if was main
C1BF:7A          110 somain
C1C0:68          111         ply
C1C1:28          112 sordy2
C1C2:29 30      113         pla
C1C4:C9 10      114         and      #$30
C1C4:C9 11      115         cmp      #$10

```

```
C1C6:D0 E1    C1A9  115      bne    sordy
C1C8:68          116      pla
C1C9:48          117      pha      ;Get char to XMIT
C1CA:99 F8 BF   118      sta     sdata,y ;Out it goes
C1CD:3C B8 06   119      bit     flags,x ;V=1 if LF after CR
C1D0:49 0D      120      eor     #$0D ;check for CR.
C1D2:0A          121      asl     A      ;preserve bit 7
C1D3:D0 0D      C1E2   122      bne     sodone ;branch if not CR.
C1D5:50 06      C1DD   123      bvc     clrcol ;branch if no LF after CR
C1D7:A9 14      124      lda     #$14 ;Get LF*2
C1D9:6A          125      ror     A      ;no shift in high bit
C1DA:20 9D C1   126      jsr     serout3 ;Output the LF but don't echo it
C1DD:64 24      127      clrcol ;0 position & column
C1DF:9E 38 07   128      stz     ch
                                stz     col,x
C1E2:68          129      sodone ;Get the char back
C1E3:60          130      pla
                                rts
```

```
C1E4:          132 * Pascal support stuff

C1E4:48      134 plinit    pha
C1E5:20 C8 C2 135 jsr default   ;set defaults, enable acia
C1E8:9E B8 06 136 stz flags,x
C1EB:68      137 pla
C1EC:80 05   C1F3 138 bra plread2 ;all done...

C1EE:20 C5 C8 140 plread   jsr XRDSER ;read data from serial port (or buffer)
C1F1:90 FB   C1EE 141 bcc plread   ;Branch if data not ready
C1F3:A2 00   142 plread2  ldx #0
C1F5:60      143 rts

C1F6:20 8C C1 145 plwrite  jsr serout ;Go output character
C1F9:80 F8   C1F3 146 bra plread2
C1FB:80 1A   C217 147 plstatus bra p2status

C1FD:        0003 149      ds comslot-$,00
C200:          19      INCLUDE COMM ;Communications port @ $C200
```

```

C200:2C 58 FF      3       bit    iorts      ;Set V to indicate initial entry
C203:70 2B C230    4       bvs    entr
C205:38           5 sin    sec
C206:90           6         dfb    $90      ;BCC opcode to skip next byte
C207:18           7 sout   clc
C208:B8           8         clv
C209:50 25 C230   9       bvc    entr      ;Mark not initial entry
                                         ;Branch around pascal entry stuff

C20B:01           11      dfb    $01      ;pascal signature byte
C20C:31           12      dfb    $31      ;device signature

C20D:11           13      dfb    >p2init
C20E:13           14      dfb    >p2read
C20F:15           15      dfb    >p2write
C210:17           16      dfb    >p2status

C211:              18 * Pascal support stuff

C211:80 D1 C1E4   20 p2init   bra    plinit
C213:80 D9 C1EE   21 p2read   bra    plread
C215:80 DF C1F6   22 p2write  bra    plwrite

C217:              C217   24 p2status equ    *
C217:A2 40        25 ldx    #$40      ;anticipate bad status request
C219:4A           26 lsr    a          ;shift request to carry
C21A:D0 12 C22E   27 bne    notrdy
C21C:AA           28 tax
C21D:A9 08        29 lda    #8          ;clear x for no error return code
C21F:B0 01 C222   30 bcs    pstat2  ;anticipate input ready request
C221:0A           31 asl    a          ;branch if good guess.
C222:09 20        32 pstat2 ora    #$20      ;include DCD in test
C224:39 89 C0     33 and   sstat+$90,y
C227:F0 05 C22E   34 beq    notrdy
C229:49 20        35 eor    #$20      ;branch if not ready for I/O
C22B:38           36 sec
C22C:D0 01 C22F   37 bne    isrdy   ;assume port is ready
C22E:18           38 notrdy clc
C22F:60           39 isrdy rts   ;branch if good assumption
                                         ;indicate acia not ready for I/O

C230:DA           41 entr    phx
C231:A2 C2        42 ldx    #<comslot ;X = <CN00
C233:              C233   43 setup   equ    *
C233:5A           44 phy
C234:48           45 pha
C235:8E F8 07     46 stx    mslot
C238:50 22 C25C   47 bvc    sudone
C23A:A5 36        48 lda    cswl      ;First call?
C23C:45 38        49 eor    kswl      ;If both hooks CN00 setup defaults
C23E:F0 06 C246   50 beq    sudodef
C240:A5 37        51 lda    cswh      ;If both hooks CN then don't do def
C242:C5 39        52 cmp    kswh      ;since it has already been done
C244:F0 03 C249   53 beq    sunodef
C246:20 C8 C2     54 sudodef jsr    default
C249:8A           55 sunodef txa
C24A:45 39        56 eor    kswh      ;Input call?
C24C:05 38        57 ora    kswl
C24E:D0 07 C257   58 bne    suout
C250:A9 05        59 lda    #>sin   ;Must be Cn00
C252:85 38        60 sta    kswl   ;Fix the input hook

```

```

C254:38      61      sec      ;C = 1 for input call
C255:80 05   C25C    62      bra     sudone
C257:A9 07      63      suout   ;Fix output hook
C259:85 36      64      sta      cswl   ;Note C might not be 0
C25B:18      65      clc      ;C=0 for output
C25C:BD B8 06   66      sudone  ;Check if serial or comm port
C25F:89 01      67      bit      #1    ;Leave flags in a for serport
C261:D0 03   C266    68      bne     commport
C263:4C 17   C1      69      comout  serport
C266:90 FB   C263    70      commport comout ;Output?
C268:68      71      pla      ;Get the char
C269:80 28   C293    72      bra     terml  ;Input
C26B:3C B8 03   73      noesc   sermode,x ;In terminal mode?
C26E:50 1C   C28C    74      bvc     exitl  ;If not, return key
C270:20 91   C1      75      jsr     serout2 ;Out it goes
C273:80 1E   C293    76      bra     terml
C275:          C275    77      testkbd equ    *
C275:68      78      pla      ;Get current char
C276:20 70   CC      79      jsr     update ;Update cursor & check keyboard
C279:10 1B   C296    80      bpl     serin  ;N=0 if no new key
C27B:20 EB   C9      81      jsr     command ;Test for command
C27E:B0 EB   C26B    82      bcs     noesc  ;Branch if not
C280:29 5F      83      and    #$5f  ;upshift for following tests
C282:C9 51      84      cmp     #'Q' ;Quit?
C284:F0 04   C28A    85      beq     exitX ;Reset?
C286:C9 52      86      cmp     #'R' ;Go check serial
C288:D0 09   C293    87      bne     terml ;return a CTRL-X
C28A:A9 98      88      exitX lda    #$98
C28C:7A      89      exitl  ply
C28D:FA      90      plx
C28E:60      91      rts
C28F:18      92      goreMOTE clc   ;Into remote mode
C290:20 CD   CA      93      goterm jsr   settERM ;Into terminal mode
C293:          C293    94      termL  equ   *
C293:20 4C   CC      95      jsr     showcur ;Get current char on screen
C296:48      96      serin  pha
C297:20 C5   C8      97      jsr     XRDSER ;Is it ready?
C29A:90 D9   C275    98      bcc     testkbd ;If not, try the keyboard
C29C:A8      99      tay
C29D:68      100     pla
C29E:5A      101     phy
C29F:20 B8   C3      102     jsr     storCh ;Save new char on stack
C2A2:68      103     pla ;Fix the screen
C2A3:BC 38 06   104     ldy     eschar,x ;Get the new data
C2A6:F0 16   C2BE    105     beq     sinomod ;If 0, don't modify char
C2A8:09 80      106     ora    #$80 ;Apple loves the high bit
C2AA:C9 8A      107     cmp    #$8A ;Ignore line feed
C2AC:F0 E5   C293    108     beq     terml
C2AE:C9 91      109     cmp    #xon
C2B0:F0 E1   C293    110     beq     terml ;Ignore ^Q
C2B2:C9 FF      111     cmp    #$FF ;Ignore FFs
C2B4:F0 DD   C293    112     beq     terml
C2B6:C9 92      113     cmp    #$92 ;^R for remote?
C2B8:F0 D5   C28F    114     beq     goreMOTE
C2BA:C9 94      115     cmp    #$94 ;^T for terminal mode?
C2BC:F0 D2   C290    116     beq     goterm
C2BE:3C B8 03   117     sinomod bit   sermode,x ;In terminal mode?
C2C1:50 C9   C28C    118     bvc     exitl ;Return to user if not A = char

```

```

C2C3:20 ED FD      119      jsr    cout      ;Onto the screen with it
C2C6:80 CB C293    120      bra    terml
C2C8:          C2C8    121 default   equ    *
                                         ;Set up the defaults
C2C8:20 A2 C8      122      jsr    moveirq   ;make sure irq vectors ok
C2CB:BC 3B C2      123      ldy    defidx-$C1,x ;Index into alt screen. Table in command
C2CE:20 7C C3      124 defloop   jsr    getalt   ;Get default from alt screen
C2D1:48           125      pha
C2D2:88           126      dey
C2D3:30 04 C2D9    127      bmi    defff     ;Done if minus
C2D5:C0 03         128      cpy    #3
C2D7:D0 F5 C2CE    129      bne    defloop   ;Or if 2
C2D9:20 A2 C8      130 deffff   jsr    moveirq   ;Jam irq vector into LC
C2DC:68           131      pla
C2DD:BC 85 C8      132      ldy    devno,x  ;Command, control & flags on stack
C2E0:99 FB BF      133      sta    scntl,y  ;Set command reg
C2E3:68           134      pla
C2E4:99 FA BF      135      sta    scomd,y
C2E7:68           136      pla
C2E8:9D B8 06      137      sta    flags,x  ;And the flags
C2EB:29 01         138      and    #1       ;A = $01 (^A) if comm mode
C2ED:D0 02 C2F1    139      bne    defcom
C2EF:A9 09         140      lda    #9       ;^I for serial port
C2F1:9D 38 06      141 defcom   sta    eschar,x ;Get printer width
C2F4:68           142      pla
C2F5:9D B8 04      143      sta    pwdth,x
C2F8:9E B8 03      144      stz    sermode,x
C2FB:60           145      rts
C2FC:03 07         146 defidx   dfb    3,7
C2FE:          0002 147      ds    $C300-*,$00
C300:              20      INCLUDE C3SPACE ;80 column card @ $C300

```

```

C300:          2 ****
C300:          3 *
C300:          4 * THIS IS THE $C3XX ROM SPACE:
C300:          5 *
C300:          6 ****
C300:48      7 C3ENTRY   PHA           ; save regs
C301:DA     8   PHX
C302:5A     9   PHY
C303:80 12  C317    10  BRA   BASICINIT ; and init video firmware
C305:38      11 C3KEYIN  SEC           ; Pascal 1.1 ID byte
C306:90      12 DFB   $90            ; BCC OPCODE (NEVER TAKEN)
C307:18      13 C3COUT1 CLC           ; Pascal 1.1 ID byte
C308:80 1A  C324    14  BRA   BASICENT ;=>go print/read char
C30A:EA     15  NOP
C30B:          16 *
C30B:          17 * PASCAL 1.1 FIRMWARE PROTOCOL TABLE:
C30B:          18 *
C30B:01      19  DFB   $01            ; GENERIC SIGNATURE BYTE
C30C:88      20  DFB   $88            ; DEVICE SIGNATURE BYTE
C30D:          21 *
C30D:2C      22  DFB   >JPINIT        ; PASCAL INIT
C30E:2F      23  DFB   >JPREAD        ; PASCAL READ
C30F:32      24  DFB   >JPWRITE       ; PASCAL WRITE
C310:35      25  DFB   >JPSTAT        ; PASCAL STATUS
C311:          26 ****
C311:          27 *
C311:          28 * 128K SUPPORT ROUTINE ENTRIES:
C311:          29 *
C311:4C 86 CF 30  JMP   MOVEAUX       ; MEMORY MOVE ACROSS BANKS
C314:4C CD CF 31  JMP   XFER          ; TRANSFER ACROSS BANKS
C317:          32 ****
C317:          33 *
C317:          34 ****
C317:          35 * BASIC I/O ENTRY POINT:
C317:          36 ****
C317:          37 *
C317:20 20 CE 38 BASICINIT JSR   HOOKUP      ; COPYROM if needed, sethooks
C31A:20 BE CD 39   JSR   SET80         ; setup 80 columns
C31D:20 58 FC 40   JSR   HOME          ; clear screen
C320:7A      41   PLY
C321:FA      42   PLX           ; restore X
C322:68      43   PLA           ; restore char
C323:18      44   CLC           ; output a character
C324:          45 *
C324:80 03  C329    46 BASICENT BCS   BINPUT      ;=>carry me to input
C326:4C F6 FD 47 BPRINT  JMP   COUTZ        ; print a character
C329:4C 1B FD 48 BINPUT  JMP   KEYIN        ; get a keystroke
C32C:          49 *
C32C:4C 41 CF 50 JPINIT  JMP   PINIT        ; pascal init
C32F:4C 35 CF 51 JPREAD  JMP   PASREAD      ; pascal read
C332:4C C2 CE 52 JPWRITE JMP   PWRITE       ; pascal write
C335:4C B1 CE 53 JPSTAT  JMP   PSTATUS      ; pascal status call
C338:          54 *
C338:          55 * COPYROM is called when the video firmware is
C338:          56 * initialized. If the language card is switched
C338:          57 * in for reading, it copies the F8 ROM to the
C338:          58 * language card and restores the state of the
C338:          59 * language card.

```

```

C338:          60 *
C338:A9 06      61 COPYROM  LDA #GOODF8      ;get the ID byte
C33A:          62 *
C33A:          63 * Compare ID bytes to whatever is readable. If it
C33A:          64 * matches, all is ok. If not, need to copy.
C33A:          65 *
C33A:CD B3 FB  66      CMP F8VERSION     ;does it match?
C33D:FO 3C C37B 67      BEQ ROMOK
C33F:20 60 C3  68      JSR SETROM       ;read ROM, write RAM, save state
C342:A9 F8      69      LDA #$F8        ;from F800-FFFF
C344:85 37      70      STA CSWH
C346:64 36      71      STZ CSWL
C348:B2 36      72 COPYROM2  LDA (CSWL)    ;get a byte
C34A:92 36      73      STA (CSWL)    ;and save a byte
C34C:E6 36      74      INC CSWL
C34E:D0 F8  C348 75      BNE COPYROM2
C350:E6 37      76      INC CSWH
C352:D0 F4  C348 77      BNE COPYROM2    ;fall into RESETLC
C354:          78 *
C354:          79 * RESETLC resets the language card to the state
C354:          80 * determined by SETROM. It always leaves the card
C354:          81 * write enabled.
C354:          82 *
C354:DA          83 RESETLC PHX           ;save X
C355:AE 78 04      84 LDX ROMSTATE      ;get the state
C358:3C 81 C0      85 BIT ROMIN,X      ;set bank & ROM/RAM read
C35B:3C 81 C0      86 BIT ROMIN,X      ;set write enable
C35E:FA          87 PLX             ;restore X
C35F:60          88 RTS
C360:          89 *
C360:          90 * SETROM switches in the ROM for reading, the RAM
C360:          91 * for writing, and it saves the state of the
C360:          92 * language card. It does not save the write
C360:          93 * protect status of the card.
C360:          94 *
C360:DA          95 SETROM PHX           ;save x
C361:A2 00          96 LDX #0            ;assume write enable,bank2,ROMRD
C363:2C 11 C0          97 BIT RDLCBNK2   ;is bank 2 switched in?
C366:30 02  C36A 98 BMI NOT1          ;=>yes
C368:A2 08          99 LDX #$8          ;indicate bank 1
C36A:2C 12 C0         100 NOT1         ;BIT RDLCRAM   ;is LC RAM readable?
C36D:10 02  C371 101 BPL NOREAD       ;=>no
C36F:E8          102 INX             ;indicate RAM read
C370:E8          103 INX
C371:2C 81 C0         104 NOREAD        BIT $C081      ;ROM read
C374:2C 81 C0         105 BIT $C081      ;RAM write
C377:8E 78 04         106 STX ROMSTATE    ;save state
C37A:FA          107 PLX             ;restore X
C37B:60          108 ROMOK         RTS
C37C:          109 *
C37C:          110 * GETALT reads a byte from aux memory screenholes.
C37C:          111 * Y is the index to the byte (0-7) indexed off of
C37C:          112 * address $478.
C37C:          113 *
C37C:AD 13 C0         114 GETALT        LDA RDRAMRD    ;save state of aux memory
C37F:0A          115 ASL A
C380:AD 18 C0         116 LDA RD80COL    ;and of the 80STORE switch
C383:08          117 PHP

```

```

C384:8D 00 C0      118      STA    CLR80COL      ;no 80STORE to get page 1
C387:8D 03 C0      119      STA    RDCARDRAM    ;pop in the other half of RAM
C38A:B9 78 04      120      LDA    $478,Y      ;read the desired byte
C38D:28             121      PLP
C38E:B0 03 C393    122      BCS    GETALT1
C390:8D 02 C0      123      STA    RDMAINRAM
C393:10 03 C398    124      GETALT1      BPL    GETALT2
C395:8D 01 C0      125      STA    SET80COL
C398:60             126      GETALT2      RTS
C399:
C399:09 80          127      *                   ;and restore memory
C39B:C9 FB          128      UPSHIFTTO    ORA    #$80      ;set high bit for execs
C39D:00 06 C3A5     129      UPSHIFT      CMP    #$FB
C39F:C9 E1          130      BCS    X.UPSHIFT
C3A1:90 02 C3A5     131      CMP    #$E1
C3A3:29 DF          132      BCC    X.UPSHIFT
C3A3:29 DF          133      AND    #$DF
C3A5:60             134      X.UPSHIFT      RTS
C3A6:
C3A6:135      *
C3A6:136      * GETCOUT performs COUT for GETLN. It disables the
C3A6:137      * echoing of control characters by clearing the
C3A6:138      * M.CTL mode bit, prints the char, then restores
C3A6:139      * M.CTL. NOESC is used by the RDKEY routine to
C3A6:140      * disable escape sequences.
C3A6:141      *
C3A6:142      GETCOUT      PHA      ;save char to print
C3A7:A9 08          143      LDA    #M.CTL      ;disable control chars
C3A9:1C FB 04      144      TRB    VMODE      ;by clearing M.CTL
C3AC:68             145      PLA
C3AD:20 ED FD      146      JSR    COUT      ;restore character
C3B0:4C 44 FD      147      JMP    NOESCAPE    ;and print it
C3B0:4C 44 FD      148      *                   ;enable control chars
C3B3:
C3B3:149      * STORCH determines loads the current cursor position,
C3B3:150      * inverts the character, and displays it
C3B3:151      * STORCHAR inverts the character and displays it at the
C3B3:152      * position stored in Y
C3B3:153      * STORY determines the current cursor position, and
C3B3:154      * displays the character without inverting it
C3B3:155      * STORE displays the char at the position in Y
C3B3:156      *
C3B3:157      * If mouse characters are enabled (VMODE bit 0 = 0)
C3B3:158      * then mouse characters ($40-$5F) are displayed when
C3B3:159      * the alternate character set is switched in. Normally
C3B3:160      * values $40-$5F are shifted to $0-$1F before display.
C3B3:161      *
C3B3:162      * Calls to GETCUR trash Y
C3B3:163      *
C3B3:20 9D CC      164      STORY      JSR    GETCUR      ;get newest cursor into Y
C3B6:80 09 C3C1     165      BRA    STORE
C3B8:
C3B8:166      *
C3B8:20 9D CC      167      STORCH      JSR    GETCUR      ;first, get cursor position
C3BB:24 32          168      BIT    INVFLG      ;normal or inverse?
C3BD:30 02 C3C1     169      BMI    STORE      ;=>normal, store it
C3BF:29 7F          170      AND    #$7F      ;inverse it
C3C1:5A             171      STORE      PHY
C3C2:09 00          172      ORA    #0      ;does char have high bit set?
C3C4:30 15 C3DB     173      BMI    STORE1     ;=>yes, don't do mouse check
C3C6:48             174      PHA
C3C7:AD FB 04      175      LDA    VMODE      ;save char
C3C7:AD FB 04      176      *                   ;is mouse bit set?

```

C3CA:6A	176	ROR	A	
C3CB:68	177	PLA		;restore char
C3CC:90 0D C3DB	178	BCC	STORE1	;=>no, don't do mouse shift
C3CE:2C 1E C0	179	BIT	ALTCHARSET	;no shift if ][ char set
C3D1:10 08 C3DB	180	BPL	STORE1	;=> it is!
C3D3:49 40	181	EOR	#\$40	;\$40-\$5F=>0-\$1f
C3D5:89 60	182	BIT	#\$60	
C3D7:F0 02 C3DB	183	BEQ	STORE1	
C3D9:49 40	184	EOR	#\$40	
C3DB:2C 1F C0	185	STORE1	BIT	;80 columns?
C3DE:10 19 C3F9	186	BPL	STORE5	;=>no, store char
C3E0:48	187	PHA		;save (shifted) char
C3E1:8D 01 C0	188	STA	SET80COL	;hit 80 store
C3E4:98	189	TYA		;get proper Y
C3E5:45 20	190	EOR	WNDLFT	C=1 if char in main ram
C3E7:4A	191	LSR	A	
C3E8:B0 04 C3EE	192	BCS	STORE2	;=>yes, main RAM
C3EA:AD 55 C0	193	LDA	TXTPAGE2	;else flip in aux RAM
C3ED:C8	194	INY		;do this for odd left, aux bytes
C3EE:98	195	STORE2	TYA	;divide pos'n by 2
C3EF:4A	196	LSR	A	
C3F0:A8	197	TAY		
C3F1:68	198	PLA		;get (shifted) char
C3F2:91 28	199	STORE3	STA (BASL),Y	;stuff it
C3F4:2C 54 C0	200	BIT	TXTPAGE1	;else restore page1
C3F7:7A	201	STORE4	PLY	;restore real Y
C3F8:60	202	RTS		;und exit
C3F9:	203 *			
C3F9:91 28	204	STORE5	STA (BASL),Y	;do 40 column store
C3FB:7A	205	PLY		;restore Y
C3FC:60	206	RTS		;and exit
C3FD:	0003	DS \$C400-*,\$00		
C400:	21	INCLUDE MOUSE		;Equates for the mouse

```

C400:      2           MSB    ON
C400:      3 ****
C400:      4 *
C400:      5 * Mouse firmware for the Chels
C400:      6 *
C400:      7 * by Rich Williams
C400:      8 * July, 1983
C400:      9 *
C400:     10 ****

C400:     12 ****
C400:     13 *
C400:     14 * Equates
C400:     15 *
C400:     16 ****

C400:     18 * Input bounds are in scratch area
C400: 0478 19 moutemp   equ   $478          ;Temporary storage
C400: 0478 20 minl      equ   $478
C400: 04F8 21 maxl      equ   $4F8
C400: 0578 22 minh      equ   $578
C400: 05F8 23 maxh      equ   $5F8
C400:     24 * Mouse bounds in slot 5 screen area
C400: 047D 25 minxl     equ   $47D
C400: 04FD 26 minyl     equ   $4FD
C400: 057D 27 minxh     equ   $57D
C400: 05FD 28 minyh     equ   $5FD
C400: 067D 29 maxx1     equ   $67D
C400: 06FD 30 maxyl     equ   $6FD
C400: 077D 31 maxxh     equ   $77D
C400: 07FD 32 maxyh     equ   $7FD
C400:     33 * Mouse holes in slot 4 screen area
C400: 047C 34 mouxl     equ   $47C          ;X position low byte
C400: 04FC 35 mouyl     equ   $4FC          ;Y position low byte
C400: 057C 36 mouxh     equ   $57C          ;X position high byte
C400: 05FC 37 mouyh     equ   $5FC          ;Y position high byte
C400: 067C 38 mouarm    equ   $67C          ;Arm interrupts from movement or button
C400: 077C 39 moustat   equ   $77C          ;Mouse status
C400:     40 * Moustat provides the following
C400:     41 * D7= Button pressed
C400:     42 * D6= Status of button on last read
C400:     43 * D5= Moved since last read
C400:     44 * D4= Reserved
C400:     45 * D3= Interrupt from VBL
C400:     46 * D2= Interrupt from button
C400:     47 * D1= Interrupt from movement
C400:     48 * D0= Reserved
C400: 07FC 49 mouemode   equ   $7FC          ;Mouse mode
C400:     50 * D7-D4= Unused
C400:     51 * D3= VBL active
C400:     52 * D2= VBL interrupt on button
C400:     53 * D1= VBL interrupt on movement
C400:     54 * D0= Mouse active
C400: 0020 55 movarm    equ   $20

```

```
C400:    000C  56 vblmode   equ   $0C
C400:    0004  57 butmode    equ   $04          ;D2 mask
C400:    0002  58 movmode    equ   $02          ;D1 mask

C400:      60 * Hardware addresses
C400:    C015  61 mouxint   equ   $C015        ;D7 = x interrupt
C400:    C017  62 moyuint   equ   $C017        ;D7 = y interrupt
C400:    C019  63 vblint    equ   $C019        ;D7 = vbl interrupt
C400:    C078  64 ioudsbl   equ   $C078        ;Disable iou access
C400:    C079  65 iouenbl   equ   $C079        ;Enable iou access
C400:    C048  66 mouclr    equ   $C048        ;Clear mouse interrupt
C400:    C058  67 iou     equ   $C058        ;IOU interrupt switches
C400:    C058  68 moudsbl   equ   $C058        ;Disable mouse interrupts
C400:    C059  69 mouenbl   equ   $C059        ;Enable mouse interrupts
C400:    C063  70 moubut    equ   $C063        ;D7 = Mouse button
C400:    C066  71 mouxl    equ   $C066        ;D7 = X1
C400:    C067  72 mouyl    equ   $C067        ;D7 = Y1
C400:    C070  73 vblclr   equ   $C070        ;Clear VBL interrupt
C400:    74 *
C400:      75 * Other addresses
C400:    76 *
C400:    0200  77 inbuf     equ   $200         ;Input buffer
C400:    0214  78 binl      equ   inbuf+20      ;Temp for binary conversion
C400:    0215  79 binh      equ   inbuf+21      ;Mouse @ $C400
C400:    22      INCLUDE MCODE
```

```
C400:          2 ****
C400:          3 *
C400:          4 * Entry points for mouse firmware
C400:          5 *
C400:          6 ****
C400:80 05    C407  7 mbasic   bra    outent
C402:A2 03      pnull     ldx    #3
C404:60          9         rts          ;Null for pascal entry
C405:38          10        inent    sec          ;Signature bytes
C406:90          11         dfb    $90
C407:18          12        outent   clc
C408:4C 80 C7  13         jmp    xmbasic   ;Go do basic entry
C40B:01          14         dfb    $01       ;More signature stuff
C40C:20          15         dfb    $20
C40D:02          16         dfb    >pnull
C40E:02          17         dfb    >pnull
C40F:02          18         dfb    >pnull
C410:02          19         dfb    >pnull
C411:00          20         dfb    $0
C412:3D          21         dfb    >xsetmou  ;SETMOUSE
C413:FC          22         dfb    >xmtstint ;SERVEMOUSE
C414:95          23         dfb    >xmread   ;READMOUSE
C415:84          24         dfb    >xmclear  ;CLEARMOUSE
C416:6B          25         dfb    >noerror  ;POSMOUSE
C417:B0          26         dfb    >xmclamp  ;CLAMPMOUSE
C418:6D          27         dfb    >xmhome   ;HOMEMOUSE
C419:1C          28         dfb    >initmouse ;INITMOUSE
C41A:02          29         dfb    >pnull
C41B:CF          30         dfb    >xmint
```

```

C41C:          32 ****
C41C:          33 *
C41C:          34 * Initmouse - resets the mouse
C41C:          35 * Also clears all of the mouse holes
C41C:          36 * note that iou access fires pdlstrb & makes mouse happy
C41C:          37 *
C41C:          38 ****
C41C:          C41C 39 initmouse equ *
C41C:9C 07      40       stz    mousstat      ;Clear status
C41F:A2 80      41       ldx    #$80
C421:A0 01      42       ldy    #1
C423:9E 7D 04    43 xrloop   stz    minxl,x      ;Minimum = $0000
C426:9E 7D 05    44       stz    minxh,x     ;Maximum = $03FF
C429:A9 FF      45       lda    #$FF
C42B:9D 7D 06    46       sta    maxx1,x
C42E:A9 03      47       lda    #03
C430:9D 7D 07    48       sta    maxxh,x
C433:A2 00      49       ldx    #0
C435:88          50       dey
C436:10 EB      C423 51       bpl    xrloop
C438:20 6D C4      52       jsr    xmhome      ;Clear the mouse holes
C43B:A9 00      53       lda    #0           ;Fall into SETMOU

```

```

C43D:          55 ****
C43D:          56 *
C43D:          57 * XSETMOU - Sets the mouse mode to A
C43D:          58 *
C43D:          59 ****
C43D:          C43D 60 xsetmou equ *
C43D:AA         61       tax
C43E:20 A2 C8    62       jsr    moveirq      ;Make sure interrupt vector is right
C441:8A         63       txa
C442:8D 78 04    64       sta    moutemp
C445:4A         65       lsr    A             ;D0 = 1 if mouse active
C446:0D 78 04    66       ora    moutemp      ;D2 = 1 if vbl active
C449:C9 10      67       cmp    #$10        ;If >=$10 then invalid mode
C44B:B0 1F      C46C 68       bcs    sminvalid
C44D:29 05      69       and    #5           ;Extract VBL & Mouse
C44F:F0 01      C452 70       beq    xswoff      ;Turning it off?
C451:58          71       cli
C452:69 55      72       xswoff      ;If not, ints active
C452:69 55      72       adc    #$55        ;Make iou byte C=0

```

```

C454:          74 ****
C454:          75 *
C454:          76 * SETIOU - Sets the IOU interrupt modes to A
C454:          77 * Inputs: A = Bits to change
C454:          78 * D7 = Y int on falling edge
C454:          79 * D6 = Y int on rising edge
C454:          80 * D5 = X int on falling edge
C454:          81 * D4 = X int on rising edge
C454:          82 * D3 = Enable VBL int
C454:          83 * D2 = Disable VBL int
C454:          84 * D1 = Enable mouse int
C454:          85 * D0 = Disable mouse int

```

```

C454:          86 *
C454:          87 *
C454:          88 ****
C454:          C454  89 setiou   equ   *
C454:08         90      php
C455:78         91      sei           ;Don't allow ints while iou enabled
C456:8E FC 07  92      stx   moumode
C459:8D 79 C0  93      sta   iouenbl  ;Enable iou access
C45C:A2 08     94      ldx   #8
C45E:CA         95 siloop    dex
C45F:0A         96      asl   A       ;Get a bit to check
C460:90 03 C465  97      bcc   sinoch  ;No change if C=0
C462:9D 58 C0  98      sta   iou,x   ;Set it
C465:D0 F7 C45E  99 sinoch    bne   siloop   ;Any bits left in A?
C467:8D 78 C0  100     sta   ioudsbl  ;Turn off iou access
C46A:28         101     plp
C46B:18         102 noerror   clc
C46C:60         103 sminvalid rts

C46D:          105 ****
C46D:          106 *
C46D:          107 * XMHOME- Clears mouse position & status
C46D:          108 *
C46D:          109 ****
C46D:          C46D  110 xmhome   equ   *
C46D:A2 80     111     ldx   #$80      ;Point mouse to upper left
C46F:80 02 C473  112     bra   xmh2
C471:A2 00     113 xmhloop   ldx   #0
C473:BD 7D 04  114 xmh2     lda   minxl,x
C476:9D 7C 04  115      sta   mouxl,x
C479:BD 7D 05  116      lda   minxh,x
C47C:9D 7C 05  117      sta   mouxh,x
C47F:CA         118     dex
C480:10 EF C471  119     bpl   xmhloop
C482:80 0C C490  120     bra   xmcdone

C484:          122 ****
C484:          123 *
C484:          124 * XMCLEAR - Sets the mouse to 0,0
C484:          125 *
C484:          126 ****
C484:          C484  127 xmclear   equ   *
C484:9C 7C 04  128      stz   mouxl
C487:9C 7C 05  129      stz   mouxh
C48A:9C FC 04  130      stz   mouyl
C48D:9C FC 05  131      stz   mouyh
C490:9C 7C 06  132 xmcdone   stz   mouarm
C493:18         133     clc
C494:60         134     rts

```

```

C495:          136 ****
C495:          137 *
C495:          138 * XMREAD - Updates the screen holes
C495:          139 *
C495:          140 ****
C495:          C495 141 xmread   equ   *
C495:A9 20    142 lda      #movarm      ;Has mouse moved?
C497:2D 7C 06 143 and     mouarm
C49A:1C 7C 06 144 trb      mouarm      ;Clear arm bit
C49D:2C 63 C0 145 bit      moubut      ;Button pressed?
C4A0:30 02   C4A4 146 bmi      xrbut
C4A2:09 80    147 ora      #$80
C4A4:2C 7C 07 148 xrbut   bit      mousstat   ;Pressed last time?
C4A7:10 02   C4AB 149 bpl      xrbut2
C4A9:09 40    150 ora      #$40
C4AB:8D 7C 07 151 xrbut2 sta      mousstat
C4AE:18      152 clc
C4AF:60      153 rts

C4B0:          155 ****
C4B0:          156 *
C4B0:          157 * XMCLAMP - Store new bounds
C4B0:          158 * Inputs A = 1 for Y, 0 for X axis
C4B0:          159 *      minl, minh, maxl, maxh = new bounds
C4B0:          160 *
C4B0:          161 ****
C4B0:          C4B0 162 xmclamp  equ   *
C4B0:6A        163 ror      A      ;1 -> 80
C4B1:6A        164 ror      A
C4B2:29 80    165 and     #$80
C4B4:AA        166 tax
C4B5:AD 78 04 167 lda      minl
C4B8:9D 7D 04 168 sta      minxl,x
C4BB:AD 78 05 169 lda      minh
C4BE:9D 7D 05 170 sta      minxh,x
C4C1:AD F8 04 171 lda      maxl
C4C4:9D 7D 06 172 sta      maxx1,x
C4C7:AD F8 05 173 lda      maxh
C4CA:9D 7D 07 174 sta      maxxh,x
C4CD:18        175 clc      ;No error
C4CE:60        176 rts

```

```

C4CF:          178 ****
C4CF:          179 *
C4CF:          180 * Mouse interrupt handler
C4CF:          181 *
C4CF:          182 * MOUSEINT - Monitor's interrupt handler
C4CF:          183 * XMINT - Interrupt handler the user can use
C4CF:          184 * XMTSTINT - Checks mouse status bits
C4CF:          185 ****
C4CF: C4CF 186 xmint    equ   *
C4CF:AE 66 C0 187      ldx   mouxl      ;Get X1 & Y1 asap
C4D2:AC 67 C0 188      ldy   mouyl
C4D5: C4D5 189 mouseint equ   *      ;Entry point if X & Y set up
C4D5:A9 0E 190      lda   #$0E      ;Clear status bits
C4D7:1C 7C 07 191      trb   mousstat

C4DA:38       193      sec      ;Assume interrupt not handled
C4DB:          194 * Check for vertical blanking interrupt
C4DB:AD 19 C0 195      lda   vblint    ;VBL interrupt?
C4DE:10 48 C528 196      bpl   chkmou
C4E0:8D 79 C0 197      sta   iouenbl   ;Enable iou access & clear VBL interrupt
C4E3:A9 0C 198      lda   #vblmode  ;Should we leave vbl active?
C4E5:2C FC 07 199      bit   mouemode
C4E8:D0 03 C4ED 200      bne   cvnovb1
C4EA:8D 5A C0 201      sta   iou+2    ;Disable VBL
C4ED:09 02 202 cvnovb1 ora   #movmode
C4EF:80 1B C50C 203      bra   xmskip

C4F1:A9 0E 205 mistat  lda   #$0E
C4F3:2D 7C 07 206      and   mousstat
C4F6:D0 01 C4F9 207      bne   nostat2
C4F8:38       208      sec
C4F9:68       209 nostat2  pla
C4FA:60       210      rts
C4FB: 0000 211      ds   $C4FB-* ;Signature byte
C4FB:D6 212      dfb   $D6
C4FC:48       213 xmtstint pha
C4FD:18       214      clc
C4FE:80 F1 C4F1 215      bra   mistat  ;Go check status
C500:FF       216      dfb   $FF
C501:20 4D CE 217      jsr   zzquit ;Get out of the hooks
C504:A2 FF 218      ldx   #$FF
C506:20 24 CB 219 qloop   jsr   znm2
C509:10 FB C506 220      bpl   qloop
C50B:60       221      rts
C50C: C50C 222 xmskip  equ   *
C50C:8D 78 C0 223      sta   ioudsbl
C50F:2C 7C 06 224      bit   mouarm  ;VBL bit in arm isn't used
C512:D0 02 C516 225      bne   cvmoved
C514:A9 0C 226      lda   #vblmode ;Didn't move
C516:2C 63 C0 227 cvmoved bit   moubut ;Button pressed?
C519:10 02 C51D 228      bpl   cvbut
C51B:49 04 229      eor   #butmode ;Clear the button bit
C51D:2D FC 07 230 cvbut   and   moumode ;Which bits were set in the mode
C520:0C 7C 07 231      tsb   mousstat

```

```

C523:1C 7C 06      232      trb    mouarm
C526:69 FE          233      adc    #$FE           ;C=1 if int passes to user
C528:              234 * Check & update mouse movement
C528:      C528     235 chkmou   equ    *
C528:AD 15 CO       236      lda    mouxint        ;Mouse interrupt?
C52B:0D 17 CO       237      ora    mouyint
C52E:10 6A  C59A    238      bpl    xmdone        ;If not return with C from vbl
C530:8A             239      txa    #0             ;Get Xl in A
C531:A2 00          240      ldx    #0
C533:2C 15 CO       241      bit    mouxint        ;X movement?
C536:30 0A  C542    242      bmi    cmxmov
C538:98             243      cmloop   tya    #0           ;Get Yl into A
C539:49 80          244      eor    #$80          ;Complement direction
C53B:A2 80          245      ldx    #$80
C53D:2C 17 CO       246      bit    mouyint
C540:10 39  C57B    247      bpl    cmnoy
C542:0A             248      cmxmov   asl    A
C543:BD 7C 04       249      lda    mouxl,x       ;A = current low byte
C546:80 1A  C562    250      bcs    cmrght        ;Which way?
C548:DD 7D 04       251      cmp    minxl,x       ;Move left
C54B:D0 08  C555    252      bne    cmlok
C54D:BD 7C 05       253      lda    mouxh,x
C550:DD 7D 05       254      cmp    minxh,x
C553:F0 22  C577    255      beq    cmnoint
C555:BD 7C 04       256      cmlok   lda    mouxl,x
C558:D0 03  C55D    257      bne    cmnt0          ;Borrow from high byte?
C55A:DE 7C 05       258      dec    mouxh,x
C55D:DE 7C 04       259      cmnt0   dec    mouxl,x
C560:80 15  C577    260      bra    cmnoint
C562:DD 7D 06       261      cmp    maxxl,x       ;At high bound?
C565:D0 08  C56F    262      bne    cmrok
C567:BD 7C 05       263      lda    mouxh,x
C56A:DD 7D 07       264      cmp    maxxh,x
C56D:F0 08  C577    265      beq    cmnoint
C56F:FE 7C 04       266      cmrok   inc    mouxl,x       ;Move right
C572:D0 03  C577    267      bne    cmnoint
C574:FE 7C 05       268      inc    mouxh,x
C577:E0 00          269      cpx    #0
C579:F0 BD  C538    270      beq    cmloop
C57B:8D 48 CO       271      cmnoy   sta    mouclr
C57E:A9 02          272      lda    #movmode        ;Should we enable VBL?
C580:2D FC 07       273      and    mouemode
C583:F0 09  C58E    274      beq    cmnovbl        ;Branch if not
C585:8D 79 CO       275      sta    iouenbl
C588:8D 5B CO       276      sta    iou+3          ;Enable VBL int
C58B:8D 78 CO       277      sta    ioudsbl
C58E:09 20          278      cmnovbl ora    #movarm        ;Mark that we moved
C590:0C 7C 06       279      tsb    mouarm
C593:A9 0E          280      lda    #$OE
C595:2D 7C 07       281      and    moustat
C598:69 FE          282      adc    #$FE           ;C=1 iff any bits were 1
C59A:60             283      xmdone  rts

```

