

Apple IIe Repair Guide

INTRODUCTION

I bring this series to all of the Apple //e users who have experienced the unfair and outrageous prices that repairmen of computers (especially at Computerland) charge for their services, only to replace a \$.50 chip. I myself have been charged \$75 to have a \$2.50 chip replaced, not to mention it took them two weeks to get to my computer to replace the damn thing. At the end of this series, most repairs on your computer you should be able to do on your own, and most for less than the cost of a movie.

Open your computer and take a look at the motherboard. Looks confusing, eh? Not really. The big black things are called integrated circuits, and these are what break down or fail most often. The other things we will not worry about at the moment.

Up and down the left side of the motherboard you will see letters A-F, and along the bottom the numbers 1-14. This is the way Apple locates their chips on the board - much like a city map with grids. Here are the names, and locations, and the approximate costs for each of the chips on the board. Don't let the names of the chips scare you or anything on this chart. It is mainly for information, and you won't need to know anything about the chips on the board (aside from the fact they are broken, which will come later).

IC #	Location	Approx \$	Description	Notes
74LS02	B8	0.78	Quad 2-input NOR	
74S10	C5	0.78	Triple 3-input NAND	
74S109	C1	1.34	Dual JK Flip-flop	
74LS125	E1	1.12	Tri-state quad buffer	
74LS138	B5	1.22	Expandable 3/8 Encoder	
74LS154	C10	2.80	4-16 decoder/multiplexer	
74LS166	F5	1.84	8-bit serial in, parallel out shift register	

74LS244	B1,B3	2.80	Tri-State octal line driver
74LS245	B2	1.70	Tri-State octal bus receiver
74LS251	C11	1.55	Tri-State 8-input multiplexer
74LS374	D3	1.98	Tri-State octal-D flip-flop
NE558	A12	2.00	Quad 555 timer
MC741	A11	0.75	Operational Amplifier
ULN2003	Analog Card	?	7-channel input (from Apple)
LM3146	Analog Card	?	Transistor Array (from Apple)
MC3470	Analog Card	?	Floppy disk (from Apple)
MC3764	F6-F13	20.00	64k x 1 bit RAM
6502B	B4	14.00	8 bit microprocessor
KB ROM	D12	8.00	Keyboard ROM
VID ROM	F4	12.00	Video ROM
CD ROM	D10	20.00	Applesoft ROM
EF ROM	D8	20.00	Monitor ROM
HAL	D1	56.00	Programmed Array (from Apple)
IOU	D6	56.00	I/O unit (from Apple)
MMU	D4	56.00	Memory Mgmt Unit (from Apple)
AY3600	D14	16.00	Keyboard Decoder

Ok, that's all of the chips on the motherboard, and a few from the Analog card, that is the one inside your disk drive (apple drives only). If you need to order one of these chips from Radio Shack or some other local electronics store, then you ask for the chips by the number in the left hand column. For example, if your paddles were not working and the cables were good, you would need to start with the NE558 chip, and that is what you order. More about that later, though. Don't worry about the big costs of the ROM chips or the CPU. Most computer breakdowns are of the 74LSxxxx series and you will most normally have to deal with those only.

Now, before you go poking around your motherboard popping out chips and sticking them back in, a few tips and reminders to keep your apple running right, and how not to screw anything up...

- 1) Never touch ANYTHING in or on your computer, including your disk drives, before grounding yourself on something. Static electricity, especially in the wintertime can reach as high as 10,000 volts - enough to fry any of the delicate chips inside your computer.
- 2) Buy a chip puller. They are cheap, and you will save your fingers from getting pins from the chips stuck in them, and blood all over everything.
- 3) Always note the orientation of the chip you pull out, so that you can put the new chip in the same way. There is a notch in one end of the chip, or a dot at one end. Either way, be sure the new chip has the notch or dot in the same place as the old one.
- 4) Use power strips and surge protectors. The surge protector for obvious reasons, and the power strip for preventing wear and tear on the switches.
- 5) Keep your coke off the keyboard. Liquids can blow every chip they touch.
- 6) Take special care about static electricity when messing around with the CPU, the ROM chips, the MMU and the IOU chips. These are quite sensitive to static charges.
- 7) Don't open your monitor. This is stupid, x-rays and 30kV's are running around inside and if you don't know what you are doing, you will have radiation damage, or worse yet, your parent will smile when they collect life insurance on you.
- 8) Don't pull cards out or put cards in when the power is on. You will kill either the card or the computer, I promise.
- 9) Check everything outside of the computer before you start fiddling around inside. Usually cables, switches or other shit like that are the cause of the problem.

