HEWLETT PACKARD

HP-87

ASSEMBLY LEVEL

SERVICE MANUAL

00087-90016

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Personal Computer Division
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Contents

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Illustrations

Tables

Section
I

General Information

1-1. INTRODUCTION

This manual contains the necessary information to allow you to test, adjust and service the HP-87 computer, which is shown in figure 1-1. For ease of reference, this manual has been divided into five sections as follows:

Section I	General Information
Section II	Troubleshooting and Repair
Section III	Disassembly and Reassembly
Section IV	Replaceable Parts
Section V	Schematic Diagrams

Before using this manual in an actual repair, first read all of this section to become familiar with the computer and the organization of this manual, then read through the rest of the manual to become familiar with the service procedures.

Additional information related to service is included in appendix C of the HP-87 Operating and BASIC Programming Manual.

1-2. PRODUCT DESCRIPTION

The HP-87 is an integrated system that features:

- Enhanced ANSI BASIC language.
- 32K read/write memory, expandable to 544K.
- 80 character CRT display, 16 or 24 lines.

- Typewriter keyboard and numeric keypad.
- Graphics capability standard.
- Built-in HP-IB.
- Four I/O ports.
- Programmable tone output.

Detailed specifications for the HP-87 are listed in table 1-1.

Table 1-1. HP-87 Specifications

Size

- Width: 41.9 cm (16.5 in.).
- Depth: 45.2 cm (17.8 in.).
- Height: 19.7 cm (7.75 in.).
- Weight: 9.75 kg (21.5 lb), including power cord.

Power Requirements

- AC Line Voltage: 90 to 127, 200 to 254.
- Line Frequency: 50 to 60 Hz.
- Power Consumption: 36 watts (nominal).

Environmental Limits

- Operating Temperature: 0 to 55 degrees C (32 to 131 degrees F).
- Storage Temperature: -40 to 55 degrees C (-40 to 131 degrees F).
- Operating Humidity: 0% to 95% relative humidity at 40 degrees C (104 degrees F).

CRT Display

- Size: 12.7 cm by 22.9 cm (5 in. by 9 in.)
- Capacity: 16 or 24 lines, 80 characters per line (alphanumeric mode); 240 dots by 544 dots graphics mode).
- Refresh Rate: 50 or 60 Hz.

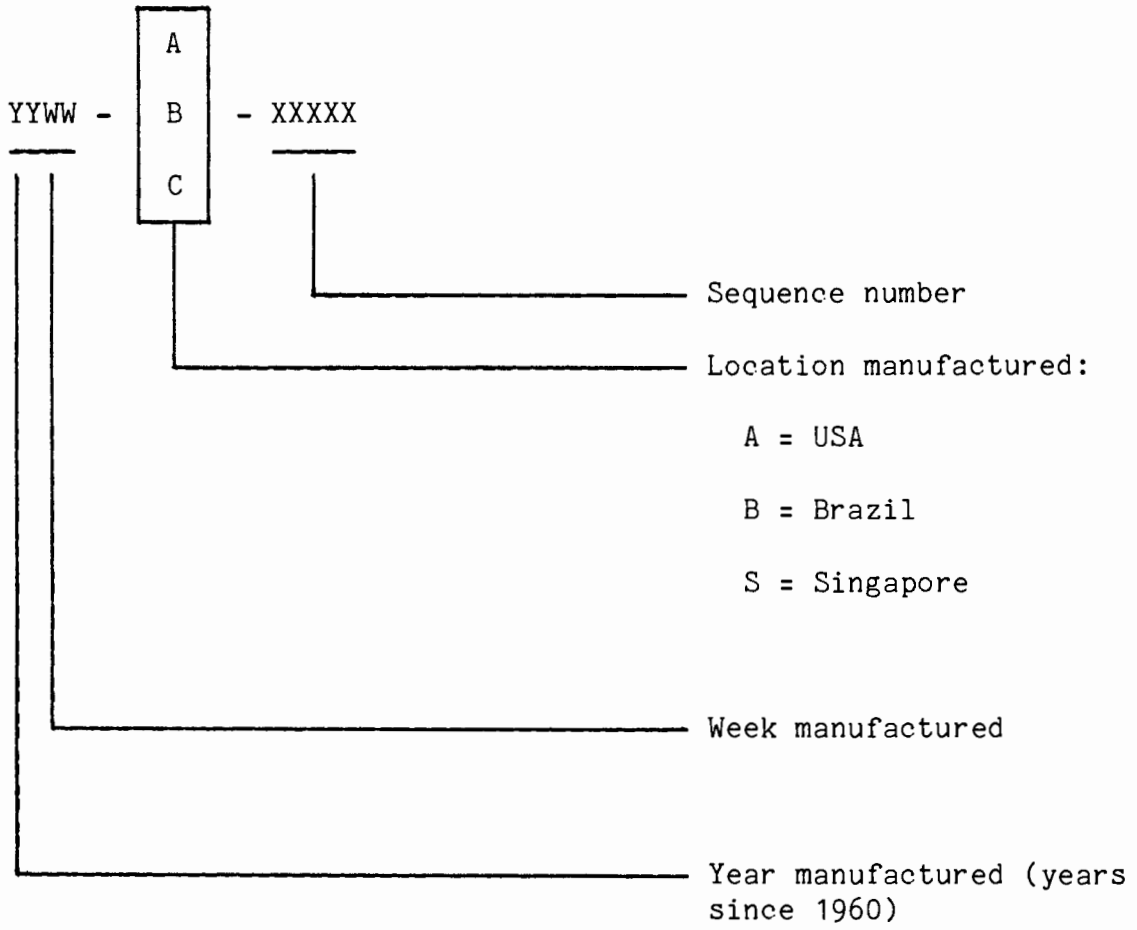
Table 1-1. HP-87 Specifications (Continued)

Keyboard

- 91 keys.
- Typewriter keyboard.
- Numeric keypad.
- Fourteen special function keys.

1-3. IDENTIFICATION

The serial number of the computer is used for identification and determination of warranty status. It is located at the top of the back panel, above the brightness control. Its format is shown below:



1-4. SAFETY CONSIDERATIONS

> WARNING
> Lethal voltages are exposed when the top case of the HP-87 is removed. At certain points these voltages are present not only while power is on, but also for up to several days after power has been turned off. Electrical and mechanical failures may cause dangerous voltages to be present at points that normally are safe. For your own safety, read and heed the safety guidelines listed below.

The dangerous voltages present in the HP-87 include not only the 115 Vac or 230 Vac line voltage, but also 32 Vdc used on the logic PCA, and pulsed voltages of 28V, -48V, 290V, 670V, and 15 kV used in the CRT assembly. The high-voltage area on the CRT PCA is shown in figure 3-1.

Observe the following safety guidelines while working on an HP-87:

- Do all possible operations with the computer turned off.
- NEVER WORK ALONE. Be familiar with the location of power switches in your service area and what they control. Know how to free another worker from contact with high voltage without endangering yourself.
- In case of an accident, know where to obtain respiratory resuscitation and/or cardiac pulmonary resuscitation (CPR).
- Have available and use approved warning signs in areas where high voltage testing is in progress.
- Keep your work area neat and free of any nonessential conducting material or sharp objects. Remember that reaction to an electrical shock can make you strike nearby objects, which could result in serious injury.
- Do not exceed the rated specifications of test instruments.

- Make sure that any probe being used has insulation with a voltage rating higher than the voltage being measured. Check all instrument wires and probes for cracked insulation and other defects. If you find any problems, don't risk your safety by using the defective instrument.

- While measuring high voltages, keep one hand behind your back or in your pocket. This helps prevent you from touching a point that could close a high-voltage loop.

- Always be certain that the computer is turned off and all high voltages are discharged before touching or removing any electrical or mechanical part. Keep in mind while servicing that some circuits can be lethally charged, if a component or connector is faulty or disconnected, even after the computer has been turned off.

- Do not make measurements in a circuit where corona is present. Corona can be identified by a pale blue color, by a buzzing sound emanating from sharp metal points in the circuit, or by the odor of ozone.

- Never leave your work area with high voltage circuits energized and exposed.

- Never do any service work while your hands, shoes, workbench, or the floor is wet. Avoid making measurements under humid, damp, or other environmental conditions that could affect the dielectric voltage tolerance of the test leads or instruments.

Associated with certain procedures throughout this manual you will see a warning. Enclosed within a box like the one in section 1-4, these warnings caution you about possible dangers while you perform the service procedures.

1-5. SERVICING THE HP-87

The HP-87 is designed to be easy to service. Most parts are included in the following assemblies (see figure 1-1):

- o Logic one PCA (printed-circuit assembly).
- o Logic two PCA (printed-circuit assembly).
- o CRT PCA (printed-circuit assembly).
- o Power Supply PCA (printed-circuit assembly).
- o Keyboard assembly.
- o Back panel assembly.
- o Top case assembly.
- o Bottom case assembly.

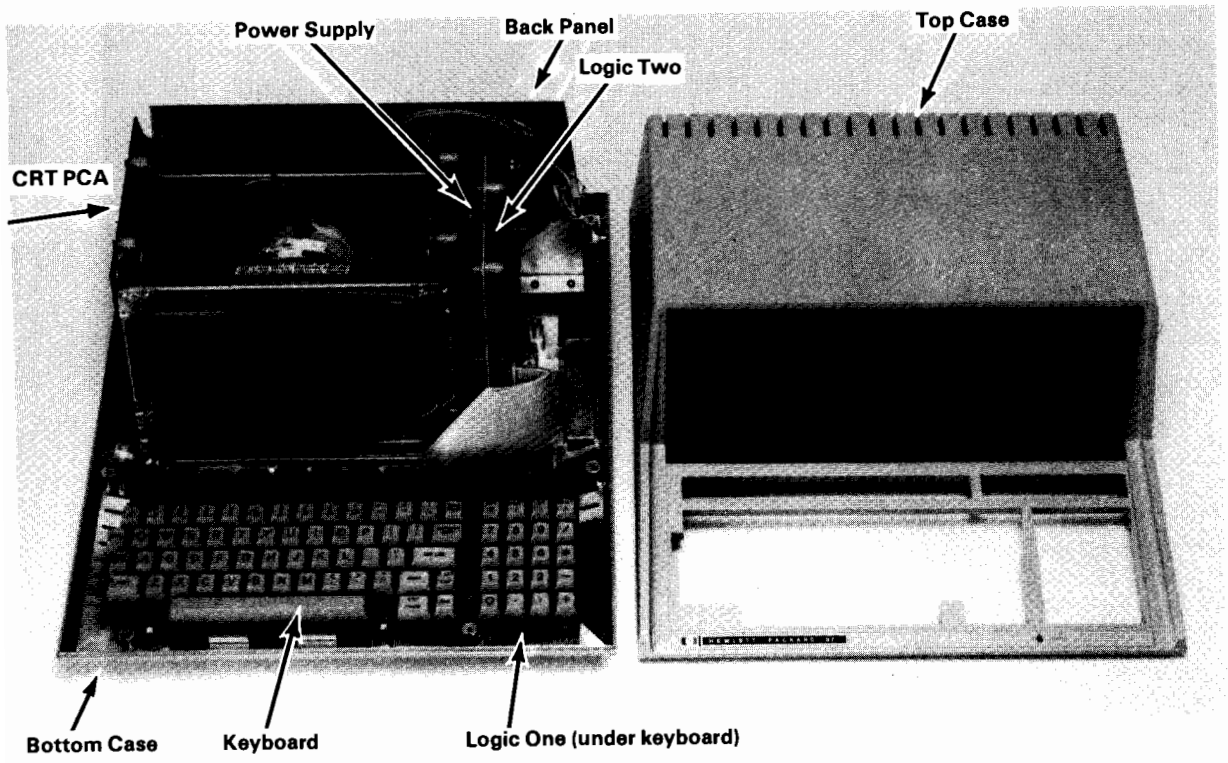


Figure 1-1. HP-87

To avoid the necessity of frequent unsoldering and soldering, all major ICs (37) are mounted in sockets. Also, troubleshooting the HP-87 is greatly facilitated by the use of the service ROMs. Tests provided in these ROMs tell you if a socketed IC is bad and enable you to check for proper operation of the CRT assembly. The tests provided in the service ROMs go much further than the self-test performed by the computer when the power is switched on or when the [TEST] key is pressed.

1-6. Using This Manual

Here is an outline of how you might use this manual in servicing an HP-87:

a. Follow the procedures in section II. They will help isolate a problem to one of the major HP-87 assemblies and then give specific troubleshooting and repair procedures for that assembly.

b. If it is necessary to disassemble the computer in order to access a bad assembly, refer to the procedures in section III.

c. To order replacement parts or assemblies, obtain the HP part numbers from the list of replaceable parts in section IV.

1-7. Recommended Tools

Table 1-2 lists the tools recommended for servicing the HP-87.

Table 1-2. Recommended Tools

HP PART NUMBER	DESCRIPTION
HP 82937A	HP-IB Interface Module
HP 3465/3466	Digital Voltmeter
HP 1220A	Oscilloscope
0960-0062	Continuity Tester
8710-1355*	CRT Alignment Tool (GC #8606 or equivalent)
00087-60920	CRT Test Pattern Overlay
8500-0232	FREON TF
8650-0029	Gloves, small nylon
8650-0030	Gloves, large nylon
8710-1254*	Key Contact Insertion Tool
8720-0002*	Nut Driver, 1/4 inch
8710-1217	Nut Driver, 7 mm
8720-0007	Nut Driver, 1/2 inch
8710-1107*	Pliers, long-nose, serrated tip
0470-0304	RTV 108 Silicon Rubber Adhesive/Sealant
8710-0945*	Screwdriver, holding
8710-0899*	Screwdriver, Pozidriv, #1

Table 1-2. Recommended Tools (Continued)

HP PART NUMBER	DESCRIPTION
8710-0900*	Screwdriver, Pozidriv, #2
8730-0008*	Screwdriver, small flat-blade
00087-60912	System Service ROM
00087-60913	HP-IB Service ROM
8520-0023	Swabs, cotton
00087-90002	Introduction to the HP-87
00087-90017	HP-87 Operating and BASIC Programming Manual
00087-90016	HP-87 Assembly-Level Service Manual

* These tools are included in the HP-85 Product Support Package (00085-67801)

Section
II

Troubleshooting and Repair

2-1. INTRODUCTION

This section helps isolate the cause of a problem to a part or assembly that you can replace without soldering.

Frequently a computer is received for repair with a message from the customer describing the problem. This information can be very helpful in troubleshooting. Nevertheless, because of the complexity of the HP-87, you should always begin troubleshooting any HP-87 problem by using the procedures described in paragraph 2-7.

> CAUTION
> Ensure that the bench setup for troubleshooting and repair has adequate electrostatic protection; otherwise, ICs may be damaged.

2-2. SAFETY CONSIDERATIONS

> WARNING
> Lethal voltages are exposed when the top case of the HP-87 is removed. At certain points these voltages are present not only while power is on, but also for up to several days after power is turned off. Electrical and mechanical failures may cause dangerous voltages to be present at points that normally are safe. For your own safety, read and heed the safety guidelines listed in section I.

2-3. SYSTEM OVERVIEW

The HP-87 (see figure 2-1) consists of:

- The CPU (central processing unit), an 8-bit microprocessor.
- Read-only memory (ROM) containing microprogrammed instructions. The HP-87 has 48K bytes of ROM distributed among six ICs.
- Random access memory (RAM) for storage of user programs and data and the BASIC operating system. The HP-87 has 48K bytes of RAM, which are distributed among 24 ICs and accessed through the RAM controller. Approximately 4K of RAM are used for the BASIC operating system.

- A 92 character keyboard which is controlled by the CPU via the keyboard controller. The keyboard controller also provides four timers for use by the operating system and the user.

- A cathode ray tube (CRT) display capable of displaying up to 80 characters on each of 16 or 24 lines (user programmable). Graphics patterns may be created using a matrix of 400 dots by 240 dots or 544 by 240 dots. The display is controlled by the CPU through the CRT controller and associated RAM, analog drive circuitry, and a high-voltage power supply.

- A built-in HP-IB interface that conforms to IEEE Standard 488-1978. An industry-standard HP-IB connector is provided on the rear panel of the computer.