```

C59B:          285 ****
C59B:          286 *
C59B:          287 * HEXTODEC - Puts +0000, into the input buffer
C59B:          288 *   inputs: A = Low byte of number
C59B:          289 *           X = High byte of number
C59B:          290 *           Y = Position of ones digit
C59B:          291 *
C59B:          292 ****
C59B:          C59B 293 hextodec equ  *
C59B:E0 80    294 cpx #$80      ;Is it a negative number?
C59D:90 0D    C5AC 295 bcc hexdec2
C59F:49 FF    296 eor #$FF     ;Form two's complement
C5A1:69 00    297 adc #0       ;C = 1 from compare
C5A3:48      298 pha          ;Save it
C5A4:8A      299 txa
C5A5:49 FF    300 eor #$FF
C5A7:69 00    301 adc #0
C5A9:AA      302 tax
C5AA:68      303 pla
C5AB:38      304 sec
CSAC:8D 14 02 305 hexdec2 sta binl      ;Store the number to convert
C5AF:8E 15 02 306 stx binh
C5B2:A9 AB    307 lda #'+'     ;Store the sign in the buffer
C5B4:90 02    C5B8 308 bcc hdpos2
C5B6:A9 AD    309 lda #'-'     ;Save the sign
C5B8:48      310 hdpos2 pha
C5B9:A9 AC    311 lda #',,'    ;Store a comma after the number
C5BB:99 01 02 312 sta inbuf+1,y
C5BE:          C5BE 313 hdloop equ  *      ;Divide by 10
C5BE:          314 *
C5BE:          315 * Divide BINH,L by 10 and leave remainder in A
C5BE:          316 *
C5BE:A2 11    317 ldx #16+1    ;16 bits and first time do nothing
C5C0:A9 00    318 lda #0
C5C2:18      319 clc          ;C=0 so first ROL leaves A=0
C5C3:2A      320 dvl0loop rol A
C5C4:C9 0A    321 cmp #10      ;A >= 10?
C5C6:90 02    C5CA 322 bcc dvl0lt    ;Branch if <
C5C8:E9 0A    323 sbc #10      ;C = 1 from compare and is left set
C5CA:2E 14 02 324 dvl0lt rol binl
C5CD:2E 15 02 325 rol binh
C5D0:CA      326 dex
C5D1:D0 F0    C5C3 327 bne dvl0loop
C5D3:09 B0    328 ora #'0'      ;Make a ascii char
C5D5:99 00 02 329 sta inbuf,y
C5D8:88      330 dey
C5D9:F0 08    C5E3 331 beq hddone    ;Stop on 0,6,12
C5DB:CO 07    332 cpy #7
C5DD:F0 04    C5E3 333 beq hddone
C5DF:CO 0E    334 cpy #14
C5E1:D0 DB    C5BE 335 bne hdloop
C5E3:68      336 hddone pla      ;Get the sign
C5E4:99 00 02 337 sta inbuf,y
C5E7:60      338 rts
C5E8:DF 67 37 1C 339 qtbl  dfb $DF,$67,$37,$1C,$07,$0C,$45,$62
C5F0:6E 7E 3B 0A 340 dfb $6E,$7E,$3B,$0A,$0B,$48,$77,$7B
C5F8:66 2B 0C 08 341 dfb $66,$2B,$0C,$08,$16,$53,$68,$C5
C600:        0000 342 ds   $C600-*

```

```

C600:      0356   3 DNIBL    EQU   $356
C600:      0300   4 NBUFL    EQU   $300
C600:      07DB   5 BOOTSCRN EQU   $7DB
C600:      002B   6 SLOTZ    EQU   $2B
C600:      003C   7 BOOTTMP   EQU   $3C
C600:      004F   8 BOOTDEV   EQU   $4F
C600:A2 20  9          LDX   #$20
C602:A0 00  10         LDY   #$00
C604:64 03  11         STZ   $03
C606:64 3C  12         STZ   $3C
C608:A9 60  13         LDA   #$60
C60A:AA    14         TAX
C60B:86 2B  15 DRV2ENT  STX   SLOTZ
C60D:85 4F  16 STA    BOOTDEV
C60F:5A    17          PHY
C610:BD 8E C0  18          LDA   $C08E,X
C613:BD 8C C0  19          LDA   $C08C,X
C616:7A    20          PLY
C617:B9 EA C0  21          LDA   $COEA,Y      ;Y=1 IF DRIVE 2 BOOT, ELSE Y=0
C61A:BD 89 C0  22          LDA   $C089,X      ;SELECT DRIVE 1 OR 2
C61D:A0 50    23          LDY   #$50
C61F:BD 80 C0  24 SEEKZERO LDA   $C080,X
C622:98    25          TYA
C623:29 03  26          AND   #$03
C625:0A    27          ASL   A
C626:05 2B  28          ORA   SLOTZ
C628:AA    29          TAX
C629:BD 81 C0  30          LDA   $C081,X
C62C:A9 56    31          LDA   #$56
C62E:20 A8 FC  32          JSR   WAIT
C631:88    33          DEY
C632:10 EB  C61F  34          BPL   SEEKZERO
C634:85 26    35          STA   $26
C636:85 3D    36          STA   $3D
C638:85 41    37          STA   $41
C63A:20 09 C7  38          JSR   MAKTBL
C63D:64 03    39 EXTENT1 STZ   $03
C63F:18    40 RDADR   CLC
C640:08    41          PHP
C641:28    42 RETRY1  PLP
C642:A6 2B  43 RDDHDR  LDX   SLOTZ      ;RESTORE X TO $60
C644:C6 03  44          DEC   $03      ;UPDATE RETRY COUNT
C646:DO 0E  C656  45          BNE   RDHD0      ;BRANCH IF NOT OUT OF RETRIES
C648:BD 88 C0  46 FUGIT   LDA   SC088,X      ;SHUT OFF DISK AND QUIT!
C64B:BD CF C6  47 FUG1    LDA   MSG-$60,X     ;(X STARTS AT $60)
C64E:10 FE  C64E  48 HANGING BPL   HANGING    ;HANG, HANG, HANG!
C650:9D 7B 07  49          STA   BOOTSCRN-$60,X
C653:E8    50          INX
C654:80 F5  C64B  51          BRA   FUG1
C656:08    52 RDHD0   PHP
C657:88    53 RETRY   DEY
C658:DO 04  C65E  54          BNE   RDHD1
C65A:FO E5  C641  55          BEQ   RETRY1
C65C:80 DF  C63D  56 EXTENT  BRA   EXTENT1
C65E:      57 * * * * * * * * * * * * * * * * * *
C65E:      58 * The following code is sacred in it's *
C65E:      59 * present form. To change it would   *
C65E:      60 * cause volcanos to erupt, the ground  *

```

```

C65E:          61 * to shake, and ProDOS not to boot!      *
C65E:          62 * * * * * * * * * * * * * * * * * * * * *
C65E:BD 8C C0 63 RDHD1    LDA   $C08C,X
C661:10 FB C65E 64     BPL   RDHD1
C663:49 D5 65 ISMRK1   EOR   #$D5
C665:D0 F0 C657 66     BNE   RETRY
C667:BD 8C C0 67 RDHD2    LDA   $C08C,X
C66A:10 FB C667 68     BPL   RDHD2
C66C:C9 AA 69     CMP   #$AA
C66E:D0 F3 C663 70     BNE   ISMRK1
C670:EA 71     NOP
C671:BD 8C C0 72 RDHD3    LDA   $C08C,X
C674:10 FB C671 73     BPL   RDHD3
C676:C9 96 74     CMP   #$96
C678:F0 09 C683 75     BEQ   RDSECT
C67A:28 76     PLP
C67B:90 C2 C63F 77     BCC   RDADR
C67D:49 AD 78     EOR   #$AD
C67F:F0 25 C6A6 79     BEQ   RDATA
C681:D0 BC C63F 80     BNE   RDADR
C683:A0 03 81 RDSECT   LDY   #$03
C685:85 40 82 RDSEC1   STA   $40
C687:BD 8C C0 83 RDSEC2   LDA   $C08C,X
C68A:10 FB C687 84     BPL   RDSEC2
C68C:2A 85     ROL   A
C68D:85 3C 86     STA   BOOTTMP
C68F:BD 8C C0 87 RDSEC3   LDA   $C08C,X
C692:10 FB C68F 88     BPL   RDSEC3
C694:25 3C 89     AND   BOOTTMP
C696:88 90     DEY
C697:D0 EC C685 91     BNE   RDSEC1
C699:28 92     PLP
C69A:C5 3D 93     CMP   $3D
C69C:D0 A1 C63F 94     BNE   RDADR
C69E:A5 40 95     LDA   $40
C6A0:C5 41 96     CMP   $41
C6A2:D0 9B C63F 97 BADRD1   BNE   RDADR
C6A4:B0 9C C642 98     BCS   RDDHDR
C6A6:A0 56 99 RDATA    LDY   #$56
C6A8:84 3C 100 RDATO   STY   BOOTTMP
C6AA:BC 8C C0 101 RDAT1   LDY   $C08C,X
C6AD:10 FB C6AA 102     BPL   RDAT1
C6AF:59 D6 02 103     EOR   DNIBL-$80,Y
C6B2:A4 3C 104     LDY   BOOTTMP
C6B4:88 105     DEY
C6B5:99 00 03 106     STA   NBUF1,Y
C6B8:D0 EE C6A8 107     BNE   RDATO
C6BA:84 3C 108 RDAT2   STY   BOOTTMP
C6BC:BC 8C C0 109 RDAT3   LDY   $C08C,X
C6BF:10 FB C6BC 110     BPL   RDAT3
C6C1:59 D6 02 111     EOR   DNIBL-$80,Y
C6C4:A4 3C 112     LDY   BOOTTMP
C6C6:91 26 113     STA   ($26),Y
C6C8:C8 114     INY
C6C9:D0 EF C6BA 115     BNE   RDAT2
C6CB:BC 8C C0 116 RDAT4   LDY   $C08C,X
C6CE:10 FB C6CB 117     BPL   RDAT4
C6D0:59 D6 02 118     EOR   DNIBL-$80,Y

```

```

C6D3:D0 CD    C6A2   119 BADREAD   BNE   BADRD1
C6D5:A0 00      120 LDY   #$00
C6D7:A2 56      121 DENIBL    LDX   #$56
C6D9:CA      122 DENIBL    DEX
C6DA:30 FB    C6D7   123 BMI    DENIBL
C6DC:B1 26      124 LDA   ($26),Y
C6DE:5E 00 03    125 LSR   NBUF1,X
C6E1:2A      126 ROL   A
C6E2:5E 00 03    127 LSR   NBUF1,X
C6E5:2A      128 ROL   A
C6E6:91 26      129 STA   ($26),Y
C6E8:C8      130 INY
C6E9:D0 EE    C6D9   131 BNE   DENIBL
C6EB:          132 * * * * * * * * * * * * * * *
C6EB:          133 * Code beyond this point is not *
C6EB:          134 * sacred... It may be perverted *
C6EB:          135 * in any manner by any pervert. *
C6EB:          136 * * * * * * * * * * * * * * *
C6EB:E6 27      137 INC   $27
C6ED:E6 3D      138 INC   $3D
C6EF:A5 3D      139 LDA   $3D
C6F1:CD 00 08    140 CMP   $0800
C6F4:A6 4F      141 LDX   BOOTDEV
C6F6:90 DB    C6D3   142 BCC   BADREAD
C6F8:4C 01 08    143 JMP   $0801
C6FB:4C 0B C6      144 DODRV2   JMP   DRV2ENT
C6FE: 0002      145 DS    $C700-* ,0
C700:FF      146 DFB   $FF      ;MAKE IT LOOK LIKE NOTHING IN SLOT
C701:A9 E0      147 DRV2BOOT  LDA   #$EO      ;FOR DEVICE #2
C703:A0 01      148 LDY   #1       ;TO SELECT DRIVE 2
C705:A2 60      149 LDX   #$60
C707:80 F2    C6FB   150 BRA   DODRV2
C709:A2 03      151 MAKTBL   LDX   #$03
C70B:A0 00      152 LDY   #0
C70D:86 3C      153 TBLLOOP  STX   BOOTTMP
C70F:8A      154 TXA
C710:0A      155 ASL   A
C711:24 3C      156 BIT   BOOTTMP
C713:F0 10    C725   157 BEQ   NOPATRN
C715:05 3C      158 ORA   BOOTTMP
C717:49 FF      159 EOR   #$FF
C719:29 7E      160 AND   #$7E
C71B:80 08    C725   161 TBLLOOP2 BCS   NOPATRN
C71D:4A      162 LSR   A
C71E:DO FB    C71B   163 BNE   TBLLOOP2
C720:98      164 TYA
C721:9D 56 03    165 STA   DNIBL,X
C724:C8      166 INY
C725:E8      167 NOPATRN INX
C726:10 E5    C70D   168 BPL   TBLLOOP
C728:A9 08      169 LDA   #$08
C72A:85 27      170 STA   $27
C72C:A0 7F      171 LDY   #$7F
C72E:60      172 RTS
C72F:        C72F   173 MSG   EQU   *
C72F:        174 MSB   ON
C72F:C3 E8 E5 E3  175 ASC   'Check      Disk Drive.'
C740:          176 *

```

```

C740:          177 * The following code is Teri's memory and
C740:          178 * soft switch exercise program. The only
C740:          179 * purpose is exercise, not diagnostic
C740:          180 * functions. This code is activated on
C740:          181 * a system without a keyboard, or when
C740:          182 * both open and closed apple keys are
C740:          183 * pressed during the reset sequence.
C740:          184 *
C740:08 50 52   185 TBL1    DFB  $08,$50,$52 ;These are low order
C743:00 02 04   186      DFB  $00,$02,$04 ; addresses of $COXX
C746:8B 8B E8   187      DFB  $8B,$8B,$E8 ; that must be re-selected
C749:09 50 52   188 TBL2    DFB  $09,$50,$52 ; after each page write
C74C:00 03 05   189      DFB  $00,$03,$05 ; (especially $C000!)
C74F:83 83 E8   190      DFB  $83,$83,$E8
C752:          191 *
C752:64 00     192 XLOOP1  STZ  $00      ;Reset low address to 2
C754:E6 00     193      INC  $00      ;Hi addr assumed to = 0
C756:E6 00     194      INC  $00
C758:92 00     195 XPAGE   STA  ($00)   ;Write entire page with
C75A:9D 00 C0   196      STA  $C000,X ; shifted data... BUT
C75D:6A         197      ROR  A       ; restore Z-page after
C75E:E6 00     198      INC  $00      ; write in case $C008-9
C760:D0 F6   C758  199      BNE  XPAGE   ; is current pointer
C762:18         200      CLC
C763:98         201      XMODE   TYA
C764:A0 08     202      LDY  #$08   ;Get settings, each bit
C766:BE 40 C7   203      XRSET   LDX  TBL1,Y ;Assume Main $C000 setting
C769:90 03   C76E  204      BCC  XRST1 ;Branch if Main setting
C76B:BE 49 C7   205      LDX  TBL2,Y ;Else get Alternate index
C76E:9D 00 C0   206      STA  $C000,X
C771:2A         207      ROL  A       ;Accumulator makes full
C772:88         208      DEY
C773:10 F1   C766  209      BPL  XRSET ;Preserve settings in Y
C775:A8         210      TAY
C776:B0 DA   C752  211      BCS  XLOOP1 ;Branch if new setting
C778:E6 01     212      INC  $01
C77A:D0 DC   C758  213      BNE  XPAGE ;Loop til all pages written
C77C:38         214      BANGER SEC ;Indicate new settings,
C77D:C8         215      INY
C77E:80 E3   C763  216      BRA  XMODE ;reset mem pointer after
C780:           0000 217      DS   $C780-* ; after new settings
C780:           24      INCLUDE MBASIC ;Mouse BASIC routines @$C780

```

```

C780:          3 ****
C780:          4 *
C780:          5 * XMBASIC - Basic call to the mouse
C780:          6 *
C780:          7 ****
C780:      C780  8 xmbasic  equ   *
C780:5A          9 phy
C781:BO 1C    C79F 10 bcs basicin      ;Input?
C783:A0 C4    11 ldy #<mbasic     ;Input from $C400?
C785:C4 39    12 cpy kswh
C787:D0 04    C78D 13 bne xmbout
C789:A4 38    14 ldy kswl
C78B:F0 12    C79F 15 beq basicin
C78D:DA        16 xmbout phx           ;Save X too
C78E:48        17 pha
C78F:29 7F    18 and #$7F          ;We don't care about high bit
C791:C9 02    19 cmp #2
C793:BO 06    C79B 20 bge mbbad       ;Only 0,1 valid
C795:20 3D C4 21 jsr xsetmou
C798:20 6D C4 22 jsr xmhome
C79B:68        23 mbbad pla
C79C:FA        24 plx
C79D:7A        25 ply
C79E:60        26 rts

```

```

C79F:          28 ****
C79F:          29 *
C79F:          30 * BASICIN - Input from basic
C79F:          31 *
C79F:          32 * Creates +XXXXX,+YYYYY,+SS
C79F:          33 * XXXXX = X position
C79F:          34 * YYYYY = Y position
C79F:          35 * SS = Status
C79F:          36 * - = Key pressed
C79F:          37 * 1 = Button pressed
C79F:          38 * 2 = Button just pressed
C79F:          39 * 3 = Button just released
C79F:          40 * 4 = Button not pressed
C79F:          41 *
C79F:          42 ****
C79F:      C79F  43 basicin  equ   *
C79F:91 28    44 sta (basl),y      ;Fix flashing char
C7A1:A9 05    45 lda #>inent     ;Fix input entry
C7A3:85 38    46 sta kswl
C7A5:AD 00 C0 47 lda kbd         ;test the keyboard
C7A8:0A        48 asl A
C7A9:08        49 php             ;Save kbd and int stat for later
C7AA:78        50 sei             ;No interrupts while getting position
C7AB:20 95 C4 51 jsr xmread
C7AE:A0 05    52 ldy #5           ;Move X position into the buffer
C7B0:AE 7C 05  53 ldx mouxh
C7B3:AD 7C 04  54 lda mouxl
C7B6:20 9B C5  55 jsr hextodec  ;Convert it
C7B9:A0 0C    56 ldy #12
C7BB:AE FC 05  57 ldx mouyh
C7BE:AD FC 04  58 lda mouyl

```

```

C7C1:20 9B C5      59      jsr    hextodec
C7C4:AD 7C 07      60      lda    mousstat
C7C7:2A             61      rol    A
C7C8:2A             62      rol    A
C7C9:2A             63      rol    A
C7CA:29 03          64      and   #3
C7CC:49 03          65      eor   #3
C7CE:1A             66      inc    A
C7CF:28             67      plp    ;Restore int & kbd status
C7D0:A0 10          68      ldy   #16
C7D2:20 AC C5      69      jsr    hexdec2 ;X=0 from last div10
C7D5:7A             70      ply
C7D6:A2 11          71      ldx   #17 ;X = EOL
C7D8:A9 8D          72      lda   #$8D ;Carriage return
C7DA:9D 00 02      73      putinbuf sta   inbuf,x
C7DD:60             74      rts

```

```

C7DE:               76 ****
C7DE:               77 *
C7DE:               78 * PADDLE patch
C7DE:               79 *
C7DE:               80 ****
C7DE:     C7DE 81 mpaddle equ  *
C7DE:AD FC 07       82      lda   moumode ;Is the mouse active?
C7E1:C9 01          83      cmp   #01 ;Only transparent mode
C7E3:F0 06  C7EB   84      beq   pdon
C7E5:AD 70 C0       85      lda   vblclr ;Fire the strobe
C7E8:4C 21 FB       86      jmp   $FB21
C7EB:     C7EB 87 pdon  equ  *
C7EB:E0 01          88      cpx   #1 ;C=1 if X=1
C7ED:6A             89      ror   A ;A=80 or 0
C7EE:A8             90      tay
C7EF:B9 7C 05       91      lda   mouxh,y ;Get high byte
C7F2:F0 02  C7F6   92      beq   pdok
C7F4:A9 FF          93      lda   #$FF
C7F6:19 7C 04       94      pdok  ora   mouxl,y
C7F9:A8             95      tay
C7FA:60             96      rts
C7FB:5D E8 C5       97      zznml eor   qtbl,x
C7FE:80 DA  C7DA   98      bra   putinbuf
C800:     0000       99      ds    $C800-* ,0
C800:               25      INCLUDE IRQBUF ;Interrupt stuff @$C800

```

```

C800:          3 *
C800:          4 * this is the main (only) IRQ handling routines
C800:          5 *
C800:4C E4 C1  6      jmp    plinit      ;Pascal 1.0 Initialization
C803:48        7 NEWIRQ  PHA      ;SAVE ACC ON STACK, NOT $45
C804:68        8 PLA      ;LEGAL BECAUSE IF IRQ, IRQ DISABLED.
C805:68        9 PLA      ;GET STATUS REGISTER
C806:48       10 IRQ1  PHA
C807:D8       11 CLD      ;CLEAR DEC MODE, ELSE THINGS GET SCREWED.
C808:29 10    12 AND    #$10      ;SET CARRY TO INDICATE BRK
C80A:69 F0    13 ADC    #$F0
C80C:8A       14 TXA      ;SAVE X IN A WHILE
C80D:BA       15 TSX      ;FUTZING WITH THE STACK
C80E:CA       16 DEX      ;RECOVER A-REG AT TOP...
C80F:9A       17 TXS
C810:48       18 PHA      ;SAVE X ON STACK (ON TOP OF A)
C811:5A       19 PHY      ;AND Y ALSO
C812:AE 66 CO 20 LDX    MOUX1     ;Get mouse info
C815:AC 67 CO 21 LDY    MOUY1
C818:AD 18 CO 22 LDA    RD80COL   ;TEST FOR 80-STORE WITH
C81B:2D 1C CO 23 AND    RDPAGE2   ; PAGE 2 TEXT.
C81E:29 80    24 AND    #$80      ; MAKE IT ZERO OR $80
C820:F0 05 C827 25 BEQ    IRQ2
C822:8D 54 CO 26 STA    TXTPAGE1
C825:A9 40    27 LDA    #$40      ;SET PAGE 2 RESET BIT.
C827:2C 13 CO 28 IRQ2  BIT    RDRAMRD
C82A:10 05 C831 29 BPL    IRQ3      ;BRANCH IF MAIN RAM READ
C82C:8D 02 CO 30 STA    RDMAINRAM ;ELSE, SWITCH IT IN
C82F:09 20    31 ORA    #$20      ;AND RECORD THE EVENT!
C831:2C 14 CO 32 IRQ3  BIT    RDRAMWRT ;DO THE SAME FOR RAM WRITE.
C834:10 05 C83B 33 BPL    IRQ4
C836:8D 04 CO 34 STA    WRMAINRAM
C839:09 10    35 ORA    #$10
C83B:80 13 C850 36 IRQ4  BCS    IRQ5      ;BRANCH IF BREAK, NOT INTERRUPT
C83D:48        37 PHA      ;SAVE MACHINE STATES SO FAR...
C83E:20 D5 C4 38 JSR    MOUSEINT  ;GO TEST THE MOUSE
C841:90 3F C882 39 BCC    IRQDONE   ;BRANCH IF IT WAS THE MOUSE
C843:20 00 C9 40 JSR    ACIAINT   ;GO TEST ACIA AND KEYBOARD INTERRUPTS
C846:90 3A C882 41 BCC    IRQDONE   ;BRANCH IF INTERRUPT SERVICED
C848:68        42 PLA      ;RESTORE STATES RECORDED SO FAR
C849:18        43 CLC      ;RESET BREAK/INTERRUPT INDICATOR
C84A:80 04 C850 44 bra    passkipl  ;Skip around pascal 1.0 stuff
C84C: 0001    45 ds     $C84D-*,$00
C84D:4C EE C1 46 jmp    plread   *
C850:          47 passkipl equ    *
C850:2C 12 CO 48 IRQ5  BIT    RDLCRAM  ;DETERMINE IF LANGUAGE CARD ACTIVE
C853:10 0C C861 49 BPL    IRQ7
C855:09 0C    50 ORA    #$C       ;SET TWO BITS SO RESTORED
C857:2C 11 CO 51 BIT    RDLCBNK2 ;LANGUAGE CARD IS WRITE ENABLED
C85A:10 02 C85E 52 BPL    IRQ6      ;BRANCH IF NOT PAGE 2 OF $D000
C85C:49 06    53 EOR    #$6       ;ENABLE READ FOR PAGE 2 ON EXIT
C85E:8D 81 CO 54 IRQ6  STA    ROMIN    ;LAST...AND VERY IMPORTANT!
C861:2C 16 CO 55 IRQ7  BIT    RDALTZP ;UNLESS IT IS NOT ENABLED
C864:10 0D C873 56 BPL    IRQ8      ;SAVE CURRENT STACK POINTER
C866:BA        57 TSX
C867:8E 01 01  58 STX    $101      ;AT BOTTOM OF STACK
C86A:AE 00 01  59 LDX    $100      ;GET MAIN STACK POINTER
C86D:9A        60 TXS

```

```

C86E:8D 08 C0      61      STA    SETSTDZP
C871:09 80          62      ORA    #$80
C873:80 2A  C89F   63  IRQ8     BCS    GOBREAK
C875:48            64      PHA
C876:A9 C8          65      LDA    #<IRQDONE
C878:48            66      PHA
C879:A9 82          67      LDA    #>IRQDONE ;SAVE RETURN IRQ ADDR
C87B:48            68      PHA
C87C:A9 04          69      LDA    #4      ; SO WHEN INTERRUPT DOES RTI
C87E:48            70      PHA
C87F:6C FE 03       71      JMP    ($3FE) ;IT RETURNS TO IRQDONE.
                                         ;PROCESS EXTERNAL INTERRUPT

C882:68            73  IRQDONE    PLA    ;RECOVER MACHINE STATE
C883:10 07  C88C   74      BPL    IRQDNE1 ;BRANCH IF MAIN ZP WAS ACTIVE
C885:8D 09 C0       75      STA    SETALTZP
C888:AE 01 01       76      LDX    $101   ;RESTORE ALTERNATE STACK POINTER
C88B:9A            77      TXS
C88C:0A            78  IRQDNE1   ASL    A
C88D:A0 05          79      LDY    #$05
C88F:BE 89 C9       80  IRQDNE2   LDX    IRQTBLE,Y
C892:88            81      DEY
C893:0A            82      ASL    A
C894:90 03  C899   83      BCC    IRQDNE3 ;BRANCH IF SWITCH IS OK.
C896:9D 00 C0       84      STA    $C000,X
C899:DO F4  C88F   85  IRQDNE3   BNE    IRQDNE2 ;BRANCH IF MORE SWITCHES
C89B:7A            86      PLY
C89C:FA            87      PLX
C89D:68            88      PLA
C89E:40            89      RTI    ;DO THE REAL RTI!
C89F:4C 47 FA       90  GOBREAK   JMP    NEWBRK ;PASS THE BREAKER THROUGH

C8A2:               92 ****
C8A2:               93 *
C8A2:               94 * MOVEIRQ - This routine transfers the roms interrupt vector into
C8A2:               95 * both language cards
C8A2:               96 *
C8A2:               97 ****
C8A2:               C8A2  98 moveirq  equ   *
C8A2:20 60 C3       99      JSR    SETROM   ;Read ROM and Write to RAM
C8A5:AD 16 C0       100     LDA    RDALTZP ;Which language card?
C8A8:0A            101     ASL    A        ;C=1 if alternate card
C8A9:A0 01          102     LDY    #1      ;Move two bytes
C8AB:B9 FE FF       103  MIRQLP   LDA    IRQVECT,Y ;Get byte from ROM
C8AE:8D 09 C0       104     STA    SETALTZP ;Set alternate card
C8B1:99 FE FF       105     STA    IRQVECT,Y ;Store it in the RAM card
C8B4:8D 08 C0       106     STA    SETSTDZP ;Set main card
C8B7:99 FE FF       107     STA    IRQVECT,Y
C8BA:88            108     DEY
C8BB:10 EE  C8AB   109     BPL    MIRQLP ;Go do the second byte
C8BD:90 03  C8C2   110     BCC    MIRQSTD ;Is the card set right?
C8BF:8D 09 C0       111     STA    SETALTZP ;No, it wasn't
C8C2:4C 54 C3       112  MIRQSTD  JMP    RESETLC ;Clean up & go home

```

```

C8C5:          114 * This is the serial input routine. Carry
C8C5:          115 * flag set indicates that returned data is
C8C5:          116 * valid.
C8C5:          117 *
C8C5:          118 * GETBUF- Gets a byte from the buffer & updates pointers
C8C5:          119 * On entry Y=0 for Serial buffer Y=$80 for Keyboard buffer
C8C5:EC FF 04  120 XRDSER   CPX ACIABUF      ;is serial input buffered?
C8C8:D0 26    C8F0 121 BNE XNOSBUF      ;(in english "NO SERIAL BUFFER")
C8CA:A0 00    122 LDY #0           ;Y=0 for serial buffer
C8CC:         C8CC 123 GETBUF   EQU *
C8CC:B9 7F 06  124 LDA TRSER,Y      ;Test for data in buffer
C8CF:D9 7F 05  125 CMP TWSER,Y      ;If = then no data
C8D2:F0 24    C8F8 126 BEQ GBEMPTY
C8D4:48       127 PHA             ;Save current value
C8D5:1A       128 INC A            ;Update the pointer
C8D6:89 7F    129 BIT #$7F        ;Overflow
C8D8:D0 01    C8DB 130 BNE GBNOOVR
C8DA:98       131 TYA             ;Store the updated pointer
C8DB:99 7F 06  132 GBNOOVR STA TRSER,Y      ;Get the old value of the pointer
C8DE:7A       133 PLY             ;Are we in main ram
C8DF:AD 13 CO  134 LDA RDRAMRD
C8E2:0A       135 ASL A            ;C=1 for Aux ram
C8E3:8D 03 CO  136 STA RDCARDRAM ;Force Aux ram
C8E6:B9 00 08  137 LDA THBUF,Y      ;Get byte from buffer
C8E9:BO 14    C8FF 138 BCS XRDSNO      ;Branch if we were in aux bank
C8EB:8D 02 CO  139 STA RDMAINRAM ;Set back to main
C8EE:38       140 SEC             ;Note C=1
C8EF:60       141 RTS             ;Get index to ACIA
C8FO:         142 *              ;Test ACIA directly for data
C8FO:BC 85 C8  143 XNOSBUF LDY DEVNO,X      ;indicate no data
C8F3:B9 F9 BF  144 LDA SSTAT,Y      ;Branch if no data!
C8F6:29 08    145 AND #$8          ;get serial input
C8F8:18       146 GBEMPTY CLC             ;indicate valid data returned.
C8F9:F0 04    C8FF 147 BEQ XRDSNO
C8FB:B9 F8 BF  148 LDA SDATA,Y
C8FE:38       149 notacia SEC
C8FF:         C8FF 150 acdone equ *
C8FF:60       151 XRDSNO RTS

```

```

C900:      153 * This routine will determine if the source of
C900:      154 * is either of the built in ACIAs. If neither port
C900:      155 * generated the interrupt, or the interrupt was due
C900:      156 * to a transmit buffer empty, protocol converter, or
C900:      157 * 'unbuffered' receiver full, the carry is set indi-
C900:      158 * cating an externally serviced interrupt.
C900:      159 * If the interrupt source was keyboard, 'buffered'
C900:      160 * serial input, or the DCD, the interrupt is serviced
C900:      161 * and the carry is cleared indicating interrupt was
C900:      162 * serviced. (DCD handshake replaces CTS.)
C900:      163 * Location "ACIABUF" specifies which (if either) re-
C900:      164 * ceiver data is buffered. For port 1 it must contain
C900:      165 * $C1, for port 2 a $C2. Any other values are cause
C900:      166 * interrupts to pass to external (RAM based) routines.
C900:      167 * Location "TYPHED" specifies whether Keyboard in-
C900:      168 * put should be buffered, ignored, or processed by
C900:      169 * RAM based routines. If bit 7=1 and bit 6=0, key-
C900:      170 * board data is placed in the type-ahead buffer. If
C900:      171 * bit 6 is set the interrupt is cleared, but must
C900:      172 * be recognized and serviced by a RAM routine. If
C900:      173 * both bits = 0, the interrupt is serviced, but the
C900:      174 * keyboard data is ignored.
C900:      175 * While using type-ahead, Open-Apple CTRL-X will
C900:      176 * flush the buffer. No other code is recognized.
C900:      177 * If the source was an ACIA that has the transmit
C900:      178 * interrupt enabled, the original value of the ACIAs
C900:      179 * status registers is preserved. Automatic serial input
C900:      180 * buffering is not serviced from a port so configured.
C900:      181 * Interrupts originating from the protocol converter or
C900:      182 * keyboard (RAM serviced) do not inhibit serial buffering
C900:      183 * and are passed thru. The RAM service routine can rec-
C900:      184 * ognize the interrupt source by a 1 state in bit 6 of
C900:      185 * the ACIAs status register. The RAM service routine must
C900:      186 * cause the clearing of DSR (bit 6) AND make a second ac-
C900:      187 * cess to the status register before returning.
C900:      188 *
C900:      189 *
C900:      190 aciaint  equ   *
C900:A2 C2    191 ldx   #<comslot ;Test port 2 first
C902:20 08 C9  192 jsr   aciatst ;Check for interrupt
C905:90 F8 C8FF 193 bcc   acdone ;Return if interrupt done
C907:CA      194 dex    ;Try port 1
C908:BC 85 C8  195 aciatst ldy   devno,x ;Get index for acia
C90B:A9 04      196 lda   #$4   ;If xmit ints enabled pass to user
C90D:59 FA BF  197 eor   scomd,y ;Check if D<3>, D<2> = 01
C910:29 0C      198 and   #$0C ;
C912:F0 EA C8FE 199 beq   notacia ;User better take it!
C914:B9 F9 BF  200 lda   sstat,y ;Get status
C917:9D 38 04  201 sta   astat,x ;Save it away
C91A:10 E2 C8FE 202 bpl   notacia ;No interrupt
C91C:E0 C2      203 aitst2 cpx   #<comslot ;C=1 if com port
C91E:B0 02 C922  204 bcs   aiport2 ;Invert DSR if port1
C920:49 40      205 eor   #$40
C922:3C 38 05  206 aiport2 bit   extint,x ;Is DSR enabled?
C925:70 26 C94D  207 bvs   aiport2 ;Yes, user wants it
C927:10 22 C94B  208 bpl   aieatit ;No, eat it
C929:90 20 C94B  209 bcc   aieatit ;Yes but I don't want it for port 1
C92B:89 40      210 bit   #$40 ;Is DSR 1?

```

```

C92D:F0 1E C94D 211      beq    aipass      ;If not, skip it
C92F:          212 * It's a keyboard interrupt
C92F:AD 00 C0 213      lda     kbd        ;Get the key
C932:A0 80 214      ldy     #$80
C934:20 67 C9 215      jsr     putbuf     ;Put it in the buffer
C937:C9 98 216      cmp     #$98      ;Is it a ^x?
C939:D0 08 C943 217      bne    ainoflsh
C93B:AD 62 C0 218      lda     butnl     ;And the closed apple?
C93E:10 03 C943 219      bpl    ainoflsh
C940:20 1B CB 220      jsr     flush      ;Flush the buffer
C943:AD 10 C0 221      lda     kbdstrb   ;Clear the keyboard
C946:          222 * $A0 $B0 table needed by serial firmware
C946:          00C1 223 sltdmy    equ    <serslot
C946:          C885 224 devno     equ    *-sltdmy
C946:A0 B0 225      ldy     #$B0      ;Restore y
C948:B9 F9 BF 226      lda     sstat,y   ;Read status to clear int
C94B:29 BF 227      and     #$BF      ;Clear the DSR bit
C94D:0A          228 aipass     asl    A         ;Shift DSR into C
C94E:0A          229          asl    A
C94F:29 20 230      and     #$20      ;Is the receiver full?
C951:F0 35 C988 231      beq    aciadone   ;If not, we're done
C953:B9 FA BF 232      lda     scomd,y   ;Are receive interrupts enabled?
C956:49 01 233      eor     #1         ;Check for D<1>,D<0> = 01
C958:29 03 234      and     #3
C95A:D0 2C C988 235      bne    aciadone   ;If not, were done
C95C:8A          236          txa    aciabuf   ;Is this acia buffered?
C95D:4D FF 04 237      eor     aciabuf
C960:D0 9C C8FE 238      bne    notacia   ;The user better handle it!
C962:B9 F8 BF 239      lda     sdata,y   ;It's mine
C965:A0 00 240      ldy     #0
C967:          C967 241 putbuf    equ    *
C967:DA          242          phx
C968:48          243          pha
C969:B9 7F 05 244      lda     twser,y   ;Get buffer pointer
C96C:AA          245          tax
C96D:1A          246          inc    A         ;Save it for later
C96E:89 7F 247      bit     #$7F      ;Bump it to next free byte
C970:D0 01 C973 248      bne    pbok
C972:98          249          tya
C973:08          250 pbok     php
C974:D9 7F 06 251      cmp     trser,y   ;Buffer full?
C977:F0 03 C97C 252      beq    pbfull
C979:99 7F 05 253      sta     twser,y   ;Save the new pointer
C97C:28          254 pbfull    plp
C97D:68          255          pla
C97E:8D 05 C0 256      sta     wrcardram ;Get the data
C981:9D 00 08 257      sta     thbuf,x   ;It goes to aux ram
C984:8D 04 C0 258      sta     wrmainram
C987:FA          259          plx
C988:60          260 aciadone   rts

C989:83 8B 8B 262 IRQTBLE   DFB    >LCBANK2,>LCBANK1,>LCBANK1
C98C:05 03 55 263          DFB    >WRCARDRAM,>RDCARDRAM,TXTPAGE2

```

```

C98F:          266 * The following two routines are for reading key-
C98F:          267 * board and serial input from buffers or directly.
C98F:          268 * Type-ahead buffering only occurs for non auto-
C98F:          269 * repeat keypresses. When a key is pressed for
C98F:          270 * auto-repeat the buffer is first emptied, then the
C98F:          271 * repeated characters are returned.
C98F:          272 * The minus flag is used to indicate if a keystroke
C98F:          273 * is being returned.
C98F:          274 *

C98F:20 AD C9      276 XRDKBD   JSR   XBITKBD    ;is keyboard input ready?
C992:10 14 C9A8    277 BPL     XNOKEY    ;Branch if not.
C994:90 0A C9AO    278 BCC     XRKBDI    ;Branch if direct KBD input.
C996:5A           279 PHY
C997:A0 80         280 LDY     #$80      ;Y=$80 for keyboard buffer
C999:20 CC C8     281 JSR     GETBUF    ;Get data from buffer
C99C:7A           282 PLY
C99D:09 00         283 ORA     #0        ;Set minus flag
C99F:60           284 RTS

C9A0:AD 00 C0      286 XRKBDI   LDA   KBD        ;test keyboard directly
C9A3:10 EA C98F    287 BPL     XRDKBD    ;loop if buffered since test.
C9A5:8D 10 C0      288 STA     KBDSTRB   ;Clear keyboard strobe.
C9A8:60           289 XNOKEY   RTS     ;Minus flag indicates valid character