This series is divided into 5 parts:

- 1) Start-Up Problems
- 2) Run Problems
- 3) Display Problems
- 4) Keyboard Problems
- 5) Other I/O Problems

Part I - Start-Up Problems

This section covers all problems that occur at the time you turn the power on, or at start up, including no power, no boot up, no beep and no display.

1) No power light, no beep, drive won't run:

- Probable defect:
- 1) 74LS125 at E1 is bad (replace and test)
 - 2) 74S109 at C1 is bad (replace and test)
 - 3) 74S02 at B8 is bad (replace and test)

2) Power light on, no message, no beep:

- Probable defect:
- 1) 74S02 at B8 is bad (replace and test)
 - 2) 74S109 at C1 is bad (replace and test)

3) Power light on, message, no beep:

- Probable defect:
- 1) (experts only) PAL 16R8/8323T at D1 is bad

4) System won't boot, power light on, drive won't run, garbage on screen:

- Probable defect:
- 1) Bad EF ROM at E10 (replace and test)
 - 2) Bad 6502B at C4 (replace and test)

5) System won't boot, power light on, message on screen, drive won't boot:

- Probable defect:
- 1) Clean connector pins
 - 2) Clean or replace ribbon cable
 - 3) Bad ULN2003 on analog card (replace & test)
 - 4) Bad regulator on analog card (replace card)

- 6) System won't boot, everything on, drive keeps running:
 Probable defect: 1) Reseat disk, check disk, check cable, reseat card.
- 7) System won't boot, disk drive runs and then stops:
 Probable defect: 1) Bad DOS
 2) Bad Disk
 3) Bad RAM chip on motherboard (f6-14) replace and test
- 8) System boots and then stops, no display:
 Probable defect: 1) Video cable bad (replace and test)
 2) Video connector bad (replace)
 3) Brightness knob on monitor?
 4) 74LS02 at B8 bad (replace and test)
 5) 74LS10 at C5 bad (replace and test)
 6) 74LS166 at F5 bad (replace and test)
 7) 74LS374 at D3 bad (replace and test)
 8) IOU at E5 bad (replace and test)
 9) 2732 ROM at F4 bad (replace and test)

Part II - Run Problems

- 1) Disk drive will not read (I/O error or disk just runs on and on)

Probable Defect:	Remedy:
a) Bad Disk	Replace Disk
b) Wrong DOS	Try another disk
c) Disk not seated	Reseat disk
d) Read head not reading	Replace head
e) Cable loose or bad	Reseat or replace cable
f) Bad chip on analog card	Replace Analog Card

2) Disk drive will not write (read is OK)

Probable Defect:	Remedy:
a) Write protected	Remove tab
b) Protect switch bad	Replace switch
c) Disk not formatted	Format disk
d) Cable bad or loose	Check/Replace cable
e) Corroded connectors	Clean connectors
f) Bad 74LS125	Replace (analog card)
g) Bad CA3146	Replace (analog card)
h) Bad MC3470	Replace (analog card)
i) Bad ULN2003	Replace (analog card)
j) Bad Write head	Replace (analog card)
k) head alignment off	Replace (analog card)

3) Disk reads or writes occasionally

Probable Defect:	Remedy:
a) Cable corrosion	Clean connector pins
b) Connector corrosion	Clean connector pins
c) noise interference	Good luck
d) disk tracking off	Realign head

4) Occasionally keyboard locks up and computer locks up

Probable Defect:	Remedy:
a) Program error	debug program
b) no keyboard output	coming later
c) bad RAM chip	replace and test
d) bad MMU chip	replace and test
e) bad CPU at C4	replace and test

Part III - Display Problems

1) No Display - Screen all White

Probable Defect:	Remedy:
a) Shift register latch-up b) ROM data hung up	replace 74LS166 at F5 and test replace 2732 character ROM (F4)

2) No Display - No Video

Probable Defect:	Remedy:
a) Bad Cable b) low signal c) Bad monitor d) Bad 74LS02 at E8 e) Bad 2N3906 at A14 f) Bad 2N3904 at A14 g) Bad 74LS10 at C5 h) Bad 74LS166 at F5 i) Bad 2732 ROM at F4 j) Bad 74LS374 at D3 k) Bad IOU at E5 l) Bad PAL 16R8 at D1	replace and test adjust brightness test monitor replace and test replace and test replace and test replace and test replace and test replace and test replace and test replace and test replace and test