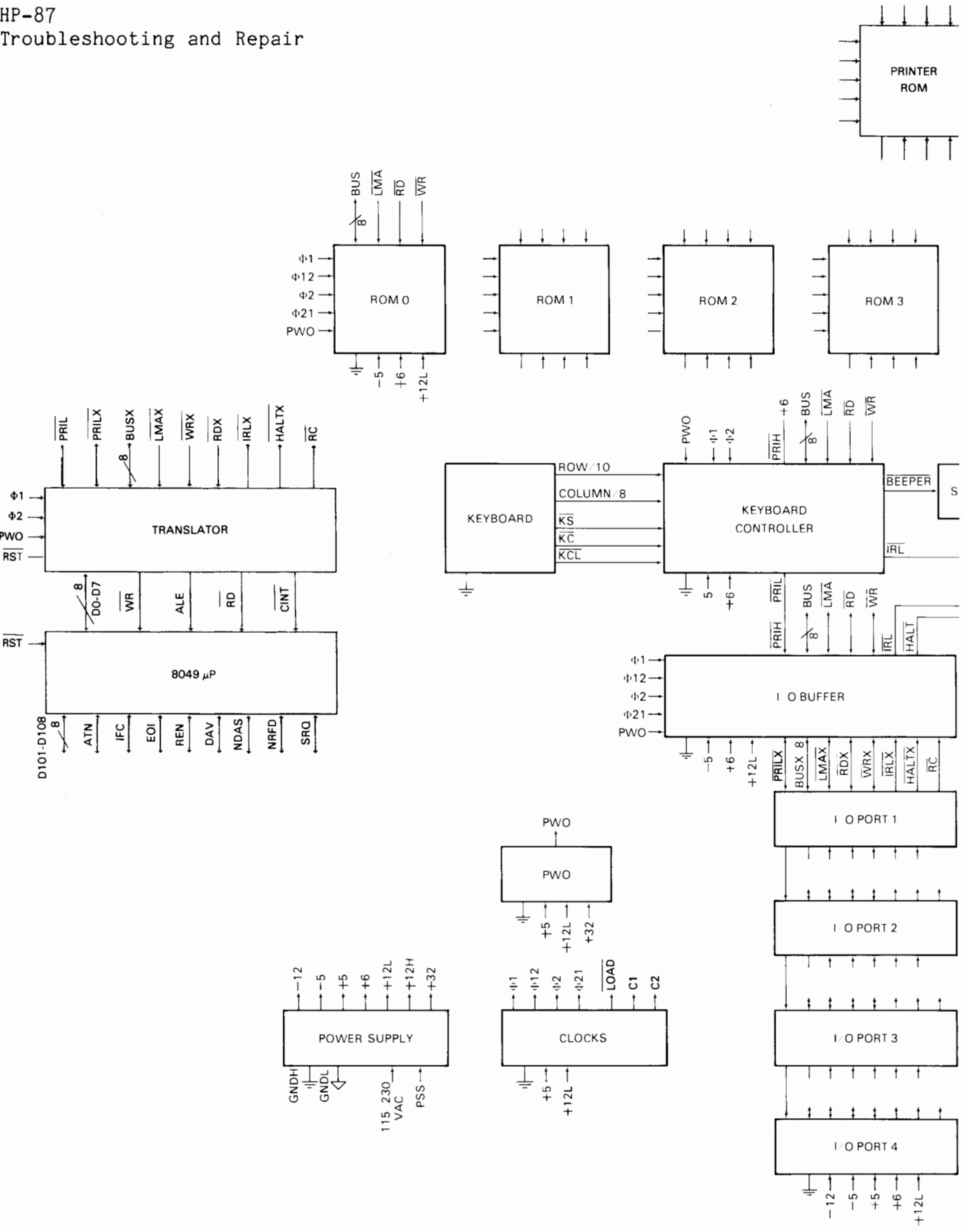
- Four I/O ports for plug-in modules that provide additional memory or functional capabilities, or for connecting non-HP-IB peripheral devices such as printers, plotters, etc. An I/O buffer IC interfaces between the CPU and modules or devices plugged into the I/O ports.

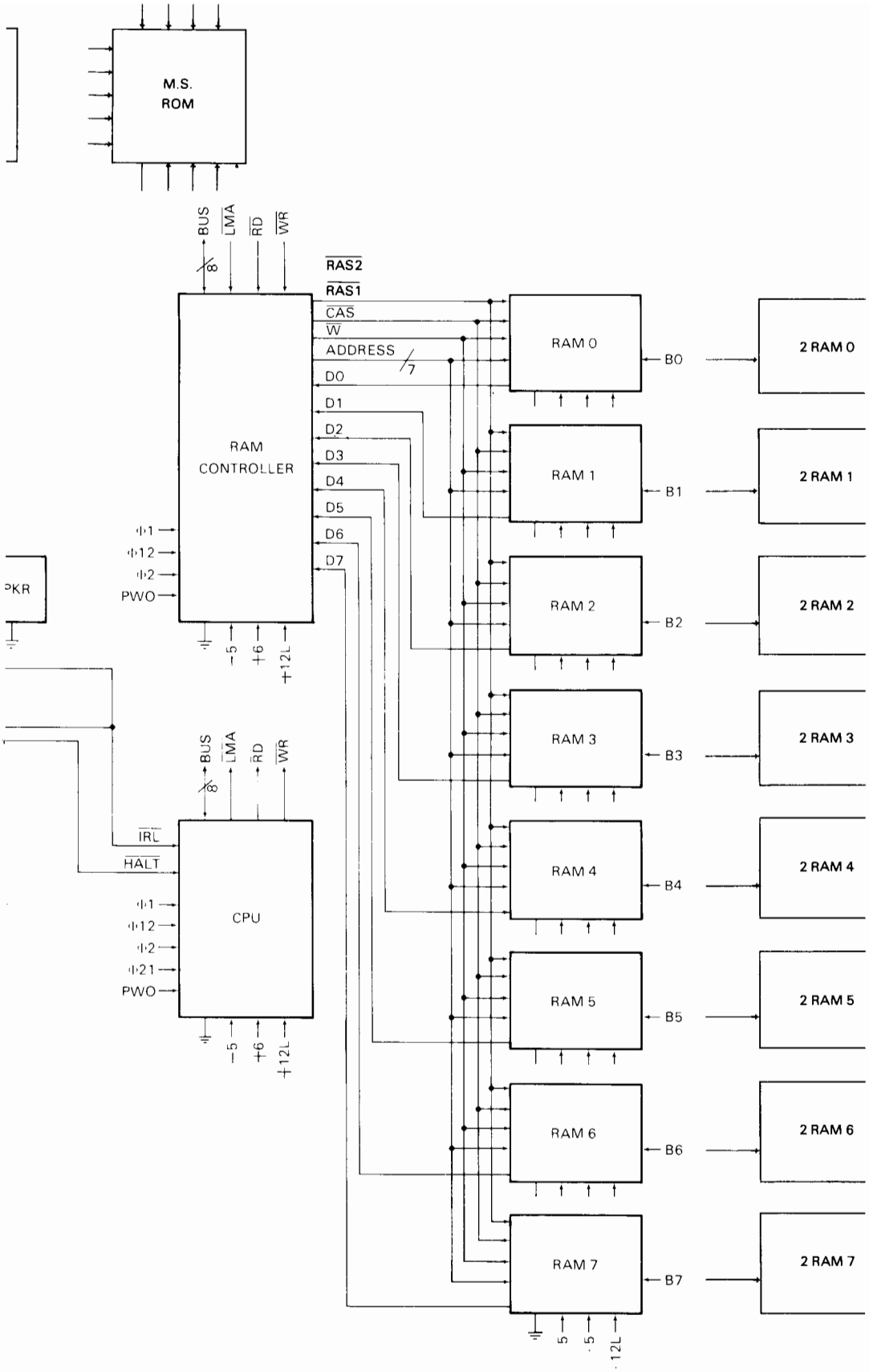
- A 1 3/4-inch speaker, controlled by the CPU through the keyboard controller to produce audible tones ("beeps") of variable frequency and duration.

- An 8-bit bus that transfers instructions and addresses between the CPU and the various controllers, the I/O buffer, and the ROMs.

- System timing circuitry.

- Power supply circuitry.


PRINTER ROM
BUS
8
LMA
RD
WR
Φ1
Φ12
Φ2
Φ21
PWO
ROM 0
ROM 1
ROM 2
ROM 3
-5
+6
+12L
PRIL
PRILX
BUSX
LMAX
WRX
RDX
IRLX
HALTX
RC
TRANSLATOR
RST
D0-D7
WR
ALE
RD
CINT
8049 μP
D101-D108
ATN
IFC
EOI
REN
DAV
NDAS
NRFD
SRQ
KEYBOARD
ROW/10
COLUMN/8
KS
KC
KCL
KEYBOARD CONTROLLER
BEEPER
IRL
PRIH
+6
I/O BUFFER
HALT
I/O PORT 1
I/O PORT 2
I/O PORT 3
I/O PORT 4
PWO
+5
+12L
+32
POWER SUPPLY
-12
+12H
GNDH
GNDL
115 230 VAC
PSS
CLOCKS
LOAD
C1
C2


M.S.
ROM
BUS
LMA
RD
WR
8
RAS2
RAS1
CAS
W
ADDRESS
7
D0
D1
D2
D3
D4
D5
D6
D7
RAM
CONTROLLER
Φ1
Φ12
Φ2
PWO
-5
+6
+12L
RAM 0
RAM 1
RAM 2
RAM 3
RAM 4
RAM 5
RAM 6
RAM 7
B0
B1
B2
B3
B4
B5
B6
B7
2 RAM 0
2 RAM 1
2 RAM 2
2 RAM 3
2 RAM 4
2 RAM 5
2 RAM 6
2 RAM 7
IRL
HALT
CPU
Φ21
5
.5
12L

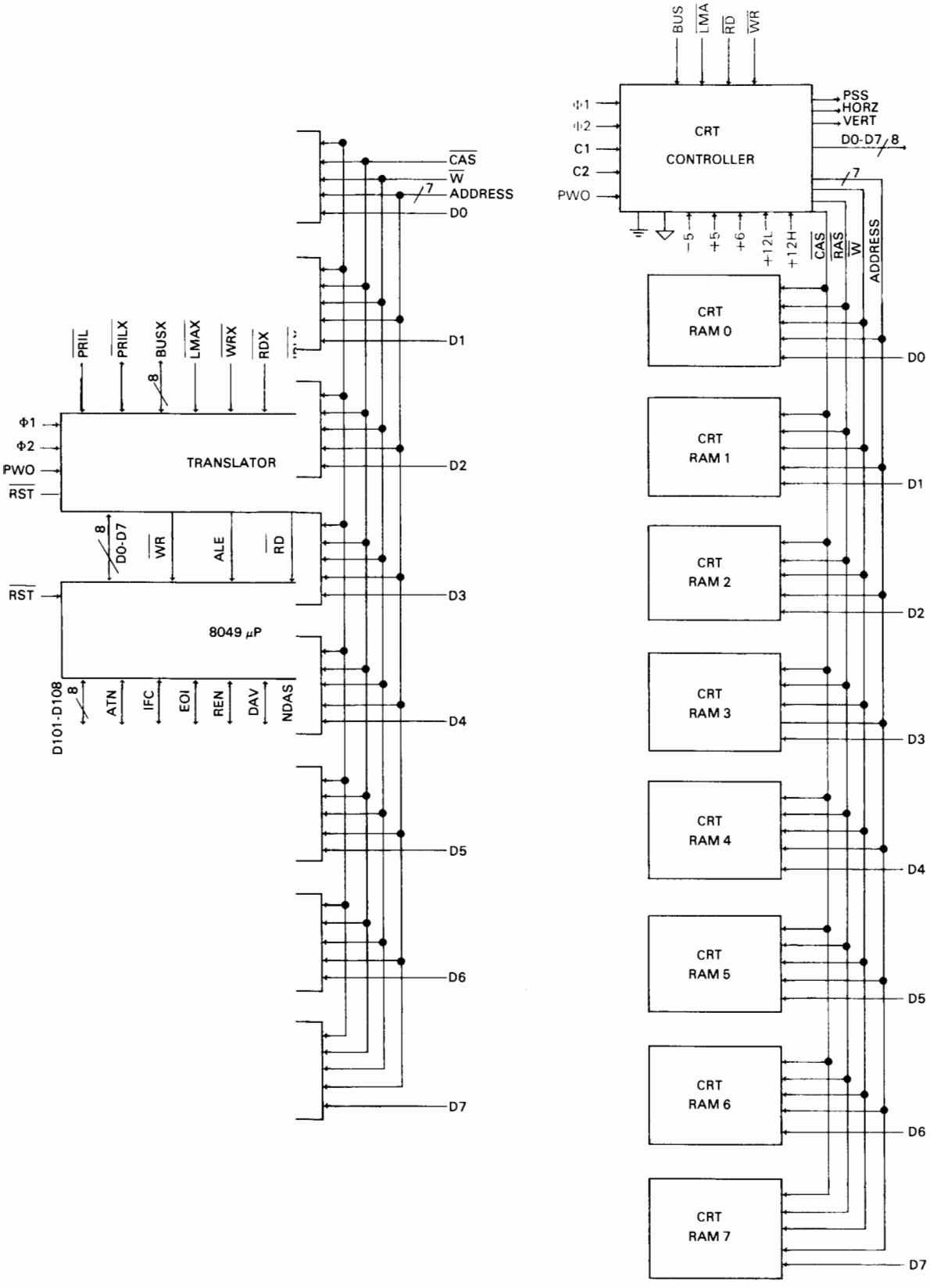


Figure 2-1. HP-87 Block Diagram

2-4. TROUBLESHOOTING OVERVIEW

Troubleshooting the HP-87 is facilitated by the use of the service ROMs. Two service ROMs are provided for the HP-87: the System Service ROM (HP part number 00087-60912) and the HP-IB Service ROM (HP part number 00087-60913).

The service ROMs identify bad ICs and enable you to further check the CRT and keyboard assemblies. Paragraph 2-10 gives a general description of the service ROMs.

In order to the troubleshoot an HP-87:

a. Set up the computer as described in paragraph 2-7. If the computer does not turn on properly, troubleshoot it as described in paragraph 2-9.

b. Run the System Test from the System Service ROM as described in paragraph 2-14.

c. Replace any bad ICs identified by the Service ROMs. After replacing an IC, you need to run only the individual test for that IC from a service ROM to verify that the replacement has corrected the problem.

d. For some problems, the service ROMs will not identify a possible cause. In such cases, an IC may nevertheless be bad or some other part of an assembly may be bad. If you observe a problem with the beeper or the CRT correct it as described in paragraph 2-14. After replacing any part or assembly, run the appropriate test from the service ROMs to verify that the replacement has corrected the problem.

e. After correcting all problems and installing the top case, run the System Test again to make sure that the computer is working properly before returning it to the customer.

f. If the customer reported an intermittent problem, you can attempt to reproduce it in either of two ways:

   o Run the Cycle Test. (Refer to paragraph 2-22.)

- Write and run a BASIC program containing a continuous loop of a test or tests from the service ROMs. (For more information about running service ROM tests under control of the BASIC operating system, refer to paragraph 2-12; for assistance in programming, refer to the HP-87 Operating and BASIC Programming Manual.)

2-5. TROUBLESHOOTING TIPS

> CAUTION
> Always switch the power off before disconnecting or connecting an assembly, cable, or installing an IC. If power is on while this is done, ICs could be damaged.

Do not attempt to leave the keyboard PCA connected with its short ribbon cables while the keyboard hinge pins are disengaged from their retainers in the bottom case. If this is done, the strain on the ribbon cable connectors may open the connection between a connector pin and the keyboard PCA. If you want to access the logic one PCA with the keyboard PCA connected, prop up the keyboard assembly as shown in figure 2-2.

If ribbon cables are not inserted properly into their connectors, components could be damaged. Refer to paragraph 3-5 for information about connecting cables.

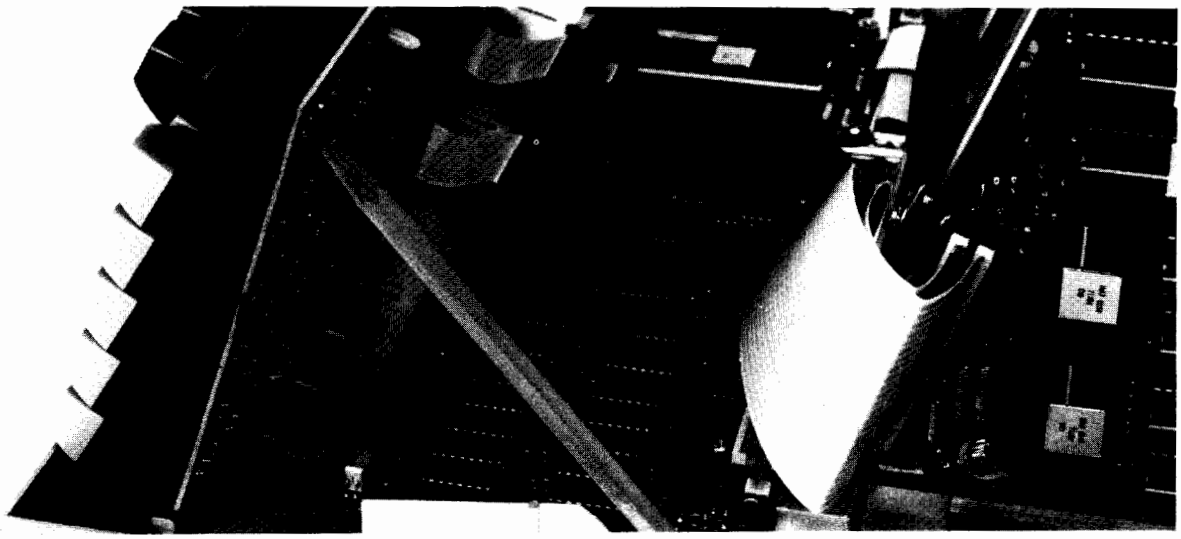


Figure 2-2. Keyboard Assembly Propped Up

- If a service ROM indicates that an IC is bad but replacing it results in the same message, check that all power supplies, clocks, bus lines, control lines, etc., are present at the pins of the IC. If not, the line may be open or shorted between the socket and the source of the signal; in this situation, the bad printed-circuit assembly should be replaced. If an oscilloscope is not available and the IC indicated is a ROM, try exchanging its location with that of another ROM. If the service ROM then indicates that the other ROM is bad, one of the lines to the socket is bad.

- If the computer won't turn on after you replace an IC identified by a service ROM, make sure that no pin of the new IC was bent over and shorted against another pin when you inserted it. Recommended procedures for removing and inserting ICs are described in paragraph 2-6 .

- Don't connect GND/H to GND/L.

2-6. REMOVING AND INSERTING SOCKETED ICs

There are 37 socketed ICs in the HP-87. These socketed ICs are held tightly in their sockets and cannot easily be removed with your fingers. Furthermore, unless you are careful you can bend the pins of an IC while inserting it into a socket. The recommended removal and insertion procedures are as follows.

To remove an IC from its socket:

a. Insert a small, flat-blade screwdriver between one end of the IC and the socket. (See figure 2-3.)

> CAUTION
> In the next step, do not insert the screwdriver more than about 2.5 millimeters (3/32 inch) between the IC and its socket. If you do so with certain sockets, the screwdriver could damage traces on the printed-circuit board.

b. Pry the end of the IC up by raising the handle of the screwdriver.

c. Raise the other end of the IC up either by prying it with the screwdriver, if possible, or by pushing the first end down so that the other end rocks up.