C9A9:      0001 291   ds    $C9AA-*,$00
C9AA:4C F6 C1     292   jmp   plwrite  ;Pascal 1.0 entry point

C9AD:2C FA 05      294 XBITKBD  BIT   TYPHED    ;This routine replaces "BIT KBD" instrucs
C9B0:10 10 C9C2    295 BPL     XBKB2     ; so as to function with type-ahead.
C9B2:38           296 SEC
C9B3:08           297 PHP
C9B4:48           298 PHA
C9B5:AD FF 06      299 LDA     TRKEY    ;anticipate data in buffer is ready
C9B8:CD FF 05      300 CMP     TWKEY    ;save carry and minus flags
C9BB:F0 03 C9C0    301 BEQ     XBKB1    ;preserve accumulator
C9BD:68           302 PLA
C9BE:28           303 PLP
C9BF:60           304 RTS     ;Carry and minus flag already set.
C9C0:             305 *
C9C0:68           306 XBKB1   PLA
C9C1:28           307 PLP     ;restore ACC and Status
C9C2:2C 00 C0      308 XBKB2   BIT   KBD     ;test KBD Directly
C9C5:18           309 CLC
C9C6:60           310 RTS
C9C7:              26    INCLUDE COMMAND ;Serial firmware command processor

```

```

C9C7:      3      MSB  OFF
C9C7: C9C7  4 cmdtable equ  *
C9C7:66   5      dfb  >cmdi-1
C9C8:66   6      dfb  >cmdk-1
C9C9:66   7      dfb  >cmdl-1
C9CA:5C   8      dfb  >cmdn-1
C9CB:5C   9      dfb  >cmdcr-1
C9CC:7C   10     dfb  >cmdb-1
C9CD:78   11     dfb  >cmdd-1
C9CE:77   12     dfb  >cmdp-1
C9CF:C3   13     dfb  >cmdq-1
C9D0:B4   14     dfb  >cmdr-1
C9D1:98   15     dfb  >cmds-1
C9D2:C5   16     dfb  >cmdt-1
C9D3:54   17     dfb  >cmdz-1
C9D4:7F BF BF 7F  18 mask1  dfb  $7F,$BF,$BF,$7F,$FF
C9D9:80 00 40 00  19 mask2  dfb  $80,$00,$40,$00,$00
C9DE:    C9DE  20 cmdlist equ  *
C9DE:49 4B 4C 4E  21 asc   "IKLN"
C9E2:0D   22     dfb  $0D      ;Carriage return
C9E3:42 44 50 51  23 asc   "BDPQRSTZ"
C9EB:48   24 command pha   ;Check for command to firmware
C9EC:3C B8 03   25 bit   sermode,x ;Already in command?
C9EF:30 1B CA0C  26 bmi   incmd   ;If so, go do it
C9F1:BC 38 06   27 ldy   eschar,x ;If eschar = 0 ignore commands
C9F4:F0 13 CA09  28 beq   nocmd
C9F6:5D 38 06   29 eor   eschar,x ;Is it the command char?
C9F9:0A   30     asl   A        ;Ignore high bit
C9FA:D0 0D CA09  31 bne   nocmd
C9FC:AC FB 07   32 ldy   cursor  ;Save the cursor
C9FF:8C 79 06   33 sty   oldcur
CA02:A0 BF   34 ldy   #cmdcur ;Set command cursor
CA04:8C FB 07   35 sty   cursor
CA07:80 2D CA36  36 bra   cominit
CA09:38   37 nocmd sec   ;Mark char not handled
CA0A:68   38 pla   ;Restore char
CA0B:60   39 rts
CA0C:    CA0C  40 incmd equ  *      ;Command mode
CA0C:BC 85 C8   41 ldy   devno,x ;Get index for ACIA
CA0F:29 5F   42 and   #$5F    ;Ignore hi bit: just upshift lowercase
CA11:DA   43 phx
CA12:A2 0C   44 ldx   #12      ;Save slot
CA14:DD DE C9   45 cmdloop cmp   cmdlist,x ;Check 13 commands
CA17:FO 34 CA4D  46 beq   cmfound ;Right char?
CA19:CA   47 dex
CA1A:10 F8 CA14  48 bpl   cmdloop ;We didn't find it
CA1C:FA   49 plx
CA1D:68   50 pla
CA1E:48   51 pha
CA1F:29 7F   52 and   #$7F    ;if char is cntl char
CA21:C9 20   53 cmp   #$20    ;it can be the new comd char
CA23:80 03 CA28  54 bcs   ckdig  ;branch if not cntl character
CA25:9D 38 06  55 cmdz2 sta   eschar,x ;Save comd char, drop thru ckdig to cdone
CA28:49 30   56 ckdig eor   #$30    ;Is it a number?
CA2A:C9 0A   57 cmp   #$0A
CA2C:80 0E CA3C  58 bcs   cdone  ;If so, branch
CA2E:A0 0A   59 ldy   #10      ;A = A + 10 * current number
CA30:6D 7F 04  60 digloop adc   number ;C=0 on first entry

```

```

CA33:88          61      dey
CA34:D0 FA     CA30  62      bne    digloop
CA36:8D 7F 04   63      cominit sta    number
CA39:38          64      sec
CA3A:80 07     CA43  65      bra    cmset
CA3C:18          66      cdone  clc
CA3D:AD 79 06   67      lda    oldcur
CA40:8D FB 07   68      sta    cursor
CA43:08          69      cmset  php
CA44:1E B8 03   70      asl    sermode,x ;set command mode according to carry
CA47:28          71      plp
CA48:7E B8 03   72      ror    sermode,x ;leaves carry clear
CA4B:68          73      pla
CA4C:60          74      rts
CA4D:A9 CA       76      cmfound lda  #<cmdcr
CA4F:48          77      pha
CA50:BD C7 C9   78      lda  cmdtable,x ;do JMP via RTS
CA53:48          79      pha
CA54:60          80      rts
                           ;Go to it

CA55:FA          82      cmdz   plx
CA56:9E B8 04   83      stz    pwdth,x ;Zero escape character
CA59:A9 00       84      lda    #0
CA5B:80 C8     CA25  85      bra    cmdz2 ;And the width

CA5D:           CA5D  87      cmdcr equ  *
CA5D:           CA5D  88      cmdn  equ  *
CA5D:7A          89      ply
CA5E:AD 7F 04   90      lda    number ;Get number inputted
CA61:F0 05     CA68  91      beq    cmdi2 ;Don't change printer width if 0
CA63:99 B8 04   92      sta    pwdth,y ;Update printer width
CA66:F0          93      dfb    $FO ;BEQ opcode to skip next byte
CA67:           CA67  94      cmdi  equ  *
CA67:           CA67  95      cmdk  equ  *
CA67:           CA67  96      cmdl  equ  *
CA67:7A          97      ply
CA68:B9 B8 06   98      cmdi2 lda  flags,y ;Mask off bit we'll change
CA6B:3D D4 C9   99      and    mask1,x
CA6E:1D D9 C9   100     ora    mask2,x ;Change it
CA71:99 B8 06   101     sta    flags,y ;Back it goes
CA74:98          102     tya
CA75:AA          103     tax
CA76:80 C4     CA3C  104     cdone2 bra  cdone ;Put slot back in x ;Good bye

CA78:88          106     cmdp  dey  ;Make y point to command reg
CA79:A9 1F       107     cmdd  lda  #$1F ;Mask off high three bits
CA7B:38          108     sec   ;C=1 means high 3 bits
CA7C:90          109     dfb  $90 ;BCC opcode to skip next byte
CA7D:A9 F0       110     cmdb  lda  #$FO ;Mask off lower 4 bits F0 = BNE
CA7F:18          111     clc
CA80:39 FB BF   112     and  scntl,y ;F0 will skip this if cmdp or cmdd ;Mask off bits being changed

```

```

CA83:8D F8 06      113     sta   temp          ;Save it
CA86:FA            114     plx
CA87:AD 7F 04      115     lda   number        ;Get inputed number
CA8A:29 0F          116     and  #$0F         ;Only lower nibble valid
CA8C:90 05      CA93 117   bcc  noshift      ;If C=1 shift to upper 3 bits
CA8E:0A            118     asl   A
CA8F:0A            119     asl   A
CA90:0A            120     asl   A
CA91:0A            121     asl   A
CA92:0A            122     asl   A
CA93:0D F8 06      123 noshift    ora   temp          ;Get the rest of the bits
CA96:C8            124     iny
CA97:80 17      CAB0 125     bra   cmdp2        ;Put them in the ACIA
                                         ;increment puts em away where they go.

CA99:B9 FA BF      127 cmds       lda   scomd,y      ;Transmit a break
CA9C:48            128 pha          pha
CA9D:09 0C          129 ora  #$0C        ;Save current ACIA state
CA9F:99 FA BF      130 sta  scomd,y      ;Do the braek
CAA2:A9 E9          131 lda  #233        ;For 233 ms
CAA4:A2 53          132 mswait     ldx  #83         ;Wait 1 ms
CAA6:48            133 msloop      pha
CAA7:68            134 pla
CAA8:CA            135 dex
CAA9:D0 FB      CAA6 136 bne  msloop
CAA8:3A            137 dec  a
CAAC:D0 F6      CAA4 138 bne  mswait
CAAE:68            139 pla
CAAF:FA            140 plx
CAB0:99 FA BF      141 cmdp2      sta   scomd,y      ;Reset the ACIA
CAB3:80 C1      CA76 142     bra   cdone2        ;Check if video firmware active
                                         ;Save it in C
                                         ;assume video firmware active
                                         ;branch if good guesser...
                                         ;Reset the hooks
                                         ;Quit terminal mode
                                         ;BCS to skip next byte
                                         ;Into terminal mode
                                         ;Recover X
                                         ;Get terminal mode status
                                         ;Z=1 if not in terminal mode
                                         ;Branch if clearing terminal mode
                                         ;Was already set
                                         ;Are we in the input hooks
                                         ;Leaves C=1 if =
                                         ;Set term mode bit
                                         ;Save what was in oldcur
                                         ;Get new cursor value

```

```

CAE6:F0 0E    CAF6  167 stclr      beq   stwasok      ;Branch if already clear
CAE8:29 BF    168      and  #$BF      ;Clear the bit
CAEA:AC 7A 06  169      ldy   oldcur2     ;Restore the cursor
CAED:9D B8 03  170 stset      sta    sermode,x
CAF0:8C 79 06  171      sty   oldcur      ;Save cursor to be restored after command
CAF3:8C FB 07  172      sty   cursor
CAF6:BC 85 C8  173 stwasok      ldy   devno,x
CAF9:58          174      cli
CAF A:08          175      php
CAF B:78          176      sei
CAF C:B9 FA BF  177      lda   scomd,y
CAF F:09 02        178      ora   #$2
CB01:90 02    CB05  179      bcc   cmdat2
CB03:29 FD        180      and  #$FD
CB05:99 FA BF  181 cmdat2      sta   scomd,y
CB08:A9 00        182      lda   #0
CBOA:6A          183      ror   a
CBOB:8D FA 05  184      sta   typded
CBOE:10 07    CB17  185      bpl   cmdat3
CB10:9C 7F 05  186      stz   twser
CB13:9C 7F 06  187      stz   trser
CB16:8A          188      txa
CB17:8D FF 04  189 cmdat3      sta   aciabuf
CB1A:28          190      plp
CB1B:8E FF 05  191 flush      stx   twkey
CB1E:8E FF 06  192      stx   trkey
CB21:60          193 strts      rts
CB22:      0002  194      ds    $CB24-*,$00
CB24:E8          195 zznm2      inx
CB25:4C FB C7  196      jmp   zznml
CB28:9E 0B 40 50 197 comtbl      dfb   $9E,$0B,$40,$50,$16,$0B,$01,$00
CB30:              27      INCLUDE SCROLLING ;More Video stuff @$CB30

```

```

CB30:      3 *
CB30:      4 * SCROLLIT scrolls the screen either up or down, depending
CB30:      5 * on the value of X. It scrolls within windows with even
CB30:      6 * or odd edges for both 40 and 80 columns. It can scroll
CB30:      7 * windows down to 1 characters wide.
CB30:      8 *
CB30:DA    9 SCROLLDN PHX          ;save X
CB31:A2 00 10 LDX #0             ;direction = down
CB33:80 03 CB38 11 BRA SCROLLIT ;do scroll
CB35:      12 *
CB35:DA    13 SCROLLUP PHX        ;save X
CB36:A2 01 14 LDX #1             ;direction = up
CB38:A4 21 15 SCROLLIT LDY WNDWDTH ;get width of screen window
CB3A:2C 1F CO 16 BIT RD80VID   ;in 40 or 80 columns?
CB3D:10 18 CB57 17 BPL GETST    ;=>40, determine starting line
CB3F:8D 01 CO 18 STA SET80COL  ;make sure this is enabled
CB42:98    19 TYA               ;get WNDWDTH for test
CB43:4A    20 LSR A              ;divide by 2 for 80 column index
CB44:A8    21 TAY               ;and save
CB45:A5 20 22 LDA WNDLFT       ;test oddity of right edge
CB47:4A    23 LSR A              ;by rotating low bit into carry
CB48:B8    24 CLV               ;V=0 if left edge even
CB49:90 03 CB4E 25 BCC CHKRT   ;=>check right edge
CB4B:2C C1 CB 26 BIT SEV1      ;V=1 if left edge odd
CB4E:2A    27 CHKRT ROL A       ;restore WNDLFT
CB4F:45 21 28 EOR WNDWDTH     ;get oddity of right edge
CB51:4A    29 LSR A              ;C=1 if right edge even
CB52:70 03 CB57 30 BVS GETST   ;if odd left, don't DEY
CB54:80 01 CB57 31 BCS GETST   ;if even right, don't DEY
CB56:88    32 DEY               ;if right edge odd, need one less
CB57:8C F8 05 33 GETST STY TEMPY ;save window width
CB5A:AD 1F CO 34 LDA RD80VID  ;N=1 if 80 columns
CB5D:08    35 PHP               ;save N,Z,V
CB5E:A5 22 36 LDA WNDTOP      ;assume scroll from top
CB60:E0 00 37 CPX #0           ;up or down?
CB62:DO 03 CB67 38 BNE SETDBAS ;=>up
CB64:A5 23 39 LDA WNDBTM     ;down, start scrolling at bottom
CB66:3A    40 DEC A            ;really need one less
CB67:      41 *
CB67:8D 78 05 42 SETDBAS STA TEMPA ;save current line
CB6A:20 24 FC 43 JSR VTABZ   ;calculate base with window width
CB6D:      44 *
CB6D:A5 28 45 SCRLIN LDA BASL  ;current line is destination
CB6F:85 2A 46 STA BAS2L
CB71:A5 29 47 LDA BASH
CB73:85 2B 48 STA BAS2H
CB75:      49 *
CB75:AD 78 05 50 LDA TEMPA   ;get current line
CB78:E0 00 51 CPX #0         ;going up?
CB7A:DO 07 CB83 52 BNE SETUP2 ;=>up, inc current line
CB7C:C5 22 53 CMP WNDTOP   ;down. Reached top yet?
CB7E:F0 39 CBB9 54 BEQ SCRL3 ;yes! clear top line, exit
CB80:3A    55 DEC A           ;no, go up a line
CB81:80 05 CB88 56 BRA SETSRC ;set source for scroll
CB83:1A    57 SETUP2 INC A   ;up, inc current line
CB84:C5 23 58 CMP WNDBTM   ;at bottom yet?
CB86:80 31 CBB9 59 BCS SCRL3 ;yes! clear bottom line, exit
CB88:      60 *

```

CB88:8D 78 05	61	SETSRC	STA	TEMPA	;save new current line
CB8B:20 24 FC	62		JSR	VTABZ	;get base for new current line
CB8E:AC F8 05	63		LDY	TEMPY	;get width for scroll
CB91:28	64		PLP		;get status for scroll
CB92:08	65		PHP		;N=1 if 80 columns
CB93:10 1F CBB4	66		BPL	SKPRT	;=>only do 40 columns
CB95:AD 55 CO	67		LDA	TXTPAGE2	;scroll aux page first (even bytes)
CB98:98	68		TYA		;test Y
CB99:F0 07 CBA2	69		BEQ	SCRLEFT	;if Y=0, only scroll one byte
CB9B:B1 28	70	SCRLEVEN	LDA	(BASL),Y	
CB9D:91 2A	71		STA	(BAS2L),Y	
CB9F:88	72		DEY		
CBA0:D0 F9 CB9B	73		BNE	SCRLEVEN	;do all but last even byte
CBA2:70 04 CBA8	74	SCRLEFT	BVS	SKPLFT	;odd left edge, skip this byte
CBA4:B1 28	75		LDA	(BASL),Y	
CBA6:91 2A	76		STA	(BAS2L),Y	
CBA8:AD 54 CO	77	SKPLFT	LDA	TXTPAGE1	;now do main page (odd bytes)
CBAB:AC F8 05	78		LDY	TEMPY	;restore width
CBAE:BO 04 CBB4	79		BCS	SKPRT	;even right edge, skip this byte
CBB0:B1 28	80	SCRLODD	LDA	(BASL),Y	
CBB2:91 2A	81		STA	(BAS2L),Y	
CBB4:88	82	SKPRT	DEY		
CBB5:10 F9 CBB0	83		BPL	SCRLODD	
CBB7:80 B4 CB6D	84		BRA	SCRLIN	;scroll next line
CBB9:	85 *				
CBB9:20 A0 FC	86	SCRL3	JSR	CLRLIN	;clear current line
CBCB:20 22 FC	87		JSR	VTAB	;restore original cursor line
CBBF:28	88		PLP		;pull status off stack
CBC0:FA	89		PLX		;restore X
CBC1:60	90	SEVI	RTS		;done!!!

```

CBC2:          92 *
CBC2:          93 * DOCLR is called by CLREOL. It decides whether
CBC2:          94 * to do a (quick) 40 or 80 column clear to end of line.
CBC2:          95 *
CBC2:2C 1F C0  96 DOCLR    BIT    RD80VID      ;40 or 80 column clear?
CBC5:30 13    CBDA  97 BMI     CLR80        ;=>clear 80 columns
CBC7:91 28    98 CLR40    STA    (BASL),Y
CBC9:C8       99 INY
CBCA:C4 21    100 CPY     WNDWDTH
CBCC:90 F9    CBC7  101 BCC     CLR40
CBCE:60       102 RTS
CBCF:          103 *
CBCF:DA       104 CLRHALF   PHX
CBD0:A2 D8    105 LDX     #$D8        ;clear right half of screen
CBD2:A0 14    106 LDY     #20        ;for SCRN48
CBD4:A5 32    107 LDA     INVFLG
CBD6:29 A0    108 AND     #$AO
CBD8:80 17    CBF1  109 BRA     CLR2        ;=>jump into middle
CBDA:          110 *
CBDA:DA       111 CLR80    PHX
CBDB:48       112 PHA
CBDC:98       113 TYA
CBDD:48       114 PHA        ;get count for CH
CBDE:38       115 SEC        ;save for left edge check
CBDF:E5 21    116 SBC     WNDWDTH    ;count=WNDWDTH-Y-1
CBE1:AA       117 TAX
CBE2:98       118 TYA        ;save CH counter
CBE3:4A       119 LSR     A           ;div CH by 2 for half pages
CBE4:A8       120 TAY
CBE5:68       121 PLA        ;restore original CH
CBE6:45 20    122 EOR     WNDLFT      ;get starting page
CBE8:6A       123 ROR     A
CBE9:BO 03    CBEE  124 BCS     CLRO
CBEB:10 01    CBEE  125 BPL     CLRO
CBED:C8       126 INY        ;iff WNDLFT odd, starting byte odd
CBEE:68       127 CLR0    PLA        ;get blankity blank
CBEF:BO 0B    CBFC  128 BCS     CLR1        ;starting page is 1 (default)
CBF1:2C 55    CO    129 CLR2    BIT     TXTPAGE2
CBF4:91 28    130 STA     (BASL),Y    ;else do page 2
CBF6:2C 54    CO    131 BIT     TXTPAGE1
CBF9:E8       132 INX        ;now do page 1
CBFA:FO 06    CC02  133 BEQ     CLR3        ;all done
CBFC:91 28    134 CLR1    STA    (BASL),Y
CBFE:C8       135 INY        ;forward 2 columns
CBFF:E8       136 INX        ;next CH
CC00:DO EF    CBF1  137 BNE     CLR2        ;not done yet
CC02:FA       138 CLR3    PLX
CC03:60       139 RTS        ;restore X
CC04:          140 *
CC04:9C FA 05  141 CLRPORT   STZ     TYPHED
CC07:9C F9 05  142 STZ     EXTINT2    ;disable typeahead
CC0A:60       143 RTS        ;and external interrupts

```

```

CCOB:      145 *
CCOB:      146 * PASINVERT is used by Pascal to display the cursor. Pascal
CCOB:      147 * normally leaves the cursor on the screen at all times. It
CCOB:      148 * is fleetingly removed while a character is displayed, then
CCOB:      149 * promptly redisplayed. CTL-F and CTL-E, respectively,
CCOB:      150 * disable and enable display of the cursor when printed using
CCOB:      151 * the Pascal 1.1 entry point (PWRITE). Screen I/O is
CCOB:      152 * significantly faster when the cursor is disabled. This
CCOB:      153 * feature is supported by Pascal 1.2 and later.
CCOB:      154 *
CCOB:AD FB 04 155 PASINVERT LDA VMODE      ;Called by pascal to
CCOE:29 10   156 AND #M.CURSOR    ;display cursor
CC10:DO 0A CC1C 157 BNE INVX      ;=>cursor off, don't invert
CC12:      CC12 158 INVERT     EQU *
CC12:20 1D CC 159 JSR PICKY      ;load Y and get char
CC15:48    160 PHA
CC16:49 80   161 EOR #$80      ;FLIP INVERSE/NORMAL
CC18:20 B3 C3 162 JSR STORY     ;stuff onto screen
CC1B:68    163 PLA          ;for RDCHAR
CC1C:60    164 INVX        RTS
CC1D:
CC1D:      165 *
CC1D:      166 * PICK lifts a character from the screen in either
CC1D:      167 * 40 or 80 columns from the current cursor position.
CC1D:      168 * If the alternate character set is switched in,
CC1D:      169 * character codes $0-$1F are returned as $40-$5F (which
CC1D:      170 * is what must have been originally printed to the location).
CC1D:      171 *
CC1D:5A    172 PICKY       PHY      ;save Y
CC1E:20 9D CC 173 JSR GETCUR     ;get newest cursor into Y
CC21:AD 1F CO 174 LDA RD80VID   ;80 columns?
CC24:10 17 CC3D 175 BPL PICK1     ;=>no
CC26:8D 01 CO 176 STA SET80COL  ;force 80STORE if 80 columns
CC29:98    177 TYA
CC2A:45 20   178 EOR WNDLFT    ;C=1 if char in main RAM
CC2C:6A    179 ROR A          ;get low bit into carry
CC2D:B0 04 CC33 180 BCS PICK2     ;=>store in main memory
CC2F:AD 55 CO 181 LDA TXTPAGE2  ;else switch in page 2
CC32:C8    182 INY          ;for odd left, aux bytes
CC33:98    183 PICK2       TYA      ;divide pos'n by 2
CC34:4A    184 LSR A          ;and use as offset into line
CC35:A8    185 TAY
CC36:B1 28   186 LDA (BASL),Y  ;pick character
CC38:8D 54 CO 187 STA TXTPAGE1  ;80 columns, switch in
CC3B:80 02 CC3F 188 BRA PICK3     ;skip 40 column pick
CC3D:B1 28   189 PICK1       LDA (BASL),Y  ;pick 40 column char
CC3F:2C 1E CO 190 PICK3     BIT ALTCHARSET ;only allow if alt set
CC42:10 06 CC4A 191 BPL PICK4
CC44:C9 20   192 CMP #$20
CC46:B0 02 CC4A 193 BCS PICK4
CC48:09 40   194 ORA #$40
CC4A:7A    195 PICK4       PLY      ;restore real Y
CC4B:60    196 RTS
CC4C:
CC4C:      197 *
CC4C:      198 * SHOWCUR displays either a checkerboard cursor, a solid
CC4C:      199 * rectangle, or the current cursor character, depending
CC4C:      200 * on the value of the CURSOR location. 0=inverse cursor,
CC4C:      201 * $FF=checkerboard cursor, anything else is displayed
CC4C:      202 * after being anded with inverse mask.

```

```

CC4C:          203 *
CC4C:AC FB 07 204 SHOWCUR LDY   CURSOR      ;what's my type?
CC4F:D0 02    CC53  205   BNE   NOTINV     ;=>not inverse
CC51:80 BF    CC12  206   BRA   INVERT     ;else invert the char (exit)
CC53:          207 *
CC53:          208 * Exit with char in accumulator
CC53:          209 *
CC53:20 1D CC 210 NOTINV  JSR   PICKY      ;get char on screen
CC56:48        211   PHA   NOTINV2    ;preserve it
CC57:8D 7B 07  212   STA   NXTCUR     ;save for update
CC5A:98        213   TYA   NOTINV2    ;test for checkerboard
CC5B:C8        214   INY   NOTINV2    ;=checkerboard, display it
CC5C:F0 0D    CC6B  215   BEQ   NOTINV2    ;test char
CC5E:7A        216   PLY   NOTINV2    ;don't need inverse
CC5F:5A        217   PHY   NOTINV2    ;mask = $7F if alternate
CC60:30 09    CC6B  218   BMI   NOTINV2    ;character set,
CC62:AD 1E C0 219   LDA   ALTCHARSET  ;$3F if normal char set
CC65:09 7F    220   ORA   #$7F       ;form char to display
CC67:4A        221   LSR   A          ;and display it
CC68:2D FB 07  222 NOTINV1 AND   CURSOR     ;restore real char
CC6B:20 B3 C3  223 NOTINV2 JSR   STORY      ;screen, and we return with BMI.
CC6E:68        224   PLA   NOTINV2    ;NOTE: this routine used by COMM firmware!!
CC6F:60        225   RTS   NOTINV2    232 *
CC70:          226 *
CC70:          227 * The UPDATE routine increments the random seed.
CC70:          228 * If a certain value is reached and we are in Apple II
CC70:          229 * mode, the blinking check cursor is updated. If a
CC70:          230 * key has been pressed, the old char is replaced on the
CC70:          231 * screen, and we return with BMI.
CC70:          232 *
CC70:          233 * NOTE: this routine used by COMM firmware!!
CC70:          234 *
CC70:48        235 UPDATE  PHA   RNDL      ;save char
CC71:E6 4E    236   INC   UD2       ;update seed
CC73:D0 1C    CC91  237   BNE   RNDH      ;check for key
CC75:A5 4F    238   LDA   RNDH
CC77:E6 4F    239   INC   RNDH
CC79:45 4F    240   EOR   RNDH
CC7B:29 10    241   AND   #$10      ;need to update cursor?
CC7D:F0 12    CC91  242   BEQ   UD2       ;=>no, check for key
CC7F:AD FB 07 243   LDA   CURSOR     ;what cursor are we using?
CC82:F0 0D    CC91  244   BEQ   UD2       ;=>/e cursor, leave alone
CC84:20 1D CC  245   JSR   PICKY      ;get the character into A
CC87:AC 7B 07  246   LDY   NXTCUR     ;get next character
CC8A:8D 7B 07  247   STA   NXTCUR     ;save next next character
CC8D:98        248   TYA   NOTINV2    ;and print it
CC8E:20 B3 C3  249   JSR   STORY      ;get real char
CC91:68        250 UD2    JSR   XBITKBD   ;was a key pressed?
CC92:20 AD C9  251   BPL   GETCURX   ;=>no key pressed
CC95:10 28    CCBF  252   JSR   STORY      ;restore old key
CC97:20 B3 C3  253 CLRKBD  JMP   XRDKBD    ;look for keystroke and exit
CC9A:4C 8F C9  254   JSR   XRDKBD
CC9D:          255 *
CC9D:          256 * ON CURSORS. Whenever the horizontal cursor position is
CC9D:          257 * needed, a call to GETCUR is done. This is the equivalent
CC9D:          258 * of a LDY CH. This returns the current cursor for II and
CC9D:          259 * //e mode, which may have been poked as either CH or OURCH.
CC9D:          260 *

```

```

CC9D:      261 * It also forces CH and OLDCH to 0 if 80 column mode active.
CC9D:      262 * This prevents LDY CH, STA (BASL),Y from trashing non screen
CC9D:      263 * memory. It works just like the //e.
CC9D:      264 *
CC9D:      265 * All routines that update the cursor's horizontal position
CC9D:      266 * are here. This ensures that the newest value of the cursor
CC9D:      267 * is always used, and that 80 column CH is always 0.
CC9D:      268 *
CC9D:      269 * GETCUR only affects the Y register
CC9D:      270 *
CC9D:A4 24 271 GETCUR   LDY   CH           ;if CH=OLDCH, then
CC9F:CC 7B 04 272       CPY   OLDCH        ;OURCH is valid
CCA2:D0 03 CCA7 273       BNE   GETCUR1     ;=>else CH must have been changed
CCA4:AC 7B 05 274       LDY   OURCH        ;use OURCH
CCA7:C4 21 275 GETCUR1  CPY   WNDWDTH    ;is the value too big
CCA9:90 02 CCAD 276       BCC   GETCUR2     ;=>no, fits just fine
CCAB:A0 00 277       LDY   #0            ;else force CH to 0
CCAD:      278 *
CCAD:      279 * GETCUR2 is commonly used to set the current cursor
CCAD:      280 * position when Y can be used.
CCAD:      281 *
CCAD:8C 7B 05 282 GETCUR2  STY   OURCH        ;update real cursor
CCB0:2C 1F C0 283       BIT   RD80VID     ;80 columns?
CCB3:10 02 CCB7 284       BPL   GETCUR3     ;=>no, set all cursors
CCB5:A0 00 285       LDY   #0            ;yes, peg CH to 0
CCB7:84 24 286 GETCUR3  STY   CH
CCB9:8C 7B 04 287       STY   OLDCH
CCBC:AC 7B 05 288       LDY   OURCH        ;get cursor
CCBF:60 289 GETCURX  RTS
CCCO:      28       INCLUDE ESCAPE

```

```

CCCO: 2 * START AN ESCAPE SEQUENCE:
CCCO: 3 * WE HANDLE THE FOLLOWING ONES:
CCCO: 4 * @ - HOME & CLEAR
CCCO: 5 * A - Cursor right
CCCO: 6 * B - Cursor left
CCCO: 7 * C - Cursor down
CCCO: 8 * D - Cursor up
CCCO: 9 * E - CLR TO EOL
CCCO: 10 * F - CLR TO EOS
CCCO: 11 * I, Up Arrow - CURSOR UP (stay escape)
CCCO: 12 * J, Lft Arrow - CURSOR LEFT (stay escape)
CCCO: 13 * K, Rt Arrow - CURSOR RIGHT (stay escape)
CCCO: 14 * M, Dn Arrow - CURSOR DOWN (stay escape)
CCCO: 15 * 4 - GOTO 40 COLUMN MODE
CCCO: 16 * 8 - GOTO 80 COLUMN MODE
CCCO: 17 * CTL-D- Disable the printing of control chars
CCCO: 18 * CTL-E- Enable the printing of control chars
CCCO: 19 * CTL-Q- QUIT (PR#0/IN#0)
CCCO: 20 *
CCCC:B9 0C CD 21 ESC3 LDA ESCCHAR,Y ;GET CHAR TO "PRINT"
CCCC:5A 22 PHY ;save index
CCC4:20 58 CD 23 JSR CTLCHAR ;execute character
CCC7:7A 24 PLY ;restore index
CCC8:00 08 25 CPY #YHI ;If Y<YHI, stay escape
CCCA:B0 21 CCED 26 BCS ESCRDKEY ;=>exit escape mode
CCCC: 27 *
CCCC: 28 * This is the entry point called by RDKEY iff escapes
CCCC: 29 * are enabled and an escape is encountered. The next
CCCC: 30 * keypress is read and processed. If it is a key that
CCCC: 31 * terminates escape mode, a new key is read by ESCRDKEY.
CCCC: 32 * If escape mode should not be terminated, NEWESC is
CCCC: 33 * called again.
CCCC: 34 *
CCCC:20 1D CC 35 NEWESC JSR PICKY ;get current character
CCCF:48 36 PHA ;and save it
CCDO:29 80 37 AND #$80 ;save invert bit
CCD2:49 AB 38 EOR #$AB ;make it inverted "+"
CCD4:20 B3 C3 39 JSR STORY ;and pop it on the screen
CCD7:20 AD C9 40 ESC0 JSR XBITKBD ;check for keystroke
CCDA:10 FB CCD7 41 BPL ESCO
CCDC:68 42 PLA ;get old char
CCDD:20 97 CC 43 JSR CLRKBD ;restore char, get key
CCE0:20 9B C3 44 JSR UPSHIFT ;upshift esc char
CCE3:A0 13 45 ESC1 LDY #ESCNUM ;COUNT/INDEX
CCE5:D9 F8 CC 46 ESC2 CMP ESCTAB,Y ;IS IT A VALID ESCAPE?
CCE8:F0 D6 CCC0 47 BEQ ESC3 =>yes
CCEA:88 48 DEY
CCEB:10 F8 CCE5 49 BPL ESC2 ;TRY 'EM ALL...
CCED: 50 *
CCED: 51 * End of escape sequence, read next character.
CCED: 52 * This is initially called by RDCHAR which is usually called
CCED: 53 * by GETLN to read characters with escapes enabled.
CCED: 54 *
CCED:A9 08 55 ESCRDKEY LDA #M.CTL ;enable escape sequences
CCEF:1C FB 04 56 TRB VMODE
CCF2:20 0C FD 57 JSR RDKEY ;read char with escapes
CCF5:4C 44 FD 58 JMP NOESCAPE ;got the key, disable escapes
CCF8: 59 *

```

```

CCF8:      60 * When in escape mode, the characters in ESCTAB (high)
CCF8:      61 * bits set), are mapped into the characters in ESCCHAR.
CCF8:      62 * These characters are then executed by a call to CTLCHAR.
CCF8:      63 *
CCF8:      64 * CTLCHAR looks up a character in the table starting at
CCF8:      65 * CTLTAB. It uses the current index as an index into the
CCF8:      66 * table of routine addresses, CTLADR. If the character is
CCF8:      67 * not in the table, a call to VIDOUT1 is done in case the
CCF8:      68 * character is BS, LF, CR, or BEL.
CCF8:      69 *
CCF8:      70 * NOTE: CTLON and CTLOFF are not accessible except through
CCF8:      71 * and escape sequence
CCF8:      72 *
CCF8:      73          MSB    ON           ;high bit on
CCF8:      CCF8 74 ESCTAB   EQU   *
CCF8:      CCF8:CA 75 ASC     'J'          ;left (stay esc)
CCF9:88    76 DFB     $88         ;left arrow (stay esc)
CCFA:CD    77 ASC     'M'          ;down (stay esc)
CCFB:8B    78 DFB     $8B         ;up arrow (stay esc)
CCFC:95    79 DFB     $95         ;right arrow (stay esc)
CCFD:8A    80 DFB     $8A         ;down arrow (stay esc)
CCFE:C9    81 ASC     'I'          ;up (stay esc)
CCFF:CB    82 ASC     'K'          ;right (stay esc)
CD00:      0008 83 YHI     EQU   *-ESCTAB
CD00:C2    84 ASC     'B'          ;left
CD01:C3    85 ASC     'C'          ;down
CD02:C4    86 ASC     'D'          ;up
CD03:C1    87 ASC     'A'          ;right
CD04:CO    88 ASC     '@'          ;formfeed
CD05:C5    89 ASC     'E'          ;clear EOL
CD06:C6    90 ASC     'F'          ;clear EOS
CD07:B4    91 ASC     '4'          ;40 column mode
CD08:B8    92 ASC     '8'          ;80 column mode
CD09:91    93 DFB     $91         ;CTL-Q = QUIT
CD0A:84    94 DFB     $84         ;CTL-D ;ctl char disable
CD0B:85    95 DFB     $85         ;CTL-E ;ctl char enable
CD0C:      96 *
CD0C:      0013 97 ESCNUM   EQU   *-ESCTAB-1
CD0C:      98 *
CD0C:      CDOC 99 ESCCHAR  EQU   *           ;list of escape chars
CD0C:88    100 DFB    $88         ;J: BS (stay esc)
CD0D:88    101 DFB    $88         ;<:BS (stay esc)
CD0E:8A    102 DFB    $8A         ;M: LF (stay esc)
CD0F:9F    103 DFB    $9F         ;UP:US (stay esc)
CD10:9C    104 DFB    $9C         ;->:FS (stay esc)
CD11:8A    105 DFB    $8A         ;DN: LF (stay esc)
CD12:9F    106 DFB    $9F         ;I: UP (stay esc)
CD13:9C    107 DFB    $9C         ;K: RT (stay esc)
CD14:88    108 DFB    $88         ;ESC-B = BS
CD15:      CD15 109 CTLTAB  EQU   *           ;list of control characters
CD15:8A    110 DFB    $8A         ;ESC-C = DN
CD16:9F    111 DFB    $9F         ;ESC-D = UP
CD17:9C    112 DFB    $9C         ;ESC-A = RT
CD18:8C    113 DFB    $8C         ;@: Formfeed
CD19:9D    114 DFB    $9D         ;E: CLREOL
CD1A:8B    115 DFB    $8B         ;F: CLREOP
CD1B:91    116 DFB    $91         ;SET40
CD1C:92    117 DFB    $92         ;SET80

```

```

CD1D:95      118      DFB  $95      ;QUIT
CD1E:04      119      DFB  $04      ;Disable controls (escape only)
CD1F:05      120      DFB  $05      ;Enable controls (escape only)
CD20:          121 * escape chars end here
CD20:85      122      DFB  $85      ;X.CUR.ON
CD21:86      123      DFB  $86      ;X.CUR.OFF
CD22:8E      124      DFB  $8E      ;Normal
CD23:8F      125      DFB  $8F      ;Inverse
CD24:96      126      DFB  $96      ;Scroll down
CD25:97      127      DFB  $97      ;Scroll up
CD26:98      128      DFB  $98      ;mouse chars off
CD27:99      129      DFB  $99      ;home cursor
CD28:9A      130      DFB  $9A      ;clear line
CD29:9B      131      DFB  $9B      ;mouse chars on
CD2A:          132 *
CD2A: 0014    133 CTLNUM   EQU  *--CTLTAB-1
CD2A:          134 *
CD2A: CD2A    135 CTLADR   EQU  *
CD2A:66 FC    136      DW   LF       ;move cursor down
CD2C:1A FC    137      DW   UP       ;move cursor up
CD2E:A0 FB    138      DW   NEWADV   ;forward a space
CD30:58 FC    139      DW   HOME     ;home cursor, clear screen
CD32:9C FC    140      DW   CLREOL   ;clear to end of line
CD34:42 FC    141      DW   CLREOP   ;clear to end of page
CD36:C0 CD    142      DW   SET40    ;set 40 column mode
CD38:BE CD    143      DW   SET80    ;set 80 column mode
CD3A:45 CE    144      DW   QUIT     ;Quit video firmware
CD3C:91 CD    145      DW   CTLOFF   ;disable //e control chars
CD3E:95 CD    146      DW   CTLON    ;enable //e control chars
CD40:89 CD    147      DW   X.CUR.ON ;turn on cursor (pascal)
CD42:8D CD    148      DW   X.CUR.OFF;turn off cursor (pascal)
CD44:80 CD    149      DW   X.SO     ;normal video
CD46:B7 CD    150      DW   X.SI     ;inverse video
CD48:30 CB    151      DW   SCROLLDN;scroll down a line
CD4A:35 CB    152      DW   SCROLLUP;scroll up a line
CD4C:9F CD    153      DW   MOUSOFF  ;disable mouse characters
CD4E:A5 CD    154      DW   HOMECUR  ;move cursor home
CD50:A0 FC    155      DW   CLRLIN   ;clear current line
CD52:99 CD    156      DW   MOUSON   ;enable mouse characters
CD54:          157 *
CD54:          158      MSB  ON
CD54:          159 *
CD54:          160 * CTLCHAR executes the control character in the
CD54:          161 * accumulator. If it is called by Pascal, the character
CD54:          162 * is always executed. If it is called by the video
CD54:          163 * firmware, the character is executed if M.CTL is set
CD54:          164 * and M.CTL2 is clear.
CD54:          165 *
CD54:          166 * Note: This routine is only called if the video firmware
CD54:          167 * is active. The Monitor ROM calls VIDOUT1 if the video
CD54:          168 * firmware is inactive.
CD54:          169 *
CD54:2C C1 CB  170 CTLCHARO BIT   SEV1      ;set V (use M.CTL)
CD57:50      171      DFB  $50      ;BVC opcode (never taken)
CD58:          172 *
CD58:B8      173 CTLCHAR  CLV       ;Always do control character
CD59:DA      174      PHX       ;save X
CD5A:8D F8 04  175      STA   TEMP1    ;temp save of A

```