3) No Display - Screen Black

Probable Defect:	Remedy:
a) Brightness bad b) Bad monitor	adjust test monitor

c) Bad IOU at E5	replace and test
d) Bad 2732 ROM at F4	replace and test

4) No Color

Probable Defect:	Remedy:
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a) Bad IOU at E5	replace and test
b) Capacitor C32 shorted	replace (soldering required)
c) Inductor L3 Bad	replace (soldering required)

5) No Synchronization

Probable Defect:	Remedy:
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a) Bad IOU at E5	replace and test
b) Bad monitor	replace or repair

6) Bad cursor or no cursor

Probable Defect:	Remedy:
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a) Bad EF ROM at E10	replace and test
b) Bad 2732 ROM at F4	replace and test

7) Bad inverse or flash

Probable Defect:	Remedy:
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a) Bad 2732 ROM at F4	replace and test
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8) No text

Probable Defect:	Remedy:
a) Bad 2732 ROM at F4	replace and test
b) Bad IOU ROM at E5	replace and test

9) Video - Bad color

Probable Defect:	Remedy:
a) Bad HAL at D1	replace and test

10) Bad Graphics (lo and Hi bad); text ok

Probable Defect:	Remedy:
a) Bad IOU at E5	replace and test

11) Bad Graphics (HI), low and text ok

Probable Defect:	Remedy:
a) Bad IOU at E5	replace and test

Part IV - Keyboard Problems

1) Bad key action - some keys or no keys work

Probable Defect:	Remedy:
a) Bad Key	replace key
b) Bad or loose cable	check and replace cable
c) Bad AY3600 at E14	replace and test
d) Bad 2716 ROM at E12	replace and test

2) Bad key action - prints wrong characters

Probable Defect:	Remedy:
a) Bad 2716 ROM at E12	replace and test
b) Bad AY3600 at E14	replace and test

3) Bad key action - unwanted repeat

Probable Defect:	Remedy:
a) Bad AY3600 at E14	replace and test
b) Bad capacitor C71	replace (soldering required)

4) Repeat key won't work

Probable Defect:	Remedy:
a) Bad Key	replace and test
b) Bad AY3600 at E14	replace and test
c) Bad Capacitor C70	replace (soldering required)

5) Key top pops off

Well, just glue that bugger back on or get a new keyboard!

Part V - Other input/output problems

1) Speaker - volume too low

Probable Defect:	Remedy:
a) transistor Q5 marginal	replace (soldering required)

2) Speaker - won't click

Probable Defect:	Remedy:
a) Bad speaker	replace speaker
b) speaker wires bad/loose	check or replace
c) Bad transistor (Q5)	replace (soldering)
d) Bad IOU at E5	replace and test

3) Cassette - can't load data

Probable Defect:	Remedy:
a) Bad cable	replace and test
b) Volume not set properly	retry at different volume
c) No signal on tape	replace tape
d) Bad LM741 at A11	replace and test
e) Bad 74LS251 at C12	replace and test
f) Bad 74LS154 at C10	replace and test

4) Cassette - Can't write data

Probable Defect:	Remedy:
a) No signal to tape	reconnect or replace cable
b) Tape bad	replace tape
c) Bad IOU at E5	replace and test

5) Game paddle - does not work at all

Probable Defect:	Remedy:
a) Bad cable	replace
b) Bad 558 timer at A12	replace and test
c) Bad 74LS251 at C12	replace and test
d) Bad 74LS154 at C10	replace and test

6) Game paddle button won't work

Probable Defect:	Remedy:
a) Button bad	replace button
b) Broken wire	replace wire

7) Game Paddle - knob does not work correctly

Probable Defect:	Remedy:
a) Bad pot in paddle	replace pot
b) Broken wire in cable	replace wire

8) Card in peripheral slot does not work

Probable Defect:	Remedy:
a) Bad 74LS138 at B5	replace and test
b) Bad 74LS154 at C10	replace and test
c) Bad 74LS10 at C5	replace and test

Apple II Service Notes

LEVEL 2 SERVICE NOTES

Motherboard

A no reset condition when there is no cursor, no prompt, and no speaker beep as obvious symptoms.