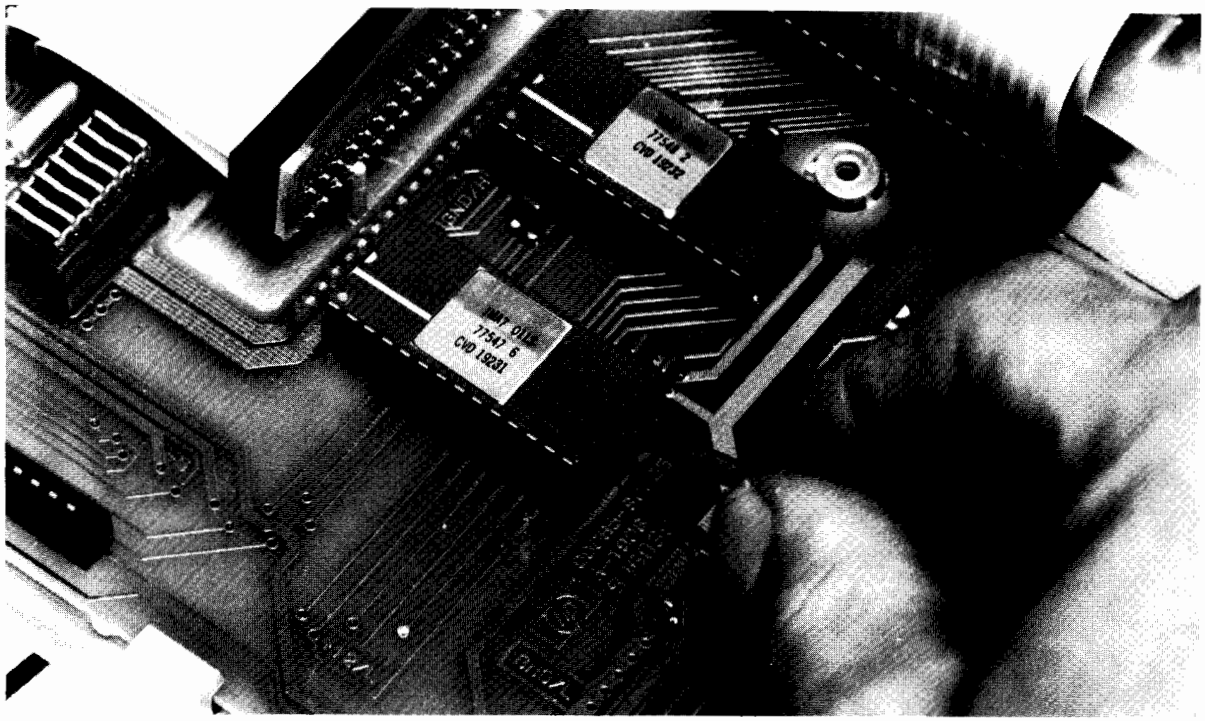


Figure 2-3. Removing IC From Socket

To insert an IC into its socket:

a. Position the IC over the socket so that the semicircle in the top end of the IC is pointing in the same direction as the semicircle in the socket. (See figure 2-4.)

b. Rest the IC on the socket.

c. Press down evenly along both sides of the IC until it snaps securely in the socket. (See figure 2-5.) When the IC is properly inserted, both sides of the IC should be the same height above the socket.

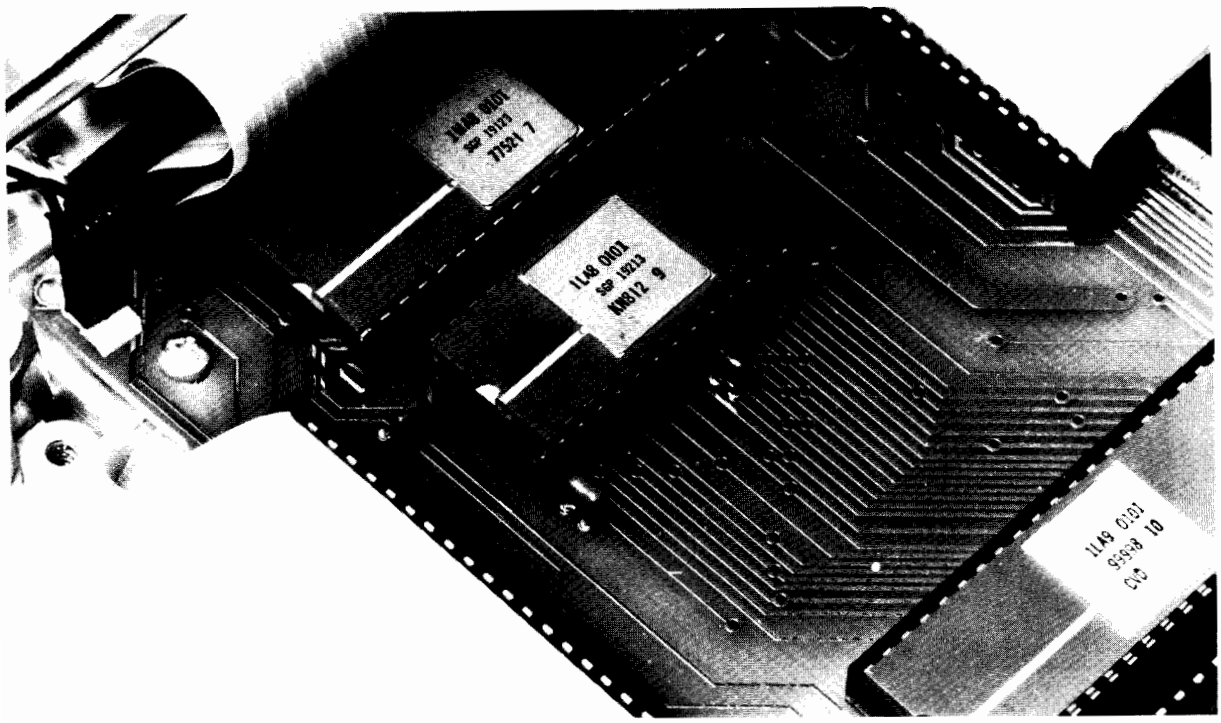


Figure 2-4. Positioning IC for Insertion

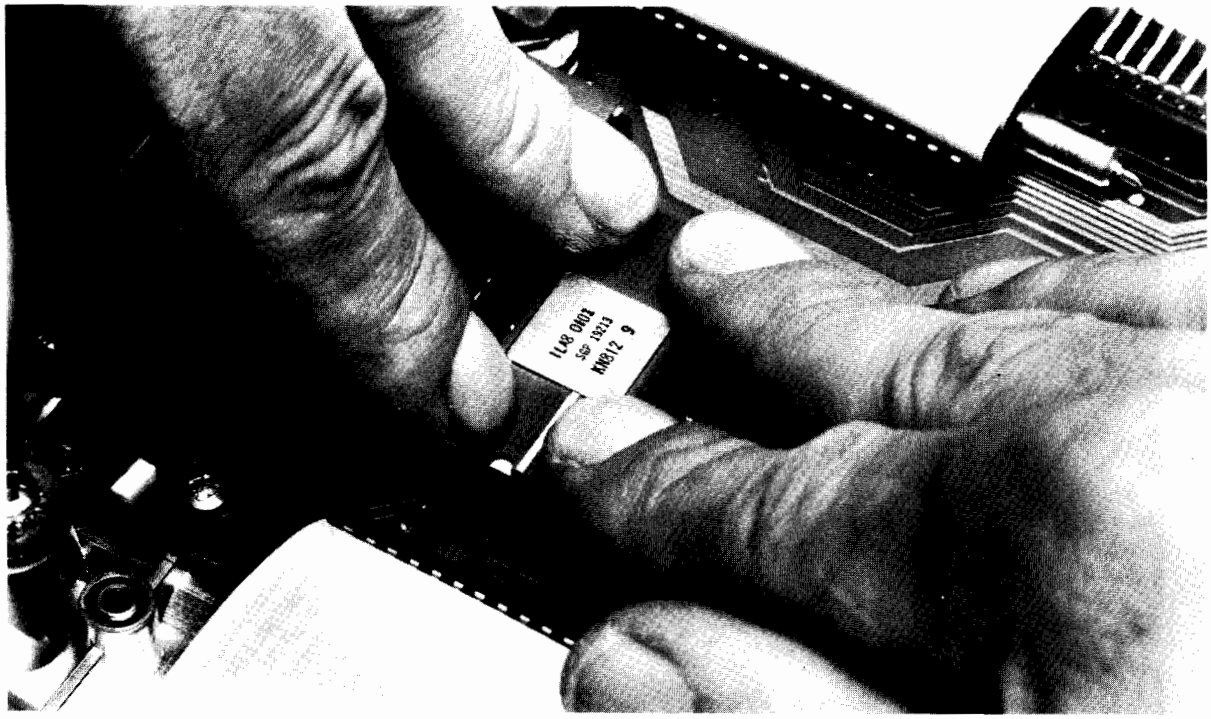


Figure 2-5. Pressing IC Into Socket

Table 2-1. Socketed ICs

LOCATION (PCA)	INTEGRATED CIRCUIT	REFERENCE DESIGNATION
Logic One	CRT Controller	U27
	Keyboard Controller	U29
	CPU	U25
	RAM Controller	U28
	RAM	U1-U24
Logic Two	Translator	U1
	I/O Buffer	U11
	System ROM	U12,U13, U14,U15
	Internal Enhancement ROM	U16,U17
	8049 Microprocessor	U2

2-7. SETUP

To set up an HP-87 for checkout and troubleshooting:

a. Disconnect the power cord and ensure that the ON-OFF switch on the back panel is set to OFF.

b. Make sure that the line voltage selector switch on the back panel is set to the nominal line voltage in the customer's area.

CAUTION
The computer will be damaged if the switch is set to 115V and the computer is switched on while connected to a 230V supply.

c. Ensure that an intact fuse of the proper rating is installed in the fuse receptacle on the back panel. Use a 800 mA fuse for 115V operation; use a 315 mA fuse for 230V operation.

d. Connect the power cord to its receptacle on the back panel. Plug the other end of the cord into an ac power source of the proper voltage.

CAUTION
The computer must be switched off when the ROM drawer (as well as any other plug-in module) is inserted into a module port. If the power were on, ICs could be damaged.

e. Install the service ROMs in a ROM drawer, and insert the ROM drawer into one of the I/O ports in the back panel assembly.

f. Switch the computer on.

2-8. INITIAL TROUBLESHOOTING

Within 10 to 15 seconds after you switch the computer on, the following message should be displayed:

{SERVICE ROM: SELECT TEST A-V}*

This message will be preceded by other messages indicating tests of the CPU, RAM, the four system ROMs, external ROMs, and the HP-IB. These messages may identify bad ICs; such messages will be repeated during the System Test (if the System Test can be run). Watch the display for these messages.

If the {SERVICE ROM} message appears correctly on the CRT, run the System Test from the System Service ROM, as described in paragraph 2-14.

Note: If the computer has a keyboard problem, the System Test may not run. In this situation:

- If the message {NO KEY!} appears, refer to No Key Entry, paragraph 2-44.
- If the message {KEY STUCK!} appears, refer to Key Stuck, paragraph 2-49.
- If a service ROM test other than the System Test is run, look up the key entered in table 2-11, then refer to paragraph 2-46.
- If only the message {RETURN TO BASIC SYSTEM} appears, refer to paragraph 2-45 if the character following the message is one of the first 32 characters listed in table 2-11; otherwise, refer to paragraph 2-46.
- If there is no response to pressing any key (that is, no test is run and no message appears), replace the keyboard controller.

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*Throughout the rest of this manual, this message is referred to simply as "the {SERVICE ROM} message."

If no message appears within 15 seconds after you switch the computer on and the computer does not beep, the computer is not turning on properly; refer to paragraph 2-9.

If no message appears but the computer beeps once, watch the display while you switch the computer off and immediately on again. (This shortens the time required for the CRT to warm up.) If no message appears, replace the CPU. If still no message appears, the computer is not turning on properly; refer to paragraph 2-9.

If the {SERVICE ROM} message does not appear on the display but a {CPU BAD!}, {RAM BIT n BAD!}, {EMC BAD!}, {ROM n BAD!}, or {XROM nnn BAD!} message appears, replace the indicated IC. (Refer to table 2-5 for the reference designation of the IC identified by a service ROM message.)

If the {SERVICE ROM} message does not appear on the display but the message {CPU BAD! N OR RAM BAD!} appears, perform the following steps until the {SERVICE ROM} message appears:

a. If the character following the message is listed in table 2-2, replace the indicated RAM IC. Otherwise, look up the character in appendix D of the HP-87 Operating and BASIC Programming Manual in the table under Character and Key Codes. The binary code corresponding to the character shown indicates which RAM IC is bad: the leftmost bit in the code represents RAM 7 of the first bank of RAM (U16); the rightmost bit represents RAM 0 of the first bank of RAM (U9). A "1" in a bit position indicates that the corresponding RAM IC is probably bad; a "0" in a bit position indicates that the corresponding RAM IC is probably OK. If the character following the message is in inverse video, RAM 7 (U16)--as well as the RAM ICs indicated by the binary code in the table--is probably bad.

b. Check the voltage on the power supply lines at the pins of the indicated RAM IC. (Table 2-3 shows the acceptable values for the power supply lines.) If any line is bad, remove all the ICs from the logic one PCA, install them on a new logic one printed-circuit board, and install the new logic one PCA in the computer.

c. Replace the RAM controller.

d. Replace the CPU.

e. Remove all the ICs from the logic one PCA, install them on a new logic printed-circuit board, and install the new logic PCA in the computer.

Table 2-2. ICs Indicated by {CPU BAD! N OR RAM BAD!} Message

CHARACTER	RAM	REFERENCE DESIGNATION
	0	U9
	1	U10
	2	U11
	3	U12
	4	U13
(blank)	5	U14
	6	U15
	7	U16

2-9. NO TURN-ON

If the computer does not beep and messages do not appear when it is switched on with the service ROMs installed, the computer is not "turning on" properly. This condition could be caused by any of the following:

- The power supply, PWO, or clock circuitry is not operating properly.
- An output of one of these three circuits is being pulled low by a failure on another assembly.
- The CPU is bad.
- One of the bus lines or control lines, is being pulled low by a failure on another assembly.
- ROM 0 is bad. This IC is necessary for turn-on.
- The RAM controller or any of the first bank of RAM ICs (U9-U16) is bad. A portion of RAM is used by the service ROMs and the CPU.
- The I/O buffer is bad. This IC is necessary to interface between the service ROMs and the CPU.
- One of the power supply, PWO, clock, bus or control lines to an IC is open.
- The connector on the I/O PCA is bad.
- The connection between the I/O PCA and the logic two PCA is bad.
- The service ROMs are bad.

> Note: Always check the power supply voltages when first trying to isolate a no-turn on condition.

To isolate a no turn-on condition to a socketed IC or an assembly, perform the following steps until the computer turns on:

a. Check the voltage on the power supply lines at the ribbon cable connector on the logic one PCA. Refer to table 2-3 for the test point and acceptable voltage range for each supply line. If any line is out of range, refer to paragraph 2-59.

b. Check the PWO line at Test Point 6 on the logic one PCA. Monitor the signal with an oscilloscope as you switch the power on. PWO should reach at least 4.4 Vdc a fraction of a second after you switch the power on, but not instantly. If PWO is bad, refer to paragraph 2-60.

c. Check the clock lines at the test points on the logic one PCA. Refer to table 2-3 for the clock test points. If any clock line is bad, refer to paragraph 2-60.

d. Check the power supply, PWO, and clock lines at the socket of the CPU. If any line is bad, remove all the ICs from the logic one PCA, install them on a new logic one printed-circuit board, and install the new logic one PCA in the computer.

e. Replace the CPU.

f. Check the control and bus lines at the pins of the CPU with an oscilloscope. Each line should be switching between 0V and 6V. Since these lines are asynchronous (their waveforms do not have a period), with an ordinary oscilloscope you can verify only that they are switching. If any line is not switching, refer to paragraph 2-60.

g. Check the power supply, PWO, clock, control, and bus lines at the sockets of ROM 0 (U12/logic two PCA), the RAM controller (U28), the RAM ICs (U9 through U24), the I/O buffer (U11/logic two PCA) and the translator (U1/logic two PCA). If any line is bad, remove all the ICs from the corresponding PCA, install them on a new printed-circuit board, and install the new PCA in the computer.

h. Replace (one at a time) ROM 0, the RAM controller, and then each of the RAM ICs in the first bank of RAM (U9-U16).

i. Replace the I/O buffer.

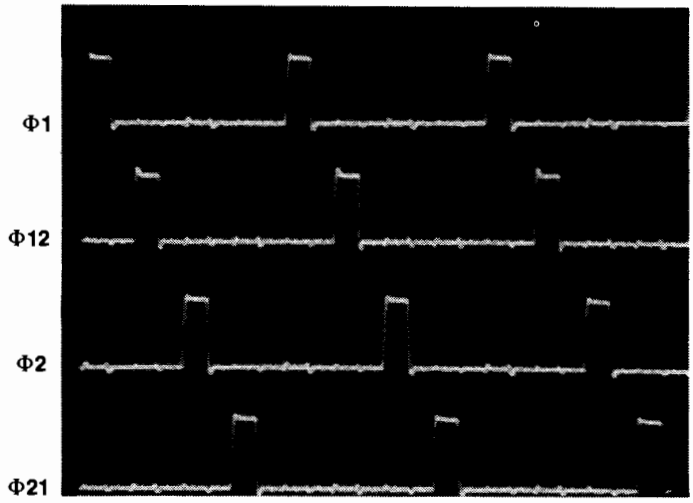
j. Check continuity between the ribbon cables on the logic two PCA and those on the I/O PCA. Replace the cable(s) or the printed-circuit assembly that has the bad connector.

k. Try different service ROMs.

Table 2-3. Power Supply, PWO, and Clock Test Points

LINES	TEST ASSEMBLY	CHECK		ACCEPTABLE
		SIGNAL	PIN	
Power Supply	Logic One	+12	J7-16,17, 18,19,20, 21	11.4V to 12.6V
		+6	J7-15	5.70V to 6.30V
		+5	J7-11,12, 13,14	4.75V to 5.25V
		-12	J7-1	-10.8V to -13.2V
		-5	J7-10	-4.75V to -5.25V
		+32	J7-22	33.6V to 30.1V
PWO	Logic One	PWO	TP6	At least 4.4 Vdc.*
Clocks		ϕ1	TP2	See figure 2-6.
		ϕ12	TP3	
		ϕ2	TP4	
		ϕ21	TP5	

*Monitor the PWO signal with an oscilloscope as you switch the power on. PWO should reach at least 4.4 Vdc a fraction of a second after you switch the power on--but not instantly.