```

CD5D:20 04 FC      176      JSR    VIDOUT1      ;try to execute CR, LF, BS, or BEL
CD60:CD F8 04      177      CMP    TEMP1       ;if acc has changed
CD63:DO 0A          CD6F     178      BNE    CTLDONE    ;then function done
CD65:A2 14          179      LDX    #CTLNUM    ;number of CTL chars
CD67:DD 15 CD      180 FNDCTL   CMP    CTLTAB,X  ;is it in table
CD6A:F0 05          CD71     181      BEQ    CTLGO      ;=>yes, should we execute?
CD6C:CA            182      DEX    FNDCTL    ;else check next
CD6D:10 F8          CD67     183      BPL    FNDCTL    ;=>try next one
CD6F:FA            184 CTLDONE   PLX    CTLGO      ;restore X
CD70:60            185      RTS    FNDCTL    ;and return
CD71:              186 *
CD71:48            187 CTLGO    PHA    CTLGO1      ;save A
CD72:50 0C          CD80     188      BVC    CTLGO1      ;V clear, always do (pascal,escape)
CD74:AD FB 04      189      LDA    VMODE       ;controls are enabled iff
CD77:29 28          190      AND    #M.CTL+M.CTL2 ; M.CTL = 1 and
CD79:49 08          191      EOR    #M.CTL      ; M.CTL2 = 0
CD7B:F0 03          CD80     192      BEQ    CTLGO1      ;=>they're enabled!!
CD7D:68            193 CGO     PLA    CTLGO1      ;restore A
CD7E:FA            194      PLX    CTLGO1      ;restore X
CD7F:60            195      RTS    CTLGO1      ;and return
CD80:              196 *
CD80:8A            197 CTLGO1   TXA    A           ;double X as index
CD81:0A            198 ASL    TAX        A           ;into address table
CD82:AA            199 TAX
CD83:68            200 PLA
CD84:20 A4 FC      201 JSR    CTLDO      ;execute the char
CD87:FA            202 PLX
CD88:60            203 RTS
CD89:              204 *
CD89:              205 * X.CUR.ON = Allow Pascal cursor display
CD89:              206 * X.CUR.OFF = Disable Pascal cursor display
CD89:              207 * Cursor is not displayed during call, so it will
CD89:              208 * be right when "redisplayed".
CD89:              209 * Note: Though these commands are executed from BASIC,
CD89:              210 * they have no effect on firmware operation.
CD89:              211 *
CD89:A9 10          212 X.CUR.ON LDA    #M.CURSOR  ;clear cursor bit
CD8B:80 0E          CD9B     213 BRA    CLRIT
CD8D:              214 *
CD8D:A9 10          215 X.CUR.OFF LDA    #M.CURSOR  ;set cursor bit
CD8F:80 10          CDA1     216 BRA    SETIT
CD91:              217 *
CD91:              218 * The control characters other than CR,LF,BEL,BS
CD91:              219 * are normally enabled when video firmware is active.
CD91:              220 * They can be disabled and enabled using the ESC-D
CD91:              221 * and ESC-E escape sequences.
CD91:              222 *
CD91:A9 20          223 CTLOFF   LDA    #M.CTL2    ;disable control characters
CD93:80 0C          CDA1     224 BRA    SETIT    ;by setting M.CTL2
CD95:              225 *
CD95:A9 20          226 CTLON    LDA    #M.CTL2    ;enable control characters
CD97:80 02          CD9B     227 BRA    CLRIT    ;by clearing M.CTL2
CD99:              228 *
CD99:              229 * Enable mouse text by clearing M.MOUSE
CD99:              230 *
CD99:A9 01          231 MOUSON   LDA    #M.MOUSE
CD9B:1C FB 04      232 CLRIT    TRB    VMODE
CD9E:60            233 RTS

```

```

CD9F:          234 *
CD9F:          235 * Disable mouse text by setting M.MOUSE
CD9F:          236 *
CD9F:A9 01    237 MOUSOFF   LDA   #M.MOUSE
CDA1:0C FB 04 238 SETIT     TSB   VMODE
CDA4:60       239         RTS
CDA5:          240 *
CDA5:          241 * EXECUTE HOME:
CDA5:          242 *
CDA5:20 E9 FE 243 HOMECUR  JSR   CLRCH      ;move cursors to far left
CDA8:A8        244         TAY   ;(probably not needed)
CDA9:A5 22    245         LDA   WNDTOP     ;and to top of window
CDA8:85 25    246         STA   CV
CDAD:4C 88 FC 247         JMP   NEWVTABZ   ;then set base address, OURCV
CDB0:          248 *
CDB0:          249 * EXECUTE "NORMAL VIDEO"
CDB0:          250 *
CDB0:20 84 FE 251 X.SO     JSR   SETNORM    ;set INVFLG to $FF
CDB3:A9 04    252         LDA   #M.VMODE   ;then clear inverse mode bit
CDB5:80 E4    CD9B       253         BRA   CLRIT
CDB7:          254 *
CDB7:          255 * EXECUTE "INVERSE VIDEO"
CDB7:          256 *
CDB7:20 80 FE 257 X.SI     JSR   SETINV    ;set INVFLG to $3F
CDBA:A9 04    258         LDA   #M.VMODE   ;then set inverse mode bit
CDBC:80 E3    CDA1       259         BRA   SETIT
CDBE:          260 *
CDBE:          261 * EXECUTE '40COL MODE' or '80COL MODE':
CDBE:          262 *
CDBE:38        263 SET80    SEC   ;flag an 80 column window
CDBF:90        264 DFB      $90   ;BCC opcode (never taken)
CDC0:18        265 SET40    CLC   ;flag a 40 column window
CDC1:2C FB 04 266 BIT      VMODE  ;but...is it pascal?
CDC4:10 54    CE1A       267 BPL      SETX   ;=>yes, don't execute
CDC6:08        268 PHP      ;save window size
CDC7:20 1B CE  269 JSR      HOOKITUP ;COPYROM if needed, set I/O hooks
CDCA:28        270 PLP      ;and get 40/80
CDCB:80 08    CDD5       271 BRA      WINO   ;=>set window
CDCD:          272 *
CDCD:          273 * CHK80 is called by PR#0 to convert to 40 if it was
CDCD:          274 * 80. Otherwise the window is left ajar.
CDCD:          275 *
CDCD:2C 1F CO 276 CHK80   BIT   RD80VID   ;don't set 40 if
CDD0:10 48    CE1A       277 BPL      SETX   ;already 40
CDD2:          278 *
CDD2:18        279 WIN40   CLC   ;flag 40 column window
CDD3:80        280 DFB      $B0   ;BCS opcode (never taken)
CDD4:38        281 WIN80   SEC   ;flag 80 column window
CDD5:64 22    282 WIN0    STZ   WNDTOP    ;set window top now
CDD7:2C 1A CO 283 BIT      RDTEXT   ;for text or mixed
CDDA:30 04    CDE0       284 BMI      WIN1   ;=>text
CDDC:A9 14    285 LDA      #20
CDDE:85 22    286 STA      WNDTOP   ;used by 80<->40 conversion
CDE0:2C 1F CO 287 WIN1    BIT   RD80VID   ;80 columns now?
CDE3:08        288 PHP      ;save 80 or 40
CDE4:B0 07    CDED       289 BCS      WIN2   ;=>80: convert if 40
CDE6:10 0A    CDF2       290 BPL      WIN3   ;=>40: no convert
CDE8:20 53    CE        291 JSR      SCRNN84 ;80: convert to 40

```

```

CDEB:80 05 CDF2 292      BRA  WIN3      ;done converting
CDED:30 03 CDF2 293 WIN2    BMI  WIN3      ;=>80: no convert
CDEF:20 80 CE              294      JSR  SCRN48   ;40: convert to 80
CDF2:20 9D CC              295 WIN3    JSR  GETCUR   ;determine absolute CH
CDF5:98                  296      TYA
CDF6:18                  297      CLC
CDF7:65 20              298      ADC  WNDLFT
CDF9:28                  299      PLP
CDFA:B0 06 CEO2 300      BCS  WIN4      ;pin to right edge if
CDFC:C9 28              301      CMP  #40      ;80 to 40 leaves cursor
CDFE:90 02 CEO2 302      BCC  WIN4      ;off the screen
CEO0:A9 27              303      LDA  #39
CEO2:20 EC FE              304 WIN4    JSR  SETCUR   ;set new cursor
CEO5:A5 25              305      LDA  CV       ;set new base address
CEO7:20 C1 FB              306      JSR  BASCALC  ;for left = 0 (always)
CEOA:                   307 *
CEOA:64 20              308 WNDREST  STZ  WNDLFT   ;Called by INIT and Pascal
CEOC:A9 18              309      LDA  #$18      ;and bottom
CEOE:85 23              310      STA  WNDBTM
CE10:A9 28              311      LDA  #$28      ;set left,width,bottom
CE12:2C 1F CO              312      BIT  RD80VID  ;set width to 80 if 80 columns
CE15:10 01 CE18 313      BPL  WINS
CE17:0A                  314      ASL  A
CE18:85 21              315 WINS     STA  WNDWDTH  ;set width
CE1A:60                  316 SETX     RTS
CE1B:                   317 *
CE1B:                   318 * Turn on video firmware:
CE1B:                   319 *
CE1B:                   320 * This routine is used by BASIC init, ESC-4, ESC-8
CE1B:                   321 * It copies the Monitor ROM to the language card
CE1B:                   322 * if necessary; it sets the input and output hooks to
CE1B:                   323 * $C30x; it sets all switches for video firmware operation
CE1B:                   324 *
CE1B:2C 7B 06              325 HOOKITUP BIT  VFACTV   ;don't touch hooks
CE1E:10 11 CE31 326      BPL  VIDMODE  ;if video firmware already active
CE20:20 38 C3              327 HOOKUP   JSR  COPYROM   ;Copy ROM to LC?
CE23:A9 05              328 SETHOOKS LDA  #>C3KEYIN ;set up $C300 hooks
CE25:85 38              329      STA  KSWL
CE27:A9 07              330      LDA  #>C3COUT1
CE29:85 36              331      STA  CSWL
CE2B:A9 C3              332      LDA  #<C3COUT1
CE2D:85 39              333      STA  KSWH
CE2F:85 37              334      STA  CSWH
CE31:                   335 *
CE31:                   336 * Now set the video firmware active
CE31:                   337 *
CE31:9C FB 07              338 VIDMODE  STZ  CURSOR   ;set a solid inverse cursor
CE34:A9 08              339      LDA  #M.CTL   ;preserve M.CTL bit
CE36:2D FB 04              340      AND  VMODE
CE39:09 81              341      ORA  #M.PASCAL+M.MOUSE ;no pascal,mouse
CE3B:                   342 *
CE3B:                   343 * Pascal calls here to set its mode
CE3B:                   344 *
CE3B:8D FB 04              345 PVMODE  STA  VMODE   ;set mode bits
CE3E:9C 7B 06              346      STZ  VFACTV   ;say video firmware active
CE41:8D 0F C0              347      STA  SETALTCHAR ;and set alternate char set
CE44:60                  348 QX      RTS
CE45:                   349 *

```

```
CE45:          350 * QUIT converts the screen from 80 to 40 if necessary,  
CE45:          351 * sets a 40 column window, and restores the normal I/O  
CE45:          352 * hooks (COUT1 and KEYIN).  
CE45:          353 *  
CE45:2C FB 04  354 QUIT      BIT    VMODE      ;no quitting from pascal  
CE48:10 FA    CE44  355        BPL    QX  
CE4A:20 D2 CD  356        JSR    WIN40      ;first, do an escape 4  
CE4D:20 89 FE  357 ZZQUIT   JSR    SETKBD     ;do a IN#0 (used by COMM)  
CE50:4C 93 FE  358        JMP    SETVID     ;and a PR#0
```

```

CE53:      360 *
CE53:      361 * SCR84 and SCR48 convert screens between 40 & 80 cols.
CE53:      362 * WNDTOP must be set up to indicate the last line to
CE53:      363 * be done. All registers are trashed.
CE53:      364 *
CE53:A2 17 365 SCR84   LDX #23      ;start at bottom of screen
CE55:8D 01 CO 366 STA SET80COL    ;allow page 2 access
CE58:8A     367 SCR1    TXA          ;calc base for line
CE59:20 C1 FB 368 JSR BASCALC
CE5C:A0 27   369 LDY #39      ;start at right of screen
CE5E:5A     370 SCR2    PHY          ;save 40 index
CE5F:98     371 TYA          ;div by 2 for 80 column index
CE60:4A     372 LSR A
CE61:80 03 CE66 373 BCS SCR3
CE63:2C 55 CO 374 BIT TXTPAGE2  ;even column, do page 2
CE66:A8     375 SCR3    TAY          ;get 80 index
CE67:B1 28   376 LDA (BASL),Y  ;get 80 char
CE69:2C 54 CO 377 BIT TXTPAGE1 ;restore pagel
CE6C:7A     378 PLY          ;get 40 index
CE6D:91 28   379 STA (BASL),Y
CE6F:88     380 DEY          ;do next 40 byte
CE70:10 EC  CE5E 381 BPL SCR2
CE72:CA     382 DEX          ;do next line
CE73:30 04 CE79 383 BMI SCR4
CE75:E4 22   384 CPX WNDTOP  ;=>done with setup
CE77:80 DF  CE58 385 BCS SCR1
CE79:8D 00 CO 386 SCR4   STA CLR80COL ;clear 80STORE for 40 columns
CE7C:8D 0C CO 387 STA CLR80VID ;clear 80VID for 40 columns
CE7F:60     388 RTS
CE80:        389 *
CE80:A2 17   390 SCR84   LDX #23      ;start at bottom of screen
CE82:8A     391 SCR5    TXA          ;set base for current line
CE83:20 C1 FB 392 JSR BASCALC
CE86:A0 00   393 LDY #0       ;start at left of screen
CE88:8D 01 CO 394 STA SET80COL    ;enable page2 store
CE8B:B1 28   395 SCR6    LDA (BASL),Y ;get 40 column char
CE8D:5A     396 SCR8    PHY          ;save 40 column index
CE8E:48     397 PHA          ;save char
CE8F:98     398 TYA          ;div 2 for 80 column index
CE90:4A     399 LSR A
CE91:80 03 CE96 400 BCS SCR7
CE93:8D 55 CO 401 STA TXTPAGE2  ;save on pagel
CE96:A8     402 SCR7    TAY          ;get 80 column index
CE97:68     403 PLA          ;now save character
CE98:91 28   404 STA (BASL),Y
CE9A:8D 54 CO 405 STA TXTPAGE1 ;flip pagel
CE9D:7A     406 PLY          ;restore 40 column index
CE9E:C8     407 INY          ;move to the right
CE9F:CO 28   408 CPY #40      ;at right yet?
CEA1:90 E8  CE8B 409 BCC SCR6
CEA3:20 CF CB 410 JSR CLRHALF ;clear half of screen
CEA6:CA     411 DEX          ;else do next line of screen
CEA7:30 04 CEAD 412 BMI SCR9
CEA9:E4 22   413 CPX WNDTOP  ;=>done with top line
CEAB:80 D5  CE82 414 BCS SCR5
CEAD:8D 0D CO 415 SCR9   STA SET80VID ;convert to 80 columns
CEB0:60     416 RTS
CEB1:        29  INCLUDE PASCAL ;Pascal support stuff

```

```

CEB1:AA      3 PSTATUS   TAX      ;is request code = 0?
CEB2:F0 08   CEBC      4 BEQ     PIORDY  ;=>yes, ready for output
CEB4:CA      5 DEX      BNE     PSTERR  ;check for any input
CEB5:D0 07   CEBE      6 JSR     XBITKBD ;=>bad request, return error
CEB7:20 AD C9 7          CLC      PNOTRDY ;test keyboard
CEBA:10 04   CEC0      8          SEC      ;=>no keystroked
CEBC:38      9 PIORDY  RTS      ;good return
CEBD:60      10          RTS      ;else flag error
CEBE:A2 03   11 PSTERR  LDX #3
CECO:18      12 PNOTRDY CLC
CEC1:60      13          RTS
CEC2:        14 *
CEC2:        15 * PASCAL OUTPUT:
CEC2:        16 *
CEC2:        CEC2      17 PWRITE  EQU    *
CEC2:09 80   18 ORA     #$80    ;turn on high bit
CEC4:AA      19 TAX      JSR     PSETUP2 ;save character
CEC5:20 54 CF 20          LDA     #M.GOXY ;SETUP ZP STUFF, don't set ROM
CEC8:A9 08   21          BIT     VMODE  ;ARE WE DOING GOTOXY?
CECA:2C FB 04 22          BNE     GETX   ;=>Doing X or Y?
CECD:D0 2B   CEFA      23          TXA    ;now check for control char
CECF:8A      24          BIT     #$60  ;is it control?
CED0:89 60   25 BEQ     PCTL   ;=>yes, do control
CED2:F0 45   CF19      26 LDY     OURCH ;get horizontal position
CED4:AC 7B 05 27          BIT     INVFLG ;check for inverse
CED7:24 32   28 BMI     PWRL  ;normal, go store it
CED9:30 02   CEDD      29 AND     #$7F
CEDB:29 7F   30          JSR     STORE  ;now store it (erasing cursor)
CEDD:20 C1 C3 31 PWRL   INY    ;INC CH
CEE0:C8      32          JSR

```

```

CEE1:8C 7B 05      33      STY    OURCH
CEE4:C4 21      34      CPY    WNDWDTH
CEE6:90 0C CEF4  35      BCC    PWRET
CEE8:20 60 C3    36      JSR    SETROM
CEEB:20 E9 FE    37      JSR    CLRCH      ;set cursor position to 0
CEEE:20 66 FC    38      JSR    LF
CEF1:20 54 C3    39 PWRITERET JSR    RESETLC
CEF4:20 0B CC    40 PWRET   JSR    PASINVERT ;display new cursor
CEF7:A2 00      41 PRET    LDX    #$0      ;return with no error
CEF9:60      42      RTS
CEFA:
43 *
CEFA:
44 * HANDLE GOTOXY STUFF:
CEFA:
45 *
CEFA: CEFA 46 GETX   EQU    *
CEFA:20 0B CC 47 JSR    PASINVERT ;turn off cursor
CEFD:8A 48 TXA    ;get character
CEFE:38 49 SEC
CEFF:E9 A0 50 SBC    #160      ;MAKE BINARY
CF01:2C FB 06 51 BIT    XCOORD    ;doing X?
CF04:30 2A CF30 52 BMI    PSETX    ;=>yes, set it
CF06:
53 *
CF06: 54 * Set Y and do the GOTOXY
CF06:
55 *
CF06: CF06 56 GETY   EQU    *
CF06:8D FB 05 57 STA    OURCV
CF09:20 71 CF    58 JSR    PASCALC   ;calc base addr
CFOC:AC FB 06 59 LDY    XCOORD
CFOF:20 AD CC    60 JSR    GETCUR2   ;set proper cursors

```

```

CF12:A9 08      61     LDA    #M.GOXY      ;turn off gotoxy
CF14:1C FB 04    62     TRB    VMODE
CF17:80 DB CEF4  63     BRA    PWRET      ;=>DONE (ALWAYS TAKEN)
CF19:
CF19:20 0B CC    64 *   PCTL   JSR    PASINVERT ;turn off cursor
CF1C:8A          65     TXA    CMP    #$9E      ;get char
CF1D:C9 9E        66     BRA    STARTXY    ;is it gotoXY?
CF1F:F0 08 CF29  67     BEQ    SETROM     ;=>yes, start it up
CF21:20 60 C3    68     JSR    CTLCHAR    ;must switch in ROM for controls
CF24:20 58 CD    69     JSR    PWRITERET ;EXECUTE IT IF POSSIBLE
CF27:80 C8 CEF1  70     BRA    PWRET      ;=>display new cursor, exit
CF29:
CF29:           71     BRA    72 *
CF29:           72 *   *       *       *       *
CF29:           73 *   START THE GOTOXY SEQUENCE:
CF29:
CF29:           74 *   *       *       *       *
CF29:           75 STARTXY EQU    *       *
CF29:A9 08        76     LDA    #M.GOXY      ;turn on gotoxy
CF2B:0C FB 04    77     TSB    VMODE
CF2E:A9 FF        78     LDA    #$FF      ;set XCOORD to -1
CF30:8D FB 06    79     PSETX STA    XCOORD    ;set X
CF33:80 BF CEF4  80     BRA    PWRET      ;=>display cursor and exit
CF35:
CF35:           81 *   *       *       *       *
CF35:           82 *   PASCAL INPUT:
CF35:
CF35:           83 *   *       *       *       *
CF35:           84 PASREAD JSR    PSETUP2    ;SETUP ZP STUFF
CF38:20 8F C9    85 GKEY   JSR    XRDKBD    ;key pressed?
CF3B:10 FB CF38  86     BPL    GKEY      ;=>not yet
CF3D:29 7F        87     AND    #$7F      ;DROP HI BIT
CF3F:80 B6 CEF7  88     BRA    PRET      ;good exit
CF41:
CF41:           89 *   *       *       *       *
CF41:           90 *   PASCAL INITIALIZATION:
CF41:
CF41:           91 *   *       *       *       *
CF41:           92 PINIT EQU    *       *
CF41:A9 01        93     LDA    #M.MOUSE    ;Set mode to pascal
CF43:20 3B CE    94     JSR    PV MODE   ;without mouse characters
CF46:20 51 CF    95     JSR    PSETUP     ;setup zero page for pascal
CF49:20 D4 CD    96     JSR    WIN80      ;do 40->80 convert
CF4C:20 58 FC    97     JSR    HOME       ;home and clear screen
CF4F:80 A0 CEF1  98     BRA    PWRET      ;display cursor, set OURCH,OURCV...
CF51:
CF51:           99 *   *       *       *       *
CF51:           100 PSETUP EQU    *       *
CF51:20 60 C3    101    JSR    SETROM     ;save LC state, set ROM read
CF54:64 22        102 PSETUP2 STZ    WNDTOP    ;set top to 0
CF56:20 0A CE    103    JSR    WNDREST    ;init either 40 or 80 window
CF59:A9 FF        104    LDA    #$FF      ;assume normal text
CF5B:85 32        105    STA    INVFLG    ;INVFLG
CF5D:A9 04        106    LDA    #M.VMODE  ;is it
CF5F:2C FB 04    107    BIT    VMODE
CF62:F0 02 CF66  108    BEQ    PS1      ;=>yes
CF64:46 32        109    LSR    INVFLG    ;no, make flag inverse
CF66:AC 7B 05    110 PS1    LDY    OURCH
CF69:20 AD CC    111    JSR    GETCUR2    ;set all cursors
CF6C:AD FB 05    112    LDA    OURCV
CF6F:85 25        113    STA    CV
CF71:
CF71:           114 *   *       *       *       *
CF71:           115 *   Put BASCALC here so we don't have to switch
CF71:           116 *   in the ROMs for each character output.
CF71:
CF71:           117 *   *       *       *       *
CF71:0A           118 PASCALC ASL    A

```

```
CF72:A8      119      TAY      ;calc base addr in BASL,H
CF73:4A      120      LSR A   ;for given line no.
CF74:4A      121      LSR A
CF75:29 03   122      AND #$03 ; 0<=line no.<=$17
CF77:09 04   123      ORA #$4  ; arg=000ABCDE, generate
CF79:85 29   124      STA BASH ; BASH=000001CD
CF7B:98      125      TYA      ;and
CF7C:6A      126      ROR A   ; BASL=EABAB000
CF7D:29 98   127      AND #$98
CF7F:85 28   128 PASCLC2 STA BASL
CF81:0A      129      ASL A
CF82:0A      130      ASL A
CF83:04 28   131      TSB BASL
CF85:60      132      RTS
CF86:        30       INCLUDE AUXSTUFF ;Aux RAM routines
```

```

CF86:
4 ****
5 * NAME      : MOVEAUX
6 * FUNCTION: PERFORM CROSSBANK MEMORY MOVE
7 * INPUT     : A1=SOURCE ADDRESS
8 *          : A2=SOURCE END
9 *          : A4=DESTINATION START
10 *         : CARRY SET=MAIN-->CARD
11 *          CLR=CARD-->MAIN
12 * OUTPUT    : NONE
13 * VOLATILE: NOTHING
14 * CALLS    : NOTHING
15 ****
CF86:      CF86   16 MOVEAUX EQU  *
CF86:48    17      PHA           ;SAVE AC
CF87:AD 13 CO  18      LDA RDRAMRD ;SAVE STATE OF
CF8A:48    19      PHA           ; MEMORY FLAGS
CF8B:AD 14 CO  20      LDA RDRAMWRT
CF8E:48    21      PHA
CF8F:      22 *
CF8F:      23 * SET FLAGS FOR CROSSBANK MOVE:
CF8F:      24 *
CF8F:90 08 CF99  25      BCC MOVEC2M    ;=>CARD-->MAIN
CF91:8D 02 CO  26      STA RDMAINRAM ;SET FOR MAIN
CF94:8D 05 CO  27      STA WRCARDRAM ; TO CARD
CF97:80 06 CF9F  28      BCS MOVESTRT  ;=>(ALWAYS TAKEN)
CF99:
29 *
CF99:      CF99  30 MOVEC2M EQU  *
CF99:8D 04 CO  31      STA WRMAINRAM ;SET FOR CARD
CF9C:8D 03 CO  32      STA RDCARDRAM ; TO MAIN
CF9F:
33 *
CF9F:      CF9F  34 MOVESTRT EQU  *
CF9F:B2 3C   35 MOVELOOP LDA (A1L)      ;get a byte
CFA1:92 42   36      STA (A4L)      ;move it
CFA3:E6 42   37      INC A4L
CFA5:D0 02 CFA9  38      BNE NEXTA1
CFA7:E6 43   39      INC A4H
CFA9:A5 3C   40 NEXTA1  LDA A1L
CFAB:C5 3E   41      CMP A2L
CFAD:A5 3D   42      LDA A1H
CFAF:E5 3F   43      SBC A2H
CFB1:E6 3C   44      INC A1L
CFB3:D0 02 CFB7  45      BNE C01
CFB5:E6 3D   46      INC A1H
CFB7:90 E6 CF9F  47 C01   BCC MOVELOOP ;=>more to move
CFB9:
48 *
CFB9:8D 04 CO 49      STA WRMAINRAM ;CLEAR FLAG2
CFBC:68   50      PLA           ;GET ORIGINAL STATE
CFBD:10 03 CFC2  51      BPL C03        ;=>IT WAS OFF
CFBF:8D 05 CO  52      STA WRCARDRAM
CFC2:      CFC2  53 C03   EQU *
CFC2:8D 02 CO  54      STA RDMAINRAM ;CLEAR FLAG1
CFC5:68   55      PLA           ;GET ORIGINAL STATE
CFC6:10 03 CFCB  56      BPL MOVERET  ;=>IT WAS OFF
CFC8:8D 03 CO  57      STA RDCARDRAM
CFCB:      CFCB  58 MOVERET  EQU *
CFCB:68   59      PLA           ;Restore AC
CFCC:60   60      RTS

```