Check pin 40 of the 6502 for a high to low transition when the reset key is pressed. If no transition occurs check the following: Q5 (2N3904 near A13), 555 timer at A13, and the capacitor below Q5 (.1 microfarad). Usually, if Q5 is bad the APPLE will keyboard reset (but will not power on reset). If a transition occurs check the following points with an oscilloscope: Data Lines Do-D7 (pins 49-42 on I/O slots), Address Lines Ao to A15 (pins 2-17 on I/O slots), Read/Write (the write signal is active low) at pin 34 of the 6502, pin 5 of H5 (8T97), pin 9 (R/W in) of C14, pin 8 (R/W out) at C14. Look for low logic levels and missing (except AD7 and AD9 which are normally low) signals. The following IC's could be at fault.

<i>Symptoms</i>	<i>Cause</i>
Low Data levels	B6,7-74LS257 H10,11-8T28 Bad ROM's

Bad Address levels	H3,4,5-8T97 Bad ROM's 6502
No R/W signal	H5-8T97 C14-74LS32 A2-74LS00 6502

With an oscilloscope check for the 1 MHz clock on pin 37 of the 6502. Also check B11 pin 1 (74LS08) for the 1 MHz clock. Check B11 pin 1 for a +5 volt level, C11 pin 13 (74LS04) for a +5 volt level, and C11 pin 12 for a low level. See schematic for further details. Check the following IC's.

<i>Symptoms</i>	<i>Cause</i>
No 1 MHz at 6502	C11-74LS04 B11-74LS08 RA01 (resistor pak)

Check the following signals to make sure there is proper RAM addressing. Check the CAS bar signals at pin 15 of the RAM. The CAS bar signal at pins 4 (\$0-\$3FFF), 5 (\$4000-\$7FFF), 6 (\$8000-\$BFFF) from F2 (74LS139). Check the CS bar signal at pins 13 of the RAM and pin 7 of C1 (74LS153). Check the RAM SEL bar at pin 4 of the RAM, pin 6 of A2 (74LS00). Check inputs and outputs of D2 (74LS20) and pins 10 (\$8000-\$BFFF), 11 (\$4000-\$7FFF), and pin 12 (\$0-\$3FFF). See the schematic for complete detail and check the inputs and outputs of the following IC's.

J1-74LS257	H1-74LS08	F2-74LS139
C1-74LS153	C12-74LS257	D2-74LS20
C11-74LS04	C14-74LS32	A2-74LS00

Also check the Memory Select headers for continuity (except REV. 7 and above boards)

Check RAM pins 5, 6, 7 and 10, 11, 12 for RA0 (pin 10), RA1 (pin 11), RA2 (pin 12), RA3 (pin 7), RA4 (pin 6), and RA5 (pin 5) These are the RAM refresh, video addressing signals. Also check pins 7 and 9 of E11, 12, and 13 (74LS153's). Check the address and sync inputs to the 74LS153's (see schematic for pinouts).

If the system works with 16K RAM but not with 32K or 48K check RA02 and RA03 resistor paks. These located between E10 and E11 and D10 and D11. Check these with an ohm meter from pins 7 and 9 of E11, 12, 14 between ground and +5 volts. There should be a reading of about 500 ohms between pin 7 of E11 and ground, also, it should read the same for pin 7 of E11 and +5 volt buss (about 500 ohms). The readings should be the same for each of them (see schematic for more details).

The following are some miscellaneous reset and reset related failures and probably causes.

<i>Symptoms</i>	<i>Cause</i>
Intermittent Reset	C14-74LS32 A2-74LS00 E8 ROM
Random characters at keybd reset	B11-74LS08 F1-jumper block
Chars. moving, appearing randomly on screen	C11-74LS04
Continuous reset	B7-74LS257
Works w/16K RAM but not with 32K or 48K-	F2-74LS139 RA02, RA03

No speaker output	J13-74LS74
Beep, no prompt or cursor	E11-74LS153 E14-74LS283 F14-9334
No prompt/cursor	B3-555 timer
Split location cursor/prompt	C11-74LS04
No reset w/ROM card SW down	RA01
No reset with Disk Cd.	H2,H12-74LS138

No video, no reset- check 14MHz. output from crystal (B2-74S86 pins 8 and 10). Replace crystal if no signal. If replacing crystal doesn't help change Q₁ and Q₂ (2N4258's) below crystal. If that does not solve the problem try the following IC's:

A2-74LS00	A10-74LS194	A9-74LS151
B1-74LS175	B2-74S86	B10-74LS74
B11-74LS08	C1-74LS153	C2-74LS195
C13-74LS51	C14-74LS32	D2-74LS20
D11-74LS04	D11, 12, 13, 14-74	LS161

<i>Symptoms</i>	<i>Cause</i>
Blank white screen-	A3-74166 B5,8-74LS174 F14, 9334 6502
Blank dark grey screen	B10-74LS74

Screen goes blank when disk boots	B9-74LS194
Video goes blank during RAM test	B2-74S86
Videos wavers	C11-74LS04
Pulsating data, speaker clicks	H1-74LS08
Video distorted, reset OK	D2-74LS20
Top of video missing/distorted	B14-74LS02
Video pushed down/to right	C13-74LS02
Can't write to upper left screen	A9-74LS151
Top 3 lines HIRES gone	A11-74LS74
Rolling video	B14-74LS32, C11-LS04
Video all ????, scrolls	1-74LS153
Inverse video, cursor not flash	B2-74S86
Inverse/incorrect prompt	F8 ROM
Split video 4 corners	B1-74LS175, C1-74LS153
Split location prompt	C11-74LS04, E14-74LS283
No prompt/cursor	B3-555 timer
Horizontal lines/junk chars.	B5-74LS174
Distorted color bars	A12-74LS02
Vertical bars/cold start	C12-74LS257 D12-74LS161 F14-9334

	2513(char gen)
Vertical bars HIRES	B4-74LS194
Left margin vertical white bar	A3-74166
Graphics/color bars broken up	B4,9-74LS194
No page 2 HIRES	open trace B11-6 to R1-10
Black squares w/left-to-right moving chars.	B12,13-74LS11, 74LS02
No cursor .iuf above 555	B8
Inverse flashes instead of steady inverse	B11-74LS0
Smaller chars./vertical bars	B2-74S86
Moving chars	C11-74LS04
Random chars at reset	B11-74LS08
Part graphics/part text chars.	A11-74LS74
Entire screen	2513
Junk chars/ after warmup	27 microhenry choke
Video shows only top halves of letters, you get 2 tops instead of a top and a bottom	H1-74LS08, char gen 2513 (VC line to pin 13 2513 held low)

Miscellaneous Failures

<i>Symptoms</i>	<i>Cause</i>
Unable to access disk LED on	B5-74LS174
Unable to boot disk	H2-74LS138, H3 8T97, H12-74LS138, C1-74LS153
Prompt/no cursor	B3-555 timer
Disk boots, screen goes blank	B9-74LS194
Goes into monitor, program dies after warm	Eo ROM, ROM card, I/O slot o, H2,12-74LS138
Keyboard failures (keybd. OK)	B6,7-74LS257 B10-74LS74 C11-74LS04
Row D RAM bad, noisy speaker	H1-74LS08, J1-74LS257, D2-74LS20, Jumper blocks (except Rev. 7)
Row RAM bad	same as above
Adds chars, & scrolls from bottom	B6,7 74LS257, F12-74LS138, B10-74LS74

Peripherals

ROM CARDS

<i>Symptoms</i>	<i>Cause</i>
Apple won't reset	74LS09 INH bar line held low 74LS11 R/W being held 74S74 74LS244 Data lines being held

Won't go into FP
74S74
Do ROM
74LS138

Won't go into INT. see above

ROM fails even when replaced w/good 74LS09, 74LS138

Apple resets with switch
down but not up Bad Switch

Serial Cards

<i>Symptoms</i>	<i>Cause</i>
Apple won't power up	74LS109 74LS365 P8 Prom P7 Prom
Proms test bad after replaced	Q1,Q2-2N3906 & Q6-MPSU51
Switches test bad	74LS365
Not receiving	74LS125, Q7-2N3904
Not transmitting	74LS109, Q3-2N3906, Q4-2N3904

Communications Cards

<i>Symptoms</i>	<i>Cause</i>
Apple won't reset	Prom P2 DP8304

Prom tests bad when changed	Q1,Q2-2N3906 Q3-MPSU51
Card will not respond to PR#/IN#	MC6850 74C161 (A1 and A2) 74LS74
No RS-232 Output signal	Q4,Q5
No RS-232 Input signal	Q6