Time Base: 0.5 us/div
Vertical Gain: 10V/div

Figure 2-6. Clock Waveforms

2-10. SERVICE ROMS

Troubleshooting the HP-87 is greatly facilitated by the use of the service ROMs. Tests provided in these ROMs tell you if a socketed IC is bad and enable you to check for proper operation of the CRT assembly.

The System Service ROM contains the following tests:

System
CPU
RAM
ROM
Beeper
CRT
Timer
Key

External RAM
External ROM
Heat
Focus Pattern
Pincushion Pattern
QA
Raster Screen
Cycle

The HP-IB Service ROM contains two HP-IB tests: a short and long test.

Although any of the tests in a service ROM can be run individually, most of the tests can be run automatically as the System Test.

The System Test, which incorporates seven individual tests, is the basic test you should use to begin assembly-level troubleshooting of an entire computer. Even when you know that there is a problem in a particular assembly checked by an individual test, you should first run the entire System Test. The first few tests in the System Test check components that could cause operating problems in the assemblies checked by subsequent tests. You may run an individual test alone in either of the following circumstances:

- You have replaced a component or assembly that the System Test indicated was bad, and you want to verify, without running the entire System Test again, that replacing the component or assembly has corrected the problem.

- You are servicing only an assembly that was received for repair from an HP-87 dealer.

2-11. SELF-TEST

The HP-87 system performs a self-test each time the computer is switched on. This test does a simplified version of the ROM Test and a portion of the RAM and Keyboard Tests. The CPU, CRT, and timers are not checked. If the computer is switched on with the System Service ROM installed, the ROM takes control immediately, and the self-test is not done until control is returned to the BASIC system. At that time--if a problem is found--the computer beeps twice, and the message {Error 23:SELF TEST} is displayed. If the self-test is completed successfully, only the cursor appears on the display.

The self-test executed by pressing the [TEST] key is identical to that performed when the computer is switched on, except that if the test is completed successfully, the characters shown in figure 2-7 are displayed at the end.

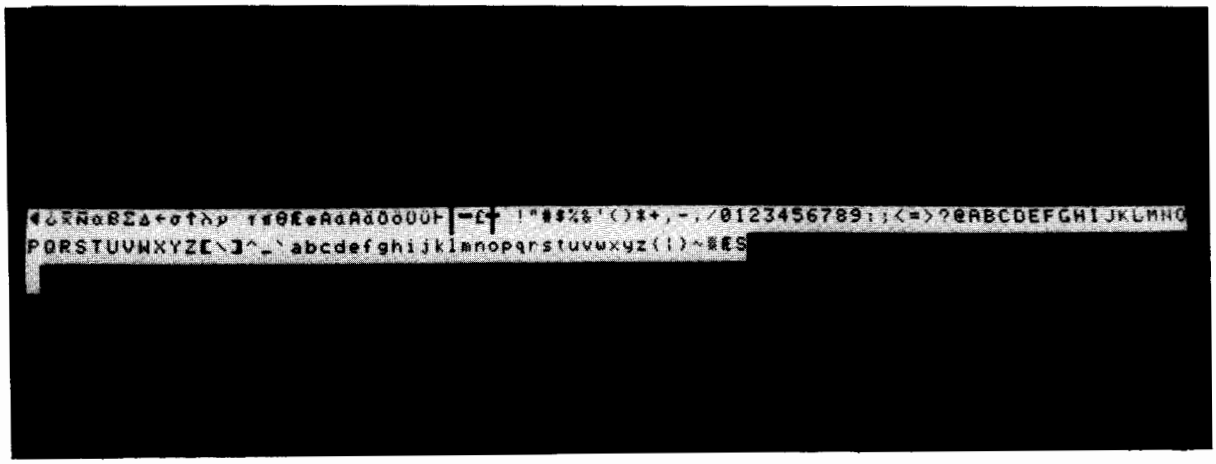


Figure 2-7. System Self-Test Results

2-12. RUNNING A SERVICE ROM TEST

When an HP-87 with the service ROMs installed is turned on, control is passed to the service ROMs. The following messages should be displayed.

```
{CPU OK}
{RAM OK}
{2RAM OK}
{EMC OK}
{ROM 0 OK}
{ROM 1 OK}
{ROM 2 OK}
{ROM 3 OK}
{XROM 001 OK}
{XROM 208 OK}
{XROM 224 OK}
{XROM 225 OK}
{HPIB SHORT TEST OK}
{SERVICE ROM: SELECT TEST A-V}
```

If you press one of the keys [A] through [V] within 15 seconds after the messages appear, the service ROMs should perform the corresponding test listed in table 2-4.

> Note: Refer to paragraph 2-8 for troubleshooting procedures in any of the following circumstances:
>
> - The {SERVICE ROM} message does not appear within 15 seconds after the computer is switched on.
> - A {NO KEY!} or {KEY STUCK!} message appears 15 seconds after the {SERVICE ROM} message appears.
> - Pressing a key has no result within 15 seconds after the {SERVICE ROM} message appears.
> - Pressing a key results in the wrong test.

When the selected test is completed, the {SERVICE ROM} message appears again, and you can then run any Service ROM test by pressing the corresponding key.

> Note: If you press [W] within 15 seconds after the {SERVICE ROM} message appears, the computer will wait indefinitely for you to press another key.

If you press any key other than those listed in table 2-4, control will be passed to the BASIC system. (The space bar is a convenient key to press if you want to return to the BASIC system.) When this happens, the message {RETURN TO BASIC SYSTEM} is momentarily displayed, then the cursor appears in the display. The message is followed by a character that indicates which key was entered. The cursor signifies that the BASIC system is in control.

If no key is pressed within 15 seconds after the {SERVICE ROM} message appears, the computer will beep, the messages {NO KEY!} and {RETURN TO BASIC SYSTEM} are momentarily displayed, then the cursor appears in the display. If a key is not released (or a key is struck) within 15 seconds after the {SERVICE ROM} message appears, the messages {KEY STUCK!} and {RETURN TO BASIC SYSTEM} are momentarily displayed, then the cursor appears in the display.

Whenever the BASIC system is in control (as signified by the presence of the cursor on the CRT), you can select any test by typing in the corresponding BASIC command listed in table 2-4, followed by [END LINE].

This capability enables you to write and run a BASIC program that automatically runs and repeats a test or group of tests from the service ROMs. For normal testing and troubleshooting it is more convenient to run the test under the direct control of the service ROMs.

Running a BASIC program--including a program that contains BASIC commands from the service ROMs--requires that the CPU, ROM, and RAM are OK. Therefore, do not run a test using a BASIC command until you have control of the service ROMs.

If you want to run a BASIC program that automatically runs and repeats a test or group of tests from the Service ROM, do not include the Keyboard Test (or the System Test, which incorporates this test) in your program. This test requires interaction from the user.

2-13. ERROR MESSAGES

Most messages that result when a component or assembly is not operating properly are followed on the same line by a letter designating the nature of the failure. For many such messages, the letter indicates the nature of the failure within an IC, and is useful information only for quality control purposes at the factory. Throughout this manual, some of these messages appear with a letter following, and some do not. If an actual message on a computer under repair is followed by one of the letters shown next to the message in a troubleshooting procedure, proceed as directed in the procedure; otherwise, ignore the letter.

Table 2-4. Service ROM Tests

TEST	KEY	COMMAND	PARAGRAPH NUMBER
System	[A]	{SYSTEM}	2-14
CPU	[B]	{CPU}	2-28
RAM	[C]	{RAM}	2-32
ROM	[D]	{ROM}	2-35
Beeper	[E]	{BEEPER}	2-70
CRT	[F]	{DISPLAY}	2-53
HP-IB (short)	[H]	{HPIB x} (x is an odd integer)	2-61
HP-IB (long)	[I]	{HPIB s} (s is an even integer)	2-64
Timer	[J]	{TIMER}	2-50
Keyboard	[K]	{KBD}	2-42
External RAM	[L]	{XRAM}	2-67
External ROM	[M]	{XROM}	2-83
Heat	[N]	{HEAT x}	2-25
Focus Pattern	[O]	{FOCUS}	2-53

Table 2-4. Service ROM Tests (Continued)

TEST	KEY	COMMAND	PARAGRAPH NUMBER
Pincushion Pattern	[P]	{PATTERN}	2-53
QA	[Q]	{QA x}	2-73
Raster	[R]	{RASTER}	2-53
Cycle	[V]	{CYCLE}	2-22

2-14. TROUBLESHOOTING WITH THE SYSTEM TEST

The System Test automatically runs the following tests from the service ROMs:

a. CPU Test
b. RAM Test
c. ROM Test
d. External ROM Test
e. Beeper Test
f. CRT Test
g. Timer Test
h. HP-IB (long)--if the HP-IB Service ROM is installed
i. Keyboard Test

To run the System Test, press [A] if the service ROMs are in control, or type in {SYSTEM} if the BASIC system is in control.

2-15. Results of the System Test

- The message {SYSTEM TEST BEGINS} is displayed, then the eight individual tests are run in the order listed in paragraph 2-14.
- If a problem is found during any of the tests within the System Test, the appropriate message appears, the individual test is terminated, and the next test is begun.

- The message {SYSTEM TEST ENDS} appears after all the tests have been run.

If the service ROMs find a bad IC during the System Test, they display a message identifying the IC, then skip to the next test. To determine the reference designation of an IC identified in a ROM message, refer to table 2-5.

> Note: The service ROMs may indicate that more than one IC is bad. If so, replace the indicated ICs one at a time, running the System Test after each replacement, until the test can be run successfully.

If the message still appears after the IC is replaced, check the power supply, PWO, clock, control, and bus lines at the indicated IC. If any line is bad, remove all the socketed ICs from the printed-circuit assembly, install a new printed-circuit board, and install the new printed-circuit assembly in the computer.

If the computer appears to "die" during any test, refer to table 2-5 and look up the last IC for which a message appeared, then replace the next IC listed. The RAM ICs and CRT RAM ICs are each tested simultaneously as a group. Therefore, if the computer goes dead during their testing, try replacing each IC in the group, one at a time, until the computer no longer goes dead during the test.

For assistance in troubleshooting problems that the steps above do not correct, refer to paragraphs 2-8 and 2-9.

2-16. RAM Test Diagnosis

If the message {RAM n BAD!} or {2 RAM n BAD!} still appears after you replace the indicated RAM IC, replace the RAM controller.

2-17. ROM Test Diagnosis

If the {ROM} n BAD!} or message is followed by the letter {C}, replace the following ICs one at a time, running the System Test after each replacement, until the test can be run successfully:

a. The ROM indicated in the message.

b. The next numbered ROM or (for a {ROM 3 BAD!} message) the RAM controller. For example, if replacing ROM 1 following a {ROM 1 BAD!} message results in the same message, replace ROM 2. Similarly, if replacing ROM 3 following a {ROM 3 BAD!} message

results in the same message, replace the RAM controller.

2-18. Beeper Test Diagnosis

If the beeper is not operating properly, try replacing the keyboard controller. If this does not result in proper beeper operation, replace the speaker.

2-19. CRT Test Diagnosis

If the message {CRT RAM n BAD!} still appears after you replace the indicated IC, replace the CRT controller.

If any of the following occur, replace the CRT assembly:

- The CRT screen does not go blank at step d of the CRT Test.
- The CRT does not go entirely white at step i of the CRT Test.
- CRT test pattern 4 is not displayed as shown in figure 2-12.
- The lines in test pattern 4 are not straight. (Refer to paragraph 2-56.)

If any of the following occur (and the lines in CRT test pattern 4 are straight), make adjustments to the CRT assembly as described in paragraph 2-58.

- CRT test pattern 4 is skewed.
- Test pattern 4 is incorrectly centered horizontally or vertically.
- The height or width of test pattern 4 is incorrect.
- CRT test pattern 3 is not correctly focused.

If any character in CRT test pattern 5 is not displayed as shown in figure 2-13, replace the CRT controller.

2-20. Timer Test Diagnosis

If the message {TIMER BAD!} appears, replace the keyboard controller.

2-21. Keyboard Test Diagnosis

If one of the following messages appears, refer to paragraph 2-41:

- {NO KEY!}
- {KEY BAD!}
- {KEY STUCK!}

Table 2-5. Service ROM IC Messages

MESSAGE	REFERENCE DESIGNATION	PRINTED-CIRCUIT ASSEMBLY
{CPU BAD!}	U25	logic one
{2} {RAM CONTROL BAD!}	U28	logic one
{RAM 0 BAD!}	U9	logic one
{RAM 1 BAD!}	U10	logic one
{RAM 2 BAD!}	U11	logic one
{RAM 3 BAD!}	U12	logic one
{RAM 4 BAD!}	U13	logic one
{RAM 5 BAD!}	U14	logic one
{RAM 6 BAD!}	U15	logic one
{RAM 7 BAD!}	U16	logic one
{2RAM 0 BAD!}	U17	logic one
{2RAM 1 BAD!}	U18	logic one
{2RAM 2 BAD!}	U19	logic one
{2RAM 3 BAD!}	U20	logic one
{2RAM 4 BAD!}	U21	logic one
{2RAM 5 BAD!}	U22	logic one
{2RAM 6 BAD!}	U23	logic one
{2RAM 7 BAD!}	U27	logic one

Table 2-5. Service ROM IC Messages (Continued)

MESSAGE	REFERENCE DESIGNATION	PRINTED-CIRCUIT ASSEMBLY
{EMC BAD!}	U28	logic one
{ROM 0 BAD!}	U12	logic two
{ROM 1 BAD!}	U13	logic two
{ROM 2 BAD!}	U14	logic two
{ROM 3 BAD!}	U15	logic two
{XROM 001 BAD!}	U16	logic two
{XROM 208 BAD!}	U17	logic two
{XROM 224 BAD!}	System Service ROM	
{XROM 225 BAD!}	HP-IB Service ROM	
{CRT CONTROL BAD!}	U27	logic one
{CRT RAM 0 BAD!}	U1	logic one
{CRT RAM 1 BAD!}	U2	logic one
{CRT RAM 2 BAD!}	U3	logic one
{CRT RAM 3 BAD!}	U4	logic one
{TIMER BAD!}	U29	logic one
{KEY CONTROL BAD!}	U29	logic one

2-22. TROUBLESHOOTING WITH THE CYCLE TEST

The Cycle Test runs and automatically repeats the System Test (refer to paragraph 2-14) continuously.

2-23. How To Run The Cycle Test

To run the Cycle Test, press [V] if the Service ROM is in control, or type in {CYCLE} if the BASIC system is in control.

To terminate the Cycle Test, press any key within 3 seconds after the message {SYSTEM TEST ENDS} appears.

2-24. Results of The Cycle Test

The results of the Cycle Test are the same as the results of the System Test, but any messages are repeated until the test is terminated.

2-25. USING THE HEAT TEST

The Heat Test turns the CRT on full so that the entire screen is white, and simultaneously runs a continuous and repeating series of IC checks. The Heat Test runs the specified number of hours (default is 48 hours) or until any key is pressed.

The capability of turning on the CRT is provided for production, so that new CRT's can be "burned in." The IC checks include the following:

a. The CPU Test.

b. The status bits in the CRT controller and keyboard controller ICs.

c. The RAM Test.

d. A checksum of the ROM ICs. (The checksum is a simplified signature analysis; this check is not the ROM Test.)

e. The short HP-IB Test.

2-26. How to Run the Heat Test

To run the Heat Test, press [N] if the service ROM is in control, or type in {HEAT} if the BASIC system is in control. To terminate the test, press any key.

2-27. Results of the Heat Test

- When the Heat Test is begun, the message {HEAT TEST BEGINS} is displayed and the CRT is turned on full.
- Each time one cycle of the test is completed (about every 25 seconds), the CRT momentarily goes blank.
- If a problem is found in any IC during the test, the CRT goes blank, the appropriate message indicating the bad IC is displayed, and the test is terminated.
- If no problem is found, the Heat Test runs until you terminate it. To do so, press any key; the message {HEAT TEST ENDS} and the elasped time in hours will be displayed within 21 seconds after you press the key.

2-28. TROUBLESHOOTING WITH THE CPU TEST

The CPU Test checks the CPU by performing machine level instructions and comparing the results to what they should be. Note that since most of the CPU must be OK in order to obtain the {SERVICE ROM} message, in effect the CPU Test checks only a portion of the CPU.

2-29. How to Run the CPU Test

To run the CPU Test, press [B] if the Service ROM is in control, or type in {CPU} if the BASIC system is in control.

2-30. Results of the CPU Test

One of the following messages appears:

- {CPU OK} indicates that the CPU is probably OK.
- {CPU BAD!} indicates that the CPU is probably bad.
- {CPU BAD! N OR RAM BAD! (character)} indicates that a failure has been found during an attempt by the CPU to store data into RAM. When this message appears, either the CPU, the RAM controller, or a RAM IC may be bad. The character at the end of the message is a code that indicates which RAM IC may be bad. Refer to paragraph 2-8 to interpret the code.

2-31. TROUBLESHOOTING THE CONTROL AND BUS LINES

The three control lines ($\overline{LMA}$, $\overline{RD}$, and $\overline{WR}$) and the eight bus lines (B0 through B7) should be switching between 0V and 6V. Since these lines are asynchronous (their waveforms do not have a period), with an ordinary oscilloscope you can verify only that they are switching.

If the CPU is good and one of the bus or control lines is not switching, either an IC is holding the line constant or the line is shorted somewhere in the system. To isolate the failure, refer to table 2-6.

Table 2-6. Control or Bus Line Failure Isolation

STEP	ACTION	DIAGNOSIS/REPAIR	
		LINE OK	LINE BAD
	Note: Do step 1 for each socketed IC on both logic PCAs, one at a time, checking the line after each removal.		
1	Remove IC. Check line.	Replace IC with new one, and return all ICs previously removed.	Proceed with step 2.
2	Substitute new logic one PCA. Check lines.	Install new logic one PCA in computer.	Proceed with step 3.
3	Substitute new logic two PCA for original. Check lines.	Install new logic two PCA in computer.	