```

CFCD:          62 ****
CFCD:          63 * NAME      : XFER
CFCD:          64 * FUNCTION: TRANSFER CONTROL CROSSBANK
CFCD:          65 * INPUT    : $03ED=TRANSFER ADDR
CFCD:          66 *           : CARRY SET=XFER TO CARD
CFCD:          67 *           : CLR=XFER TO MAIN
CFCD:          68 *           : VFLAG CLR=USE STD ZP/STK
CFCD:          69 *           : SET=USE ALT ZP/STK
CFCD:          70 * OUTPUT   : NONE
CFCD:          71 * VOLATILE: $03ED/03EE IN DEST BANK
CFCD:          72 * CALLS    : NOTHING
CFCD:          73 * NOTE     : ENTERED VIA JMP, NOT JSR
CFCD:          74 ****
CFCD:          75 *
CFCD:          CFCD  76 XFER    EQU   *
CFCD:48        77       PHA             ;SAVE AC ON CURRENT STACK
CFCE:          78 *
CFCE:          79 * COPY DESTINATION ADDRESS TO THE
CFCE:          80 * OTHER BANK SO THAT WE HAVE IT
CFCE:          81 * IN CASE WE DO A SWAP:
CFCE:          82 *
CFCE:AD ED 03  83       LDA   $03ED      ;GET XFERADDR LO
CFD1:48        84       PHA             ;SAVE ON CURRENT STACK
CFD2:AD EE 03  85       LDA   $03EE      ;GET XFERADDR HI
CFD5:48        86       PHA             ;SAVE IT TOO
CFD6:          87 *
CFD6:          88 * SWITCH TO APPROPRIATE BANK:
CFD6:          89 *
CFD6:90 08  CFE0  90       BCC   XFERC2M    ;=>CARD-->MAIN
CFD8:8D 03  CO  91       STA   RDCARDRAM  ;SET FOR RUNNING
CFDB:8D 05  CO  92       STA   WRCARDRAM  ; IN CARD RAM
CFDE:BO 06  CFE6  93       BCS   XFERZP    ;=> always taken
CFE0:          94 XFERC2M  EQU   *           ; 
CFE0:8D 02  CO  95       STA   RDMAINRAM  ;SET FOR RUNNING
CFE3:8D 04  CO  96       STA   WRMAINRAM  ; IN MAIN RAM
CFE6:          97 *
CFE6:          CFE6  98 XFERZP  EQU   *           ;SWITCH TO ALT ZP/STK
CFE6:68        99       PLA             ;STUFF XFERADDR
CFE7:8D EE 03  100      STA   $03EE      ; HI AND
CFEA:68        101      PLA             ; 
CFEB:8D ED 03  102      STA   $03ED      ; LO
CFEE:68        103      PLA             ;RESTORE AC
CFFF:70 05  CFF6  104      BVS   XFERAZP    ;=>switch in alternate zp
CFF1:8D 08  CO  105      STA   SETSTDZP  ;else force standard zp
CFF4:50 03  CFF9  106      BVC   JMPDEST    ;=>always perform transfer
CFF6:8D 09  CO  107      XFERAZP  STA   SETALTZP  ;switch in alternate zp
CFF9:6C ED 03  108      JMPDEST  JMP   ($03ED)  ;=>off we go
CFFC:          109 ****
CFFC:          0004  110      DS    $D000-$,00
---- NEXT OBJECT FILE NAME IS FIRM.1
F800:          F800  31       ORG   F8ORG
F800:          32       INCLUDE AUTOST1 ;F8 monitor rom

```

F800:4A	3	PLOT	LSR	A	;Y-COORD/2
F801:08	4		PHP		;SAVE LSB IN CARRY
F802:20 47 F8	5		JSR	GBASCALC	;CALC BASE ADR IN GBASL,H
F805:28	6		PLP		;RESTORE LSB FROM CARRY
F806:A9 0F	7		LDA	#\$OF	;MASK \$OF IF EVEN
F808:90 02 F80C	8		BCC	RTMASK	
F80A:69 E0	9		ADC	#\$EO	;MASK \$FO IF ODD
F80C:85 2E	10	RTMASK	STA	MASK	
F80E:B1 26	11	PLOT1	LDA	(GBASL),Y	;DATA
F810:45 30	12		EOR	COLOR	; XOR COLOR
F812:25 2E	13		AND	MASK	; AND MASK
F814:51 26	14		EOR	(GBASL),Y	; XOR DATA
F816:91 26	15		STA	(GBASL),Y	; TO DATA
F818:60	16		RTS		
F819:	17 *				
F819:20 00 F8	18	HLINE	JSR	PLOT	;PLOT SQUARE
F81C:C4 2C	19	HLINE1	CPY	H2	;DONE?
F81E:B0 11 F831	20		BCS	RTS1	; YES, RETURN
F820:C8	21		INY		; NO, INCR INDEX (X-COORD)
F821:20 0E F8	22		JSR	PLOT1	;PLOT NEXT SQUARE
F824:90 F6 F81C	23		BCC	HLINE1	;ALWAYS TAKEN
F826:69 01	24	VLINEZ	ADC	#\$01	;NEXT Y-COORD
F828:48	25	VLINE	PHA		; SAVE ON STACK
F829:20 00 F8	26		JSR	PLOT	; PLOT SQUARE
F82C:68	27		PLA		
F82D:C5 2D	28		CMP	V2	;DONE?
F82F:90 F5 F826	29		BCC	VLINEZ	; NO, LOOP.
F831:60	30	RTS1	RTS		
F832:	31 *				
F832:A0 2F	32	CLRSCR	LDY	#\$2F	;MAX Y, FULL SCRN CLR
F834:D0 02 F838	33		BNE	CLRSC2	;ALWAYS TAKEN
F836:A0 27	34	CLRTOP	LDY	#\$27	;MAX Y, TOP SCRN CLR
F838:84 2D	35	CLRSC2	STY	V2	;STORE AS BOTTOM COORD
F83A:	36 ;				FOR VLINE CALLS
F83A:A0 27	37		LDY	#\$27	;RIGHTMOST X-COORD (COLUMN)
F83C:A9 00	38	CLRSC3	LDA	#\$00	;TOP COORD FOR VLINE CALLS
F83E:85 30	39		STA	COLOR	;CLEAR COLOR (BLACK)
F840:20 28 F8	40		JSR	VLINE	;DRAW VLINE
F843:88	41		DEY		;NEXT LEFTMOST X-COORD
F844:10 F6 F83C	42		BPL	CLRSC3	;LOOP UNTIL DONE.
F846:60	43		RTS		
F847:	44 *				
F847:48	45	GBASCALC	PHA		;FOR INPUT OODEFGH
F848:4A	46		LSR	A	
F849:29 03	47		AND	#\$03	
F84B:09 04	48		ORA	#\$04	;GENERATE GBASH=000001FG
F84D:85 27	49		STA	GBASH	
F84F:68	50		PLA		;AND GBASL=HDEDE000
F850:29 18	51		AND	#\$18	
F852:90 02 F856	52		BCC	GBCALC	
F854:69 7F	53		ADC	#\$7F	
F856:85 26	54	GBCALC	STA	GBASL	
F858:0A	55		ASL	A	
F859:0A	56		ASL	A	
F85A:05 26	57		ORA	GBASL	
F85C:85 26	58		STA	GBASL	
F85E:60	59		RTS		
F85F:	60 *				

F85F:A5 30	61	NXTCOL	LDA	COLOR	;INCREMENT COLOR BY 3
F861:18	62		CLC		
F862:69 03	63		ADC	#\$03	
F864:29 0F	64	SETCOL	AND	#\$0F	;SETS COLOR=17*A MOD 16
F866:85 30	65		STA	COLOR	
F868:0A	66		ASL	A	
F869:0A	67		ASL	A	;BOTH HALF BYTES OF COLOR EQUAL
F86A:0A	68		ASL	A	
F86B:0A	69		ASL	A	
F86C:05 30	70		ORA	COLOR	
F86E:85 30	71		STA	COLOR	
F870:60	72		RTS		
F871:	73 *				
F871:4A	74	SCRN	LSR	A	;READ SCREEN Y-COORD/2
F872:08	75		PHP		;SAVE LSB (CARRY)
F873:20 47 F8	76		JSR	GBASCALC	;CALC BASE ADDRESS
F876:B1 26	77		LDA	(GBASL),Y	;GET BYTE
F878:28	78		PLP		;RESTORE LSB FROM CARRY
F879:90 04 F87F	79	SCRN2	BCC	RTMSKZ	;IF EVEN, USE LO H
F87B:4A	80		LSR	A	
F87C:4A	81		LSR	A	
F87D:4A	82		LSR	A	;SHIFT HIGH HALF BYTE DOWN
F87E:4A	83		LSR	A	
F87F:29 0F	84	RTMSKZ	AND	#\$0F	;MASK 4-BITS
F881:60	85		RTS		
F882:	86 *				
F882:A6 3A	87	INSDS1	LDX	PCL	;PRINT PCL,H
F884:A4 3B	88		LDY	PCH	
F886:20 96 FD	89		JSR	PRYX2	
F889:20 48 F9	90		JSR	PRBLNK	;FOLLOWED BY A BLANK
F88C:A1 3A	91	INSDS2	LDA	(PCL,X)	;GET OPCODE
F88E:A8	92		TAY		
F88F:4A	93		LSR	A	;EVEN/ODD TEST
F890:90 05 F897	94		BCC	IEVEN	
F892:6A	95		ROR	A	;BIT 1 TEST
F893:B0 OC F8A1	96		BCS	ERR	;XXXXXX11 INVALID OP
F895:29 87	97		AND	#\$87	;MASK BITS
F897:4A	98	IEVEN	LSR	A	;LSB INTO CARRY FOR L/R TEST
F898:AA	99		TAX		
F899:BD 62 F9	100		LDA	FMT1,X	;GET FORMAT INDEX BYTE
F89C:20 79 F8	101		JSR	SCRN2	;R/L H-BYTE ON CARRY
F89F:D0 04 F8A5	102		BNE	GETFMT	
F8A1:A0 FC	103	ERR	LDY	#\$FC	;SUBSTITUTE \$FC FOR INVALID OPS
F8A3:A9 00	104		LDA	#\$00	;SET PRINT FORMAT INDEX TO 0
F8A5:AA	105	GETFMT	TAX		
F8A6:BD A6 F9	106		LDA	FMT2,X	;INDEX INTO PRINT FORMAT TABLE
F8A9:85 2E	107		STA	FORMAT	;SAVE FOR ADR FIELD FORMATTING
F8AB:29 03	108		AND	#\$03	;MASK FOR 2-BIT LENGTH
F8AD:	109 ; (0=1 BYTE, 1=2 BYTE, 2=3 BYTE)				
F8AD:85 2F	110		STA	LENGTH	
F8AF:20 35 FC	111		JSR	NEWOPS	;get index for new opcodes
F8B2:F0 18 F8CC	112		BEQ	GOTONE	;found a new op (or no op)
F8B4:29 8F	113		AND	#\$8F	;MASK FOR 1XXX1010 TEST
F8B6:AA	114		TAX		; SAVE IT
F8B7:98	115		TYA		;OPCODE TO A AGAIN
F8B8:A0 03	116		LDY	#\$03	
F8BA:EO 8A	117		CPX	#\$8A	
F8BC:F0 0B F8C9	118		BEQ	MNNDX3	

F8BE:4A		119	MNNDX1	LSR	A	
F8BF:90 08	F8C9	120		BCC	MNNDX3	; FORM INDEX INTO MNEMONIC TABLE
F8C1:4A		121		LSR	A	
F8C2:4A		122	MNNDX2	LSR	A	; 1) XXXX1010 => 00101XXX
F8C3:09 20		123		ORA	#\$20	; 2) XXXYYY01 => 00111XXX
F8C5:88		124		DEY		; 3) XXXYYY10 => 00110XXX
F8C6:D0 FA	F8C2	125		BNE	MNNDX2	; 4) XXXYY100 => 00100XXX
F8C8:C8		126		INY		; 5) XXXXX000 => 000XXXXX
F8C9:88		127	MNNDX3	DEY		
F8CA:D0 F2	F8BE	128		BNE	MNNDX1	
F8CC:60		129	GOTONE	RTS		
F8CD:		130	*			
F8CD:FF FF FF		131		DFB	\$FF,\$FF,\$FF	
F8D0:		132	*			
F8D0:20 82 F8		133	INSTDSP	JSR	INSDS1	;GEN FMT, LEN BYTES
F8D3:48		134		PHA		;SAVE MNEMONIC TABLE INDEX
F8D4:B1 3A		135	PRNTOP	LDA	(PCL),Y	
F8D6:20 DA FD		136		JSR	PRBYTE	
F8D9:A2 01		137		LDX	#\$01	;PRINT 2 BLANKS
F8DB:20 4A F9		138	PRNTBL	JSR	PRBL2	
F8DE:C4 2F		139		CPY	LENGTH	;PRINT INST (1-3 BYTES)
F8EO:C8		140		INY		;IN A 12 CHR FIELD
F8E1:90 F1	F8D4	141		BCC	PRNTOP	
F8E3:A2 03		142		LDX	#\$03	;CHAR COUNT FOR MNEMONIC INDEX
F8E5:C0 04		143		CPY	#\$04	
F8E7:90 F2	F8DB	144		BCC	PRNTBL	
F8E9:68		145		PLA		;RECOVER MNEMONIC INDEX
F8EA:A8		146		TAY		
F8EB:B9 C0 F9		147		LDA	MNEML,Y	
F8EE:85 2C		148		STA	LMNEM	;FETCH 3-CHAR MNEMONIC
F8F0:B9 00 FA		149		LDA	MNEMR,Y	; (PACKED INTO 2-BYTES)
F8F3:85 2D		150		STA	RMNEM	
F8F5:A9 00		151	PRMN1	LDA	#\$00	
F8F7:A0 05		152		LDY	#\$05	
F8F9:06 2D		153	PRMN2	ASL	RMNEM	;SHIFT 5 BITS OF CHARACTER INTO A
F8FB:26 2C		154		ROL	LMNEM	
F8FD:2A		155		ROL	A	; (CLEAR CARRY)
F8FE:88		156		DEY		
F8FF:D0 F8	F8F9	157		BNE	PRMN2	
F901:69 BF		158		ADC	#\$BF	;ADD "?" OFFSET
F903:20 ED FD		159		JSR	COUT	;OUTPUT A CHAR OF MNEM
F906:CA		160		DEX		
F907:D0 EC	F8F5	161		BNE	PRMN1	
F909:20 48 F9		162		JSR	PRBLNK	;OUTPUT 3 BLANKS
F90C:A4 2F		163		LDY	LENGTH	
F90E:A2 06		164		LDX	#\$06	;CNT FOR 6 FORMAT BITS
F910:E0 03		165	PRADR1	CPX	#\$03	
F912:F0 1C	F930	166		BEQ	PRADR5	;IF X=3 THEN ADDR.
F914:06 2E		167	PRADR2	ASL	FORMAT	
F916:90 0E	F926	168		BCC	PRADR3	
F918:BD B9 F9		169		LDA	CHAR1-1,X	
F91B:20 ED FD		170		JSR	COUT	
F91E:BD B3 F9		171		LDA	CHAR2-1,X	
F921:F0 03	F926	172		BEQ	PRADR3	
F923:20 ED FD		173		JSR	COUT	
F926:CA		174	PRADR3	DEX		
F927:D0 E7	F910	175		BNE	PRADR1	
F929:60		176		RTS		

F92A:	177 *			
F92A:88	178 PRADR4	DEY		
F92B:30 E7 F914	179 BMI	PRADR2		
F92D:20 DA FD	180 JSR	PRBYTE		
F930:A5 2E	181 PRADR5	LDA	FORMAT	
F932:C9 E8	182 CMP	#\$E8	;HANDLE REL ADR MODE	
F934:B1 3A	183 LDA	(PCL),Y	;SPECIAL (PRINT TARGET,	
F936:90 F2 F92A	184 BCC	PRADR4	; NOT OFFSET)	
F938:20 56 F9	185 RELADR	JSR	PCADJ3	;PCL,PCH+OFFSET+1 TO A,Y
F93B:AA	186 TAX			
F93C:E8	187 INX			
F93D:D0 01 F940	188 BNE	PRNTYX	;+1 TO Y,X	
F93F:C8	189 INY			
F940:98	190 PRNTYX	TYA		
F941:20 DA FD	191 PRNTAX	JSR	PRBYTE	;OUTPUT TARGET ADR
F944:8A	192 PRNTX	TXA		; OF BRANCH AND RETURN
F945:4C DA FD	193 JMP	PRBYTE		
F948:	194 *			
F948:A2 03	195 PRBLNK	LDX	#\$03	;BLANK COUNT
F94A:A9 A0	196 PRBL2	LDA	#\$A0	;LOAD A SPACE
F94C:20 ED FD	197 PRBL3	JSR	COUT	;OUTPUT A BLANK
F94F:CA	198 DEX			
F950:D0 F8 F94A	199 BNE	PRBL2		;LOOP UNTIL COUNT=0
F952:60	200 RTS			
F953:	201 *			
F953:38	202 PCADJ	SEC		;0=1 BYTE, 1=2 BYTE,
F954:A5 2F	203 PCADJ2	LDA	LENGTH	; 2=3 BYTE
F956:A4 3B	204 PCADJ3	LDY	PCH	
F958:AA	205 TAX			;TEST DISPLACEMENT SIGN
F959:10 01 F95C	206 BPL	PCADJ4		; (FOR REL BRANCH)
F95B:88	207 DEY			;EXTEND NEG BY DECR PCH
F95C:65 3A	208 PCADJ4	ADC	PCL	
F95E:90 01 F961	209 BCC	RTS2		;PCL+LENGTH(OR DISPL)+1 TO A
F960:C8	210 INY			; CARRY INTO Y (PCH)
F961:60	211 RTS2	RTS		
F962:	212 *			
F962:	213 ; FMT1 BYTES:	XXXXXXYO	INSTRS	
F962:	214 ; IF Y=0		THEN RIGHT HALF BYTE	
F962:	215 ; IF Y=1		THEN LEFT HALF BYTE	
F962:	216 ;		(X=INDEX)	
F962:	217 *			
F962:0F	218 FMT1	DFB	\$0F	
F963:22	219 DFB		\$22	
F964:FF	220 DFB		\$FF	
F965:33	221 DFB		\$33	
F966:CB	222 DFB		\$CB	
F967:62	223 DFB		\$62	
F968:FF	224 DFB		\$FF	
F969:73	225 DFB		\$73	
F96A:03	226 DFB		\$03	
F96B:22	227 DFB		\$22	
F96C:FF	228 DFB		\$FF	
F96D:33	229 DFB		\$33	
F96E:CB	230 DFB		\$CB	
F96F:66	231 DFB		\$66	
F970:FF	232 DFB		\$FF	
F971:77	233 DFB		\$77	
F972:0F	234 DFB		\$0F	

F973:20	235	DFB	\$20
F974:FF	236	DFB	\$FF
F975:33	237	DFB	\$33
F976:CB	238	DFB	\$CB
F977:60	239	DFB	\$60
F978:FF	240	DFB	\$FF
F979:70	241	DFB	\$70
F97A:0F	242	DFB	\$0F
F97B:22	243	DFB	\$22
F97C:FF	244	DFB	\$FF
F97D:39	245	DFB	\$39
F97E:CB	246	DFB	\$CB
F97F:66	247	DFB	\$66
F980:FF	248	DFB	\$FF
F981:7D	249	DFB	\$7D
F982:0B	250	DFB	\$0B
F983:22	251	DFB	\$22
F984:FF	252	DFB	\$FF
F985:33	253	DFB	\$33
F986:CB	254	DFB	\$CB
F987:A6	255	DFB	\$A6
F988:FF	256	DFB	\$FF
F989:73	257	DFB	\$73
F98A:11	258	DFB	\$11
F98B:22	259	DFB	\$22
F98C:FF	260	DFB	\$FF
F98D:33	261	DFB	\$33
F98E:CB	262	DFB	\$CB
F98F:A6	263	DFB	\$A6
F990:FF	264	DFB	\$FF
F991:87	265	DFB	\$87
F992:01	266	DFB	\$01
F993:22	267	DFB	\$22
F994:FF	268	DFB	\$FF
F995:33	269	DFB	\$33
F996:CB	270	DFB	\$CB
F997:60	271	DFB	\$60
F998:FF	272	DFB	\$FF
F999:70	273	DFB	\$70
F99A:01	274	DFB	\$01
F99B:22	275	DFB	\$22
F99C:FF	276	DFB	\$FF
F99D:33	277	DFB	\$33
F99E:CB	278	DFB	\$CB
F99F:60	279	DFB	\$60
F9A0:FF	280	DFB	\$FF
F9A1:70	281	DFB	\$70
F9A2:24	282	DFB	\$24
F9A3:31	283	DFB	\$31
F9A4:65	284	DFB	\$65
F9A5:78	285	DFB	\$78
F9A6:	286 ; ZXXXXY01 INSTR'S		
F9A6:00	287 FMT2	DFB	\$00 ;ERR
F9A7:21	288	DFB	\$21 ;IMM
F9A8:81	289	DFB	\$81 ;Z-PAGE
F9A9:82	290	DFB	\$82 ;ABS
F9AA:59	291	DFB	\$59 ;(ZPAG,X)
F9AB:4D	292	DFB	\$4D ;(ZPAG),Y

F9AC:91	293	DFB	\$91	; ZPAG,X
F9AD:92	294	DFB	\$92	;ABS,X
F9AE:86	295	DFB	\$86	;ABS,Y
F9AF:4A	296	DFB	\$4A	; (ABS)
F9B0:85	297	DFB	\$85	;ZPAG,Y
F9B1:9D	298	DFB	\$9D	;RELATIVE
F9B2:49	299	DFB	\$49	; (ZPAG) (new)
F9B3:5A	300	DFB	\$5A	; (ABS,X) (new)
F9B4:	301 *			
F9B4:D9	302 CHAR2	DFB	\$D9	; 'Y'
F9B5:00	303	DFB	\$00	; (byte F of FMT2)
F9B6:D8	304	DFB	\$D8	; 'Y'
F9B7:A4	305	DFB	\$A4	; '\$'
F9B8:A4	306	DFB	\$A4	; '\$'
F9B9:00	307	DFB	\$00	
F9BA:	308 *			
F9BA:AC	309 CHAR1	DFB	\$AC	; ',',
F9BB:A9	310	DFB	\$A9	; ')'
F9BC:AC	311	DFB	\$AC	; ',',
F9BD:A3	312	DFB	\$A3	; '#'
F9BE:A8	313	DFB	\$A8	; '('
F9BF:A4	314	DFB	\$A4	; '\$'
F9C0:1C	315 MNEML	DFB	\$1C	
F9C1:8A	316	DFB	\$8A	
F9C2:1C	317	DFB	\$1C	
F9C3:23	318	DFB	\$23	
F9C4:5D	319	DFB	\$5D	
F9C5:8B	320	DFB	\$8B	
F9C6:1B	321	DFB	\$1B	
F9C7:A1	322	DFB	\$A1	
F9C8:9D	323	DFB	\$9D	
F9C9:8A	324	DFB	\$8A	
F9CA:1D	325	DFB	\$1D	
F9CB:23	326	DFB	\$23	
F9CC:9D	327	DFB	\$9D	
F9CD:8B	328	DFB	\$8B	
F9CE:1D	329	DFB	\$1D	
F9CF:A1	330	DFB	\$A1	
F9D0:1C	331	DFB	\$1C	; BRA
F9D1:29	332	DFB	\$29	
F9D2:19	333	DFB	\$19	
F9D3:AE	334	DFB	\$AE	
F9D4:69	335	DFB	\$69	
F9D5:A8	336	DFB	\$A8	
F9D6:19	337	DFB	\$19	
F9D7:23	338	DFB	\$23	
F9D8:24	339	DFB	\$24	
F9D9:53	340	DFB	\$53	
F9DA:1B	341	DFB	\$1B	
F9DB:23	342	DFB	\$23	
F9DC:24	343	DFB	\$24	
F9DD:53	344	DFB	\$53	
F9DE:19	345	DFB	\$19	
F9DF:A1	346	DFB	\$A1	; (A) FORMAT ABOVE
F9E0:AD	347	DFB	\$AD	; TSB
F9E1:1A	348	DFB	\$1A	
F9E2:5B	349	DFB	\$5B	
F9E3:5B	350	DFB	\$5B	

F9E4:A5	351	DFB	\$A5	
F9E5:69	352	DFB	\$69	
F9E6:24	353	DFB	\$24	
F9E7:24	354	DFB	\$24	; (B) FORMAT
F9E8:AE	355	DFB	\$AE	
F9E9:AE	356	DFB	\$AE	
F9EA:A8	357	DFB	\$A8	
F9EB:AD	358	DFB	\$AD	
F9EC:29	359	DFB	\$29	
F9ED:8A	360	DFB	\$8A	
F9EE:7C	361	DFB	\$7C	
F9EF:8B	362	DFB	\$8B	; (C) FORMAT
F9F0:15	363	DFB	\$15	
F9F1:9C	364	DFB	\$9C	
F9F2:6D	365	DFB	\$6D	
F9F3:9C	366	DFB	\$9C	
F9F4:A5	367	DFB	\$A5	
F9F5:69	368	DFB	\$69	
F9F6:29	369	DFB	\$29	
F9F7:53	370	DFB	\$53	; (D) FORMAT
F9F8:84	371	DFB	\$84	
F9F9:13	372	DFB	\$13	
F9FA:34	373	DFB	\$34	
F9FB:11	374	DFB	\$11	
F9FC:A5	375	DFB	\$A5	
F9FD:69	376	DFB	\$69	
F9FE:23	377	DFB	\$23	; (E) FORMAT
F9FF:A0	378	DFB	\$A0	
FA00:	379 *			
FA00:D8	380 MNEMR	DFB	\$D8	
FA01:62	381	DFB	\$62	
FA02:5A	382	DFB	\$5A	
FA03:48	383	DFB	\$48	
FA04:26	384	DFB	\$26	
FA05:62	385	DFB	\$62	
FA06:94	386	DFB	\$94	
FA07:88	387	DFB	\$88	
FA08:54	388	DFB	\$54	
FA09:44	389	DFB	\$44	
FA0A:C8	390	DFB	\$C8	
FA0B:54	391	DFB	\$54	
FA0C:68	392	DFB	\$68	
FA0D:44	393	DFB	\$44	
FA0E:E8	394	DFB	\$E8	
FA0F:94	395	DFB	\$94	
FA10:C4	396	DFB	\$C4	; BRA
FA11:B4	397	DFB	\$B4	
FA12:08	398	DFB	\$08	
FA13:84	399	DFB	\$84	
FA14:74	400	DFB	\$74	
FA15:B4	401	DFB	\$B4	
FA16:28	402	DFB	\$28	
FA17:6E	403	DFB	\$6E	
FA18:74	404	DFB	\$74	
FA19:F4	405	DFB	\$F4	
FA1A:CC	406	DFB	\$CC	
FA1B:4A	407	DFB	\$4A	
FA1C:72	408	DFB	\$72	

```

FA1D:F2      409      DFB    $F2
FA1E:A4      410      DFB    $A4
FA1F:8A      411      DFB    $8A      ; (A) FORMAT
FA20:06      412      DFB    $06      ; TSB
FA21:AA      413      DFB    $AA
FA22:A2      414      DFB    $A2
FA23:A2      415      DFB    $A2
FA24:74      416      DFB    $74
FA25:74      417      DFB    $74
FA26:74      418      DFB    $74
FA27:72      419      DFB    $72      ; (B) FORMAT
FA28:44      420      DFB    $44
FA29:68      421      DFB    $68
FA2A:B2      422      DFB    $B2
FA2B:32      423      DFB    $32
FA2C:B2      424      DFB    $B2
FA2D:72      425      DFB    $72
FA2E:22      426      DFB    $22
FA2F:72      427      DFB    $72      ; (C) FORMAT
FA30:1A      428      DFB    $1A
FA31:1A      429      DFB    $1A
FA32:26      430      DFB    $26
FA33:26      431      DFB    $26
FA34:72      432      DFB    $72
FA35:72      433      DFB    $72
FA36:88      434      DFB    $88
FA37:C8      435      DFB    $C8      ; (D) FORMAT
FA38:C4      436      DFB    $C4
FA39:CA      437      DFB    $CA
FA3A:26      438      DFB    $26
FA3B:48      439      DFB    $48
FA3C:44      440      DFB    $44
FA3D:44      441      DFB    $44
FA3E:A2      442      DFB    $A2
FA3F:C8      443      DFB    $C8      ; (E) FORMAT
FA40:        444 *          PHA      ;save accumulator
FA40:48      445 IRQ     PLA      ;rescued by stack trick later
FA41:68      446          PLA
FA42:68      447          PLA
FA43:4C 06 C8 448          JMP    IRQ1      ;do rest of IRQ handler
FA46:        449 *          NOP
FA46:EA      450          NOP
FA47:        451 *
FA47:        452 * NEWBRK is called by the interrupt handler which has
FA47:        453 * set the hardware to its default state and encoded
FA47:        454 * the state in the accumulator. Software that wants
FA47:        455 * to do break processing using full system resources
FA47:        456 * can restore the machine state from this value.
FA47:        457 *
FA47:85 44   458 NEWBRK   STA    MACSTAT    ;save state of machine
FA49:7A      459          PLY      ;restore registers for save
FA4A:FA      460          PLX
FA4B:68      461          PLA
FA4C:        462 *
FA4C:28      463 BREAK    PLP      ;Note: same as old BREAK routine!!
FA4D:20 4A FF 464          JSR    SAVE      ;save reg's on BRK
FA50:68      465          PLA      ;including PC
FA51:85 3A   466          STA    PCL

```

```

FA53:68      467      PLA
FA54:85 3B    468      STA PCH
FA56:6C F0 03 469      JMP (BRKV) ;call BRK HANDLER
FA59:          470 *
FA59:20 82 F8 471 OLDBRK  JSR INSDS1 ;PRINT USER PC
FA5C:20 DA FA 472      JSR RGDSP1 ; AND REGS
FA5F:4C 65 FF 473      JMP MON   ;GO TO MONITOR (NO PASS GO, NO $200!)
FA62:          474 *
FA62:D8      475 RESET  CLD   ;DO THIS FIRST THIS TIME
FA63:20 84 FE 476      JSR SETNORM
FA66:20 2F FB 477      JSR INIT
FA69:20 93 FE 478      JSR SETVID
FA6C:20 89 FE 479      JSR SETKBD
FA6F:20 1C C4 480      JSR INITMOUSE ;initialize the mouse
FA72:20 04 CC 481      JSR CLRPORT ;clear port setup bytes
FA75:9C FF 04 482      STZ ACIABUF ;and the commahead buffer
FA78:AD 5F CO 483      LDA SETAN3 ; AN3 = TTL HI
FA7B:20 BD FA 484      JSR RESET.X ; initialize other devices
FA7E:2C 10 CO 485      BIT KBDSTRB ; CLEAR KEYBOARD
FA81:D8      486 NEWMON CLD
FA82:20 3A FF 487      JSR BELL ; CAUSES DELAY IF KEY BOUNCES
FA85:AD F3 03 488      LDA SOFTEV+1 ;IS RESET HI
FA88:49 A5    489      EOR #$A5 ;A FUNNY COMPLEMENT OF THE
FA8A:CD F4 03 490      CMP PWRDUP ; PWR UP BYTE ???
FA8D:D0 17    FAA6 491      BNE PWRUP ; NO SO PWRUP
FA8F:AD F2 03 492      LDA SOFTEV ; YES SEE IF COLD START
FA92:D0 3B    FACF 493      BNE NOFIX ; HAS BEEN DONE YET?
FA94:A9  E0    494      LDA #$EO ; DOES SEV POINT AT BASIC?
FA96:CD F3 03 495      CMP SOFTEV+1 ; YES SO REENTER SYSTEM
FA99:D0 34    FACF 496      BNE NOFIX ; NO SO POINT AT WARM START
FA9B:AO 03    497 FIXSEV LDY #3 ; FOR NEXT RESET
FA9D:8C F2 03 498      STY SOFTEV ; AND DO THE COLD START
FAAO:4C 00 E0 499      JMP BASIC
FAA3:          500 *
FAA3:20 3A FF 501 BEEPFIX JSR BELL ;Beep on powerup
FAA6:          502 *
FAA6:20 CA FC 503 PWRUP  JSR COLDSTART ;Trash memory, init ports
FAA9:          FAA9 504 SETPG3 EQU * ; SET PAGE 3 VECTORS
FAA9:A2 05    505      LDX #5
FAAB:BD FC FA 506 SETPLP LDA PWRCON-1,X ; WITH CNTRL B ADRS
FAAE:9D EF 03 507      STA BRKV-1,X ; OF CURRENT BASIC
FAB1:CA      508      DEX
FAB2:D0 F7    FAAB 509      BNE SETPLP
FAB4:A9 C6    510      LDA #$C6 ; LOAD HI SLOT +1
FAB6:80 5A    FB12 511      BRA PWRUP2 ;branch around mnemonics
FAB8:          512 *
FAB8:          513 * Extension to MNEML (left mnemonics)
FAB8:          514 *
FAB8:8A      515      DFB $8A ;PHY
FAB9:8B      516      DFB $8B ;PLY
FABA:A5    517      DFB $A5 ;STZ
FABB:AC    518      DFB $AC ;TRB
FABC:00    519      DFB $00 ;???
FABD:          520 *
FABD:          521 * This extension to the monitor reset routine ($FA62)
FABD:          522 * checks for apple keys. If both are pressed, it goes
FABD:          523 * into an exerciser mode. If the open apple key only is
FABD:          524 * pressed, memory is selectively trashed and a cold start

```

```

FABD:          525 * is done.
FABD:          526 *
FABD:A9 FF    527 RESET.X   LDA  #$FF
FABF:8D FB 04 528 STA   VMODE      ;initialize mode
FAC2:0E 62 C0 529 ASL   BUTN1
FAC5:2C 61 C0 530 BIT   BUTNO
FAC8:10 64   FB2E 531 BPL   RTS2D
FACA:90 D7   FAA3 532 BCC   BEEPFIX
FACC:4C 7C C7 533 JMP   BANGER    ;open apple only, reboot
FACF:          534 *           ;both apples, exercise 'er
FACF:6C F2 03 535 NOFIX   JMP   (SOFTEV)
FAD2:          536 *
FAD2:C1 D8 D9 DO 537 RTBL   ASC   'AXYPS'
FAD7:          538 *
FAD7:20 8E FD 539 REGDSP  JSR   CROUT    ;DISPLAY USER REG CONTENTS
FADA:A9 45    540 RGDSP1  LDA   #$45     ;WITH LABELS
FADC:85 40    541 STA   A3L
FADE:A9 00    542 LDA   #$00
FAEO:85 41    543 STA   A3H
FAE2:A2 FB    544 LDX   #$FB
FAE4:A9 A0    545 RDSP1  LDA   #$AO
FAE6:20 ED FD 546 JSR   COUT
FAE9:BD D7 F9 547 LDA   RTBL-251,X
FAEC:20 ED FD 548 JSR   COUT
FAEF:A9 BD    549 LDA   #$BD
FAF1:20 ED FD 550 JSR   COUT
FAF4:B5 4A    551 LDA   ACC+5,X
FAF6:80 0A   FB02 552 BRA   RGDSP2    ;make room for mnemonics
FAF8:          553 *
FAF8:          554 * Right half of new mnemonics, indexed from MNEMR
FAF8:          555 *
FAF8:74        556   DFB  $74       ;PHY
FAF9:74        557   DFB  $74       ;PLY
FAFA:76        558   DFB  $76       ;STZ
FAFB:C6        559   DFB  $C6       ;TRB
FAFC:00        560   DFB  $00       ;???
FAFD:          561 *
FAFD:59 FA    562 PWRCON  DW   OLDBRK
FAFF:00 E0 45  563   DFB  $00,$E0,$45
FB02:          564 *
FB02:20 DA FD 565 RGDSP2  JSR   PRBYTE
FB05:E8        566   INX
FB06:30 DC   FAE4 567   BMI   RDSP1
FB08:60        568   RTS
FB09:          569 *
FB09:C1 FO FO EC 570 TITLE  ASC   'Apple  ]['
FB11:C4        571   DFB  $C4       ;optional filler
FB12:          572 *
FB12:86 00    573 PWRUP2  STX   LOCO    ; SETPG3 MUST RETURN X=0
FB14:85 01    574   STA  LOC1    ; SET PTR H
FB16:20 60 FB 575   JSR  APPLEII  ;Display our banner...
FB19:6C 00 00  576   JMP  (LOCO)  ;JUMP $C600
FB1C:00        577   BRK
FB1D:00        578   BRK
FB1E:          579 *
FB1E:4C DE C7 580 PREAD  JMP   MPADDLE ;read mouse paddle
FB21:A0 00    581   LDY  #$00     ;INIT COUNT
FB23:EA        582   NOP      ;COMPENSATE FOR 1ST COUNT

```

```
FB24:EA      583      NOP
FB25:BD 64 CO 584 PREAD2    LDA    PADDLO,X      ;COUNT Y-REG EVERY 12 USEC.
FB28:10 04 FB2E 585      BPL    RTS2D
FB2A:C8      586      INY
FB2B:D0 F8   FB25 587      BNE    PREAD2      ;EXIT AT 255 MAX
FB2D:88      588      DEY
FB2E:60      589 RTS2D    RTS
FB2F:          33       INCLUDE AUTOST2
```

```

FB2F:          2 *
FB2F:A9 00    3 INIT      LDA  #$00      ;CLR STATUS FOR DEBUG SOFTWARE
FB31:85 48    4 STA STATUS
FB33:AD 56 CO 5 LDA LORES
FB36:AD 54 CO 6 LDA TXTPAGE1 ;INIT VIDEO MODE
FB39:AD 51 CO 7 SETTXT   LDA TXTSET ;SET FOR TEXT MODE
FB3C:A9 00    8 LDA #$00      ;FULL SCREEN WINDOW
FB3E:FO 0B FB4B 9 BEQ SETWND
FB40:AD 50 CO 10 SETGR    LDA TXTCLR ;SET FOR GRAPHICS MODE
FB43:AD 53 CO 11 LDA MIXSET ;LOWER 4 LINES AS TEXT WINDOW
FB46:20 36 F8 12 JSR CLRTOP
FB49:A9 14    13 LDA #$14
FB4B:85 22    14 SETWND   STA WNDTOP ;SET WINDOW
FB4D:EA       15 NOP
FB4E:EA       16 NOP
FB4F:20 0A CE 17 JSR WNDREST ;40/80 column width
FB52:80 05 FB59 18 BRA VTAB23
FB54:          19 *
FB54:09 80    20 DOCTL    ORA #$80      ;controls need high bit
FB56:4C 54 CD 21 JMP CTLCHARO ;execute control char
FB59:          22 *
FB59:A9 17    23 VTAB23   LDA #$17      ;VTAB TO ROW 23
FB5B:85 25    24 TABV     STA CV        ;VTABS TO ROW IN A-REG
FB5D:4C 22 FC 25 JMP VTAB    ;don't set OURCV!!
FB60:          26 *
FB60:20 58 FC 27 APPLEII  JSR HOME     ;CLEAR THE SCRN
FB63:A0 09    28 LDY #9
FB65:B9 02 FD 29 STITLE   LDA APPLE2C-1,Y ;GET A CHAR
FB68:99 0D 04 30 STA LINE1+13,Y ;PUT IT AT TOP CENTER OF SCREEN
FB6B:88    31 DEY
FB6C:D0 F7 FB65 32 BNE STITLE
FB6E:60    33 RTS
FB6F:          34 *
FB6F:AD F3 03 35 SETPWRC LDA SOFTEV+1 ;ROUTINE TO CALCULATE THE 'FUNNY
FB72:49 A5    36 EOR #$A5      ;COMPLEMENT' FOR THE RESET VECTOR
FB74:8D F4 03 37 STA PWREDUP
FB77:60    38 RTS
FB78:          39 *
FB78:          FB78 40 VIDWAIT EQU *      ;CHECK FOR A PAUSE (CONTROL-S).
FB78:C9 8D    41 CMP #$8D      ;ONLY WHEN I HAVE A CR
FB7A:D0 18 FB94 42 BNE NOWAIT ;NOT SO, DO REGULAR
FB7C:AC 00 CO 43 LDY KBD    ;IS KEY PRESSED?
FB7F:10 13 FB94 44 BPL NOWAIT ;NO.
FB81:CO 93    45 CPY #$93      ;YES -- IS IT CTRL-S?
FB83:D0 0F FB94 46 BNE NOWAIT ;NOPE - IGNORE
FB85:2C 10 CO 47 BIT KBDSTRB ;CLEAR STROBE
FB88:AC 00 CO 48 KBDWAIT LDY KBD    ;WAIT TILL NEXT KEY TO RESUME
FB8B:10 FB FB88 49 BPL KBDWAIT ;WAIT FOR KEYPRESS
FB8D:CO 83    50 CPY #$83      ;IS IT CONTROL-C?
FB8F:FO 03 FB94 51 BEQ NOWAIT ;YES, SO LEAVE IT
FB91:2C 10 CO 52 BIT KBDSTRB ;CLR STROBE
FB94:2C 7B 06 53 NOWAIT BIT VFACTV ;is video firmware active?
FB97:30 64 FBFD 54 BMI VIDOUT ;=>no, do normal 40 column
FB99:89 60    55 BIT #$60      ;is it a control?
FB9B:FO B7 FB54 56 BEQ DOCTL ;=>yes, do it
FB9D:20 B8 C3 57 JSR STORCH ;print w/inverse mask
FBA0:EE 7B 05 58 NEWADV INC OURCH ;advance cursor
FBA3:AD 7B 05 59 LDA OURCH ;and update others

```

```

FBA6:2C 1F C0      60        BIT    RD80VID      ;but only if not 80 columns
FBA9:30 05 FBB0     61        BMI    NEWADV1     ;=>80 columns, leav'em
FBAB:8D 7B 04      62        STA    OLDCH
FBAE:85 24          63        STA    CH
FBB0:80 46 FBF8     64 NEWADV1 BRA   ADV2       ;check for CR
FBB2:              65 *
FBB2:EA             66        NOP
FBB3:              67 *
FBB3:06             68 F8VERSION DFB  GOODF8     ;//e, chels ID byte
FBB4:              69 *
FBB4:10 06 FBBC     70 DOCOUT1 BPL  DCX       ;=>video firmware active, no mask
FBB6:C9 A0           71        CMP  #$AO      ;is it control char?
FBB8:90 02 FBBC     72        BCC  DCX       ;=>yes, no mask
FBB8:25 32             73        AND  INVFLG     ;else apply inverse mask
FBBC:4C F6 FD           74 DCX   JMP  COUTZ     ;and print character
FBBF:00               75        BRK
FBC0:              76 *
FBC0:00             77        DFB  $00      ;chels ID byte
FBC1:              78 *
FBC1:48             79 BASCALC PHA
FBC2:4A             80 LSR  A       ;CALC BASE ADDR IN BASL,H
FBC3:29 03             81 AND  #$03      ;FOR GIVEN LINE NO.
FBC5:09 04             82 ORA  #$04      ; 0<=LINE NO.<=$17
FBC7:85 29             83 STA  BASH     ;ARG=000ABCDE, GENERATE
FBC9:68             84 PLA
FBCA:29 18             85 AND  #$18      ;  ; BASH=000001CD
FBCC:90 02 FBDO     86 BCC  BASCLC2
FBCE:69 7F             87 ADC  #$7F      ;  ; AND
FBDO:85 28             88 BASCLC2 STA  BASL
FBD2:0A             89 ASL  A       ;  ; BASL=000001CD
FBD3:0A             90 ASL  A       ;  ; BASL
FBD4:05 28             91 ORA  BASL
FBD6:85 28             92 STA  BASL
FBD8:60             93 RTS
FBD9:              94 *
FBD9:C9 87             95 CHKBELL CMP  #$87      ;BELL CHAR? (CONTROL-G)
FBDB:D0 12 FBEF     96 BNE  RTS2B     ;NO, RETURN.
FBDD:A9 40             97 BELL1  LDA  #$40      ;YES...
FBDF:20 A8 FC           98 JSR  WAIT     ;DELAY .01 SECONDS
FBE2:AO CO             99 LDY  #$CO      ;TOGGLE SPEAKER AT 1 KHZ
FBE4:A9 0C             100 BELL2 LDA  #$OC      ;FOR .1 SEC.
FBE6:20 A8 FC           101 JSR  WAIT
FBE9:AD 30 CO           102 LDA  SPKR
FBEC:88               103 DEY
FBED:D0 F5 FBE4     104 BNE  BELL2
FBEF:60               105 RTS2B RTS
FBFO:              106 *
FBFO:A4 24             107 STORADV LDY  CH       ;get 40 column position
FBF2:91 28             108 STA  (BASL),Y ;and store
FBF4:E6 24             109 ADVANCE INC  CH       ;increment cursor
FBF6:A5 24             110 LDA  CH
FBF8:C5 21             111 ADV2  CMP  WNDWDTH ;BEYOND WINDOW WIDTH?
FBFA:B0 66 FC62     112 BCS  CR       ;YES, CR TO NEXT LINE.
FBFC:60               113 RTS3  RTS
FBFD:              114 *
FBFD:C9 A0             115 VIDOUT CMP  #$AO      ;CONTROL CHAR?
FBFF:B0 EF FBFO     116 BCS  STORADV ;NO, OUTPUT IT.
FC01:A8               117 TAY

```

```

FC02:10 EC    FBFO   118      BPL    STORADV    ; YES, OUTPUT IT.
FC04:C9 8D    119 VIDOUT1  CMP    #$8D       ;CR?
FC06:F0 6B    FC73    120      BEQ    NEWCR      ;Yes, use new routine
FC08:C9 8A    121      CMP    #$8A       ;LINE FEED?
FC0A:F0 5A    FC66    122      BEQ    LF         ; IF SO, DO IT.
FC0C:C9 88    123      CMP    #$88       ;BACK SPACE? (CONTROL-H)
FC0E:D0 C9    FBD9    124      BNE    CHKBELL    ; NO, CHECK FOR BELL.
FC10:20 E2    FE      125 BS    JSR    DECCH     ;decrement all cursor H indices
FC13:10 E7    FBFC    126      BPL    RTS3       ;IF POSITIVE, OK; ELSE MOVE UP.
FC15:A5 21    127      LDA    WNDWDTH   ;get window width,
FC17:20 EB    FE      128      JSR    WDTHCH    ;and set CH's to WNDWDTH-1
FC1A:A5 22    129 UP    LDA    WNDTOP    ;CURSOR V INDEX
FC1C:C5 25    130      CMP    CV         ;top line, exit
FC1E:BO DC    FBFC    131      BCS    RTS3       ;not top, go up one
FC20:C6 25    132      DEC    CV         ;go update OURCV
FC22:          133 *   BRA    NEWVTAB   ;calculate the base address
FC24:20 C1    FB      134 VTAB    JSR    BASCALC   ;get the left window edge
FC27:A5 20    135 VTABZ   LDA    WNDLFT    ;80 columns?
FC29:2C 1F    CO      136      BIT    RD80VID   ;=>no, left edge ok
FC2C:10 02    FC30    137      BPL    VTAB40    ;divide width by 2
FC2E:4A      138      LSR    A          ;prepare to add
FC2F:18      139      CLC    A          ;add width to base
FC30:65 28    140      ADC    BASL      ;top line, exit
FC32:85 28    141 VTAB40   STA    BASL      ;not top, go up one
FC34:60      142      RTS    RTS        ;get the opcode
FC35:          143 RTS4    RTS    RTS        ;check through new opcodes
FC35:          144 *   TYA    #NUMOPS  ;does it match?
FC35:          145 *   NEWOPS   GETIDX  ;=>yes, get new index
FC35:          146 *   NEWOP1   NEWOP1  ;else check next one
FC35:          147 *   If Y is not a new opcode, Z=0.
FC35:          148 *   RTS    RTS        ;not found, exit with BNE
FC35:98      149 NEWOPS   CLREOP1 ;ESC F IS CLR TO END OF PAGE
FC36:A2 16    150      LDX    #OPTBL,X ;SAVE CURRENT LINE NO. ON STACK
FC38:DD FE    FE      151 NEWOP1   CLEOP1 ;CLEAR TO EOL. (SETS CARRY)
FC3B:F0 43    FC80    152      BEQ    GETINDX ;CLEAR FROM H INDEX=0 FOR REST
FC3D:CA      153      DEX    PLA      ;INCREMENT CURRENT LINE NO.
FC3E:10 F8    FC38    154      BPL    NEWOP1  ;CLEAR FROM H INDEX=0 FOR REST
FC40:60      155      RTS    RTS        ;NO, KEEP CLEARING LINES.
FC41:          156 *   BRK    BRK      ;YES, TAB TO CURRENT LINE
FC41:00      157      INC    A          ;DONE TO BOTTOM OF WINDOW?
FC42:          158 *   CLREOP2 ;move cursor home
FC44:A5 25    159 CLREOP1 ;then clear to end of page
FC46:48      160 CLREOP2 ;load Y with proper CH
FC47:20 24    FC      161 CLEOP1 ;CLEAR FROM H INDEX=0 FOR REST
FC4A:20 9E    FC      162 JSR    VTABZ   ;CLEAR FROM H INDEX=0 FOR REST
FC4D:A0 00    163 JSR    CLEOLZ  ;INCREMENT CURRENT LINE NO.
FC4F:68      164 LDY    #$00    ;NO, KEEP CLEARING LINES.
FC50:1A      165 PLA    PLA      ;YES, TAB TO CURRENT LINE
FC51:C5 23    166 INC    A          ;DONE TO BOTTOM OF WINDOW?
FC53:90 F1    FC46    167 CMP    WNDBTM ;move cursor home
FC55:B0 CB    FC22    168 BCC    CLEOP1 ;then clear to end of page
FC57:00      169 BCS    VTAB    ;load Y with proper CH
FC58:          170 BRK    BRK      ;CLEAR FROM H INDEX=0 FOR REST
FC58:20 A5    CD      171 *   CLREOP1 ;INCREMENT CURRENT LINE NO.
FC5B:80 E7    FC44    172 HOME   JSR    HOMECUR ;CLEAR FROM H INDEX=0 FOR REST
FC5D:          173 BRA    CLREOP2 ;INCREMENT CURRENT LINE NO.
FC5D:20 9D    CC      174 *   GETCUR ;CLEAR FROM H INDEX=0 FOR REST
FC5D:          175 CLREOP1 ;INCREMENT CURRENT LINE NO.

```

FC60:80 E2	FC44	176	BRA	CLREOP2	;before clearing page
FC62:		177 *			
FC62:80 0F	FC73	178 CR	BRA	NEWCR	;only LF if not Pascal
FC64:00		179		BRK	
FC65:00		180		BRK	
FC66:		181 *			
FC66:E6 25		182 LF	INC	CV	;INCR CURSOR V. (DOWN 1 LINE)
FC68:A5 25		183	LDA	CV	
FC6A:C5 23		184	CMP	WNDBTM	;OFF SCREEN?
FC6C:90 1A	FC88	185	BCC	NEWTABZ	;set base+WNDLFT
FC6E:C6 25		186	DEC	CV	;DECR CURSOR V. (BACK TO BOTTOM)
FC70:		187 *			
FC70:4C 35 CB		188 SCROLL	JMP	SCROLLUP	;scroll the screen
FC73:		189 *			
FC73:20 E9 FE		190 NEWCR	JSR	CLRCH	;set CH's to 0
FC76:2C FB 04		191	BIT	VMODE	;is it Pascal?
FC79:10 0A	FC85	192	BPL	CRRTS	;pascal, no LF
FC7B:20 44 FD		193	JSR	NOESCAPE	;else clear escape mode
FC7E:80 E6	FC66	194	BRA	LF	;then do LF
FC80:		195 *			
FC80:BD 15 FF		196 GETINDX	LDA	INDX,X	;lookup index for mnemonic
FC83:A0 00		197	LDY	#0	;exit with BEQ
FC85:60		198 CRRTS	RTS		
FC86:		199 *			
FC86:A5 25		200 NEWVTAB	LDA	CV	;update //e CV
FC88:8D FB 05		201 NEWVTABZ	STA	OURCV	
FC8B:80 97	FC24	202	BRA	VTABZ	;and calc base+WNDLFT
FC8D:		203 *			
FC8D:20 9D CC		204 NEWCLREOL	JSR	GETCUR	;get current cursor
FC90:A9 A0		205 NEWCLEOLZ	LDA	#\$AO	;get a blank
FC92:2C 7B 06		206	BIT	VFACTV	;if video firmware active,
FC95:30 02	FC99	207	BMI	NEWC1	;=>don't use inverse mask
FC97:25 32		208	AND	INVFLG	
FC99:4C C2 CB		209 NEWC1	JMP	DOCLR	;go do clear
FC9C:		210 *			
FC9C:80 EF	FC8D	211 CLREOL	BRA	NEWCLREOL	;get cursor and clear
FC9E:80 F0	FC90	212 CLEOLZ	BRA	NEWCLEOLZ	;clear from Y
FCA0:		213 *			
FCA0:A0 00		214 CLRIN	LDY	#0	;clear entire line
FCA2:80 EC	FC90	215	BRA	NEWCLEOLZ	
FCA4:		216 *			
FCA4:7C 2A CD		217 CTLDO	JMP	(CTLADR,X)	;jump to proper routine
FCA7:		218 *			
FCA7:EA		219	NOP		
FCA8:		220 *			
FCA8:38		221 WAIT	SEC		
FCA9:48		222 WAIT2	PHA		
FCAA:E9 01		223 WAIT3	SBC	#\$01	
FCAC:DO FC	FCAA	224	BNE	WAIT3	;1.0204 USEC
FCAE:68		225	PLA		;( $13 + 2712 * A + 512 * A^2$ )
FCAF:E9 01		226	SBC	#\$01	
FCB1:DO F6	FCA9	227	BNE	WAIT2	
FCB3:60		228 RTS6	RTS		
FCB4:		229 *			
FCB4:E6 42		230 NXTA4	INC	A4L	;INCR 2-BYTE A4
FCB6:DO 02	FCBA	231	BNE	NXTA1	; AND A1
FCB8:E6 43		232	INC	A4H	
FCBA:A5 3C		233 NXTA1	LDA	A1L	;INCR 2-BYTE A1.

FCBC:C5	3E	234	CMP	A2L	; AND COMPARE TO A2			
FCBE:A5	3D	235	LDA	A1H	; (CARRY SET IF >=)			
FCC0:E5	3F	236	SBC	A2H				
FCC2:E6	3C	237	INC	A1L				
FCC4:D0	02	FCC8	238	BNE	RTS4B			
FCC6:E6	3D	239	INC	A1H				
FCC8:60		240	RTS4B	RTS				
FCC9:		241	*					
FCC9:60		242	HEADR	RTS	;don't do it			
FCCA:		243	*					
FCCA:A0	B0	244	COLDSTART	LDY	#\$B0	;let it precess down		
FCCC:64	3C	245	STZ	A1L				
FCCE:A2	BF	246	LDX	#\$BF	;start from BFXX down			
FCD0:86	3D	247	BLAST	STX	A1H			
FCD2:A9	A0	248	LDA	#\$A0	;store blanks			
FCD4:91	3C	249	STA	(A1L),Y				
FCD6:88		250	DEY					
FCD7:91	3C	251	STA	(A1L),Y				
FCD9:CA		252	DEX		;back down to next page			
FCDA:EO	01	253	CPX	#1	;stay away from stack			
FCDC:D0	F2	FCDO	254	BNE	BLAST	;fall into COMINIT		
FCDE:		255	*					
FCDE:8D	01	CO	256	STA	SET80COL	;init ALT screen holes		
FCE1:AD	55	CO	257	LDA	TXTPAGE2	;for serial and comm ports		
FCE4:38		258	SEC					
FCE5:A2	88	259	LDX	#\$88				
FCE7:BD	27	CB	260	COM1	LDA	COMTBL-1,X	;XFER from rom	
FCEA:90	0A	FCF6	261	BCC	COM2		;branch if defaults ok	
FCEC:DD	77	04	262	CMP	\$477,X		;test for prior setup	
FCEF:18		263	CLC				;branch if not valid	
FCFO:D0	04	FCF6	264	BNE	COM2		;If \$4F8 & \$4FF = TBL values	
FCF2:EO	82		265	CPX	#\$82			
FCF4:90	06	FCFC	266	BCC	COM3			
FCF6:9D	77	04	267	COM2	STA	\$477,X		
FCF9:CA		268	DEX				;move all 8...	
FCFA:DO	EB	FCE7	269	BNE	COM1			
FCFC:AD	54	CO	270	COM3	LDA	TXTPAGE1	;restore switches	
FCCF:8D	00	CO	271	STA	CLR80COL		;to default states	
FD02:60		272	RTS					
FD03:		273	*					
FD03:		274	MSB	ON				
FD03:C1	F0	F0	EC	275	APPLE2C	ASC	"Apple	//c"
FD0C:		276	*					
FD0C:A4	24		277	RDKEY	LDY	CH		;get char at current position
FD0E:B1	28		278		LDA	(BASL),Y		;for those who restore it
FD10:EA		279	NOP					;if a program controls input
FD11:EA		280	NOP					;hooks, no cursor may be displayed
FD12:EA		281	NOP					
FD13:EA		282	NOP					
FD14:EA		283	NOP					
FD15:EA		284	NOP					
FD16:EA		285	NOP					
FD17:EA		286	NOP					
FD18:		287	*					
FD18:6C	38	00	288	KEYINO	JMP	(KSWL)		;GO TO USER KEY-IN
FD1B:		289	*					
FD1B:91	28		290	KEYIN	STA	(BASL),Y		;erase false images
FD1D:20	4C	CC	291		JSR	SHOWCUR		;display true cursor