Parallel Cards

<i>Symptoms</i>	<i>Cause</i>
Apple won't reset	74LS74 P1 or P9 Prom
Drive won't boot	74LS74
After PR#n command prompt doesn't return	Q2-MPSU51
Prom tests bad after replacement	Q1-2N3906, Q2-MPSU51
Wrong data being printed	74LS174 74LS298
Not acknowledging data received	74LS74 at B2
Not generating Data ready strobe	74LS74 at B2

KEYBOARD

Old Style-single board model

<i>Symptoms</i>	<i>Cause</i>
Key doesn't work (example-no A)	Keyswitch bad
Series of letters don't work (e.g., "9", "6", "5" or "Q", "ESC", "A", "Z", "1")	Encoder (331-5740); bad traces or feed throughs
No control function	Keyswitch U1 (7400) R1 (4.7K Ohm)
No shift chars.	U4 (7400)
No output at all	Cable bad 5740 (encoder)
No keyboard strobe	Encoder (U1 (7400) check pin 3)
No output/wrong output	U2 (7404) Encoder
Encoder not being clocked	U4 (7400) pin 3 on encoder
Repeat key does not work	U3 (555 timer)
Characters repeat	Encoder
Wrong characters	Encoder
Characters repeat after unit warm	Encoder

New style keyboard (two part)

<i>Symptoms</i>	<i>Cause</i>
No keyboard output	Encoder (331-0931)
No Data Strobe (no keybd output)	B3 (74LS00) B4 (74LS00) C6 (.1 microfarad cap)
Incorrect data out	Encoder B5 (74LS04) B3 (74LS00)
No output	Cable
“P”, “Return”, & “:” keys repeat	Change R10 to 3.0K ohm 1/4 watt resistor. See Apple Service Bulletin #15

Language Card

<i>Symptoms</i>	<i>Cause</i>
Apple won't reset	74LS09: Do ROM fails
Works w/Pascal but won't load Basics correctly	74LS09: will run Integer, but not Applesoft
No reset	74LS175 74LS08 Autostart ROM RAM Bad
RAM tests bad	RAM Bad cable 74LS09

Not bank switching	74LS86
	74LS00
	74LS09
	74LS08
	74LS74
	74LS175
	74LS20

When repairing Language Cards the most common failure is it just won't work, won't load Pascal or Basics. It is difficult to give symptom "X" and say that IC "Z" is the cause. Each IC has more than one function and all are interrelated.

Disk Drive

<i>Symptoms</i>	<i>Cause</i>
Apple won't power up (dc)	74LS259 74LS323 74LS05
Drive motor on	74LS125 (analog) 74LS174 (controller)
Won't boot	P5 (controller) Q1 (analog) P6 (controller) 74LS125 (analog) Q2 (controller) 74LS132 (controller) 74LS259 (controller)
Write current on	CA3146 (analog) 74LS125 (analog) CR3 (IN4148-analog)

	74LS05 (controller) ULN2003 (analog) P6 (controller)
No drive motor motion	motor control bd. (10K pot)
No stepper motion	ULN2003 (analog) cable
No motor speed displayed by test	MC3470 (analog) 74LS125 (analog) 74LS174 (controller) 74LS132 (controller)
Motor speed OK, displayed speed high (+1200)	74LS05 (controller) CA3146 (analog)
Write protect always on	Cable 74LS323 (controller) P6 (controller)
Unable to test (Rd/Wr error)	74LS05 (controller) ULN2003 (analog) P5 or P6 (controller)
Diskette not initialized (test#4)	P5 (controller) CA3146 (analog) Adjust comparator (TP7) Load button
Data error (checksum)	P6 (controller) Adjust TP7 (comparator) 74LS132 (controller)

Motor spins on pwr. up	74LS125 (analog)
Won't boot (diskette OK)	P5 (controller) Alignment 74LS259 (controller)
Won't boot (wipes diskettes)	74LS125 (analog) CA3146 (analog) 74LS05 (controller)
Drive does not run at all	Q1 (analog) P5 (controller) 74LS259 (controller) 74LS132 (controller)
Apple does not reset	P5 (controller) 74LS259 (controller) 74LS05 (controller) 74LS323 (controller) NE556 (controller)
Boots, gives I/O error for inside tracks/unable to read/unable to write when copying	Head alignment
The unchangeable chip on the drive board is an MC3470	