2-32. TROUBLESHOOTING WITH THE RAM TEST

The RAM Test checks the RAM controller IC and the RAM ICs by filling the RAM ICs with alternate 1s and 0s and reading back the result to see if the contents have been changed. If an error is found in one bit or only a few bits at a particular address, the message will indicate that the corresponding RAM IC is bad. If an error is found in all eight bits at a particular address, the message will indicate that the RAM controller is bad.

The RAM test also checks the extended memory controller (EMC) and an error message is displayed if it is bad.

When run under the control of the service ROMs, this test checks the address register in the RAM controller. When run under the control of the BASIC system, the address register is not checked since doing so would not allow you to continue using the BASIC system.

2-33. How to Run the RAM Test

To run the RAM Test, press [C] if the service ROMs are in control, or type in {RAM} if the BASIC system is in control.

2-34. Results of the RAM Test

Any of the following messages may appear:

- {RAM OK} indicates that the RAM controller and the RAM ICs are probably OK.
- {RAM CONTROL BAD!} indicates that the RAM controller is probably bad. When this message appears, the individual RAM ICs are not checked any further. Therefore, the RAM test should be run again, after replacing the RAM controller, to check for possible bad RAM ICs.
- {RAM n BAD!} indicates that the RAM IC in the first bank of RAM (U9-U16) designated by the number n is probably bad.
- {2RAM n BAD!} indicates that the RAM IC in the second bank of RAM (U17-U24) is probably bad.
- {EMC OK!} indicates that the extended memory controller is probably OK.
- {EMC BAD!} indicates that the extended memory controller is probably bad.

2-35. TROUBLESHOOTING WITH THE ROM TEST

The ROM Test checks the system ROM ICs by performing a signature analysis on their contents. This means that the contents are treated as data; the test manipulates this data and checks whether the correct results are obtained.

2-36. How to Run the ROM Test

To run the ROM Test, press [D] if the service ROMs are in control, or type in {ROM} if the BASIC system is in control.

2-37. Results of the ROM Test

For each of the four System ROM ICs, one of the following messages will be displayed.

{ROM n OK} or {ROM n BAD!}

The particular ROM IC checked is designated by the number n.

> Note: If the message {RAM BAD! ROM TEST ABORTED!} appears, the ROM Test has been aborted because the RAM controller or a RAM IC is bad. To run the ROM Test, run the RAM Test first and replace the IC indicated.

2-38. TROUBLESHOOTING WITH THE EXTERNAL ROM TEST

The External ROM Test checks the internal mass storage and graphics ROMs and any plug-in enhancement ROMs by performing a signature analysis on their contents. This check is performed in the same way that the ROM test checks the system ROMs.

Since the External ROM Test uses the computer's RAM, run the System Test (or at least the RAM Test) before running the External ROM Test to make sure that the RAM is OK.

2-39. How to Run the External ROM Test

a. If you are checking the internal enhancement ROMs, turn the power to the computer off, remove all ROMs except the service ROMs from the ROM drawer, and insert the ROM drawer into one of the module ports on the back panel. However, if you are checking an external ROM, install in the ROM drawer along with the service ROMs.

b. Switch the computer on.

c. When the {SERVICE ROM} message appears, press [M]. If the BASIC system is already in control, you can run the External ROM Test by typing in {XROM}.

2-40. Results of the External ROM Test

One of the messages shown below will appear for the internal enhancement ROMs and for any external ROM present in the ROM drawer. The number {nnn} appearing in the message designates which ROM has been checked. To identify the particular ROM from the code, refer to table 2-7.

- {XROM nnn OK} indicates that the designated ROM is probably OK.

- {XROM nnn BAD!} indicates that the designated ROM is probably bad.

> Note: If the message {RAM BAD! XROM TEST ABORTED!} appears, the External ROM Test has been aborted because the RAM controller or a RAM IC is bad. To run the External ROM Test, run the RAM test first and replace the IC indicated.

Table 2-7. Enhancement ROM Codes

nnn	ROM	IC	Location
001	Graphics	U16	Logic two
208	Mass Storage	U17	Logic two
224	System Service	00087-60912	ROM drawer
225	HP-IB Service	00087-60913	ROM drawer
xxx	External		ROM drawer

2-41. KEYBOARD TROUBLESHOOTING

To help determine what may be wrong with the keyboard (if anything), run the System Test from the System Service ROM. It is essential that you run at least the CPU, RAM, and ROM Tests before running the Keyboard Test, since the Keyboard Test uses the computer's ROM and RAM. If one of those three tests indicates a bad IC, replace it and run the System Test again. After all three tests have been passed, you need run only the Keyboard Test to check whether replacing a part has corrected a keyboard problem.

2-42. How to Run the Keyboard Test

The Keyboard Test requires you to press certain keys. In particular, at certain times you will press and hold the [CTRL] or [SHIFT] key while the next key or keys are pressed. The same is true for the [CAPS LOCK] key, except that you need not hold it down, since it locks in position. To release the [CAPS LOCK] key, press it again. The service ROM will prompt you with messages indicating whether these keys are to be down or up while pressing the next key or keys.

Since the Keyboard Test uses the computer ROM and RAM, do not run the Keyboard Test alone unless the computer has already passed the CPU, ROM, and RAM Tests. If the Keyboard Test is run with a bad ROM or RAM IC, the computer may appear to "go dead" during the test.

To begin the Keyboard Test, press [K] if the Service ROM is in control, or type in {KBD} if the BASIC system is in control. The keys to be pressed are indicated next to their prompting messages in table 2-8.

> Note: At the beginning of the test, make sure that the [CTRL] and [SHIFT] keys are not pressed and that the [CAPS LOCK] key is released to the same level as the other keys. If this is not done, the results of the test will be invalid.

In steps 4 through 7 and 9, each key is entered when it is pressed. In steps 1 through 3 and 8, each key is entered when it is released.

2-43. Results of the Keyboard Test

The following messages appear if no problem is found:

- {OK} following steps 1 through 9 indicates that the keys expected have been entered.
- {KEY TEST ENDS} indicates that the Keyboard Test has been completed.

If a problem is found, the test is terminated and one of the following messages appears:

- {KEY CONTROL BAD!} indicates that the keyboard controller is probably bad.
- {NO KEY!} indicates that no key has been entered. This message appears about 30 seconds after the key is first expected.
- {KEY STUCK!} indicates that a key appears to be stuck in the pressed position. This message appears about 30 seconds after the key is pressed.
- {KEY BAD!} indicates that the key entered is not the key expected. This message appears after an incorrect key has been entered eight times.

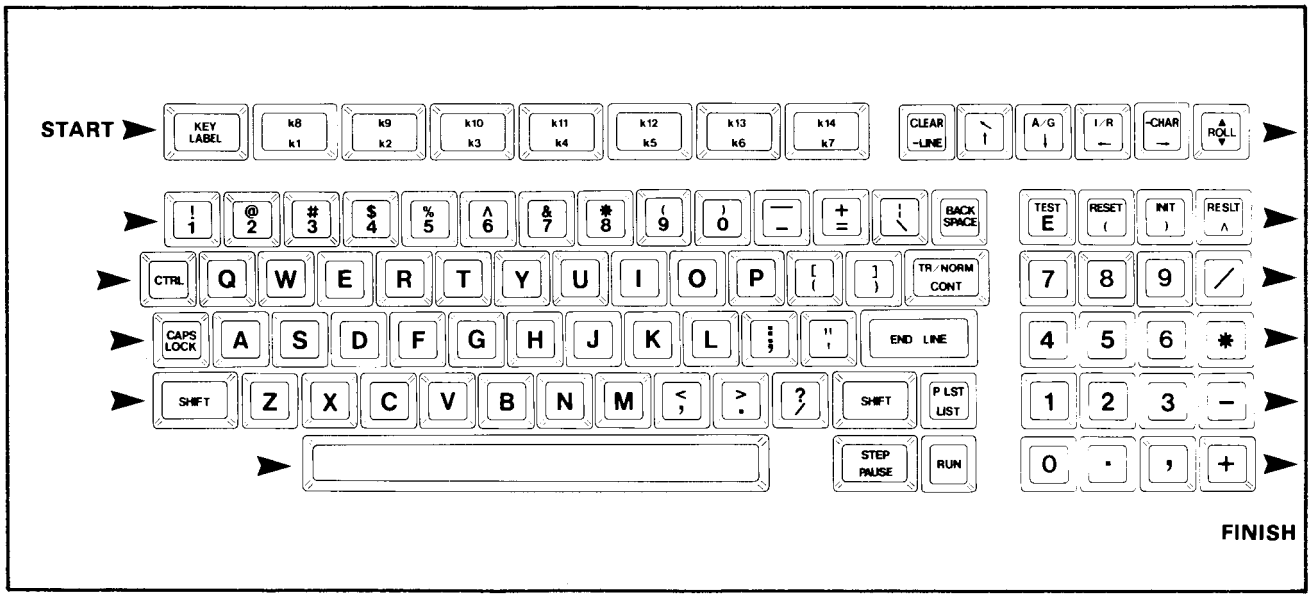


Figure 2-8. Key Sequence for Keyboard Test

Table 2-8. Keyboard Test

STEP	PROMPTING MESSAGE	ACTION
1	{KEY TEST:} {CTRL, CAPS, SHIFT UP; PRESS A}	Until otherwise indicated in subsequent prompting message, the [CTRL] and [SHIFT] keys should not be pressed, and the [CAPS LOCK] key should be released to the same level as the other keys. Press [A].
2	{PRESS A K1}	Press [A] [K1].
3	{PRESS A K1}	Press [A] [K1] again.
4	{CAPS DOWN; PRESS A K1}	Press and lock the [CAPS LOCK] key, then press [A] [K1].
5	{CAPS UP; PRESS A K1}	Press and unlock the [CAPS LOCK] key.
6	{CTRL DOWN; PRESS A K1}	While holding down the [CTRL] key, press [A] [K1].
7	{CTRL UP; PRESS A K1}	Release the [CTRL] key, then press [A] [K1] again.
8	{SHIFT DOWN; PRESS KEYS}	While holding down the [SHIFT] key press each of the keys in the order shown in figure 2-8. Do not press the [CTRL] or [CAPS LOCK] key during this sequence test.
9	{SHIFT UP; PRESS KEYS}	Release the [SHIFT] key, then again press each of the keys in the order shown in figure 2-8. Do not press the [CTRL], [CAPS LOCK], or [SHIFT] key during this sequence test.

If the keyboard is not working properly, one of the messages listed in table 2-9 will be displayed when the computer is switched on (with the service ROMs installed) or during the Keyboard Test. For each message, the table shows the reason for the message and the recommended action to correct the problem. To determine the key(s) corresponding to the character entered following a {KEY STUCK!} or {KEY BAD!} message, refer to table 2-11. To determine the key expected from the mnemonic following certain other messages, refer to table 2-10.

> Note: Remember that a message showing a digit ({0} through {9}), period ({.}), or comma ({,}) may indicate either a key on the numeric keypad (at the right of the keyboard) or a key elsewhere on the keyboard that shows the same character.

Table 2-9. Keyboard Test Diagnosis

MESSAGE	REASON	DIAGNOSIS/REPAIR
{KEY CONTROL BAD!}	Bad controller (U29, logic one PCA).	Replace controller.
{PRESS KEY}	Service ROM does not recognize that you have pressed any key within 15 seconds after the prompting message.	Press the key again.
{NO KEY!}	Service ROM does not recognize that you have pressed any key within 15 seconds after the {PRESS KEY} message.	Refer to No Key Entry paragraph 2-44.
{RELEASE KEY!}	Service ROM does not recognize that you have released a key within 15 seconds after you pressed it.	Release key.
{KEY STUCK! (character entered)}	Service ROM does not recognize that you have released a key with 15 seconds after the {RELEASE KEY} message.	Refer to Key Stuck paragraph 2-49.

Table 2-9. Keyboard Test Diagnosis (Continued)

MESSAGE	REASON	DIAGNOSIS/REPAIR
{(key expected)}	Character entered does not correspond to key expected.	1. Press expected key. If message appears again, refer to Wrong Character Entered, paragraph 2-45; if not, proceed with step 2 below. 2. Press next key in sequence. If message appears again, proceed with step 3 below; if not, continue with key sequence. 3. Press expected key twice. If no message appears, refer to No Key Entry, paragraph 2-44; if message appears, indicating next key in sequence, press that key and continue with key sequence.

Table 2-9. Keyboard Test Diagnosis (Continued)

MESSAGE	REASON	DIAGNOSIS/REPAIR
{SHIFT UP} {(key expected)}	[SHIFT] key appears to be down.	Press expected key again with [SHIFT] key up.
{SHIFT DOWN} {(key expected)}	[SHIFT] key appears to be up.	Press expected key again with [SHIFT] key down.
{CAPS UP} {(key expected)}	[CAPS LOCK] key appears to be down.	Press expected key again with [CAPS LOCK] key up.
{CAPS DOWN} {(key expected)}	[CAPS LOCK] key appears to be up.	Press expected key again with [CAPS LOCK] key down.
{CTRL UP} {(key expected)}	[CTRL] key appears to be down.	Press expected key again with [CTRL] key up.
{CTRL DOWN} {(key expected)}	[CTRL] key appears to be up.	Press expected key again with [CTRL] key down.

Table 2-9. Keyboard Test Diagnosis (Continued)

MESSAGE	REASON	DIAGNOSIS/REPAIR
[KEY BAD! (character entered)}	Character entered different from character expected.	If message occurred during key sequence test (step 8 or 9 of Keyboard Test; refer to table 2-8), refer to No Key Entry, paragraph 2-44; otherwise refer to Wrong Character Entered, Paragraph 2-45.

2-44. No Key Entry

To locate the problem when pressing a key has no effect:

a. Make sure that both ribbon cables are properly aligned in their connectors on the keyboard PCA.

b. Prop the keyboard up so that you can access the keyboard controller. Do not remove the keyboard from the bottom case. Leave the original ribbon cables connected at both the logic one PCA and the keyboard PCA; do not substitute extender cables.

c. Make sure that both ribbon cables are properly aligned in their connectors on the logic one PCA.

d. Look up the row and column lines for the bad key in table 2-10.

e. With the key pressed, check for continuity between the row and column pins for the bad key at the keyboard controller. (See the logic one schematic diagram to determine the pin locations of the row and column lines at the keyboard controller.) If continuity is OK, replace the keyboard controller.

f. Check for continuity along the row line for the bad key between the keyboard controller and the pins of J1 on the bottom of the keyboard PCA. Check for continuity along the column line for the bad key between the keyboard controller and the pins of J2 on the bottom of the keyboard PCA. If no continuity exists on either line, check the cable connectors on the keyboard PCA. If either is bad, replace the keyboard assembly; otherwise, remove all the ICs from the logic one PCA, install them on a new logic one printed-circuit board, and install the new logic one PCA in the computer.

> Note: If the connectors have been bent, a connector pin may be broken or making intermittent contact.

g. Disconnect the keyboard PCA from the logic PCA and remove the keyboard assembly from the computer. Check for continuity between the key contact pins (on the back of the keyboard PCA) for the bad key while the key is pressed.

- If continuity OK, replace the keyboard assembly.
- If no continuity, remove the key cap (refer to section III), and inspect the key plunger and the key contacts.
  - If at least three of the four fingers of the slotted key

contact appear to close against the solid key contact when the plunger is pressed, clean the key contacts. (Refer to section III.)

- o If the key contacts do not appear to close, or if cleaning the key contacts does not result in continuity between them, replace the plunger and/or the key contacts. (Refer to section III.)

2-45. Wrong Character Entered

Note: If the [SHIFT], [CAPS LOCK], and [CTRL] keys were not all released before step 1 of the Keyboard Test, the results of the test are not valid.

If pressing a key results in entering the wrong character:

- o If a {KEY BAD!} message was preceded by a {SHIFT UP}, {CAPS UP}, or {CTRL UP} message, refer to paragraph 2-47
- o If a {KEY BAD!} message was preceded by a {SHIFT DOWN}, {CAPS DOWN}, of {CTRL DOWN} message, refer to paragraph 2-48.
- o If a {KEY BAD!} message was preceded only by a mnemonic for the key expected, refer to paragraph 2-46.
- o If only a {(key expected)} mnemonic appears, refer to paragraph 2-46.

2-46. Wrong Character Entered; [SHIFT], [CAPS LOCK], and [CTRL] OK.

To locate the problem when pressing a key results in entering the wrong character:

a. Make sure that the ribbon cables are properly aligned in their connectors on the keyboard PCA and on the logic one PCA. (Refer to section III, paragraph 3-5).

b. Try replacing the controller.

c. Try replacing the keyboard assembly.

d. Remove all the ICs from the logic PCA, install them on a new logic one printed-circuit board, then install the new logic one PCA in the computer. (This solves the problem if it is caused by a bad connector or an open trace on the logic one PCA.)

2-47. Wrong Character Entered; [SHIFT], [CAPS LOCK], or [CTRL] Apparently Down

To locate the problem when pressing a key results in entering the wrong character because the [SHIFT], [CAPS LOCK], or [CTRL] key appears to be down:

a. Make sure that both ribbon cables are properly aligned in their connectors on the keyboard PCA. (Refer to section III, paragraph 3-5.)

b. Prop the keyboard up so that you can access the keyboard controller. Do not remove the keyboard from the bottom case. Leave the original ribbon cables connected at both the logic one PCA and the keyboard PCA; do not substitute extender cables.

c. Make sure that both ribbon cables are properly aligned in their connectors on the logic one PCA.

d. Remove the controller and check for continuity between pin 32 (GND) and pin 22 (KS, [SHIFT]), pin 24 (KCL, [CAPS LOCK]), or pin 21 (KC, [CTRL]) of the keyboard controller socket. If no continuity, install a new controller; otherwise, return the original controller.

e. Disconnect the keyboard PCA from the logic one PCA and check for a short between pin 11 of J1 (GND) on the bottom of the keyboard PCA and pin 11 ([SHIFT]), pin 10 ([CAPS LOCK]), or pin 4 ([CTRL]) of J2 on the bottom of the keyboard PCA. If not shorted, remove all the ICs from the logic one PCA, install them on a new logic printed-circuit board, and install the new logic one PCA in the computer.

f. Check for continuity between the key contact pins (on the back of the keyboard PCA) for the bad key.