```

FD20:20 70 CC      292 DONXTCUR  JSR   UPDATE      ;look for key, blink II cursor
FD23:10 FB FD20    293 BPL   DONXTCUR  ;loop until keypress
FD25:48            294 GOTKEY   PHA   ;save character
FD26:A9 08          295 LDA   #M.CTL   ;were escapes enabled?
FD28:2C FB 04      296 BIT   VMODE
FD2B:D0 1D FD4A    297 BNE   NOESC2   ;=>no, there is no escape
FD2D:68            298 PLA   ;yes, there may be a way out!!
FD2E:C9 9B          299 CMP   #ESC    ;escape?
FD30:D0 06 FD38    300 BNE   LOOKPICK  ;=>no escape
FD32:4C CC CC      301 JMP   NEWESC   ;=>go do escape sequence
FD35:              302 *
FD35:4C ED CC      303 RDCHAR   JMP   ESCRDKEY ;do RDKEY with escapes
FD38:              304 *
FD38:2C 7B 06      305 LOOKPICK BIT   VFACTV   ;only process f.arrow
FD3B:30 07 FD44    306 BMI   NOESCAPE ;if video firmware is active
FD3D:C9 95          307 CMP   #PICK   ;was it PICK? (->,CTL-U)
FD3F:D0 03 FD44    308 BNE   NOESCAPE ;no, just return
FD41:20 1D CC      309 JSR   PICKY    ;yes, pick the character
FD44:              310 *
FD44:              311 * NOESCAPE is used by GETCOUT too.
FD44:              312 *
FD44:48            313 NOESCAPE PHA   ;save it
FD45:A9 08          314 NOESCI   LDA   #M.CTL   ;disable escape sequences
FD47:0C FB 04      315 TSB   VMODE    ;and enable controls
FD4A:68            316 NOESC2   PLA   ;by setting M.CTL
FD4B:60            317 RTS
FD4C:              318 *
FD4C:EA            319 NOP
FD4D:              320 *
FD4D:20 A6 C3      321 NOTCR   JSR   GETCOUT  ;disable controls and print
FD50:C9 88          322 CMP   #$88    ;CHECK FOR EDIT KEYS
FD52:FO 1D FD71    323 BEQ   BCKSPC   ; - BACKSPACE
FD54:C9 98          324 CMP   #$98
FD56:FO 0A FD62    325 BEQ   CANCEL   ; - CONTROL-X
FD58:E0 F8          326 CPX   #$F8
FD5A:90 03 FD5F    327 BCC   NOTCR1  ;MARGIN?
FD5C:20 3A FF      328 JSR   BELL     ; YES, SOUND BELL
FD5F:E8            329 NOTCR1 INX   ;ADVANCE INPUT INDEX
FD60:D0 13 FD75    330 BNE   NXTCHAR ;BACKSLASH AFTER CANCELLED LINE
FD62:A9 DC          331 CANCEL   LDA   #$DC
FD64:20 A6 C3      332 JSR   GETCOUT ;OUTPUT 'CR'
FD67:20 8E FD      333 GETLNZ   JSR   CROUT   ;OUTPUT PROMPT CHAR
FD6A:A5 33          334 GETLN   LDA   PROMPT
FD6C:20 ED FD      335 JSR   COUT    ;INIT INPUT INDEX
FD6F:A2 01          336 GETLN1  LDX   #$01
FD71:8A            337 BCKSPC TXA
FD72:FO F3 FD67    338 BEQ   GETLNZ  ;WILL BACKSPACE TO 0
FD74:CA            339 DEX
FD75:20 ED CC      340 NXTCHAR JSR   ESCRDKEY ;do new RDCHAR (allow escapes)
FD78:C9 95          341 CMP   #PICK   ;USE SCREEN CHAR
FD7A:D0 08 FD84    342 BNE   ADDINP   ; FOR CONTROL-U
FD7C:20 1D CC      343 JSR   PICKY   ;lift char from screen
FD7F:EA            344 NOP
FD80:EA            345 NOP
FD81:EA            346 NOP    ;no upshifting needed
FD82:EA            347 NOP
FD83:EA            348 NOP
FD84:9D 00 02      349 ADDINP STA   IN,X    ;ADD TO INPUT BUFFER

```

```

FD87:C9 8D      350      CMP    #$8D
FD89:D0 C2      FD4D     351      BNE    NOTCR
FD8B:20 9C FC    352      CROUT1 JSR    CLREOL      ;CLR TO EOL IF CR
FD8E:A9 8D      353      CROUT   LDA    #$8D
FD90:D0 5B      FDED     354      BNE    COUT       ;(ALWAYS)
FD92:          355 * 
FD92:A4 3D      356 PRA1    LDY    A1H      ;PRINT CR,A1 IN HEX
FD94:A6 3C      357      LDX    A1L
FD96:20 8E FD    358 PRYX2   JSR    CROUT
FD99:20 40 F9    359      JSR    PRNTYX
FD9C:A0 00      360      LDY    #$00
FD9E:A9 AD      361      LDA    #$AD      ;PRINT '-'
FDA0:4C ED FD    362      JMP    COUT
FDA3:          363 * 
FDA3:A5 3C      364 XAM8    LDA    A1L
FDA5:09 07      365      ORA    #$07      ;SET TO FINISH AT
FDA7:85 3E      366      STA    A2L      ; MOD 8=7
FDA9:A5 3D      367      LDA    A1H
FDAB:85 3F      368      STA    A2H
FDAD:A5 3C      369 MOD8CHK  LDA    A1L
FDAF:29 07      370      AND    #$07
FDB1:D0 03      FDB6     371      BNE    DATAOUT
FDB3:20 92 FD    372 XAM    JSR    PRA1
FDB6:A9 A0      373 DATAOUT LDA    #$AO
FDB8:20 ED FD    374      JSR    COUT      ;OUTPUT BLANK
FDBB:B1 3C      375      LDA    (A1L),Y
FDBD:20 DA FD    376      JSR    PRBYTE    ;OUTPUT BYTE IN HEX
FDC0:20 BA FC    377      JSR    NXTA1
FDC3:90 E8      FDAD     378      BCC    MOD8CHK  ;NOT DONE YET. GO CHECK MOD 8
FDC5:60          379 RTS4C   RTS
FDC6:          380 * 
FDC6:4A          381 XAMPM   LSR    A      ;DETERMINE IF MONITOR MODE IS
FDC7:90 EA      FDB3     382      BCC    XAM      ; EXAMINE, ADD OR SUBTRACT
FDC9:4A          383      LSR    A
FDCA:4A          384      LSR    A
FDDB:A5 3E      385      LDA    AZL
FDCD:90 02      FDD1     386      BCC    ADD
FDCF:49 FF      387      EOR    #$FF      ;FORM 2'S COMPLEMENT FOR SUBTRACT.
FDD1:65 3C      388 ADD    ADC    A1L
FDD3:48          389      PHA
FDD4:A9 BD      390      LDA    #$BD      ;PRINT '=', THEN RESULT
FDD6:20 ED FD    391      JSR    COUT
FDD9:68          392      PLA
FDDA:          393 * 
FDDA:48          394 PRBYTE  PHA
FDBB:4A          395      LSR    A      ;PRINT BYTE AS 2 HEX DIGITS
FDDC:4A          396      LSR    A      ; (DESTROYS A-REG)
FDDD:4A          397      LSR    A
FDDE:4A          398      LSR    A
FDDF:20 E5 FD    399      JSR    PRHEXZ
FDE2:68          400      PLA
FDE3:          401 * 
FDE3:29 0F      402 PRHEX   AND    #$0F      ;PRINT HEX DIGIT IN A-REG
FDE5:09 B0      403 PRHEXZ  ORA    #$B0      ;LSBITS ONLY.
FDE7:C9 BA      404      CMP    #$BA
FDE9:90 02      FDED     405      BCC    COUT
FDEB:69 06      406      ADC    #$06
FDED:          407 *

```

FDED:6C 36 00	408	COUT	JMP	(CSWL)	;VECTOR TO USER OUTPUT ROUTINE
FDF0:	409	*			
FDF0:2C 7B 06	410	COUT1	BIT	VFACTV	;video firmware active?
FDF3:4C B4 FB	411		JMP	DOCOUT1	;mask II mode characters
FDF6:84 35	412	COUTZ	STY	YSAV1	;SAVE Y-REG
FDF8:48	413		PHA		;SAVE A -REG
FDF9:20 78 FB	414		JSR	VIDWAIT	;OUTPUT CHR AND CHECK FOR CTRL-S
FDPC:68	415		PLA		;RESTORE A-REG
FDFD:A4 35	416		LDY	YSAV1	;AND Y-REG
FDFF:60	417		RTS		;RETURN TO SENDER...
FE00:	418	*			
FE00:C6 34	419	BLL	DEC	YSAV	
FE02:FO 9F	FDA3	420	BEQ	XAM8	
FE04:	421	*			
FE04:CA	422	BLANK	DEX		;BLANK TO MON
FE05:D0 16	FE1D	423	BNE	SETMDZ	;AFTER BLANK
FE07:C9 BA		424	CMP	#\$BA	;DATA STORE MODE?
FE09:D0 BB	FDC6	425	BNE	XAMPM	; NO; XAM, ADD, OR SUBTRACT.
FE0B:	426	*			
FE0B:85 31	427	STOR	STA	MODE	;KEEP IN STORE MODE
FE0D:A5 3E	428		LDA	A2L	
FE0F:91 40	429		STA	(A3L),Y	;STORE AS LOW BYTE AT (A3)
FE11:E6 40	430		INC	A3L	
FE13:D0 02	FE17	431	BNE	RTS5	;INCR A3, RETURN.
FE15:E6 41		432	INC	A3H	
FE17:60		433	RTS5		
FE18:	434	*			
FE18:A4 34	435	SETMODE	LDY	YSAV	;SAVE CONVERTED ':', '+',
FE1A:B9 FF 01	436		LDA	IN-1,Y	; '-', '.' AS MODE
FE1D:85 31		437	SETMDZ	STA	MODE
FE1F:60		438		RTS	
FE20:	439	*			
FE20:A2 01	440	LT	LDX	#\$01	
FE22:B5 3E	441	LT2	LDA	A2L,X	;COPY A2 (2 BYTES) TO
FE24:95 42	442		STA	A4L,X	; A4 AND A5
FE26:95 44	443		STA	A5L,X	
FE28:CA	444		DEX		
FE29:10 F7	FE22	445	BPL	LT2	
FE2B:60		446		RTS	
FE2C:	447	*			
FE2C:B1 3C	448	MOVE	LDA	(A1L),Y	;MOVE (A1) THRU (A2) TO (A4)
FE2E:91 42	449		STA	(A4L),Y	
FE30:20 B4 FC	450		JSR	NXTA4	
FE33:90 F7	FE2C	451	BCC	MOVE	
FE35:60		452		RTS	
FE36:	453	*			
FE36:B1 3C	454	VERIFY	LDA	(A1L),Y	;VERIFY (A1) THRU (A2)
FE38:D1 42	455		CMP	(A4L),Y	; WITH (A4)
FE3A:F0 1C	FE58	456	BEQ	VFYOK	
FE3C:20 92 FD		457	JSR	PRA1	
FE3F:B1 3C		458	LDA	(A1L),Y	
FE41:20 DA FD		459	JSR	PRBYTE	
FE44:A9 A0		460	LDA	#\$AO	
FE46:20 ED FD		461	JSR	COUT	
FE49:A9 A8		462	LDA	#\$A8	
FE4B:20 ED FD		463	JSR	COUT	
FE4E:B1 42		464	LDA	(A4L),Y	
FE50:20 DA FD		465	JSR	PRBYTE	

FE53:A9 A9	466	LDA	#\$A9	
FE55:20 ED FD	467	JSR	COUT	
FE58:20 B4 FC	468	VFYOK	JSR	NXTA4
FE5B:90 D9 FE36	469		BCC	VERIFY
FE5D:60	470		RTS	
FE5E:	471 *			
FE5E:20 75 FE	472	LIST	JSR	A1PC ;MOVE A1 (2 BYTES) TO
FE61:A9 14	473		LDA	#\$14 ; PC IF SPEC'D AND
FE63:48	474	LIST2	PHA	
FE64:20 D0 F8	475		JSR	INSTDSP ;DISASSEMBLE 20 INSTRUCTIONS.
FE67:20 53 F9	476		JSR	PCADJ ;ADJUST PC AFTER EACH INSTRUCTION.
FE6A:85 3A	477		STA	PCL
FE6C:84 3B	478		STY	PCH
FE6E:68	479		PLA	
FE6F:38	480		SEC	
FE70:E9 01	481		SBC	#\$01 ;NEXT OF 20 INSTRUCTIONS
FE72:D0 EF FE63	482		BNE	LIST2
FE74:60	483		RTS	
FE75:	484 *			
FE75:8A	485	A1PC	TXA	
FE76:F0 07 FE7F	486		BEQ	A1PCRTS ;IF USER SPECIFIED AN ADDRESS,
FE78:B5 3C	487	A1PCLP	LDA	AIL,X ; COPY IT FROM A1 TO PC.
FE7A:95 3A	488		STA	PCL,X ;YEP, SO COPY IT.
FE7C:CA	489		DEX	
FE7D:10 F9 FE78	490		BPL	A1PCLP
FE7F:60	491	A1PCRTS	RTS	
FE80:	492 *			
FE80:A0 3F	493	SETINV	LDY	#\$3F ;SET FOR INVERSE VID
FE82:D0 02 FE86	494		BNE	SETIFLG ; VIA COUT1
FE84:A0 FF	495	SETNORM	LDY	#\$FF ;SET FOR NORMAL VID
FE86:84 32	496	SETIFLG	STY	INVFLG
FE88:60	497		RTS	
FE89:	498 *			
FE89:A9 00	499	SETKBD	LDA	#\$00 ;DO 'IN#0'
FE8B:85 3E	500	IMPORT	STA	A2L ;DO 'IN#AREG'
FE8D:A2 38	501	INPRT	LDX	#KSWL
FE8F:A0 1B	502		LDY	#KEYIN
FE91:D0 08 FE9B	503		BNE	IOPRT
FE93:	504 *			
FE93:A9 00	505	SETVID	LDA	#\$0 ;DO 'PR#0'
FE95:85 3E	506	OUTPORT	STA	A2L ;DO 'PR#AREG'
FE97:A2 36	507	OUTPRT	LDX	#CSWL
FE99:A0 F0	508		LDY	#COUT1
FE9B:A5 3E	509	IOPRT	LDA	A2L
FE9D:29 0F	510		AND	#\$OF
FE9F:D0 06 FEA7	511		BNE	NOTPRTO ;not slot 0
FEA1:CO 1B	512		CPY	#KEYIN ;Continue if KEYIN
FEA3:F0 39	513		BEQ	IOPRT1
FEA5:80 1B FEC2	514		BRA	OPRTO ;=>do PR#0
FEA7:09 CO	515	NOTPRTO	ORA	#<IOADR
FEA9:A0 00	516		LDY	#\$00
FEAB:94 00	517	IOPRT2	STY	LOCO,X
FEAD:95 01	518		STA	LOC1,X
FEAF:60	519		RTS	
FEBO:	520 *			
FEBO:4C 00 EO	521	XBASIC	JMP	BASIC ;TO BASIC, COLD START
FEB3:	522 *			
FEB3:4C 03 EO	523	BASCONT	JMP	BASIC2 ;TO BASIC, WARM START

```

FEB6:          524 *
FEB6:20 75 FE 525 GO      JSR   A1PC      ;ADDR TO PC IF SPECIFIED
FEB9:20 3F FF 526         JSR   RESTORE   ;RESTORE FAKE REGISTERS
FEBC:6C 3A 00 527         JMP   (PCL)    ; AND GO!
FEBF:          528 *
FEBF:4C D7 FA 529 REGZ    JMP   REGDSP   ;GO DISPLAY REGISTERS
FEC2:          530 *
FEC2:3A        531 OPRTO   DEC   A        ;Need $FF
FEC3:8D FB 07 532         STA   CURSOR   ;set checkerboard cursor
FEC6:A9 F7    533         LDA   #$FF-M.CTL ;reset mode
FEC8:80 04    FECE      534         BRA   DOPRO
FECA:          535 *
FECA:4C F8 03 536 USR     JMP   USRADR   ;JUMP TO CONTROL-Y VECTOR IN RAM
FECD:          537 *
FECD:60      538 WRITE    RTS
FECE:          539 *
FECE:8D 7B 06 540 DOPRO   STA   VFACTV   ;say video firmware inactive
FED1:8D 0E C0 541         STA   CLRALTCHAR ;switch in normal char set
FED4:0C FB 04 542         TSB   VMODE    ;don't change M.CTL
FED7:DA      543         PHX
FED8:5A      544         PHY
FED9:20 CD CD 545         JSR   CHK80    ;convert to 40 if needed
FEDC:7A      546         PLY
FEDD:FA      547         PLX
FEDE:A9 FD    548 IOPRT1  LDA   #<COUT1 ;set I/O page
FEE0:80 C9    FEAB      549         BRA   IOPRT2 ;=>go set output hook
FEE2:          550 *
FEE2:          551 * DECCH decrements the current cursor
FEE2:          552 * CLRCH sets all cursors to 0
FEE2:          553 * SETCUR sets cursors to value in Acc.
FEE2:          554 * See explanatory note with GETCUR
FEE2:          555 *
FEE2:5A      556 DECCH    PHY
FEE3:20 9D CC 557         JSR   GETCUR   ;get current CH
FEE6:88      558         DEY
FEE7:80 05    FEEE      559         BRA   SETCUR1 ;decrement it
FEE9:          560 *
FEE9:A9 01    561 CLRCH    LDA   #1       ;set all cursors to 0
FEEB:3A      562 WDTHCH   DEC   A        ;dec window width (from $FC17)
FEEC:5A      563 SETCUR   PHY
FEED:A8      564         TAY
FEEE:20 AD CC 565 SETCUR1 JSR   GETCUR2 ;need value in Y
FEF1:7A      566         PLY
FEF2:AD 7B 05 567         LDA   OURCH   ;save new CH
FEF5:60      568         RTS
FEF6:          569 *
FEF6:20 00 FE 570 CRMON   JSR   BL1     ;and get new CH into acc
FEF9:68      571         PLA
FEFA:68      572         PLA
FEFB:D0 6C    FF69      573         BNE   MONZ   ;(Need LDA to set flags)
FEFD:          574 *
FEFD:60      575 READ     RTS
FEFE:          576 *
FEFE:          577 * OPTBL is a table containing the new opcodes that
FEFE:          578 * wouldn't fit into the existing lookup table.
FEFE:          579 *
FEFE:12      580 OPTBL    DFB   $12     ;ORA (ZPAG)
FEFF:14      581         DFB   $14     ;TRB ZPAG

```

```

FF00:1A      582      DFB  $1A      ;INC A
FF01:1C      583      DFB  $1C      ;TRB ABS
FF02:32      584      DFB  $32      ;AND (ZPAG)
FF03:34      585      DFB  $34      ;BIT ZPAG,X
FF04:3A      586      DFB  $3A      ;DEC A
FF05:3C      587      DFB  $3C      ;BIT ABS,X
FF06:52      588      DFB  $52      ;EOR (ZPAG)
FF07:5A      589      DFB  $5A      ;PHY
FF08:64      590      DFB  $64      ;STZ ZPAG
FF09:72      591      DFB  $72      ;ADC (ZPAG)
FF0A:74      592      DFB  $74      ;STZ ZPAG,X
FF0B:7A      593      DFB  $7A      ;PLY
FF0C:7C      594      DFB  $7C      ;JMP (ABS,X)
FF0D:89      595      DFB  $89      ;BIT IMM
FF0E:92      596      DFB  $92      ;STA (ZPAG)
FF0F:9C      597      DFB  $9C      ;STZ ABS
FF10:9E      598      DFB  $9E      ;STZ ABS,X
FF11:B2      599      DFB  $B2      ;LDA (ZPAG)
FF12:D2      600      DFB  $D2      ;CMP (ZPAG)
FF13:F2      601      DFB  $F2      ;SBC (ZPAG)
FF14:FC      602      DFB  $FC      ;??? (the unknown opcode)
FF15: 0016 603 NUMOPS EQU *-OPTBL-1 ;number of bytes to check
FF15:
FF15: 604 *
FF15: 605 * INDX contains pointers to the mnemonics for each of
FF15: 606 * the opcodes in OPTBL. Pointers with BIT 7
FF15: 607 * set indicate extensions to MNEML or MNEMR.
FF15:
FF15: 608 *
FF15:38      609 INDX    DFB  $38
FF16:FB      610      DFB  $FB
FF17:37      611      DFB  $37
FF18:FB      612      DFB  $FB
FF19:39      613      DFB  $39
FF1A:21      614      DFB  $21
FF1B:36      615      DFB  $36
FF1C:21      616      DFB  $21
FF1D:3A      617      DFB  $3A
FF1E:F8      618      DFB  $F8
FF1F:FA      619      DFB  $FA
FF20:3B      620      DFB  $3B
FF21:FA      621      DFB  $FA
FF22:F9      622      DFB  $F9
FF23:22      623      DFB  $22
FF24:21      624      DFB  $21
FF25:3C      625      DFB  $3C
FF26:FA      626      DFB  $FA
FF27:FA      627      DFB  $FA
FF28:3D      628      DFB  $3D
FF29:3E      629      DFB  $3E
FF2A:3F      630      DFB  $3F
FF2B:FC      631      DFB  $FC      ;???
FF2C:00      632      BRK
FF2D: 633 *
FF2D:A9 C5  634 PRERR   LDA  #$C5      ;PRINT 'ERR', THEN FALL INTO
FF2F:20 ED FD 635 JSR     COUT      ; FWEPPER.
FF32:A9 D2  636 LDA  #$D2
FF34:20 ED FD 637 JSR     COUT
FF37:20 ED FD 638 JSR     COUT
FF3A: 639 *

```

FF3A:A9 87	640 BELL	LDA #\\$87	;MAKE A JOYFUL NOISE, THEN RETURN.	
FF3C:4C ED FD	641 JMP	COUT		
FF3F:	642 *			
FF3F:A5 48	643 RESTORE	LDA STATUS	;RESTORE 6502 REGISTER CONTENTS	
FF41:48	644 PHA	LDA A5H	; USED BY DEBUG SOFTWARE	
FF42:A5 45	645 LDA	LDX XREG		
FF44:A6 46	646 RESTR1	LDY YREG		
FF46:A4 47	647 PLA	PLP		
FF48:28	648 RTS			
FF49:60	649 RTS			
FF4A:	650 *			
FF4A:85 45	651 SAVE	STA A5H	;SAVE 6502 REGISTER CONTENTS	
FF4C:86 46	652 SAV1	STX XREG	; FOR DEBUG SOFTWARE	
FF4E:84 47	653 STY	YREG		
FF50:08	654 PHP	PLA		
FF51:68	655 SETVID	STATUS		
FF52:85 48	656 CLD	SPNT		
FF54:BA	657 SETKBD			
FF55:86 49	658 RTS			
FF57:D8	659 RTS			
FF58:60	660 RTS			
FF59:	661 *			
FF59:20 84 FE	662 OLDRST	JSR SETNORM	;SET SCREEN MODE	
FF5C:20 2F FB	663 JSR INIT	JSR	; AND INIT KBD/SCREEN	
FF5F:20 93 FE	664 JSR SETVID	SETVID	; AS I/O DEVS.	
FF62:20 89 FE	665 JSR SETKBD	SETKBD		
FF65:	666 *			
FF65:D8	667 MON	CLD	;MUST SET HEX MODE!	
FF66:20 3A FF	668 JSR BELL	BELL	;FWEEPER.	
FF69:A9 AA	669 MONZ	LDA #\\$AA	;'*' PROMPT FOR MONITOR	
FF6B:85 33	670 STA	PROMPT		
FF6D:20 67 FD	671 JSR	GETLNZ	;READ A LINE OF INPUT	
FF70:20 C7 FF	672 JSR	ZMODE	;CLEAR MONITOR MODE, SCAN IDX	
FF73:20 A7 FF	673 NXTITM	GETNUM	;GET ITEM, NON-HEX	
FF76:84 34	674 STY	YSAV	; CHAR IN A-REG.	
FF78:A0 13	675 LDY	#SUBTBL-CHRTBL	; X-REG=0 IF NO HEX INPUT	
FF7A:88	676 CHRSRCH	DEY		
FF7B:30 E8 FF65	677 BMI	MON	;COMMAND NOT FOUND, BEEP & TRY AGAIN.	
FF7D:D9 CD FF	678 CMP	CHRTBL,Y	;FIND COMMAND CHAR IN TABLE	
FF80:D0 F8 FF7A	679 BNE	CHRSRCH	;NOT THIS TIME	
FF82:20 BE FF	680 JSR	TOSUB	;GOT IT! CALL CORRESPONDING SUBROUTINE	
FF85:A4 34	681 LDY	YSAV	;PROCESS NEXT ENTRY ON HIS LINE	
FF87:4C 73 FF	682 JMP	NXTITM		
FF8A:	683 *			
FF8A:A2 03	684 DIG	LDX #\\$03		
FF8C:0A	685 ASL	A		
FF8D:0A	686 ASL	A	;GOT HEX DIGIT,	
FF8E:0A	687 ASL	A	; SHIFT INTO A2	
FF8F:0A	688 ASL	A		
FF90:0A	689 NXTBIT	ASL		
FF91:26 3E	690 ROL	A2L		
FF93:26 3F	691 ROL	A2H		
FF95:CA	692 DEX		;LEAVE X=\\$FF IF DIG	
FF96:10 F8 FF90	693 BPL	NXTBIT		
FF98:A5 31	694 NXTBAS	LDA MODE		
FF9A:D0 06 FFA2	695 BNE	NXTBS2	;IF MODE IS ZERO,	
FF9C:B5 3F	696 LDA	A2H,X	; THEN COPY A2 TO A1 AND A3	
FF9E:95 3D	697 STA	A1H,X		