Note: Remember that there are two [SHIFT] keys.

- If shorted, replace the key plunger and/or the key contacts. (Refer to section III.)
- If not shorted, replace the keyboard assembly.

2-48. Wrong Character Entered; [SHIFT], [CAPS LOCK], or [CTRL] Apparently Up.

To locate the problem when pressing a key results in entering the wrong character because he [SHIFT], [CAPS LOCK], or [CTRL] key appears to be up:

a. Make sure that both ribbon cables are properly aligned in their connectors on the keyboard PCA.

b. Prop the keyboard up so that you can access the keyboard controller. Do not remove the keyboard from the bottom case. Leave the original ribbon cables connected at both the logic one PCA and the keyboard PCA; do not substitute extender cables.

c. Make sure that both ribbon cables are properly aligned in their connectors on the logic one PCA.

d. With the key down, check for continuity at the controller between pin 32 (GND) and pin 22 (KS, [SHIFT]), pin 24 (KCL, [CAPS LOCK]), or pin 21 (KC, [CTRL]). If continuity is OK, replace the controller.

e. Check for continuity between the pin at the controller (refer to step d for the pin number) and pin 11 ([SHIFT]), pin 10 ([CAPS LOCK]), or pin 4 ([CTRL]) of J2 on the bottom of the keyboard PCA. If no continuity, check J1. If bad, replace the key board assembly; otherwise, remove all the ICs from the logic PCA, install them on a new logic printed-circuit board, and install the new logic PCA in the computer.

f. Disconnect the keyboard PCA from the logic one PCA and remove the keyboard assembly from the computer. With the key down, check for continuity between the key contact pins (on the back of the keyboard PCA) of the bad key.

    - If continuity OK, replace the keyboard assembly.
    - If no continuity, remove the key cap (refer to section II), and inspect the key plunger and key contacts.
        - If at least three of the four fingers of the slotted key contact appear to close against the solid key contact when the plunger is pressed, clean the key contacts.

- If the key contacts do not appear to close, or if cleaning the key contacts does not result in continuity between them, replace the plunger and/or the key contacts.

2-49. Key Stuck

To locate the problem when a key appears to be stuck:

a. Prop the keyboard up so that you can access the keyboard controller. Do not remove the keyboard from the bottom case. Leave the original ribbon cables connected at both the logic one PCA and the keyboard PCA; do not substitute extender cables.

b. Remove the controller and check for continuity between the row and column pins for the bad key at the keyboard controller. (Refer to table 2-11, if necessary, to determine the key corresponding to the character entered; then refer to table 2-10 to determine the key's row and column lines. See the logic one schematic to determine the corresponding pin locations at the keyboard controller.) If no continuity, install a new controller; otherwise, return the original controller.

c. Disconnect the keyboard PCA from the logic one PCA and check for a short between the pin of J1 (on the bottom of the keyboard PCA) for the row line of the bad key and the pin of J2 for the column line of the bad key. If not shorted, remove all the ICs from the logic PCA, install them in a new logic one printed-circuit board, and install the new logic one PCA in the computer.

d. Check for continuity between the key contact pins (on the back of the keyboard PCA) for the bad key.

   - If shorted, replace the key plunger and/or the key contacts.

   - If not shorted, replace the keyboard assembly.

Table 2-10. Mnemonics and Key Lines for Keys Expected

SERVICE ROM MNEMONIC	KEY EXPECTED	ROW LINE	COLUMN LINE
{'}	[' "]	R6	C2
{(}	[([]	R7	C2
{(}	[(RESET]	R8	C6
{)}	[) INIT]	R7	C6
{)}	[)]]	R7	C3
{*}	[*]	R1	C0
{+}	[+]	R5	C5
{,}	[,] or [,<]	R5	C0
{-L}	[-LINE CLEAR]	R9	C1
{-}	[-]	R5	C6
{-}	[-]	R8	C2
{.}	[.] or [. >]	R5	C1
{/}	[/ ?]	R5	C2
{/}	[/]	R6	C7
{0}	[0] or [0)]	R8	C1
{1}	[1] or [1 !]	R1	C7
{2}	[2] or [2@]	R1	C6

Table 2-10. Mnemonics and Key Lines for Keys Expected (Continued)

SERVICE ROM MNEMONIC	KEY EXPECTED	ROW LINE	COLUMN LINE
{3}	[3] or [3 #]	R1	C5
{4}	[4] or [4 $]	R1	C4
{5}	[5] or [5 %]	R1	C3
{6}	[6] or [6 ^]	R1	C2
{7}	[7] or [7 &]	R1	C1
{8}	[8] or [8 *]	R1	C0
{9}	[9] or [9 (]	R8	C0
{;}	[; :]	R6	C1
{=}	[= +]	R8	C3
{A}	[A]	R3	C7
{BS}	[BACK SPACE]	R8	C5
{B}	[B]	R4	C2
{C>}	[> COPY]	R9	C5
{CN}	[CONT]/[TR/NORM]	R7	C4
{C^}	[↑\ ]	R9	C2
{Cv}	[↓ A/G]	R9	C3

Table 2-10. Mnemonics and Key Lines for Keys Expected (Continued)

SERVICE ROM MNEMONIC	KEY EXPECTED	ROW LINE	COLUMN LINE
{Cv}	[← I/R]	R9	C4
{C}	[C]	R4	C4
{D}	[D}	R3	C5
{EN}	[END LINE]	R6	C3
{E}	[E]	R2	C5
{E}	[E TEST]	R7	C5
{F}	[F]	R3	C4
{G}	[G]	R3	C3
{H}	[H]	R3	C2
{I}	[I]	R2	C0
{J}	[J]	R3	C1
{K}	[K]	R3	C0
{LA}	[LABEL KEY]	R0	C6
{LI}	[LIST PLST]	R6	C4
{L}	[L]	R6	C0
{M}	[M]	R4	C0
{N}	[N]	R4	C1

Table 2-10. Mnemonics and Key Lines for Keys Expected (Continued)

SERVICE ROM MNEMONIC	KEY EXPECTED	ROW LINE	COLUMN LINE
{O}	[O]	R7	C0
{PS}	[PAUSE STEP]	R5	C3
{P}	[P]	R7	C1
{Q}	[Q]	R2	C7
{RU}	[RUN]	R5	C4
{Rv}	[ROLL]	R9	C4
{R}	[R]	R2	C4
{S}	[S]	R3	C6
{T}	[T]	R2	C3
{U}	[U]	R2	C1
{V}	[V]	R4	C3
{W}	[W]	R2	C6
{X}	[X]	R4	C5
{Y}	[Y]	R2	C2

Table 2-10. Mnemonics and Key Lines for Keys Expected (Continued)

SERVICE ROM MNEMONIC	KEY EXPECTED	ROW LINE	COLUMN LINE
{Z}	[Z]	R4	C6
{\}	[\ ¦]	R8	C4
{^}	[^ RESLT]	R8	C7
(blank)	[(space bar)]	R4	C7
{k1}	[k1 k8]	R0	C5
{k2}	[k2 k9]	R0	C4
{k3}	[k3 k10]	R0	C3
{k4}	[k4 k11]	R0	C2
{k5}	[k5 k12]	R0	C1
{k6}	[k6 k13]	R0	C0
{k7}	[k7 k14]	R9	C0

Table 2-11. Key(s) Corresponding to Character Entered

CHARACTER ENTERED	CORRESPONDING KEY(S)	CHARACTER ENTERED	CORRESPONDING KEY(S)
◀	[CTRL] [SHIFT] [2@] or [CTRL] [SHIFT] [2]	π	[CTRL] [O]
		θ	[CTRL] [P]
¿	[CTRL] [A]	Æ	[CTRL] [Q]
☒	[CTRL] [B]	æ	[CTRL] [R]
ñ	[CTRL] [C]	Å	[CTRL] [S]
α	[CTRL] [D]	å	[CTRL] [T]
ß	[CTRL] [E]	Ä	[CTRL] [U]
Σ	[CTRL] [F]	ä	[CTRL] [V]
Δ	[CTRL] [G]	Ö	[CTRL] [W]
←	[CTRL] [H]	ö	[CTRL] [X]
σ	[CTRL] [I]	Ü	[CTRL] [Y]
↑	[CTRL] [J]	ü	[CTRL] [Z]
↑	[CTRL] [K]	⊢	[CTRL] [SHIFT] [([]
μ	[CTRL] [L]	|	[CTRL] [\ ¦]
	[CTRL] [M]	⊣	[CTRL] [SHIFT] [)]]
↓	[CTRL] [N]	£	[CTRL] [^ RESULT]

Table 2-11. Keys(s) Corresponding to Character Entered (Continued)

CHARACTER ENTERED	CORRESPONDING KEY(S)	CHARACTER ENTERED	CORRESPONDING KEY(S)
+	[CTRL] [SHIFT] [- _]	*	[SHIFT] [8 *] or [SHIFT] [8] or [*]
	[(space bar)]	+	[SHIFT] [= +] or [+]
!	[SHIFT [1 !] or [SHIFT] [1]	,	[, <] or [,]
"	[SHIFT] [' ""]	-	[- =] or [-]
#	[SHIFT] [3 #] or [SHIFT] [3]	.	[. >] or [.]
$	[SHIFT] [4 $] or [SHIFT] [4]	/	[/ ?] or [/]
%	[SHIFT] [5 %] or [SHIFT] [5]	0	[0)] or [0]
&	[SHIFT] [7 &] or [SHIFT] [7]	1	[1 !] or [1]
'	[' "]	2	[2] or [2]
(	[SHIFT] [9 (] or [SHIFT] [9] or [(RESET]	3	[3 #] or [3]
)	[SHIFT] [0)] or [SHIFT] [0] or [) INIT]	4	[4 $] or [4]

Table 2-11. Key(s) Corresponding to Character Entered (Continued)

CHARACTER ENTERED	CORRESPONDING KEY(S)	CHARACTER ENTERED	CORRESPONDING KEY(S)
5	[5 %] or [5]	E	[E]
6	[6 ^] or [6]	F	[F]
7	[7 &] or [7]	G	[G]
8	[8 *] or [8]	H	[H]
9	[9)] or [9]	I	[I]
:	[SHIFT] [; :]	J	[J]
;	[; :]	K	[K]
<	[SHIFT] [,<] or [SHIFT] [,]	L	[L]
=	[=]	M	[M]
>	[SHIFT] [. >] or [SHIFT] [.]	N	[N]
?	[SHIFT] [/ ?]	O	[O]
@	[SHIFT] [2@] or [SHIFT] [2]	P	[P]
A	[A]	Q	[Q]
B	[B]	R	[R]
C	[C]	S	[S]
D	[D]	T	[T]

Table 2-11. Key(s) Corresponding to Character Entered (Continued)

CHARACTER ENTERED	CORRESPONDING KEY(S)	CHARACTER ENTERED	CORRESPONDING KEY(S)
U	[U]	f	[SHIFT] [H]
V	[V]	g	[SHIFT] [G]
W	[W]	h	[SHIFT] [H]
X	[X]	i	[SHIFT] [I]
Y	[Y]	j	[SHIFT] [J]
Z	[Z]	k	[SHIFT] [K]
[	[SHIFT] [([]	l	[SHIFT] [L]
\	[\ ¦]	m	[SHIFT] [M]
]	[SHIFT] [)]]	n	[SHIFT] [N]
^	[^ RESULT]	o	[SHIFT] [O]
_	[SHIFT] [-]	p	[SHIFT] [P]
a	[SHIFT] [A]	q	[SHIFT] [Q]
b	[SHIFT] [B]	r	[SHIFT] [R]
c	[SHIFT] [C]	s	[SHIFT] [S]
d	[SHIFT] [D]	t	[SHIFT] [T]
e	[SHIFT] [E]	v	[SHIFT] [V]

Table 2-11. Key(s) Corresponding to Character Entered (Continued)

CHARACTER ENTERED	CORRESPONDING KEY(S)	CHARACTER ENTERED	CORRESPONDING KEY(S)
w	[SHIFT] [W]	:	[SHIFT] [\ ¦]
x	[SHIFT] [X]	}	[SHIFT] [-]
y	[SHIFT] [Y]	~	[SHIFT] [*]
z	[SHIFT] [Z]	▒	[SHIFT] [+]
{	[SHIFT] [/]		

2-50. TROUBLESHOOTING WITH THE TIMER TEST

The Timer Test activates the test mode in the keyboard controller, which contains the four timers.

2-51. How to Run the Timer Test

To run the Timer Test, press [J] if the service ROMs are in control, or type in {TIMER} if the BASIC system is in control. Since the Timer Test uses the computer's ROM and RAM, do not run the Timer Test alone unless the computer has already passed the CPU, ROM, and RAM Tests. If the Timer Test is run with a bad ROM or RAM IC, the computer may appear to "die" during the test.

In test mode, the keyboard controller uses the keyboard scan to run the timers. Because of this, pressing a key during the Timer Test aborts the test. The Timer Test is begun about 3 seconds after it is selected--that is, after you press [J] (if the Service ROM is in control) or [END LINE] (if the BASIC system is in control). Therefore, be sure that all keys are released by that time.

2-52. Results of the Timer Test

One of the following messages appears:

- {TIMER OK} indicates that the timer is probably OK.
- {TIMER BAD!} indicates that the timer is probably bad.
- {TIMER TEST ABORTED!} indicates that a key was apparently pressed during the Timer Test.

2-53. TROUBLESHOOTING THE CRT

The service ROMs contain four tests that can be used to troubleshoot the CRT: the CRT Test; the Focus Pattern; Pincushion Pattern; and the Raster Test.

The CRT test is a combined test: it checks the CRT controller IC and the CRT RAM ICs, and also causes the CRT to display various test patterns. By checking whether each pattern is displayed correctly, you can determine whether the rest of the circuitry is operating properly. The test patterns are also used for making adjustments to the CRT assembly.

The Focus Pattern, Pincushion Pattern, and Raster tests are subsets of the CRT Test and merely display the focus, pincushion patterns, and a full white screen,respectively. Therefore, only the CRT Test will be described in detail.

2-54. How to Run the CRT Test

To run the CRT Test, press [F] if the service ROMs are in control, or type in {DISPLAY} if the BASIC system is in control.

2-55. Results of the CRT Test

The CRT should display the following patterns:

> Note: While the patterns of steps e, g, and i are in the display, you can cause the pattern to remain there indefinitely by pressing any key. Pressing any key again will cause the next pattern to appear.

a. Vertical bars (CRT test pattern 1), as shown in figure 2-9. These bars remain on the screen for about 15 seconds.

> Note: When the CRT Test is first run after turning on the computer, the display may appear garbled before the vertical bars are rolled onto the screen.

b. A new set of vertical bars, shifted from the previous bars. These bars also remain on the screen for about 15 seconds.

c. The pattern (CRT test pattern 2) shown in figure 2-10. This pattern remains on the screen for about 15 seconds.

d. Blank screen (signaled by a beep). This remains for about 1 second.

e. The focus pattern {B}s and {J}s (CRT test pattern 3) shown in figure 2-11. This remains for about 3 seconds.

f. Blank screen (signaled by a beep). This remains for about 3 seconds.

g. The pincushion test pattern (CRT test pattern 4) shown in figure 2-12. This remains for about 3 seconds.

h. Blank screen (signaled by a beep). This remains for about 3 seconds.

i. Entirely white screen (signaled by a beep). This remains for about 3 seconds.

j. Blank screen (signaled by a beep). This remains for about 3 seconds.

k. Four lines containing two copies of the HP-87 character set, as shown in figure 2-13: one in standard video and the other in inverse video.

If no problems are found during the CRT Test, the message {CRT TEST ENDS} appears. Otherwise, one of the following messages is (possibly) displayed:

- {CRT RAM n BAD!} indicates that the CRT RAM designated by the number n is probably bad or that the CRT RAM designated by the number n + 4 is probably bad.

- {CRT CONTROL BAD!} indicates that the CRT controller is probably bad.