```

FFA0:95 41      698      STA    A3H,X
FFA2:E8          699      NXTBS2   INX
FFA3:F0 F3      FF98     700      BEQ    NXTBAS
FFA5:D0 06      FFAD     701      BNE    NXTCHR
FFA7:A2 00      702      GETNUM   LDX    #$00      ;CLEAR A2
FFA9:86 3E      703      STX    A2L
FFAB:86 3F      704      STX    A2H
FFAD:B9 00 02    705      NXTCHR   LDA    IN,Y      ;GET CHAR
FFB0:C8          706      INY
FFB1:20 99 C3    707      JSR    UPSHIFT0 ;upshift if necessary (set high bit)
FFB4:49 B0      708      EOR    #$B0
FFB6:C9 OA      709      CMP    #$OA
FFB8:90 D0      FF8A     710      BCC    DIG      ;it's a digit
FFBA:80 37      FFF3     711      BRA    GETHEX   ;check for other digits
FFBC:00          712      BRK
FFBD:00          713      BRK
FFBE:             714 * 
FFBE:A9 FE      715      TOSUB   LDA    #<GO    ;DISPATCH TO SUBROUTINE, BY
FFC0:48          716      PHA
FFC1:B9 EO FF    717      LDA    SUBTBL,Y ; PUSHING THE HI-ORDER SUBR ADDR,
FFC4:48          718      PHA
FFC5:A5 31      719      LDA    MODE
FFC7:A0 00      720      ZMODE   LDY    #$00    ; THEN THE LO-ORDER SUBR ADDR
FFC9:84 31      721      STY    MODE    ; ONTO THE STACK,
FFCB:60          722      RTS
FFCC:             723 *      NOP
FFCD:             724      NOP
FFCD:             725 *      NOP
FFCD:BC          726      CHRTBL  DFB    $BC      ;^C (BASIC WARM START)
FFCE:B2          727      DFB    $B2      ;^Y (USER VECTOR)
FFCF:BE          728      DFB    $BE      ;^E (OPEN AND DISPLAY REGISTERS)
FFD0:EF          729      DFB    $EF      ;^V (MEMORY VERIFY)
FFD1:C4          730      DFB    $C4      ;^K (IN#SLOT)
FFD2:A9          731      DFB    $A9      ;^P (PR#SLOT)
FFD3:BB          732      DFB    $BB      ;^B (BASIC COLD START)
FFD4:A6          733      DFB    $A6      ;'-' (SUBTRACTION)
FFD5:A4          734      DFB    $A4      ;'+' (ADDITION)
FFD6:06          735      DFB    $06      ;^M (MEMORY MOVE)
FFD7:95          736      DFB    $95      ;'<' (DELIMITER FOR MOVE, VFY)
FFD8:07          737      DFB    $07      ;^N (SET NORMAL VIDEO)
FFD9:02          738      DFB    $02      ;^I (SET INVERSE VIDEO)
FFDA:05          739      DFB    $05      ;^L (DISASSEMBLE 20 INSTRS)
FFDB:00          740      DFB    $00      ;^G (EXECUTE PROGRAM)
FFDC:93          741      DFB    $93      ;';' (MEMORY FILL)
FFDD:A7          742      DFB    $A7      ;'.' (ADDRESS DELIMITER)
FFDE:C6          743      DFB    $C6      ;'CR' (END OF INPUT)
FFDF:99          744      DFB    $99      ;BLANK
FFEO:             745 * 
FFEO:             746 * Table of low order monitor routine
FFEO:             747 * dispatch addresses.
FFEO:             748 *
FFEO:B2          749      SUBTBL  DFB    >BASCONT-1
FFE1:C9          750      DFB    >USR-1
FFE2:BE          751      DFB    >REGZ-1
FFE3:35          752      DFB    >VERIFY-1
FFE4:8C          753      DFB    >INPRT-1
FFE5:96          754      DFB    >OUTPRT-1
FFE6:AF          755      DFB    >XBASIC-1

```

FFE7:17	756	DFB	>SETMODE-1
FFE8:17	757	DFB	>SETMODE-1
FFE9:2B	758	DFB	>MOVE-1
FFEA:1F	759	DFB	>LT-1
FFEB:83	760	DFB	>SETNORM-1
FFEC:7F	761	DFB	>SETINV-1
FFED:5D	762	DFB	>LIST-1
FFEE:B5	763	DFB	>GO-1
FFEF:17	764	DFB	>SETMODE-1
FFF0:17	765	DFB	>SETMODE-1
FFF1:F5	766	DFB	>CRMON-1
FFF2:03	767	DFB	>BLANK-1
FFF3:	768 *		
FFF3:69 88	769	GETHEX	ADC #\$88
FFF5:C9 FA	770	CMP	#\$FA
FFF7:B0 91 FF8A	771	BCS	DIG
FFF9:60	772	RTS	
FFFA:	773 *		
FFFA:FB 03	774	DW	NMI ;NON-MASKABLE INTERRUPT VECTOR
FFFC:62 FA	775	DW	RESET ;RESET VECTOR
FFFE:03 C8	776	DW	NEWIRQ ;INTERRUPT REQUEST VECTOR

3D A1H	3C A1L	FE78 A1PCLP	FE7F A1PCRTS
FE75 A1PC	3F A2H	3E A2L	41 A3H
40 A3L	43 A4H	42 A4L	45 A5H
44 A5L	45 ACC	C8FF ACDONE	04FF ACIABUF
C988 ACIADONE	C900 ACIAINT	C908 AC'ATST	FDD1 ADD
FD84 ADDINP	FBF8 ADV2	?FBF4 ADVANCE	C94B AIEATIT
C943 AINOFLSH	C94D AIPASS	C922 AIPORT2	C91C AITST2
C01E ALTCHARSET	?03F5 AMPERV	FD03 APPLE2C	FB60 APPLEII
0438 ASTAT	C6A2 BADRD1	C6D3 BADREAD	C77C BANGER
2B BAS2H	2A BAS2L	FBC1 BASCALC	FB00 BASCLC2
FEB3 BASCONT	29 BASH	E003 BASIC2	C324 BASICENT
C79F BASICIN	C317 BASICINIT	E000 BASIC	28 BASL
FD71 BCKSPC	FAA3 BEEPFIX	?FBDD BELL1	FF3A BELL
FBE4 BELL2	0215 BINH	0214 BINL	C329 BINPUT
FE00 BL1	FE04 BLANK	FC00 BLAST	4F BOOTDEV
07DB BOOTSCRN	3C BOOTTMP	?C326 BPRINT	?FA4C BREAK
03F0 BRKV	?FC10 BS	04 BUTMODE	C061 BUTNO
C062 BUTNI	CFC2 C03	C307 C3COUT1	?C300 C3ENTRY
C305 C3KEYIN	FD62 CANCEL	CA76 CDONE2	CA3C CDONE
?CD7D CGO	F9BA CHAR1	F9B4 CHAR2	CD0D CHK80
FBD9 CHKBELL	C528 CHKMOU	CB4E CHKRT	FF7A CHRSRCH
24 CH	C132 CHOK	FFCD CHRTBL	CA28 CKDIG
FC9E CLEOLZ	FC46 CLEOP1	CBEE CLR0	CBFC CLR1
CBF1 CLR2	CC02 CLR3	CBC7 CLR40	C000 CLR80COL
C00C CLR80VID	CBDA CLR80	CO0E CLRALTCHAR	?C058 CLRANO
?C05A CLRAN1	?C05C CLRAN2	?C05E CLRAN3	FEE9 CLRCH
C1DD CLRCOL	FC9C CLREOL	FC44 CLREOP2	FC42 CLREOP
FC5D CLREOP1	CBCF CLRHALF	CD9B CLRIT	CC97 CLRKBD
FCA0 CLRLIN	CC04 CLRPORT	?CFFF CLRROM	F838 CLRSC2
F83C CLRSC3	?F832 CLRSCR	F836 CLRTOP	CA7D CMDB
CA5D CMDCR	BF CMDCUR	CA79 CMDD	CA68 CMDI2
CA67 CMDI	CA67 CMDK	CA14 CMDLOOP	CA67 CMDL
C9DE CMDLIST	CA5D CMDN	CAB0 CMDP2	CA78 CMDP
CAC4 CMDQ	CAB5 CMDR	CA99 CMDS	CAC6 CMDT
CB05 CMDT2	CB17 CMDT3	C9C7 CMDTABLE	CA55 CMDZ
CA25 CMD22	CA4D CMFOUND	C555 CMLOK	C538 CMLOOP
C577 CMNOINT	C58E CMNOVBL	C57B CMNOY	C55D CMNTO
C562 CMRGHT	C56F CMROK	CA43 CMSET	C542 CMXMOV
CFB7 C01	0738 COL	FCCA COLDSTART	30 COLOR
FCE7 COM1	FCF6 COM2	FCFC COM3	CA36 COMINIT
C9EB COMMAND	C266 COMMPORT	C263 COMOUT	C200 COMSLOT
CB28 COMTBL	C338 COPYROM	C348 COPYROM2	FDF6 COUTZ
FDED COUT	FDF0 COUT1	FEF6 CRMON	?FD8B CROUT1
FD8E CROUT	FC62 CR	FC85 CRRTS	37 CSWH
36 CSWL	CD2A CTLADR	CD58 CTLCHAR	CD54 CTLCHARO
FCA4 CTLDO	CD6F CTLDONE	CD71 CTLGO	CD80 CTLGO1
14 CTLNUM	CD91 CTLOFF	CD95 CTLON	CD15 CTLTAB
07FB CURSOR	C51D CVBUT	C516 CVMOVED	C4ED CVNOVBL
25 CV	FDB6 DATAOUT	FBBC DCX	FEE2 DECCH
C2C8 DEFAULT	C2F1 DEFCOM	C2D9 DEFFF	C2FC DEFIDX
C2CE DEFLOOP	C6D9 DENIB1	C6D7 DENIBL	C885 DEVNO
FF8A DIG	CA30 DIGLOOP	0356 DNIBL	CBC2 DOCLR
FBB4 DOCOUT1	FB54 DOCTL	C6FB DODRV2	C188 DONE
FD20 DONXTCUR	FECE DOPRO	?C701 DRV2BOOT	C60B DRV2ENT
C5C3 DV10LOOP	C5CA DV10LT	C111 ENTR1	C230 ENTR
F8A1 ERR	9B ESC	CCD7 ESCO	?CCE3 ESC1
CCE5 ESC2	CCC0 ESC3	CDOC ESCCHAR	0638 ESCHAR
0013 ESCNUM	CCED ESCRDKEY	CCF8 ESCTAB	C28C EXIT1

C28A EXITX	?C65C EXTENT	C63D EXTENT1	05F9 EXTINT2
0538 EXTINT	F800 F8ORG	FBB3 F8VERSION	C142 FIXCH
?FA9B FIXSEV	06B8 FLAGS	CB1B FLUSH	F962 FMT1
F9A6 FMT2	CD67 FNDCTL	2E FORMAT	C64B FUG1
?C648 FUGIT	F847 GBASCALC	27 GBASH	26 GBASL
F856 GBCALC	C8F8 GBEMPTY	C8DB GBNOOVR	C393 GETALT1
C398 GETALT2	C37C GETALT	C8CC GETBUF	C3A6 GETCOUT
GCA7 GETCUR1	CC9D GETCUR	CCAD GETCUR2	CCB7 GETCUR3
CCBF GETCURX	F8A5 GETFMT	FFF3 GETHEX	FC80 GETINDX
?FD6F GETLN1	FD67 GETLNZ	?FD6A GETLN	FFA7 GETNUM
CB57 GETST	CEFA GETX	?CF06 GETY	CF38 GKEY
?FD25 GOTKEY	FEB6 GO	C89F GOBREAK	06 GOODF8
C28F GOREMOTE	C290 GOTERM	F8CC GOTONE	2C H2
C64E HANGING	C5E3 HDNONE	C5BE HDLOOP	C5B8 HDPOS2
?FCC9 HEADR	C5AC HEXDEC2	C59B HEXTODEC	?C057 HIRES
F81C HLINE1	?F819 HLINE	FC58 HOME	CDA5 HOMECUR
CE1B HOOKITUP	CE20 HOOKUP	F897 IEVEN	0200 INBUF
CA0C INCMD	FF15 INDX	?F88C INSDS2	0200 IN
C405 INENT	FB2F INIT	C41C INITMOUSE	?FE8B INPORT
FE8D INPRT	F882 INSDS1	F8D0 INSTDSP	CC12 INVERT
32 INVFLG	CC1C INVX	C000 IOADR	FE9B IOPRT
FEDE IOPRT1	FEAB IOPRT2	FF58 IORTS	C058 IOU
C078 IOUDSBL	C079 IOUENBL	C806 IRQ1	C827 IRQ2
C831 IRQ3	C83B IRQ4	C850 IRQ5	C85E IRQ6
C861 IRQ7	C873 IRQ8	C88C IRQDNE1	C88F IRQDNE2
C899 IRQDNE3	C882 IRQDONE	?03FE IRQLOC	C989 IRQTBLE
FFFE IRQVECT	?FA40 IRQ	C663 ISMRK1	C22F ISRDY
CFF9 JMPDEST	C32C JPINIT	C32F JPREAD	C335 JPSTAT
C332 JPWRITE	C010 KBDSTRB	FB88 KBDWAIT	C000 KBD
FD1B KEYIN	?FD18 KEYINO	39 KSWH	38 KSWL
C08B LCBANK1	C083 LCBANK2	2F LENGTH	FC66 LF
0400 LINE1	FE5E LIST	FE63 LIST2	2C LMNEM
00 LOCO	01 LOC1	FD38 LOOKPICK	C056 LORES
FE22 LT2	FE20 LT	? 40 M.40	20 M.CTL2
08 M.CTL	10 M.CURSOR	08 M.GOXY	01 M.MOUSE
80 M.PASCAL	04 M.VMODE	44 MACSTAT	C709 MAKTBL
2E MASK	C9D4 MASK1	C9D9 MASK2	05F8 MAXH
04F8 MAXL	077D MAXXH	067D MAXXL	?07FD MAXYH
?06FD MAXYL	C400 MBASIC	C79B MBBAD	0578 MINH
0478 MINL	057D MINXH	047D MINXL	?05FD MINYH
?04FD MINYL	C8AB MIRQLP	C8C2 MIRQSTD	C4F1 MISTAT
?C052 MIXCLR	C053 MIXSET	F9C0 MNEMML	FA00 MNEMR
F8BE MNNDX1	F8C2 MNNDX2	F8C9 MNNDX3	FDAD MOD8CHK
31 MODE	FF65 MON	FF69 MONZ	067C MOUARM
C063 MOUBUT	C048 MOUCLR	?C058 MOUDSBL	?C059 MOUENBL
07FC MOUMODE	C4D5 MOUSEINT	CD9F MOUOFF	CD99 MOUSON
077C MOUSTAT	0478 MOUTEMP	C066 MOUX1	057C MOUXH
C015 MOUXINT	047C MOUXL	C067 MOUY1	05FC MOUYH
C017 MOUYINT	04FC MOUYL	20 MOVARM	CF86 MOVEAUX
CF99 MOVEC2M	C8A2 MOVEIRQ	CF9F MOVELOOP	FE2C MOVE
CFCB MOVERET	CF9F MOVESTRT	02 MOVMODE	C7DE MPADDLE
C72F MSG	CAA6 MSLOOP	07F8 MLSOT	CAA4 MSWAIT
0300 NBUF1	FBB0 NEWADV1	FBA0 NEWADV	FA47 NEWBRK
FC99 NEWC1	FC90 NEWCLEOLZ	FC8D NEWCLREOL	FC73 NEWCR
CCCC NEWESC	C803 NEWIRQ	?FA81 NEWMON	FC38 NEWOP1
FC35 NEWOPS	FC86 NEWVTAB	FC88 NEWVTABZ	CFA9 NEXTA1
O3FB NMI	CA09 NOCMD	C46B NOERROR	?FD45 NOESC1
FD4A NOESC2	FD44 NOESCAPE	C26B NOESC	FACF NOFIX

C725 NOPATRN	C371 NOREAD	CA93 NOSHIFT	C4F9 NOSTAT2
C36A NOT1	C8FE NOTACIA	FD5F NOTCR1	FD4D NOTCR
?CC68 NOTINV1	CC6B NOTINV2	CC53 NOTINV	FEA7 NOTPRTO
C22E NOTRDY	FB94 NOWAIT	047F NUMBER	0016 NUMOPS
FCBA NXTA1	FCB4 NXTA4	FF98 NXTBAS	FF90 NXTBIT
FFA2 NXTBS2	FD75 NXTCHAR	FFAD NXTCHR	?F85F NXTCOL
077B NXTCUR	FF73 NXTITM	FA59 OLDBRK	047B OLDCH
067A OLDCUR2	0679 OLDCUR	?FF59 OLDRST	FEC2 OPRTO
FEFE OPTBL	057B OURCH	05FB OURCV	C407 OUTENT
?FE95 OUTPORT	FE97 OUTPRT	C1E4 P1INIT	C1F3 P1READ2
C1EE P1READ	C1FB P1STATUS	C1F6 P1WRITE	C211 P2INIT
C213 P2READ	C217 P2STATUS	C215 P2WRITE	C064 PADDLO
CF71 PASCALC	?CF7F PASCLC2	CC0B PASINVERT	CF35 PASREAD
C850 PASSKIP1	C97C PBFULL	C973 PBOK	?F954 PCADJ2
F95C PCADJ4	F953 PCADJ	F956 PCADJ3	3B PCH
3A PCL	CF19 PCTL	C7F6 PDOK	C7EB PDON
CC3D PICK1	CC33 PICK2	CC3F PICK3	CC4A PICK4
95 PICK	CC1D PICKY	CF41 PINIT	CEBC PIORDY
F800 PLOT	F80E PLOT1	CECO PNOTRDY	C402 PNULL
FD92 PRA1	F910 PRADR1	F914 PRADR2	F926 PRADR3
F92A PRADR4	F930 PRADR5	F94A PRBL2	?F94C PRBL3
F948 PRBLNK	FDDA PRBYTE	?FB1E PREAD	FB25 PREAD2
?FF2D PRERR	CEF7 PRET	?FDE3 PRHEX	FDE5 PRHEXZ
F8F5 PRMN1	F8F9 PRMN2	C168 PRNOW	?F941 PRNTAX
F8DB PRNTBL	F8D4 PRNTOP	F940 PRNTYX	C14C PRNT
?F944 PRNTX	33 PROMPT	FD96 PRYX2	CF66 PS1
CF51 PSETUP	CF54 PSETUP2	CF30 PSETX	C222 PSTAT2
CEB1 PSTATUS	CEBE PSTERR	?C070 PTRIG	C967 PUTBUF
C7DA PUTINBUF	CE3B PVMODE	04B8 PWDTH	CEDD PWR1
FAFD PWRCON	03F4 PWREDUP	CEF4 PWRET	CEC2 PWRITE
CEF1 PWRITERET	FB12 PWRUP2	FAA6 PWRUP	C506 QLOOP
C5E8 QTBL	CE45 QUIT	CE44 QX	?C060 RD40SW
C018 RD80COL	C01F RD80VID	C63F RDADR	C016 RDALTZP
C6A8 RDATA0	C6AA RDAT1	C6BA RDAT2	C6BC RDAT3
C6CB RDAT4	C6A6 RDATA	C003 RDCARDRAM	?FD35 RDCHAR
C642 RDDHDR	C656 RDHD0	C65E RDHD1	C667 RDHD2
C671 RDHD3	?C01D RDHIRES	FDOC RDKEY	C011 RDLCBNK2
C012 RDLCRAM	C002 RDMAINRAM	?C01B RDMIX	C01C RDPAGE2
C013 RDRAMRD	C014 RDRAMWRT	C685 RDSEC1	C687 RDSEC2
C68F RDSEC3	C683 RDSECT	FAE4 RDSP1	C01A RDTEXT
?C019 RDVBLBAR	?FEFD READ	FAD7 REGDSP	FEBF REGZ
?F938 RELADR	FA62 RESET	FABD RESET.X	C354 RESETLC
FF3F RESTORE	?FF44 RESTR1	C641 RETRY1	C657 RETRY
FADA RGDSP1	FB02 RGDSP2	2D RMNEM	4F RNDH
4E RNDL	C081 ROMIN	C37B ROMOK	0478 ROMSTATE
FAD2 RTBL	F80C RTMASK	F87F RTMSKZ	F831 RTS1
FBEF RTS2B	F961 RTS2	FB2E RTS2D	FBFC RTS3
FCC8 RTS4B	?FDC5 RTS4C	?FC34 RTS4	FE17 RTS5
?FCB3 RTS6	?FF4C SAV1	FF4A SAVE	BFFB SCNTL
BFFA SCOMD	CE58 SCR1	CE5E SCR2	CE66 SCR3
CE79 SCR4	CE82 SCR5	CE8B SCR6	CE96 SCR7
?CE8D SCR8	CEAD SCR9	CBB9 SCR13	CB9B SCRLEVEN
CBA2 SCRLEFT	CB6D SCRIN	CBBO SCRLODD	?F871 SCRN
F879 SCR2	CE80 SCR48	CE53 SCR84	CB30 SCROLLDN
CB38 SCROLLIT	CB35 SCROLLUP	?FC70 SCROLL	BFF8 SDATA
C61F SEEKZERO	C296 SERIN	C11E SERISOUT	03B8 SERMODE
C18C SEROUT	C191 SEROUT2	C19D SEROUT3	C117 SERPORT
C100 SERSLOT	C146 SERVID	CDC0 SET40	C001 SET80COL

CDBE SET80	COOD SET80VID	COOF SETALTCHAR	CO09 SETALTZP
?C059 SETANO	?C05B SETAN1	?C05D SETAN2	C05F SETAN3
C184 SETCH	?F864 SETCOL	FEEE SETCUR1	FEEC SETCUR
CB67 SETDBAS	?FB40 SETGR	CE23 SETHOOKS	FE86 SETIFLG
FE80 SETINV	?C454 SETIOU	CDA1 SETIT	FE89 SETKBD
FE1D SETMDZ	FE18 SETMODE	FE84 SETNORM	?FAA9 SETPG3
FAAB SETPLP	?FB6F SETPWRC	C360 SETROM	CB88 SETSRC
C008 SETSTDZP	CACD SETTERM	?FB39 SETTXT	C233 SETUP
CB83 SETUP2	FE93 SETVID	FB4B SETWND	CE1A SETX
CBC1 SEV1	CC4C SHOWCUR	C45E SILOOP	C2BE SINOMOD
C205 SIN 2B SLOTZ	C465 SINOCH C1	CBA8 SKPLFT C46C SMINVALID	CBB4 SKPRT C18B SOCMD
C1E2 SDONE	SLTDMY 03F2 SOFTEV	C1BF SOMAIN	C1A9 SORDY
C1C1 SORDY2	C207 SOUT	C030 SPKR	49 SPNT
BFF9 SSTAT	CF29 STARTXY	48 STATUS	CAE6 STCLR
FB65 STITLE	?FEOB STOR	FBFO STORADV	C3B8 STORCH
C3DB STORE1	?C3F7 STORE4	C3C1 STORE	C3EE STORE2
?C3F2 STORE3	C3F9 STORE5	C3B3 STORY	CB21 STRTS
CAED STSET	CAF6 STWASOK	FFEO SUBTBL	C246 SUDODEF
C25C SUDONE	C249 SUNODEF	C257 SUOUT	C160 TAB
?FB5B TABV	?C020 TAPEOUT	C740 TBL1	C749 TBL2
C71B TBLLOOP2	C70D TBLLOOP	04F8 TEMP1	06F8 TEMP
0578 TEMPA	05F8 TEMPY	C293 TERM1	DF TERMCUR
C275 TESTKBD	0800 THBUF	?FB09 TITLE	C15E TOOFAR
FFBE TOSUB	06FF TRKEY	067F TRSER	05FF TWKEY
057F TWSER	C050 TXTCLR	C054 TXTPAGE1	C055 TXTPAGE2
C051 TXTSET	05FA TYPHED	CC91 UD2	C39B UPSHIFT
FC1A UP	CC70 UPDATE	C399 UPSHIFT0	03F8 USRADR
FECA USR OC VBLMODE	2D V2 FE36 VERIFY	C070 VBLCLR 067B VFACTV	C019 VBLINT FE58 VFYOK
CE31 VIDMODE	FC04 VIDOUT1	FBFD VIDOUT	FB78 VIDWAIT
F826 VLINEZ	F828 VLINE	04FB VMODE	FC30 VTAB40
FC22 VTAB	FB59 VTAB23	FC24 VTABZ	FCA8 WAIT
FCA9 WAIT2	FCAA WAIT3	FEEB WDTHCH	CDD5 WIN0
CDE0 WIN1	CDED WIN2	CDF2 WIN3	CEO2 WIN4
CDD2 WIN40 20 WNDLFT	CE18 WIN5 CEO4 WNDREST	CDD4 WIN80 22 WNDTOP	23 WNDBTM 21 WNDWDTH
C005 WRCARDRAM	?FECD WRITE	C004 WRMAINRAM	CD8D X.CUR.OFF
CD89 X.CUR.ON	CDB7 X.SI	CDB0 X.SO	C3A5 X.UPSHIFT
FDB3 XAM	FDA3 XAM8	FDC6 XAMP	FEBO XBASIC
C9AD XBITKBD	C9C0 XKBK1	C9C2 XKBK2	06FB XCOORD
cff6 XFERAZP	CFE0 XFERC2M	CFE6 XFERZP	CFCD XFER
C752 XLOOP1	C780 XMBASIC	C78D XMBOUT	C490 XMCDONE
C4B0 XMCLAMP	C484 XMCLEAR	C59A XMDONE	C473 XMH2
C471 XMHLOOP	C46D XMHOME	C4CF XMINT	C763 XMODE
C495 XMREAD	C50C XMSKIP	C4FC XMTSTINT	C9A8 XNOKEY
C8F0 XNOSBUF	91 XON	C758 XPAGE	C4A4 XRBUT
C4AB XRBUT2 46 XREG	C98F XRDKBD C9AO XRKBD1	C8C5 XRDSER C423 XRLOOP	C8FF XRDSNO C766 XRSET
C76E XRST1	C43D XSETMOU	C452 XSOFF	?C100 XXX
0008 YHI	47 YREG	35 YSAV1	34 YSAV
FFC7 ZMODE	C7FB ZZNM1	CB24 ZZNM2	CE4D ZZQUIT

\*\* SUCCESSFUL ASSEMBLY := NO ERRORS  
 \*\* ASSEMBLER CREATED ON 15-JAN-84 21:28  
 \*\* TOTAL LINES ASSEMBLED 4406  
 \*\* FREE SPACE PAGE COUNT 47



# *Glossary*

**65C02:** The microprocessor used in the Apple IIc computer.

**ACIA:** Asynchronous Communications Interface Adapter. A single chip that converts data from parallel to serial form, and vice versa, and handles serial transmission and reception and RS-232-C signals, under the control of its internal registers set and changed by firmware or software.

**accumulator:** The register in the 6502 and 65C02 microprocessors where most computations are performed.

**acronym:** A word formed from the initial letters of a name or phrase, such as ROM, from read-only memory.

**ADC:** See **analog-to-digital converter**.

**address:** A number used to identify something, such as a location in the computer's memory.

**analog:** Represented in terms of a physical quantity that can vary smoothly and continuously over a range of values. For example, a conventional 12-hour clock face is an analog device that represents the time of day in terms of the angles of the clock's hands. Compare **digital**.

**analog-to-digital converter:** A device that converts quantities from analog to digital form. For example, the Apple IIc's hand control converts the position of the control dial (an analog quantity) into a discrete number (a digital quantity) that changes in steps even when the dial is turned smoothly.

**AND:** A logical operator that produces a true result if both of its operands are true, a false result if either or both of its operands are false; compare **OR**, **exclusive OR**, **NOT**.

**Apple IIc:** A personal computer in the Apple II family, manufactured and sold by Apple Computer, Inc.

**Applesoft:** An extended version of the BASIC programming language used with the Apple IIc computer. The firmware for interpreting and executing programs in Applesoft is included in the Apple IIc ROM.

**ASCII:** American Standard Code for Information Interchange; a code in which the numbers from 0 to 127 stand for text characters, used for representing text inside a computer and for transmitting text between computers or between a computer and a peripheral device.

**assembler:** A language translator that converts a program written in assembly language into an equivalent program in machine language.

**assembly language:** A low-level programming language in which individual machine-language instructions are written in a symbolic form more easily understood by a human programmer than machine language itself.

**asserted:** Made true (positive in positive-true logic; negative in negative-true logic).

**asynchronous:** Having a variable time interval between characters.

**back panel:** The rear face of the Apple IIc computer, which includes the power switch, the power connector, and connectors for two serial devices, a video display device, an external disk drive, and a mouse or hand control.

**bandwidth:** A measure of the range of frequencies a device can handle. In the case of a video monitor, greater bandwidth enables it to display more information; to display 80 columns of text, a monitor should have a bandwidth of at least 12 MHz.

**base address:** In indexed addressing, the fixed component of an address.

**baud:** A unit of signaling speed equal to the number of discrete conditions or signal events per second. Often equated (though not precisely) with bits per second.

**binary:** The representation of numbers in terms of powers of two, using the two digits 0 and 1. Commonly used in computers, since the values 0 and 1 can easily be represented in physical form in a variety of ways, such as the presence or absence of current, positive or negative voltage, or a white or black dot on the display screen.

**bit:** A binary digit (0 or 1); the smallest possible unit of information, consisting of a simple two-way choice, such as yes or no, on or off, positive or negative, something or nothing.

**board:** See **printed-circuit board**.

**boot:** To start up a computer by loading a program into memory from an external storage medium such as a disk. Often accomplished by first loading a small program whose purpose is to read the larger program into memory. The program is said to *pull itself up by its own bootstraps*.

**bootstrap:** See **boot**.

**BREAK:** A SPACE (0) signal sent over a communication line, of long enough duration to interrupt the sender. This signal is often used to end a session with a timesharing service.

**BRK:** A 65C02 instruction that causes the microprocessor to halt.

**buffer:** An area of the computer's memory used as a *holding area* where information can be stored by one program or device and then read out by another at a different speed.

**bus:** A group of wires that transmit related information from one part of a computer system to another. In the Apple IIc, the address bus has 16 wires, and the data bus has eight.

**byte:** A unit of information consisting of a fixed number of bits; on the Apple IIc, one byte consists of eight bits and can represent any value between 0 and 255.

**carriage return:** An ASCII character (decimal 13; Appendix H) that ordinarily causes a printer or display device to place the subsequent character on the left margin. On a manual typewriter, this movement is combined with line feed (the advancement of the paper to the next line). With computers, carriage return and line feed are separate, causing hair-raising problems for the user.

**carrier:** The background signal on a communication channel that is modified to *carry* the information. Under RS-232-C rules, the carrier signal is equivalent to a continuous MARK (1) signal; a transition to 0 then represents a start bit.

**carry flag:** The C bit in the 65C02 processor status register, used to hold the *carry bit* in addition and subtraction.

**cathode-ray tube:** An electronic device, such as a television picture tube, that produces images on a screen coated with phosphors that emit light when struck by a focused beam of electrons.

**central processing unit:** See **processor**.

**character:** A letter, digit, punctuation mark, or other symbol used in printing, displaying or transferring information.

**character code:** A number used to represent a text character for processing by a computer system.

**chip:** The small piece of semiconducting material (usually silicon) on which an integrated circuit is fabricated.

**Clear To Send:** An RS-232-C signal from a DCE to a DTE that is normally kept false until the DCE makes it true, indicating that all circuits are ready to transfer data out.

**code:** (1) A number or symbol used to represent some piece of information in a compact or easily processed form. (2) The statements or instructions making up a program.

**cold start:** The process of starting up the Apple IIc when the power is first turned on (or as if the power had just been turned on) by loading the operating system into main memory, then loading and running a program. Compare **warm start**.

**command:** A communication from the user to a computer system (usually typed from the keyboard) directing it to perform some action.

**command character:** An ASCII character, usually **CONTROL-A** or **CONTROL-I**, that causes the serial port firmware to interpret subsequent characters as a command.

**command register** An ACIA location (at address \$C09A for port 1 and \$C0AA for port 2) that stores parity type and RS-232-C signal characteristics.

**communication mode:** An operating state in which serial port 2 (or 1, if so set) is prepared to exchange data and signals with a DCE (such as a modem).

**compiler:** A language translator that converts a program written in a high-level programming language into an equivalent program in some lower-level language (such as machine language) for later execution. Compare **interpreter**.

**composite video:** A video signal that includes both display information and the synchronization (and other) signals needed to display it.

**computer:** An electronic device for performing predefined (programmed) computations at high speed and with great accuracy.

**computer system:** A computer and its associated hardware, firmware, and software.

**connector:** A physical device such as a plug, socket, or jack, used to connect two devices to one another.

**control character:** A character that controls or modifies the way information is printed or displayed. Control characters have ASCII codes between \$00 and \$1F (or between \$80 and \$9F if the high-order bit is set). You can generate them at the Apple IIc keyboard by holding down CONTROL while typing one of the letter keys or @ [ \ ] ^ or \_.

**control register:** An ACIA location (at address \$C09B for port 1, or \$C0AB for port 2) that stores data format and baud rate selections.

**CPU:** Central processing unit; see **processor**.

**CRT:** See **cathode-ray tube**.

**cursor:** A symbol displayed on the screen that marks where the user's next action will take effect or where the next character typed from the keyboard will appear.

**DAC:** See **digital-to-analog converter**.

**data:** Information; especially information used or operated on by a program.

**data bit:** One of five to eight bits representing a character.

**Data Carrier Detect:** An RS-232-C signal from a DCE (such as a modem) to a DTE (such as an Apple IIc) indicating that a communication connection has been established.

**Data Communication Equipment:** As defined by the RS-232-C standard, any device that transmits or receives information. Usually this is a modem. However, when a Modem Eliminator is used, the Apple IIc itself looks like a DCE to the other device, and the other device looks like a DCE to the Apple IIc.

**data format:** The form in which data is stored, manipulated or transferred. Serial data transmitted and received by port 1 or 2 has a data format of: one start bit, five to eight data bits, an optional parity bit, and one, one and a half, or two stop bits.

**Data Set Ready:** An RS-232-C signal from a DCE to a DTE indicating that the DCE has established a connection.

**Data Terminal Equipment:** As defined by the RS-232-C standard, any device that generates or absorbs information, thus acting as a terminus of a communication connection.

**Data Terminal Ready:** An RS-232-C signal from a DTE to a DCE indicating a readiness to transmit or receive data.

**DCD:** See **Data Carrier Detect**.

**DCE:** See **Data Communication Equipment**.

**debug:** To locate and correct an error or the cause of a problem or malfunction in a computer system. Typically used to refer to software-related problems.

**decimal:** The common form of number representation used in everyday life, in which numbers are expressed in terms of powers of ten, using the ten digits 0 to 9.

**default:** A value, action, or setting that is assumed or set in the absence of explicit instructions otherwise.

**demodulate:** To recover the information being transmitted by a modulated signal; for example, a conventional radio receiver demodulates an incoming broadcast signal to convert it into sound emitted by a speaker.

**device:** (1) A physical apparatus for performing a particular task or achieving a particular purpose. (2) In particular, a hardware component of a computer system.

**digit:** (1) One of the characters 0 to 9, used to express numbers in decimal form. (2) One of the characters used to express numbers in some other form, such as 0 and 1 in binary or 0 to 9 and A to F in hexadecimal.

**digital:** Represented in a discrete (noncontinuous) form, such as numerical digits. For example, contemporary digital clocks display the time in numerical form (such as 2:57) instead of using the positions of a pair of hands on a clock face. Compare **analog**.

**digital-to-analog converter:** A device that converts quantities from digital to analog form.

**DIP:** See **dual in-line package**.

**disassembler:** A language translator that converts a machine-language program into an equivalent program in assembly language, more easily understood by a human programmer. The opposite of an assembler.

**disk:** An information storage medium consisting of a flat, circular magnetic surface on which information can be recorded in the form of small magnetized spots, similarly to the way sounds are recorded on tape.

**disk drive:** A device that writes and reads information on the surface of a magnetic disk.

**diskette:** A term sometimes used for the small (5-1/4-inch) flexible disks used with the Apple Disk II drive.

**Disk II drive:** A model of disk drive made and sold by Apple Computer for use with the Apple IIe computer; uses 5-1/4-inch flexible (*floppy*) disks.

**Disk Operating System:** An optional software system for the Apple IIe that enables the computer to control and communicate with one or more Disk II drives.

**display:** (1) Information exhibited visually, especially on the screen of a display device. (2) To exhibit information visually. (3) A display device.

**display device:** A device that exhibits information visually, such as a television receiver or video monitor.

**display screen:** The glass or plastic panel on the front of a display device, on which images are displayed.

**DOS:** See **Disk Operating System**.

**DSR:** See **Data Set Ready**.

**DTE:** See **Data Terminal Equipment**.

**DTR:** See **Data Terminal Ready**.

**dual in-line package:** An integrated circuit packaged in a narrow rectangular box with a row of metal pins along each side; similar in appearance to an armored centipede.

**echo:** To send an input character to a video display, printer, or other output device.

**edit:** To change or modify; for example, to insert, remove, replace, or move text in a document.

**editor:** A program that enables the user to create and edit information of a particular form; for example, a *text editor* or a *graphics editor*.

**effective address:** In machine-language programming, the address of the memory location on which a particular instruction actually operates, which may be arrived at by indexed addressing or some other addressing method.

**emulation mode:** A manner of operating in which one computer or interface imitates another.

**even parity:** Use of an extra bit set to 0 or 1 as necessary to make the total number of 1 bits (among the data bits plus the parity bit) an even number.

**error message:** A message displayed or printed to notify the user of an error or problem in the execution of a program.

**escape mode:** A state of the Apple IIe computer, entered by pressing the `ESC` key, in which certain keys on the keyboard take on special meanings for positioning the cursor and controlling the display of text on the screen.

**escape sequence:** A sequence of keystrokes, beginning with `ESC`, used for positioning the cursor and controlling the display of text on the screen.

**exclusive OR:** A logical operator that produces a true result if one of its operands is true and the other false, a false result if its operands are both true or both false; compare **OR**, **AND**, **NOT**.

**execute:** To perform or carry out a specified action or sequence of actions, such as those described by a program.

**firmware:** Software stored permanently in hardware: programs in read-only memory (ROM). Such programs (for example, the Applesoft interpreter and the Apple IIc Monitor program) are built into the computer at the factory; they can be executed at any time but cannot be modified or erased from main memory. Compare **hardware**, **software**.

**fixed-point:** A method of representing numbers inside the computer in which the decimal point (more correctly, the binary point) is considered to occur at a fixed position within the

number. Typically, the point is considered to lie at the right end of the number, so that the number is interpreted as an integer. Compare **floating-point**.

**flexible disk:** A disk made of flexible plastic; often called a *floppy* disk. Compare **rigid disk**.

**floating-point:** A method of representing numbers inside the computer in which the decimal point (more correctly, the binary point) is permitted to *float* to different positions within the number. Some of the bits within the number itself are used to keep track of the point's position. Compare **fixed-point**.

**form feed:** An ASCII character (decimal 12; Appendix H) that causes a printer or other paper-handling device to advance to the top of the next page.

**framing error:** In serial data transfer, absence of the expected stop bit(s) at the end of a received character. The serial port 1 and 2 ACIAs record this error by setting bit 1 (FRM) of its status register to 1. The ACIA checks and records each framing error separately: if the next character is OK, the FRM bit is cleared.

**full duplex:** Capable of simultaneous two-way communication.

**graphics:** (1) Information presented in the form of pictures or images. (2) The display of pictures or images on a computer's display screen. Compare **text**.

**half duplex:** Capable of communication in one direction at a time.

**hand control:** An optional peripheral device that can be connected to the Apple IIc's hand control connector and has a rotating dial and a pushbutton; typically used to control game-playing programs, but can be used in more serious applications as well.

**hand control connector:** A 9-pin connector on the Apple IIc's back panel, used for connecting hand controls to the computer.

**hardware:** Those components of a computer system consisting of physical (electronic or mechanical) devices. Compare **software, firmware**.

**hertz:** The unit of frequency of vibration or oscillation, also called cycles per second; named for the physicist Heinrich Hertz and abbreviated Hz. The Apple IIc's 65C02 microprocessor operates at a clock frequency of 1 million hertz, or 1 megahertz (MHz).

**hexadecimal:** The representation of numbers in terms of powers of sixteen, using the sixteen digits 0 to 9 and A to F. Hexadecimal numbers are easier for humans to read and understand than binary numbers, but can be converted easily and directly to binary form: each hexadecimal digit corresponds to a sequence of four binary digits, or bits.

**high-level language:** A programming language that is relatively easy for humans to understand. A single statement in a high-level language typically corresponds to several instructions of machine language.

**high-order byte:** The more significant half of a memory address or other two-byte quantity. In the Apple IIc's 65C02 microprocessor, the low-order byte of an address is usually stored first and the high-order byte second.

**high-resolution graphics:** The display of graphics on the Apple IIc's display screen as a six-color array of points, 280 columns wide and 192 rows high.

**hold time:** In computer circuits, the amount of time a signal must remain valid after some related signal has been turned off; compare **setup time**.

**Hz:** See **hertz**.

**IC:** See **integrated circuit**.

**index:** (1) A number used to identify a member of a list or table by its sequential position. (2) A list or table whose entries are identified by sequential position. (3) In machine-language programming, the variable component of an indexed address, contained in an index register and added to the base address to form the effective address.

**indexed addressing:** A method of specifying memory addresses used in machine-language programming.

**index register:** A register in a computer processor that holds an index for use in indexed addressing. The Apple IIc's 65C02 microprocessor has two index registers, called the X register and the Y register.

**input:** (1) Information transferred into a computer from some external source, such as the keyboard, a disk drive, or a modem. (2) The act or process of transferring such information.

**instruction:** A unit of a machine-language or assembly-language program corresponding to a single action for the computer's processor to perform.

**integer:** A whole number, with no fractional part; represented inside the computer in fixed-point form.

**integrated circuit:** An electronic component consisting of many circuit elements fabricated on a single piece of semiconducting material, such as silicon; see **chip**.

**interface:** The devices, rules, or conventions by which one component of a system communicates with another.

**interpreter:** A language translator that reads a program written in a particular programming language and immediately carries out the actions that the program describes. Compare **compiler**.

**interrupt:** A temporary suspension in the execution of a program by a computer in order to perform some other task, typically in response to a signal from a peripheral device or other source external to the computer.

**inverse video:** The display of text on the computer's display screen in the form of black dots on a white (or other single phosphor color) background, instead of the usual white dots on a black background.

**I/O:** Input/output; the transfer of information into and out of a computer. See **input**, **output**.

**I/O device:** Input/output device; a device that transfers information into or out of a computer. See **input**, **output**, **peripheral device**.

**I/O link:** A fixed location that contains the address of an input/output subroutine in the Apple IIC Monitor program.

**K:** Two to the tenth power, or 1024 (from the Greek root *kilo*, meaning one thousand); for example, 64K equals 64 times 1024, or 65,536.

**keyboard:** The set of keys built into the Apple IIC computer, similar to a typewriter keyboard, for typing information to the computer.

**keystroke:** The act of pressing a single key or a combination of keys (such as **CONTROL**-**C**) on the Apple IIc keyboard.

**kilobyte:** A unit of information consisting of 1K (1024) bytes, or 8K (8192) bits; see **K**.

**KSW:** The symbolic name of the location in the Apple IIc's memory where the standard input link is stored; stands for *keyboard switch*. See **I/O link**.

**language:** See **programming language**.

**language translator:** A system program that reads a program written in a particular programming language and either executes it directly or converts it into some other language (such as machine language) for later execution. See **interpreter**, **compiler**, **assembler**.

**least significant bit:** The right-hand bit of a binary number as written down; its positional value is 0 or 1.

**line feed:** An ASCII character (decimal 10; Appendix H) that ordinarily causes a printer or video display to advance to the next line.

**load:** To transfer information from a peripheral storage medium (such as a disk) into main memory for use; for example, to transfer a program into memory for execution.

**local:** Nearby; capable of direct connection using wires only.

**location:** See **memory location**.

**logical operator:** An operator, such as **AND**, that combines logical values to produce a logical result.

**low-level language:** A programming language that is relatively close to the form that the computer's processor can execute directly. Low-level languages available for the Apple IIc include 65C02 machine language and 65C02 assembly language.

**low-order byte:** The less significant half of a memory address or other two-byte quantity. In the Apple IIc's 65C02 microprocessor, the low-order byte of an address is usually stored first and the high-order byte second.

**low-power Schottky:** A type of TTL integrated circuit having lower power and higher speed than a conventional TTL integrated circuit.

**low-resolution graphics:** The display of graphics on the Apple IIc's display screen as a sixteen-color array of blocks, 40 columns wide and 48 rows high.

**machine language:** The form in which instructions to a computer are stored in memory for direct execution by the computer's processor. Each model of computer processor (such as the 65C02 microprocessor used in the Apple IIc) has its own form of machine language.

**main memory:** The memory component of a computer system that is built into the computer itself and whose contents are directly accessible to the processor.

**MARK parity:** A bit of value 1 appended to a binary number for transmission. The receiving device can then check for errors by looking for this value on each character.

**memory:** A hardware component of a computer system that can store information for later retrieval; see **main memory**, **random-access memory**, **read-only memory**, **read-write memory**.

**memory location:** A unit of main memory that is identified by an address and can hold a single item of information of a fixed size; in the Apple IIc, a memory location holds one byte, or eight bits, of information.

**MHz:** Megahertz; one million hertz. See **hertz**.