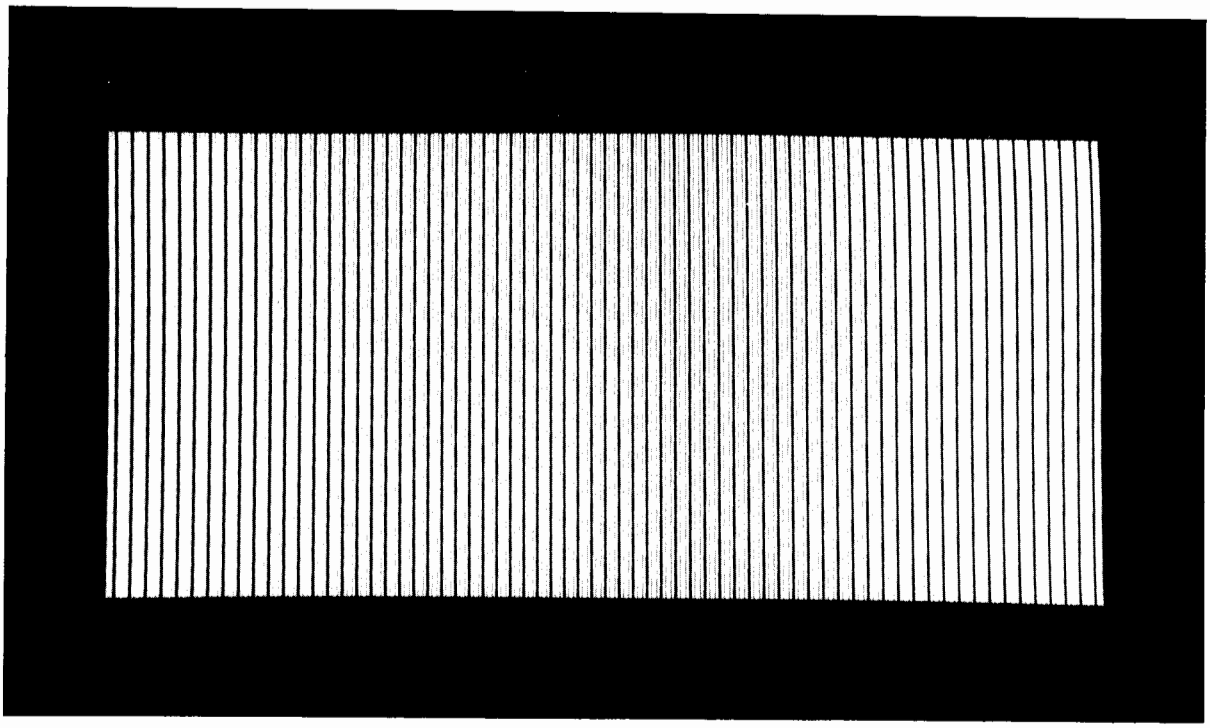


Figure 2-9. CRT Test Pattern 1

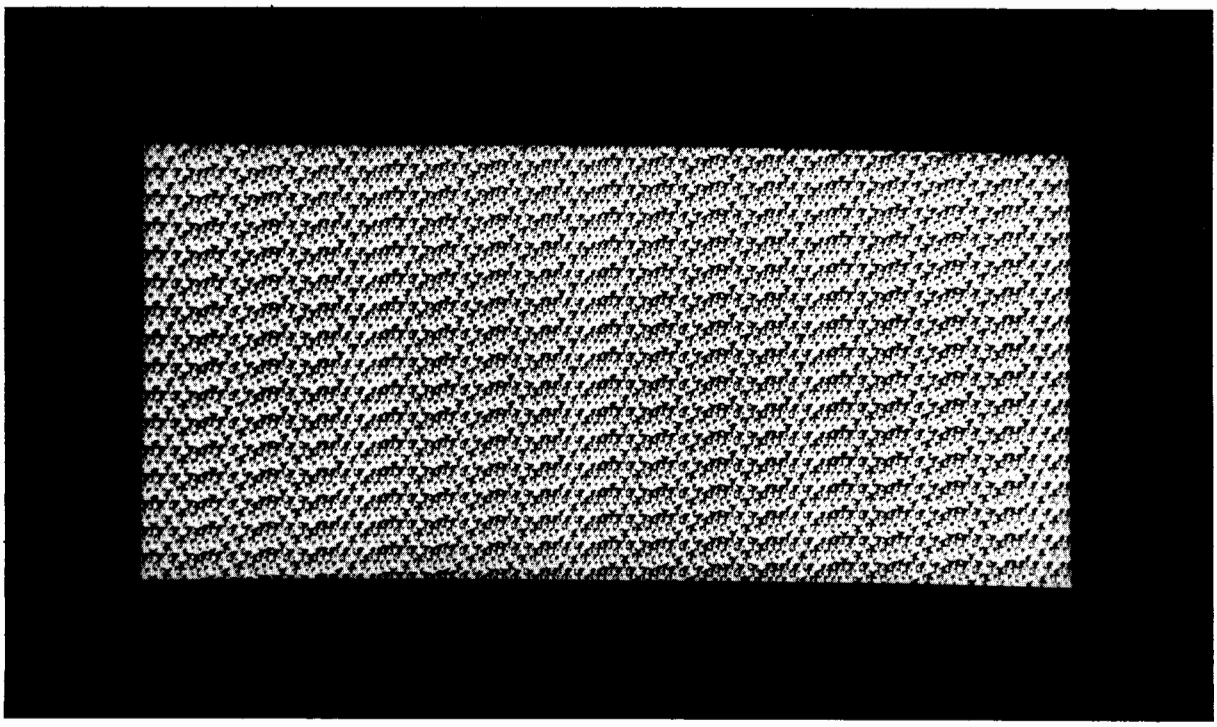


Figure 2-10. CRT Test Pattern 2

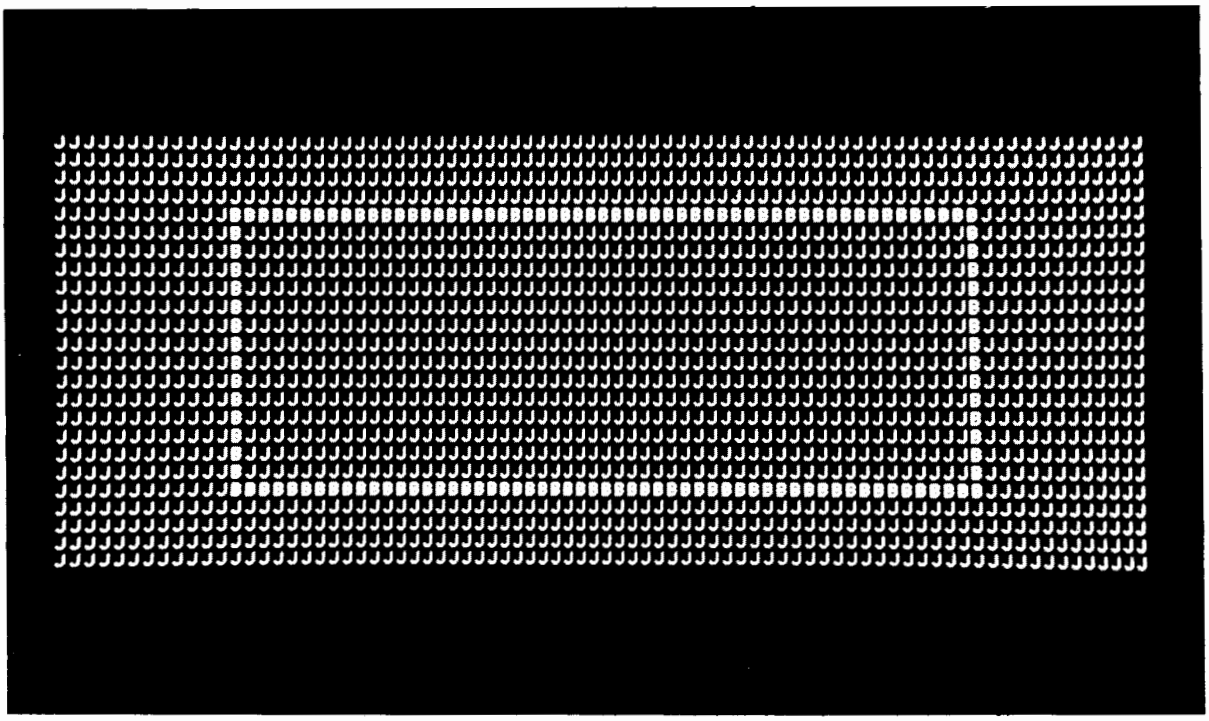


Figure 2-11. CRT Test Pattern 3

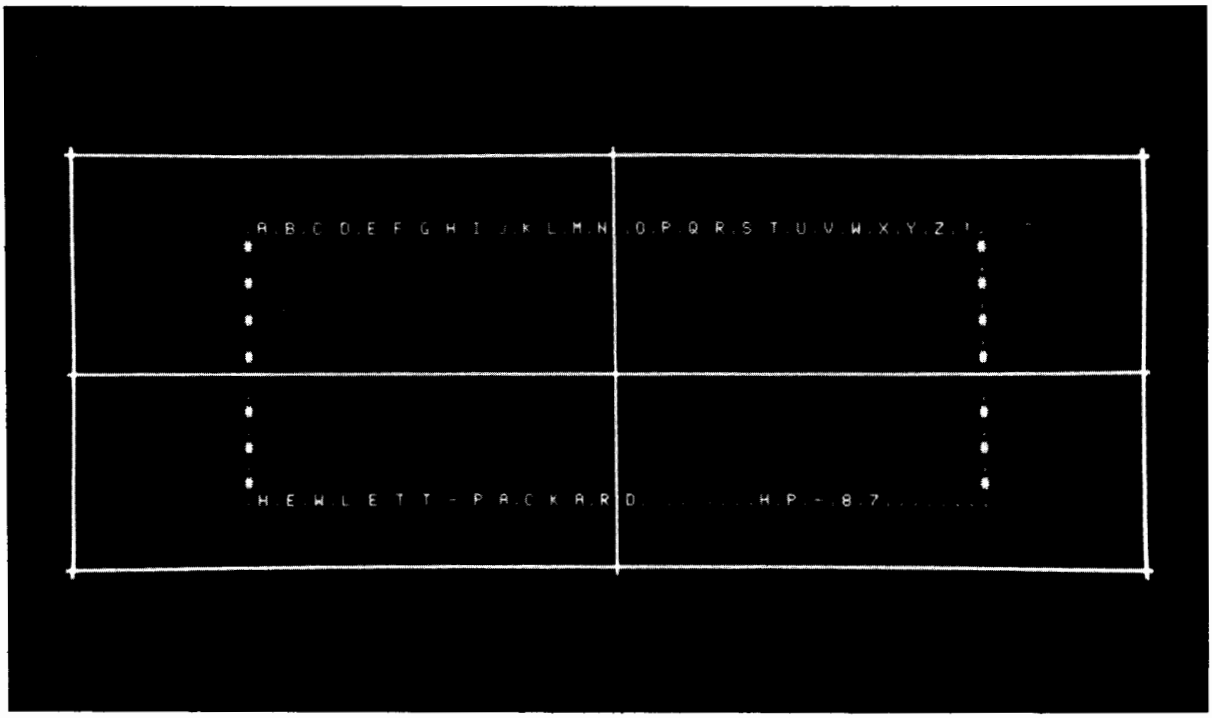


Figure 2-12. CRT Test Pattern 4

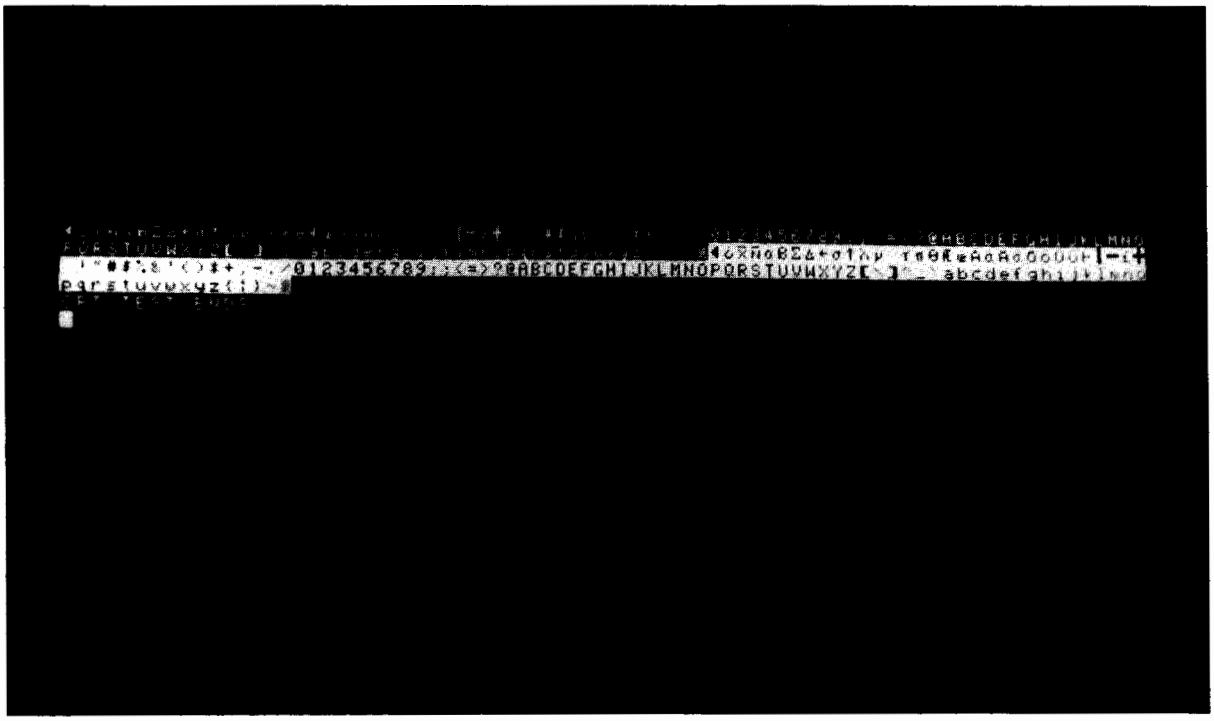


Figure 2-13. CRT Test Pattern 5

2-56. CRT Adjustments

After long periods of use, certain characteristics of the CRT circuitry may drift and cause the conditions listed below.

- Skew, adjusted by rotating the yoke around the CRT tube.
- Horizontal centering, adjusted by rotating the circular magnets around the CRT.
- Size, adjusted by the coil L1.
- Brightness, adjusted by the variable resistor normally accessible only through the back panel.
- Vertical centering, adjusted by variable resistor R7.
- Height, adjusted by variable resistor R6.
- Focus, adjusted by variable resistor R19.

In addition to adjustments for the conditions listed above, a CRT assembly may also require adjustment for pincushioning. This is a condition where straight lines, especially those at the edges of the display, are bowed inward or outward.* This condition can be corrected only by replacing the entire CRT assembly. To check whether the display requires adjustment for pincushioning, refer to paragraph 2-57.

The locations of the coil and all the variable resistors are shown in figure 2-14. The location of the magnets adjusted for horizontal centering and the screw for adjusting the yoke are shown in photographs accompanying those steps.

---

* Strictly speaking, "pincushioning" refers to the condition where the lines of a displayed rectangle bow inward, like the sides of a pincushion; while "barreling" refers to the condition where the lines of a displayed rectangle bow outward, like the sides of a barrel. For simplicity, throughout this manual the term "pincushioning" is generally used to refer to both conditions.

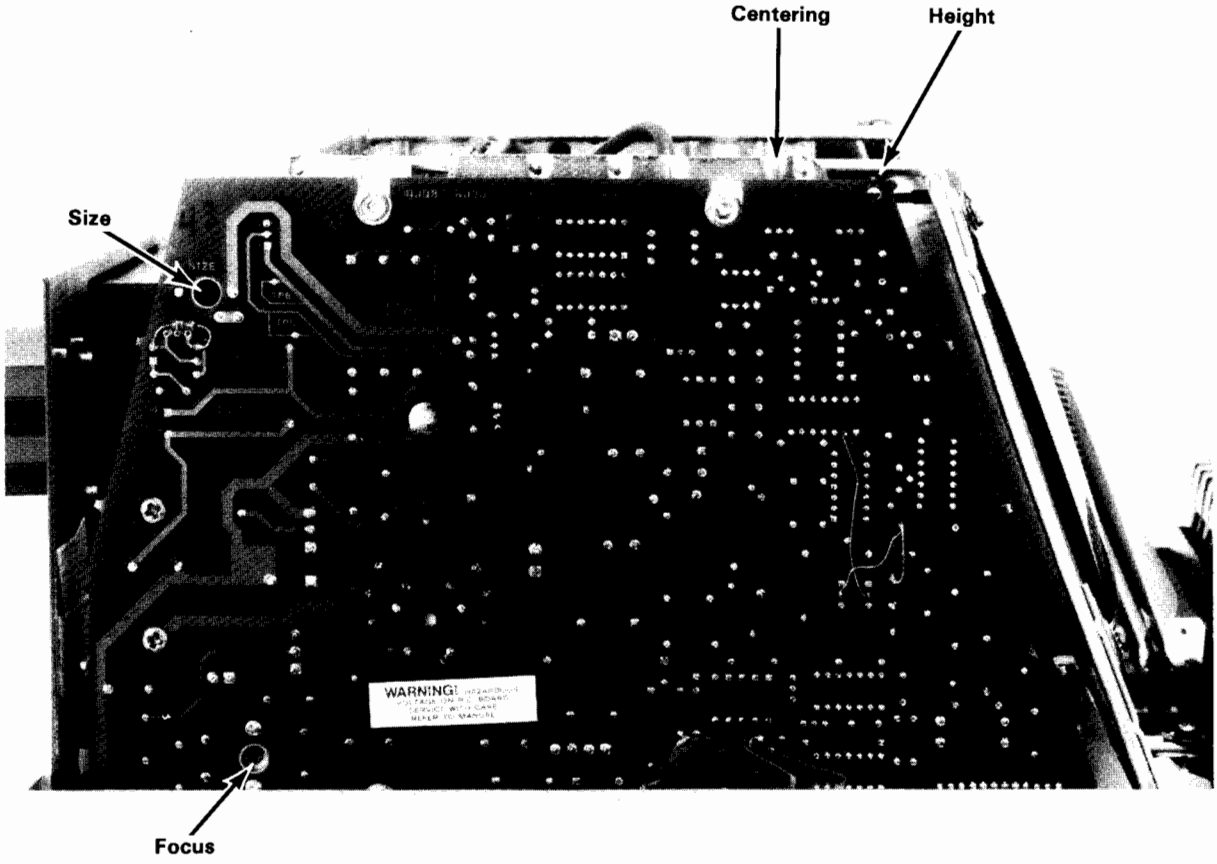


Figure 2-14. CRT Adjustments

WARNING

Lethal voltages may be present within and on the CRT assembly not only while power is on, but also for up to several days after power has been switched off. Electrical and mechanical failures may cause these voltages to be present at points that normally are safe. For your own safety, read and heed Safety Considerations in section I and the warning at the beginning of section II.

2-57. Checking Whether the Display is Pincushioned

To check whether a display is pincushioned, first remove the top case, then:

a. Place the CRT test pattern overlay on the CRT screen.

b. Adjust the position of the overlay until the wide outer lines are parallel to, and centered both horizontally and vertically between the edges of the screen. The proper position is shown in figure 2-15.