**microcomputer:** A computer, such as the Apple IIc, whose processor is a microprocessor.

**microprocessor:** A computer processor contained in a single integrated circuit, such as the 65C02 microprocessor used in the Apple IIc.

**microsecond:** One millionth of a second; abbreviated us.

**millisecond:** One thousandth of a second; abbreviated ms.

**mode:** A state of a computer or system that determines its behavior.

**modem:** Modulator/demodulator; a peripheral device that enables the computer to transmit and receive information over a telephone line; a DCE that connects a DTE to communication lines.

**modem eliminator:** The physical crossing of wires that replaces a pair of modems for direct connection of two DTEs.

**modulate:** To modify or alter a signal so as to transmit information; for example, conventional broadcast radio transmits sound by modulating the amplitude (amplitude modulation, or AM) or the frequency (frequency modulation, or FM) of a carrier signal.

**monitor:** See **video monitor**.

**Monitor program:** A system program built into the Apple IIc in firmware, used for directly inspecting or changing the contents of main memory and for operating the computer at the machine-language level.

**most significant bit:** The leftmost bit of a binary number as written down. This bit represents 0 or 1 times 2 to the power one less than the total number of bits in the binary number. For example, in the binary number 10000, which contains five digits, the 1 represents 1 times two to the fourth power—or sixteen.

**nanosecond:** One billionth (in British usage, one thousand-millionth) of a second; abbreviated ns.

**network:** A collection of interconnected, individually controlled computers, together with the hardware and software used to connect them.

**nibble:** A unit of information equal to half a byte, or four bits; can hold any value from 0 to 15. Sometimes spelled *nybble*.

**NOT:** A unary logical operator that produces a true result if its operand is false, a false result if its operand is true; compare **AND**, **OR**, **exclusive OR**.

**NTSC:** (1) National Television Standards Committee; the committee that defined the standard format used for transmitting broadcast video signals in the United States. (2) The standard video format defined by the NTSC.

**object code:** See **object program**.

**object program:** The translated form of a program produced by a language translator such as a compiler or assembler; also called object code. Compare **source program**.

**odd parity:** Use of an extra bit set to 0 or 1 as necessary to make the total number of 1 bits an odd number.

**opcode:** See **operation code**.

**operand:** A value to which an operator is applied; the value on which an opcode operates.

**operating system:** A software system that organizes the computer's resources and capabilities and makes them available to the user or to application programs running on the computer.

**operation code:** The part of a machine-language instruction that specifies the operation to be performed; often called **opcode**.

**operator:** A symbol or sequence of characters, such as `+` or `AND`, specifying an operation to be performed on one or more values (the operands) to produce a result.

**OR:** A logical operator that produces a true result if either or both of its operands are true, a false result if both of its operands are false; compare **exclusive OR, AND, NOT**.

**output:** Information transferred from a computer to some external destination, such as the display screen, a disk drive, a printer, or a modem.

**overrun:** A condition that occurs when the Apple IIc processor does not retrieve a received character from the ACIAs receive data register before the subsequent character arrives. The ACIA automatically sets bit 2 (OVR) of its status register; subsequent characters are lost. The receive data register contains the last valid data word received.

**page:** (1) A screenful of information on a video display, consisting on the Apple IIc of 24 lines of 40 or 80 characters each. (2) An area of main memory containing text or graphical information being displayed on the screen. (3) A segment of main memory 256 bytes long and beginning at an address that is an even multiple of 256 bytes.

**page zero:** See **zero page**.

**parallel interface:** An interface in which many bits of information (typically eight bits, or one byte) are transmitted simultaneously over different wires or channels. Compare **serial interface**.

**parity:** Maintenance of a sameness of level or count, usually the count of 1 bits in each character, for error checking.

**parity error:** Absence of the correct parity bit value in a received character. The serial port ACIAs record this error by setting bit 0 (PAR) of their status registers to 1.

**PC board:** See **printed-circuit board**.

**phase:** (1) A stage in a periodic process; a point in a cycle; for example, the 65C02 microprocessor uses a clock cycle consisting of two phases called PHI0 and PHI1. (2) The relationship between two periodic signals or processes; for example, in NTSC color video, the color of a point on the screen is expressed by the instantaneous phase of the video signal relative to the color reference signal.

**pipelining:** A feature of a processor that enables it to begin fetching the next instruction before it has finished executing the current instruction. All other things equal, processors that have this feature run faster than those without it.

**pointer:** An item of information consisting of the memory address of some other item.

**pop:** To remove the top entry from a stack.

**port:** The point of connection, usually a physical connector, between a computer and a peripheral device, another computer, or a network.

**power supply:** The hardware component of a computer that draws electrical power from a power outlet and converts it to the forms needed by some other hardware component.

**printed-circuit board:** A hardware component of a computer or other electronic device, consisting of a flat, rectangular piece of rigid material, commonly fiberglass, from which all conducting material except the desired circuits is etched, and to which integrated circuits and other electronic components are connected.

**processor:** The hardware component of a computer that performs the actual computation by directly executing instructions represented in machine language and stored in main memory.

**program:** (1) A set of instructions describing actions for a computer to perform in order to accomplish some task, conforming to the rules and conventions of a particular programming language. (2) To write a program.

**programming language:** A set of rules or conventions for writing programs.

**prompt:** To remind or signal the user that some action is expected, typically by displaying a distinctive symbol, a reminder message, or a menu of choices on the display screen.

**prompt character:** A text character displayed on the screen to prompt the user for some action. Often also identifies the program or component of the system that is doing the prompting; for example, the prompt character ] is used by the Applesoft BASIC interpreter, > by Integer BASIC, and \* by the system Monitor program.

**prompt message:** A message displayed on the screen to prompt the user for some action.

**protocol:** A predefined exchange of control signals between devices enabling them to prepare for and carry out coordinated data transfers.

**push:** To add an entry to the top of a stack.

**radio-frequency modulator:** A device for converting the video signals produced by a computer to a form that can be accepted by a television receiver.

**RAM:** See **random-access memory**.

**random-access memory:** Memory in which the contents of individual locations can be referred to in an arbitrary or random order.

**raster:** The pattern of parallel lines making up the image on a video display screen. The image is produced by controlling the brightness of successive dots on the individual lines of the raster.

**read:** To transfer information into the computer's memory from a source external to the computer (such as a disk drive or modem) or into the computer's processor from a source external to the processor (such as the keyboard or main memory).

**read-only memory:** Memory whose contents can be read but not written; used for storing firmware. Information is written into read-only memory once, during manufacture; it then remains there permanently, even when the computer's power is turned off, and can never be erased or changed. Compare **read-write memory**, **random-access memory**, **write-only memory**.

**read-write memory:** Memory whose contents can be both read and written; often misleadingly called *random-access memory*, or *RAM*. The information contained in read-write memory is erased when the computer's power is turned off, and is

permanently lost unless it has been saved on a more permanent storage medium, such as a disk. Compare **read-only memory**, **random-access memory**, **write-only memory**.

**receive data register:** A read-only register in each serial port ACIA (at location \$C098 for port 1 and \$C0A8 for port 2) that stores the most recent character successfully received.

**register:** A location in a computer processor where an item of information, such as a byte, is held and modified under program control. Registers in the 65C02 microprocessor include the accumulator (A), two index registers (X and Y), the stack pointer (S), the processor status register (P), and the program counter (PC). The PC register holds two bytes (sixteen bits); the other registers hold one byte (eight bits) each.

**remote:** Too distant for direct connection using wires or cables only.

**Request To Send:** An RS-232-C signal from a DTE to a DCE to prepare the DCE for data transmission.

**return address:** The point in a program to which control returns on completion of a subroutine.

**RF modulator:** See **radio-frequency modulator**.

**RI:** See **Ring Indicator**.

**rigid disk:** A disk made of a hard, nonflexible material. Compare **flexible disk**.

**Ring Indicator:** An optional RS-232-C signal from a DCE to a DTE that indicates the arrival of a call.

**ROM:** See **read-only memory**.

**routine:** A part of a program that accomplishes some task subordinate to the overall task of the program.

**RS-232-C:** A standard created by the Electronic Industries Association (EIA) to allow devices of different manufacturers to exchange serial data—particularly via telephone lines.

**RTS:** See **Request To Send**.

**run:** (1) To execute a program. (2) To load a program into main memory from a peripheral storage medium, such as a disk, and execute it.

**save:** To transfer information from main memory to a peripheral storage medium for later use.

**screen:** See **display screen**.

**scroll:** To change the contents of all or part of the display screen by shifting information out at one end (most often the top) to make room for new information appearing at the other end (most often the bottom), producing an effect like that of moving a scroll of paper past a fixed viewing window. See **viewport, window**.

**serial interface:** An interface in which information is transmitted sequentially, one bit at a time, over a single wire or channel. Compare **parallel interface**.

**setup time:** The amount of time a signal must be valid in advance of some event; compare **hold time**.

**silicon:** A non-metallic, semiconducting chemical element from which integrated circuits are made.

**soft switch:** A means of changing some feature of the Apple IIc from within a program; specifically, a location in memory that produces some special effect whenever its contents are read or written.

**software:** Those components of a computer system consisting of programs that determine or control the behavior of the computer. Compare **hardware, firmware**.

**source code:** See **source program**.

**source program:** The original form of a program given to a language translator such as a compiler or assembler for conversion into another form; sometimes called *source code*. Compare **object program**.

**space character:** A text character whose printed representation is a blank space, typed from the keyboard by pressing the SPACE bar.

**SPACE parity:** A bit of value 0 appended to a binary number for transmission. The receiving device can look for this value on each character as a means of error checking.

**stack:** A list in which entries are added or removed at one end only (the top of the stack), causing them to be removed in LIFO (last-in-first-out) order.

**start bit:** A transition from a MARK signal to a SPACE signal for one bit-time, indicating that the next string of bits represents a character.

**status register:** A register in an ACIA (at location \$C099 for port 1 and \$C0A9 for port 2) that stores the state of two of the RS-232-C signals and the state of the transmit and receive data registers, as well as the outcome of the most recent character transfer.

**stop bit:** A MARK signal following a string of data bits (or their optional parity bit) to indicate the end of a character.

**string:** An item of information consisting of a sequence of text characters.

**strobe:** (1) An event, such as a change in a signal, that triggers some action. (2) A signal whose change is used to trigger some action.

**subroutine:** A part of a program that can be executed on request from any point in the program, and which returns control to the point of the request on completion.

**television receiver:** A display device capable of receiving broadcast video signals (such as commercial television) by means of an antenna. Can be used in combination with a radio-frequency modulator as a display device for the Apple IIc computer. Compare **video monitor**.

**television set:** See **television receiver**.

**terminal:** A device consisting of a typewriterlike keyboard and a display device, used for communicating between a computer system and a human user. Personal computers such as the Apple IIc typically have all or part of a terminal built into them.

**terminal mode:** An operating state of the Apple IIc communication port in which the firmware makes the computer act like a simple ASCII terminal.

**text:** (1) Information presented in the form of characters readable by humans. (2) The display of characters on the Apple IIc's display screen. Compare **graphics**.

**text window:** An area on the Apple IIc's display screen within which text is displayed and scrolled.

**transistor-to-transistor logic:** (1) A family of integrated circuits used in computers and related devices. (2) A standard for interconnecting such circuits that defines the voltages used to represent logical zeros and ones.

**transmit data register:** A write-only register in one of the serial port ACIAs (at location \$C098 for port 1 and \$C0A8 for port 2) that holds the current character to be transmitted.

**troubleshoot:** To locate and correct the cause of a problem or malfunction in a computer system. Typically used to refer to hardware-related problems; compare **debug**.

**TTL:** See **transistor-to-transistor logic**.

**unary operator:** An operator that applies to a single operand; for example, the minus sign (–) in a negative number such as –6 is a unary arithmetic operator.

**user:** The person operating or controlling a computer system.

**user interface:** The rules and conventions by which a computer system communicates with the person operating it.

**vector:** (1) The starting address of a program segment, when used as a common point for transferring control from other programs. (2) A memory location used to hold a vector, or the address of such a location.

**video:** (1) A medium for transmitting information in the form of images to be displayed on the screen of a cathode-ray tube. (2) Information organized or transmitted in video form.

**video monitor:** A display device capable of receiving video signals by direct connection only, and which cannot receive broadcast signals such as commercial television. Can be connected directly to the Apple IIc computer as a display device. Compare **television receiver**.

**viewport:** All or part of the display screen, used by an application program to display a portion of the information (such as a document, picture, or worksheet) that the program is working on. Compare **window**.

**warm start:** The process of restarting the Apple IIc after the power is already on, without reloading the operating system into main memory and often without losing the program or information already in main memory. Compare **cold start**.

**window:** The portion of a collection of information (such as a document, picture, or worksheet) that is visible in a viewport on the display screen; compare **viewport**.

**word:** A group of bits of a fixed size that is treated as a unit; the number of bits in a word is a characteristic of each particular computer.

**wraparound:** The automatic continuation of text from the end of one line to the beginning of the next, as on the display screen or a printer.

**write:** To transfer information from the computer to a destination external to the computer (such as a disk drive, printer, or modem) or from the computer's processor to a destination external to the processor (such as main memory).

**X register:** One of the index registers in the 65C02 microprocessor.

**Y register:** One of the index registers in the 65C02 microprocessor.

**zero page:** The first page (256 bytes) of the Apple IIc's memory, also called *page zero*. Since the high-order byte of any address in this page is zero, only the low-order byte is needed to specify a zero-page address; this makes zero-page locations more efficient to address, in both time and space, than locations in any other page of memory.



A vertical blue line is located on the right edge of the page.

# *Bibliography*

*Apple II Monitors Peeled.* Cupertino, Calif.: Apple Computer, Inc., 1978.

Currently not updated for Apple IIe and IIc, but a good introduction to Apple II series input/output procedures; also useful for historical background.

*Apple IIe Design Guidelines.* Cupertino, Calif.: Apple Computer, Inc., 1982.

*Addendum to the Design Guidelines.* Cupertino, Calif.: Apple Computer, Inc., 1984.

*Apple IIe Reference Manual.* Cupertino, Calif.: Apple Computer, Inc., 1982.

*Applesoft BASIC Programmer's Reference Manual, Volumes 1 and 2.* For the Apple II, IIe, and IIc. Cupertino, Calif.: Apple Computer, Inc., 1982.

The version that applies to both the Apple IIe and the Apple IIc has Apple product number A2L0084 (Vol. 1) and A2L0085 (Vol.2).

*Applesoft Tutorial.* Cupertino, Calif.: Apple Computer, Inc., 1982.

Leventhal, Lance. *6502 Assembly Language Programming.* Berkeley, Calif.: Osborne/McGraw-Hill, 1979.

*Synertek Hardware Manual*. Santa Clara, Calif.: Synertek Incorporated, 1976.

Does not contain instructions new to 65C02, but is the only currently available manufacturer's hardware manual for 6500 series microcomputers.

*Synertek Programming Manual*. Santa Clara, Calif.: Synertek, Incorporated, 1976.

The only currently available manufacturer's programming manual for 6500 series microcomputers.

Watson, Allen, III. "A Simplified Theory of Video Graphics, Part I." *Byte* Vol. 5, No. 11 (November, 1980).

———. "A Simplified Theory of Video Graphics, Part II." *Byte* Vol. 5, No. 12 (December, 1980).

———. "More Colors for Your Apple." *Byte* Vol. 4, No. 6 (June, 1979).

———. "True Sixteen-Color Hi-Res." *Apple Orchard* Vol. 5, No. 1 (January, 1984).

Wozniak, Steve: "System Description: The Apple II." *Byte* Vol. 2, No. 5 (May, 1977).



A vertical blue line is located on the right side of the page, extending from the top to the bottom.

# *Index*

References to entries in Volume 2 are in square brackets [ ].

### ***Cast of Characters***

- \* (asterisk) 179
- \ (backslash) 59
- \_ (blinking underscore cursor) 154
- > (greater than sign) 59
- ? (question mark) 58, 59
- ] (right bracket) 59

### **A**

- A register 17
- accumulator 17
- ACIA 134, 148, 253-262, [63]
  - block diagram 255
  - interrupts [60]
- address bus 12, 213
- AKD 218-219
- ALTCHAR 104-105, 218, [73]
- alternate character set 68, [73]
- ALTZP 25, 26, 216, [46]
- analog inputs 176, [68]
- annunciator outputs [76]
- ANSI [84]
- any-key-down 79, 229
  - flag [66]
- Apple Extended 80-Column
  - Text Card [67, 74]
- Apple Language Card [64]

- Apple II series differences [60-78]
- Apple IIc
  - block diagram 210
  - care of 205-206
  - differences from Apple IIe [61-78]
  - expansion 2
- Apple IIe ROMs [72]
- Applesoft & commands 52
- Applesoft BASIC 59, [16-18, 40]
  - BASIC interpreter 24
- Applesoft interpreter 21, 224-225
- arithmetic, hexadecimal 193
- ASCII [71, 83, 86-87]
  - character set 79, [97, 114-122]
- assemblers 199
- assembly language, and mouse 171
- asterisk (\*) 179
- automatic line feed 131, 145
- automatic repeat 3
- Autostart ROM [69]
- auxiliary memory screen holes
  - 135-136, 149-150
  - See also* screen holes
- auxiliary RAM 20
- AUXMOVE *See* MOVEAUX
- AY-3600-type keyboard decoder 229

**B**

B command 131, 144  
back panel 8, 9  
backslash (\) 59, 62  
backspace 62  
bank 25  
bank-switched memory 22, [64, 69]  
BANK2 216  
BASIC 130, 163, 175-177, 179, 180,  
    192, [114]  
    and assembly language support 171  
    and hand controls 173  
    and mouse 163, 172  
*BASIC* disk [39, 69]  
baud rate 137, 258  
BCLK 256  
BELL 84  
BELL1 84  
BIT instruction [3]  
bits [103]  
blanking intervals 233  
blinking underscore cursor (\_) 154  
block diagrams  
    ACIA 255  
    Apple IIc 210  
BREAK 132, 137, 145  
break instructions [48]  
BREAK signal [75]  
BRK 75, 189, [43]  
buffer 59  
    serial I/O [75]  
built-in diagnostics [62]  
built-in disk drive 8  
built-in self-tests [65]  
button interrupt mode 164, 167  
bypassing firmware [58-60]  
byte(s) [103, 104]  
    power-up 51

**C**

C06X 267  
C07X 217  
C3COUT1 55, 64

C3KEYIN 55  
CALL statement 179  
Canadian keyboard [91]  
cancel line 62  
CAPS-LOCK 4, 79, [84]  
card(s) [74, 75]  
care of computer 205-206  
carriage return 139, 152  
carrier 137  
CAS (column-address strobe) 228  
cassette input and output [67-68, 77]  
certifications [99]  
CH (cursor horizontal) 63  
changing memory contents 184  
changing registers 190  
character(s)  
    flashing 68  
    generator 241  
    inverse 68  
    normal 68  
    sets [71, 73]  
chips, custom [78]  
clamping boundaries 171  
CLAMPMOUSE 168  
CLEARMOUSE 168  
CLEOLZ 116  
clock 211  
    master 213  
    system 213  
CLREOL 116  
CLREOP 116  
CLRSCR 117  
CLRTOP 117  
code conversions [114-122]  
cold-start procedure 49, 50  
colors  
    high-resolution 243  
    low-resolution 242, [63]  
command character 146, [75]  
command register 134, 148, 260  
Communication Card [74]  
communication port 141  
comparing data in memory 188-189

connector(s)  
back panel 8-9  
game [76]  
power 207  
serial port 257  
CONTINUE BASIC command 192  
CONTROL 4, 79, 229  
transferring 42-43  
control characters 64  
control register 134, 148, 258-259  
CONTROL-A, as command character 143  
CONTROL-C [53]  
CONTROL-H 62  
CONTROL-I, as command character 130, 132  
CONTROL-K, as command character 193  
CONTROL-P 56, 126, 142  
as command character 193  
CONTROL-R 155  
CONTROL-S [53]  
CONTROL-T 156, 159  
CONTROL-X 62  
CONTROL-Y 197  
commands 52  
CONTROL RESET 50  
conversion, number [106]  
COUT 55, 117, 191  
COUT1 55, 68, 117  
CP/M [40]  
CPU *See* 65C02  
CR *See* carriage return  
CREF 220, 221, 251  
CROUT 117  
CROUT1 117  
CSW 56, 70, 104  
cursor 58, 130, 143, 193  
blinking underscore (\_) 154  
flashing checkerboard 55  
flashing question mark 130, 143  
inverse solid 55

custom chips [78]  
custom integrated circuits 215-223  
CV 63

## D

D command 131, 144  
data, transferring 41-42  
data bits 137  
data bus 213  
Data Carrier Detect [60]  
data format 137, 138, 144, 151  
data inputs 21  
Data Set Ready *See* DSR  
Data Terminal Ready *See* DTR  
DCB 261  
DCD [60]  
decimal, negative [107]  
device signature 72  
DEVNO [21]  
DHRES 49, 104, 106, 107, 166  
diagnostics, built-in [62, 65]  
differences among Apple II's [61-78]  
disable MouseText 65  
DISK 221, 222  
disk  
controller cards [74]  
controller unit *See* IWM  
input and output 124-126  
I/O firmware entry points 20  
disk drive 8  
connector 252  
port [50]  
speed 13  
disk-use light 6, [71]  
display  
address mapping 235-238  
inverse 191  
memory addressing 234  
memory switches 43-47  
modes 104-108, 239-247  
normal 191  
page maps 108-114  
pages 102-103

DISVBL 166  
DISXY 166  
DMA transfers [70]  
DOS 126, 130, 143, 179, 180, [39, 69]  
    interrupts [42]  
    zero page use [16-18]  
double-high-resolution 245  
    graphics [74]  
    colors 100-101  
drive, external, startup 126  
drive motor 49  
DSR 256, 261, [60]  
DSR1B 257  
DSR2B 257  
DTR 260  
DTR1B 257  
DTR2B 257  
dumb terminal 159  
Dvorak keyboard 6, [88]  
dynamic-RAM refreshment and timing  
    226-229

## E

echo 131, 145, 155, 260  
EIA standard 258  
80 columns 65, 93  
80/40 column switch 5  
80COL 104, 105, 107, 108, 218, 219,  
    220  
80STORE 39, 44, 45, 104, 105, 107,  
    108, 216, 238, 241  
electrical power 206  
EN80 217  
enable MouseText 65  
ENBVBL 166  
ENBXY 166  
ENCLCRAM 216  
English keyboard [90]  
enhanced video firmware 20, 224  
enter terminal mode 145  
entry points, firmware [31-36]  
environmental specifications 205-206

[ESC] 4  
[ESC] (4) 61  
[ESC] (8) 61  
escape codes 60  
escape sequences 4  
even-parity [114]  
EXAMINE command 190  
examining memory contents 181  
examining registers 190  
expansion ROM space 73  
Extended 80-Column Text Card [64]  
external drive startup 126  
external interrupts [55]  
external power connector 207  
EXTINT 256, [55, 60]

## F

FCC [99]  
firmware 12  
    entry points [30-36]  
    listings [126-215]  
    locations [30-36]  
    protocol 71, 134, 148  
    video routines 115-123  
flag inputs 21  
FLASH 256  
flashing characters 68  
flashing checkerboard cursor 55  
flashing power light 6  
forced cold start 50  
14M 215, 220, 221  
FORTRAN [41]  
40 columns, switching to 80 5  
40-column 65, 93  
48K memory 34, 35, 39  
framing errors 258  
French keyboard [91-92]  
full duplex 156-158

## G

GAME I/O connector [76]  
game input 267  
game paddles *See* hand controls  
GAMESW0 268  
GAMESW1 268  
General Logic Unit (GLU) 13  
German keyboard [93]  
GETLN 58-62, 180  
GETLN1 59, 82  
GETLNZ 82  
GLU 221  
GND 257  
GO command 189, 190, 192, 198  
graphic bits [109]  
graphics mode 96-102  
greater than sign (>) 59

## H

half duplex 155  
hand control 8, 173-178  
  circuits 269  
  connector 174  
  input [76]  
  signals 270  
hand controller 267  
handle 9, 206  
hardware  
  accesses 21  
  addresses [66]  
  locations 181, [15]  
  page locations 164  
headphones 232  
heat 206  
hexadecimal [106]  
  arithmetic 193

## high-resolution 97

  colors 243  
  display 243  
  double 245  
  graphics colors 98-99  
  Page 1 37  
  Page 2 38  
HIRES 44, 45, 104, 105, 107, 216,  
  218, [67]  
HLINE 117  
HOME 118  
HOMEMOUSE 168  
HRP1 37  
HRP1X 37, 45  
HRP2 45  
HRP2X 38  
humidity 205

## I

I command 131, 145, 158  
I/O firmware, video routines 120-123  
I/O links 55  
icons 68  
identification bytes 71  
IEC [99]  
IN#2 143, 154  
IN#n 56, 70  
index registers 17  
INH 217  
INITMOUSE 169  
input and output, disk 124-126  
input buffer (page \$02) 36  
Input/Output Unit (IOU) 13, 215,  
  218-219, [78]  
instruction cycle times [63]  
Integer BASIC 59, [16-18, 41, 69]  
Integrated Woz Machine (IWM) 13  
internal converter 208  
internal voltage converter 206

interrupt(s) 24, 75, 260, [40-60, 70]  
    ACIA [49]  
    Apple II and [42]  
    Apple II Plus and [42]  
    Apple Ile and [43]  
    disk drive port [49]  
    DOS and [42]  
    keyboard [52-53]  
    Monitor and [42]  
    mouse [49]  
    Pascal and [42]  
    65C02 and [43]  
    6551 [49]  
    vertical blanking [49]  
interrupt handler(s)  
    mouse 163  
    user's [57]  
interrupt requests 52  
interrupt vector [43-44]  
interrupt-handling sequence [45]  
inverse 65  
    characters 68  
    display 191  
    solid cursor 55  
INVERSE command 191  
invoking the monitor 179  
IOREST [36]  
IORTS [36]  
IOSAVE [36]  
IOU (Input/Output Unit) 13, 215,  
    218-219, [78]  
IOUDIS 49, 104, 106, 166, [67, 68]  
IOUSELIO 219  
IRQ 75, 156, 219, [43]  
    handling routine [34]  
    vector [36]  
ISO [84]  
    layout [89]  
Italian keyboard [94]  
IWM (Integrated Woz Machine) 13,  
    222

**J**  
jack 7  
JMP \$C600 126  
JMP indirect instruction [3]  
joysticks *See hand controls*

**K**  
K (1024) 17  
K command 131, 145  
KBD 217  
keyboard 229-231  
    buffer [52-53]  
    character decoder 225  
    circuit diagram 230  
    data [66]  
    input buffer 37  
    interrupts [52, 53]  
    layout [71]  
        ANSI [90]  
        British *See English*  
        Canadian [91-92]  
        Dvorak [88]  
        English [90]  
        French [91-92]  
        German [93]  
        ISO [90]  
        Italian [94-95]  
        Sholes [85]  
        Western Spanish [96]  
    signals 231  
    strobe 79, 229, [50, 66]  
    switch 5  
    standard 5  
KEYIN 55, 57, 58  
KSTRB 77, 219, 256  
KSW 56, 57, 70, 104

**L**  
L command 131, 145  
LANGSW 256  
LDPS 220, 241, 251

line feed 145, 152  
    automatic 131  
line length 136, 150  
line voltage 205  
line width 139, 144  
LIST command 199  
local 154  
low-resolution  
    colors 242  
    display 242  
graphics 96

## M

machine identification [63]  
main memory screen holes 135-136,  
    149, 150  
main RAM 20  
MARK (1) 132  
MARK parity 138, [114]  
master clock 213  
maximum current drain 252  
memory  
    addressing 223-229  
    bank-switched 22  
    bus organization 224  
    comparing data in 188-189  
    display switches 43-47  
    dump 182-184  
    examining contents 181  
    48K 34  
    map 18, [15-28]  
    moving data in 186-188  
    organization [64]  
    state [48]  
    switches, display 43-47  
Memory Management Unit *See* MMU  
microprocessor, 65C02 12, 15  
mini-phone jack 7  
MIXED 105, 107, 218, [67]  
mixed-modes displays 102  
MMU 13, 215-217, 267, 271, [78]  
mnemonic 199  
modem 8, 151  
modes, display 239-247

monitor 8, 24, 59, 179-203, 224  
    entry point [36]  
    interrupts and [42]  
    output 248  
register commands 189-190  
ROM [69]  
video routines 115  
zero page use [15]  
mouse 8, 160-174, [49-50]  
    BASIC and 163, 172  
    Pascal and 171  
button 171  
    interrupt mode 164  
    signals 266  
clamping boundaries 171  
connector 264  
direction [59]  
firmware 167  
firmware entry points 20  
hardware locations 164-167  
input 262, [76]  
interrupt handler 165  
interrupts [58]  
movement interrupt mode 163  
operating modes 163  
port 161-174  
transparent mode 163  
waveform 263  
X direction 167  
Y direction 167  
MOUSEID 264  
MouseText 65, 68-69, 90-91, [73, 114]  
MOUX1 167  
MOUY1 167  
MOVE command 186-188, 195, [36]  
MOVEAUX 41-42  
movement/button interrupt mode 164,  
    167  
movement interrupt mode 163, 167  
moving data in memory 186-188  
MSLOT [21]  
MSW 264

## N

N command 131, 145, 156  
n CONTROL-K 56  
NE556 265, 271, [77]  
negative decimal [107]  
NEWIRQ [34]  
nibble [104]  
NMI vector [36, 43]  
non-maskable interrupts 52  
NORMAL command 191  
normal characters 65, 68  
normal display 191  
NTSC 87, 233, 242, 248, 251  
#6 130  
#7 143  
#8 143

## O

odd-parity [114]  
old monitor ROM [62]  
1 CONTROL-P 130  
1VSOUND 251  
[disk] 4, 82  
operand 199  
operating systems [39-40]  
operating temperature 205  
output and input, disk 124-126  
output jack 232

## P

P command 132, 145  
P register 17  
paddle(s) 267  
    button 0 268  
    button 1 268  
    inputs [68, 76]  
    timing circuit [77]  
page 18  
page \$02 (input buffer) 36  
page \$03 36  
page \$04 36  
page \$08 37

page 0 18  
page zero 24  
page 1 18  
PAGE2 44-45, 105, 107-108, 216,  
    238, 241, [46-48, 67]  
page three [19]  
page 8, auxiliary RAM [52]  
PAL 233  
parity 145  
    bit(s) 138, 262  
    checking 260  
Pascal 67, 126, 130, 134, 170, [114]  
    ID byte 134, 148  
    interrupts and [42]  
    language [41]  
    operating system [40]  
PC (program counter) 16  
PCAS 220  
PDL0 176  
PDL0/XMOVE 219  
PDL1 176  
PEEK [40]  
peripheral identification numbers [112]  
peripheral-card memory space [65-66]  
peripheral-card ROM space [65]  
phone jack 7  
PIN numbers [112]  
PINIT 72, 121, 134, 148  
PLOT 118  
plotter 8  
POKE [40]  
ports 70, [70]  
POSMOUSE 168  
power 8  
    connector 207  
    consumption 207, 208  
    light 6, [71]  
    requirements 206  
    supply [100]  
power-on light [71]  
power-up byte 51

PR#1 130  
PR#2 143, 154  
PR#6 126  
PR#n 56, 70  
PRAS 217, 219, 220, 251  
PRBL2 118  
PRBYTE 118  
PREAD 72, 121, 134, 148, 177  
PRERR 118  
PRHEX 118  
primary character set 68, [73]  
printer 8  
PRINTER: 130  
processor status register 17  
ProDOS 126, 130, 143, 180, [39, 63]  
program counter (PC) 16, 201  
prompt 58, 154  
    characters 59  
PRTAX 118  
PSTATUS 72, 123, 134, 148  
PTRIG 166  
published entry points [32-36]  
*pull* from stack 17  
*push* onto stack 17  
PWRITE 72, 121, 134, 148

**Q**

Q command 145  
Q3 215, 217, 219  
question mark (?) 58, 59  
quit terminal mode 145

**R**

R command 132  
R/W 217, 219, 221, 257  
RA0-RA7 217  
RAM 17  
    addressing 226-229  
    locations [15]  
RAMRD 38, 39, 43, 44, 216, [46]  
RAMWRT 38, 39, 43, 44, 216, [46]

random number 58  
random-access memory (RAM) 17  
RAS (row-address strobe) 228  
RD1B 257  
RD63 167  
RD80COL 105  
RD80STORE 105  
RDALTCHAR 105  
RDALTZP 26  
RDBNK2 26  
RDCHAR 82  
RDCRAM [46]  
RDDHIRES 106  
RDHIRES 45, 105  
RDIOUDIS 106, 166  
RDKEY 55, 57  
RDLCRAM 26  
RDMIXED 105  
RDPAGE2 105  
RDRAMRD 39  
RDRAMWRT 39  
RDTEXT 105  
RDTNO 167  
RDVBLMSK 166  
RDXYMSK 166  
RDYOEDGE 166  
read-only memory (ROM) 17  
READMOUSE 163, 168, [51-52]  
receive register 262  
registers 15, 213  
    examining 190  
relative humidity 205  
REMIN 143  
remote 154, 159  
remote device 145  
REMOUT 143  
[REPT] key [71]  
Request to Send *See RTS*  
[RESET] key 4, 79, 82, 221, 113, 256,  
    [71]  
reset port 1 132  
reset port 2 145  
reset routine 48  
reset vector 49-51, [36]  
[RETURN] [84]

retype 62  
RF modulator 233  
RGB monitor 245  
rollover 3  
ROM 17  
ROM addressing 224-225  
ROMEN2 217  
RS-232 129  
RSTVBL 166  
RSTXINT 166, 216  
RSTXY 166  
RSTYINT 166, 216  
RTS instruction 260, [36]

## S

S command 132  
S register 17  
safety instructions 207, [99]  
schematic diagrams 271-276  
scratch-pad RAM [65]  
screen holes 36, 73, 74, 133, 134,  
136, 149, 171-173, [20-22, 47]  
SCRN 119  
scroll 65  
SEGA 218  
SEGB 218, 220, 251  
self-tests *See* diagnostics, built-in  
SER 221, 256  
serial buffering [55]  
serial data transfer [57]  
serial firmware [50]  
serial I/O buffers [75]  
serial I/O port 128-159  
serial input buffer 37  
Serial Interface Card [74]  
serial interrupts [55, 56]  
serial port circuits 254  
serial port 1 20, 129-139

serial port 2 20, 141-159  
command character 143, 146  
command character hardware  
locations 130, 132, 134  
firmware protocol 147  
hardware locations 148  
initial characteristics 130, 147  
SEROUT 251  
SERVEMOUSE 163, 168, [51]  
SETCOL 119  
SETMOUSE 167-168, [50-51]  
SETPWRC 51  
7M 220, 223  
[SHIFT] key 79, 229, [84]  
shift-key mod [68]  
Sholes keyboard 5  
signature byte 134, 148, 170  
simplified keyboard (Dvorak) [88]  
⑥ 126  
65C02 12, 15, [63]  
address bus 213  
addressing modes [10]  
block diagram 211  
clock 211  
cycle time [1, 2]  
data bus 213  
data sheet [5-13]  
differences from 6502 211,  
[1-3, 6-7]  
execution time [1-2]  
instruction set [12-13]  
opcodes [12]  
registers 213  
signal descriptions [11]  
timing diagram [8]  
timing signals 214-215  
6502 verus 65C02 211  
6551 Asynchronous Communication  
Interface Adapters *See* ACIA  
slot 7 drive 1 [74]  
SLOTC3ROM [66]  
SLOTCXROM [66]

slots 70  
versus ports [70]  
soft switches 22, 215, 218, 221  
 82  
SPACE (0) 132  
SPACE parity 138, [114]  
speaker 83-84, [67]  
  external 7  
  output jack 232  
  volume control 232  
SPKR 219  
stack 24, [42, 46]  
stack pointer 17  
standard I/O links 55  
standard keyboard 5  
start bit 137  
status register 134, 148, 261  
stop bits 137  
stop-list 65  
STORE command 194  
strobe 79  
  inputs 21  
SUD *See* System Utilities Disk  
Super Serial Cards [74]  
SW0 175  
SW1 175  
switch inputs 175, [76]  
switches, soft 22, 215  
SYNC 219, 233, 251  
system clock 213  
system monitor 179-203  
*System Utilities Disk* 129, 131, 136,  
  141, 145, 150, [75, 112]

## T

T command 145, 154-156, 159  
 [84]  
TD1B 257  
telephone jack 7  
temperature 205, 208

terminal mode 145, [53]  
TEXT 105, 107, 218, 220, 221, 251,  
  [67]  
text  
  and low-resolution graphics Page 1  
  36  
  and low-resolution Page 1X 36  
  and screen low-resolution Page 2  
  37  
  displays 241  
  modes 90-95  
  window 63, 66  
TLP1 36  
TLP1X 36, 45  
TLP2X 37  
toggle switches 22  
transferring control 42-43  
transferring data 41-42  
transmit/receive data register 134,  
  148  
transmit register 262  
transparent mode 163, 167, 171  
triggering paddle timers [68]

## U

USA standard keyboard 5  
USER command 197  
user's interrupt handler [57]  
utility strobe [67]

## V

validity check 49  
VBL [67, 73, 76]  
VBLINT 163, 164, 218, [67, 73]  
VDE [99]  
vectors 55  
ventilation 206  
VERIFY command 188, 196, [36]  
vertical blanking 163, [49, 50, 73]  
  interrupts [68]

VID 248  
VID7M 215, 220  
video  
  counters 233-234  
  display 225  
  display circuits 240  
  display modes 239-247  
  expansion 8  
  expansion connector 249-252  
  expansion output 249  
  output signals 248  
  routines  
    firmare 115-123  
    I/O firmware 120-123  
    monitor 115-119  
VLINE 119  
voltage 205  
  converter 10  
volume control 7, 232

## W

WAIT [36]  
warm-start procedure 50  
Western Spanish keyboard [96]  
WNDW 219, 233, 251  
word [106]  
*Woz Integrated Machine* 13, 222

## X

X register 17  
X0 215, 218, 262, 264  
X1 215, 263, 264  
XFER 41, 42  
XINT 164, [66, 67]  
XOEDGE 166

## Y

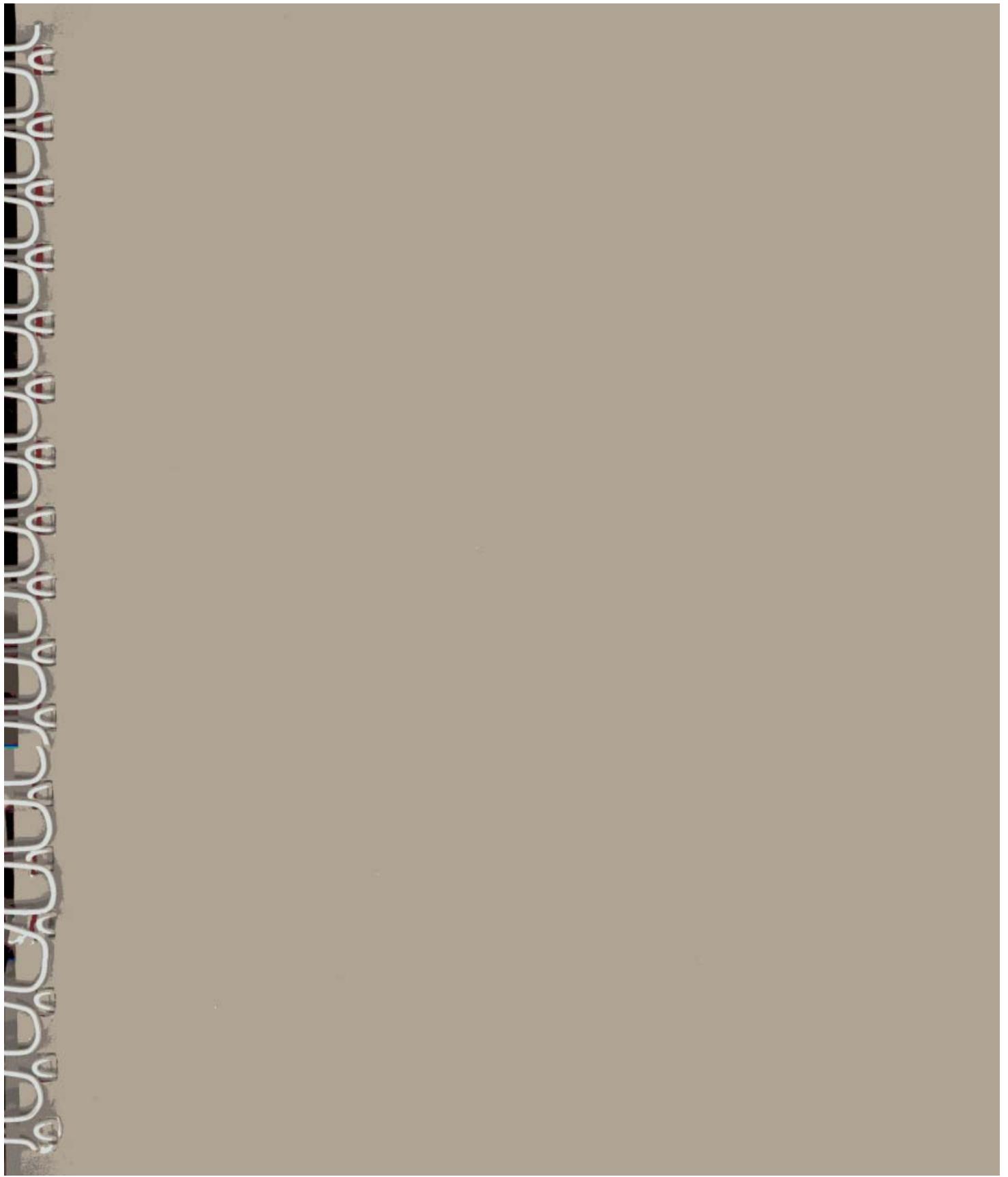
Y register 17  
Y0 218, 262, 264  
Y1 263, 264  
YINT 164, [66, 67]  
YMOVE 219  
YOEDGE 166

## Z

Z command 132, 139  
zap 132, 139, 145  
zero page 24, 184



W W W W W W W W W W W W W W W W W W





**Apple Computer, Inc.**  
20525 Mariani Avenue  
Cupertino, California 95014  
(408) 996-1010  
TLX 171-576

030-1022-A  
© 1984 Apple Computer, Inc.  
Printed in U.S.A.