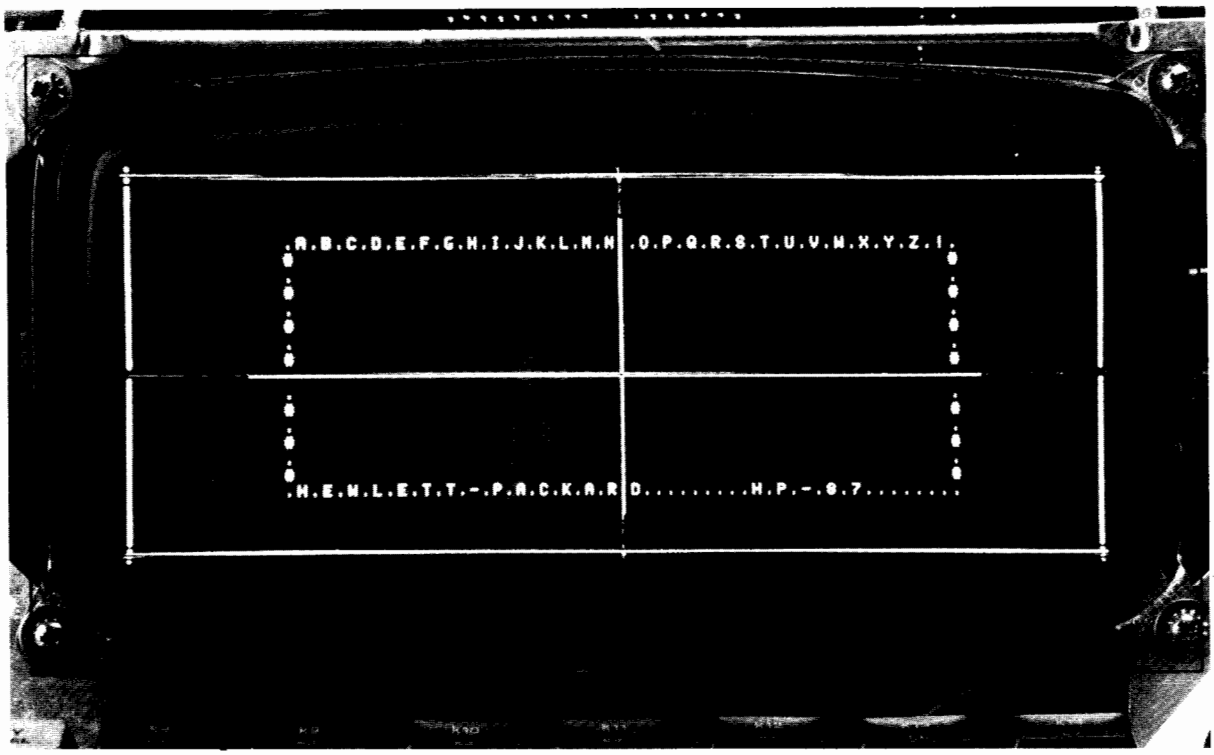


Figure 2-15. CRT Test Pattern Overlay in Position

Note: To avoid error due to parallax, when positioning the overlay you must sight on the overlay and screen with your eye along the center axis of the CRT tube.

c. Tape the overlay to the CRT tube with transparent tape.

d. Run the CRT Test or Pincushion Pattern Test from the System Service ROM.

e. Keep CRT test pattern 4 (the pincushion test pattern) on the screen by pressing any key when the pattern appears.

f. Check whether each of the four outside lines of the test pattern falls between the two parallel light lines on the overlay. You do not need to sight exactly along the axis of the CRT tube to check this, as you do when actually making an adjustment. If necessary, move your head to different positions for each line of the test pattern until you can see it between the overlay lines.

If any line is so curved that at no viewing position can you see all of it--namely, the middle and both ends--between the overlay lines, then the CRT assembly requires correction for pincushioning. (Figure 2-16 shows a normal display.) Replace the entire CRT assembly.

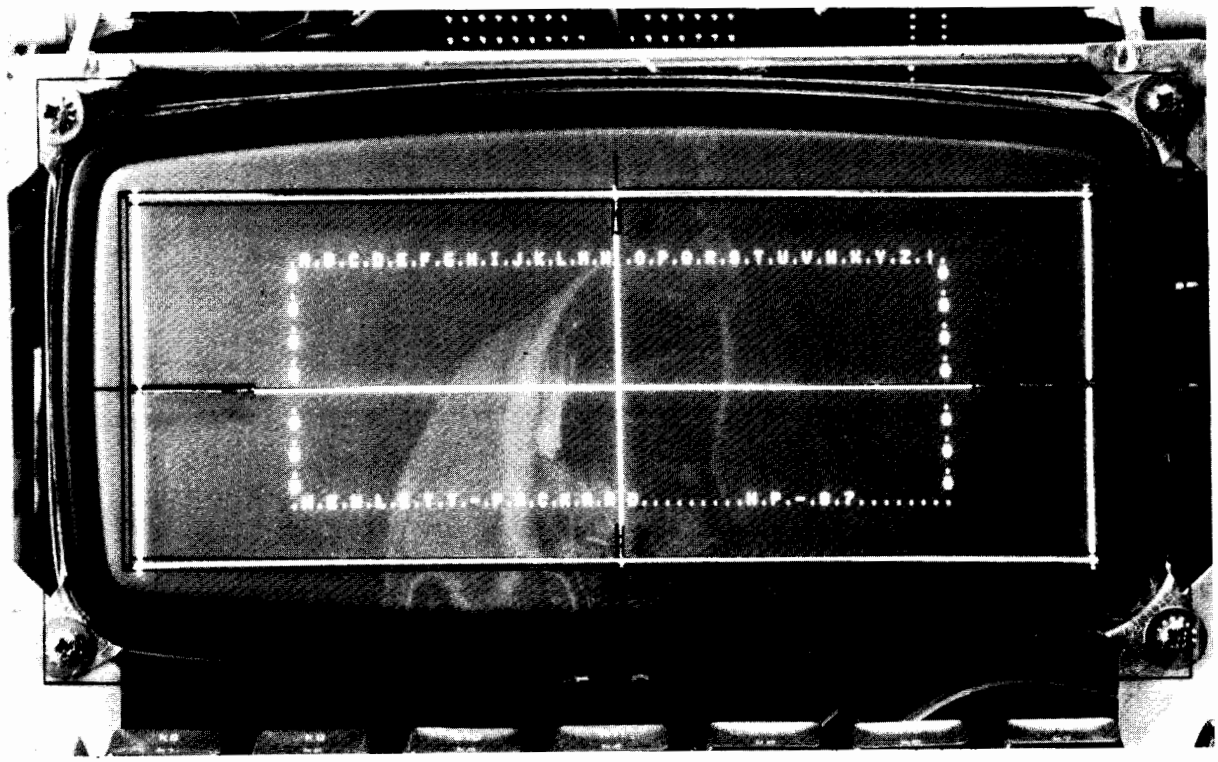


Figure 2-16. Pincushioning Correction Not Required

2-58. CRT Adjustment Procedures

To set up the CRT assembly for adjustments, attach the CRT test pattern overlay to the screen as described in paragraph 2-57, run the CRT test from the System Service ROM, and halt it with CRT test pattern 4 in the display.

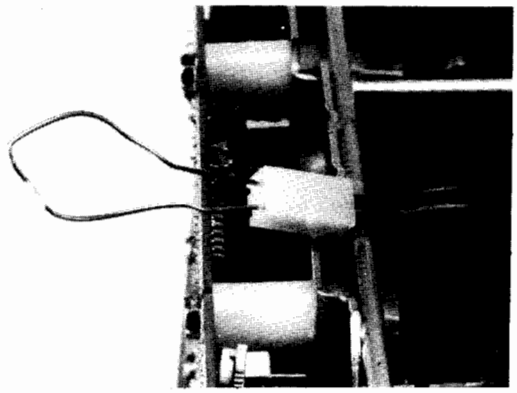
Skew

1. Turn the brightness control fully counterclockwise. This should make the display blank. (If it does not, the control is connected or wired incorrectly; refer to section III.)

2. Remove the socket connecting the vertical yoke to the CRT PCA.

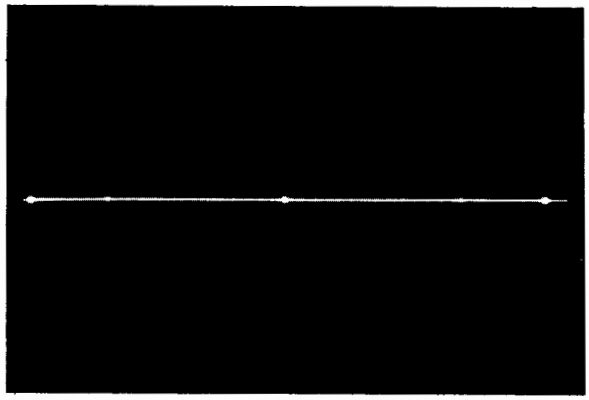
3. Short the vertical yoke by inserting into the socket the shorting plug described in Service Note 85-01.

Note: Instead of using a paper clip as shown in this photograph, use the shorting plug described in Service Note 85-01.



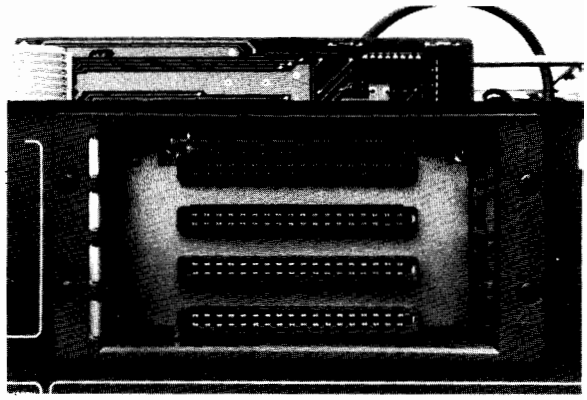
> CAUTION
> Do not turn the brightness up too far in the next step. Excessive brightness can permanently damage the CRT tube.

4. Turn the brightness control clockwise until you can clearly see the full width of the displayed horizontal line. You should see a dot at each end of the line.



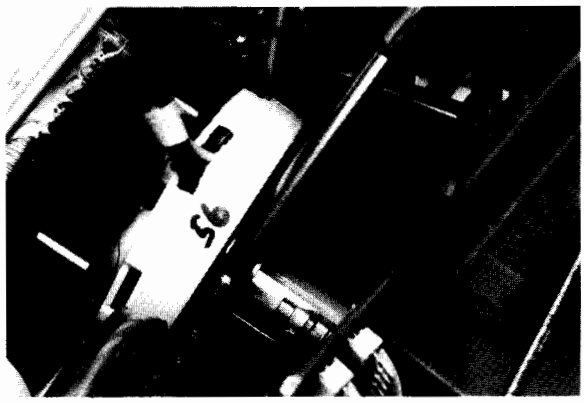
5. Check for skew in the line. It should be parallel to the horizontal center lines of the overlay. (Disregard the vertical position and width of the line at this time.) If not:

   a. Remove the four screws securing the I/O receptacle to the back panel.

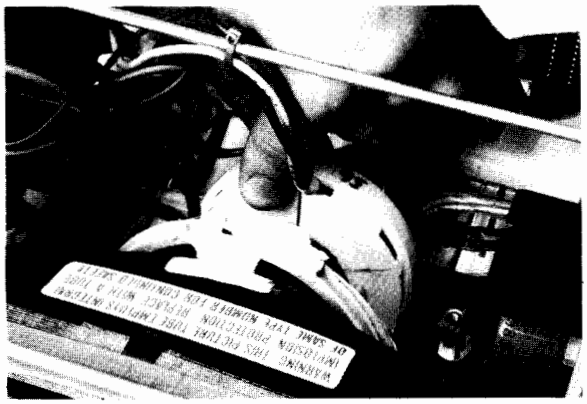


   b. Slide the I/O receptacle out through the back panel. This will provide access to the CRT yoke. Do not completely remove the I/O receptacle.

c. Loosen the screw in the yoke clamp.



d. Rotate the yoke around the neck of the CRT tube until the displayed line is properly positioned beneath the overlay.



e. Tighten the screw in the yoke clamp. Do not overtighten the clamp; it should be only tight enough so that you cannot easily rotate the yoke with your fingers.

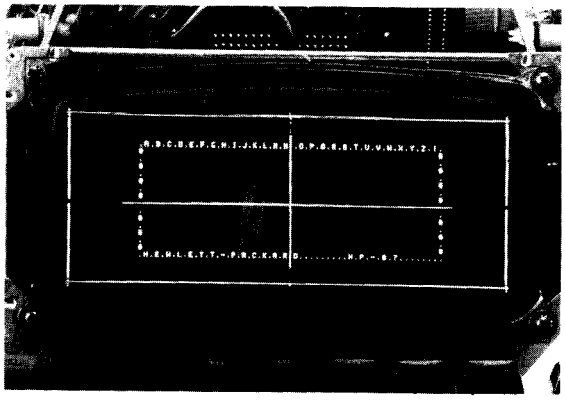
f. Recheck the skew in the line; tightening the screw can rotate the yoke slightly.

g. Remove the wire shorting the vertical yoke, and reconnect the plug to the CRT PCA. Readjust the brightness control for normal viewing intensity.

Horizontal Centering

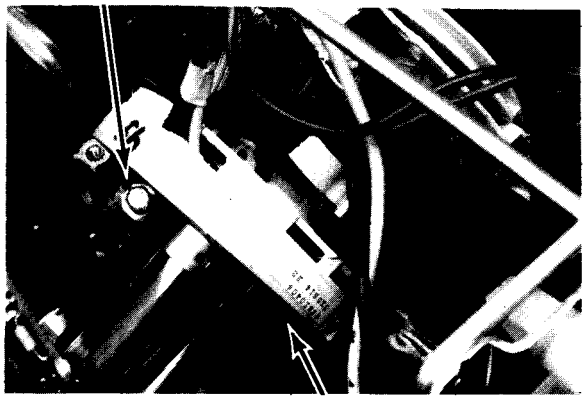
The left and right vertical lines in CRT test pattern 4 should be centered horizontally with respect to the vertical reference lines on the overlay. If not, adjust their position using both circular magnets as follows:

1. Adjust the vertical centering control (R7) until the top of bottom of the test pattern falls under one of the horizontal reference lines on the overlay.



2. Move the I/O receptacle out of the way as described in steps 5a and 5b of the skew adjustment procedure.

3. Move the magnet whose tab is furtherest from up or down until the test pattern is centered horizontally.



4. Move the other magnet until the line in the test pattern again falls under the reference line on the overlay.

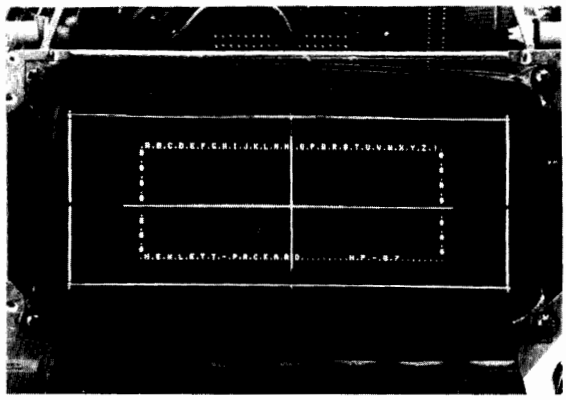
5. Repeat steps 3 and 4 until the test pattern is centered horizontally and the line falls under the reference line on the overlay.

Size

The left and right vertical lines in CRT test pattern 4 should fall betwen the two pairs of narrow vertical lines at the sides of the overlay. If not, make sure the display is centered horizontally as described above, the adjust coil L1.

Vertical Centering and Height

The top and bottom lines of CRT test pattern 4 should fall between the two pairs of narrow horizontal lines on the overlay. If not, adjust their position as follows:



1. Adjust the vertical centering control (R7) until the top line of the test pattern falls between the two narrow horizontal lines at the top of the overlay.

2. Adjust the height control (R6) until the top line of the test pattern falls between the two narrow horizontal lines at the bottom of the overlay.

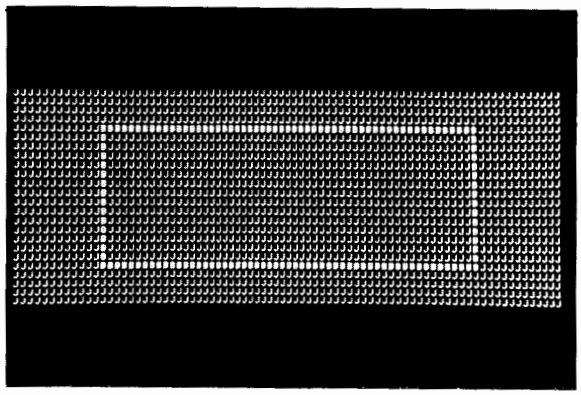
3. Repeat steps 1 and 2, if necessary, until both the top and bottom lines of the test pattern are properly located.

Focus

1. Run either the CRT Test or Focus Test from the System Service ROM to get test pattern 3 on the CRT screen.

> WARNING
> In the following step, be careful not to touch either of the pins alongside the focus control. The voltage on these pins can vary up to 220V.

2. Adjust the focus control (R19, the variable resistor at the bottom of the CRT PCA) until the {B}s on the screen are in best focus.



2-59. POWER SUPPLY TROUBLESHOOTING

If you suspect that the power supply may be bad, follow the troubleshooting procedure outlined in table 2-12.

Table 2-12. Power Supply Troubleshooting

STEP	ACTION	DIAGNOSIS/REPAIR	
		SUPPLIES OK	SUPPLIES BAD
1	Check fuse; replace if blown.		
2	Disconnect CRT PCA from logic one PCA and disconnect power supply PCA from logic one PCA. Check supplies.	Reconnect power supply PCA to logic one PCA and proceed with step 3.	Check if ac power is present at connector J7 of the power supply PCA. If so, replace the power supply PCA; otherwise, replace the backpanel assembly.
3	Check supplies.	Replace the CRT PCA. Proceed with step 4.	Reconnect original CRT assembly to logic one PCA and proceed with step 4.
4	Disconnect logic two PCA from logic one PCA. Check supplies.	Reconnect the logic two PCA to logic one PCA. Proceed with step 5, removing ICs on logic two PCA only.	Proceed with step 5, removing ICs on logic one PCA only. Remove custom ICs first, then RAM, one at a time.

Table 2-12. Power Supply Troubleshooting (Continued)

STEP	ACTION	DIAGNOSIS/REPAIR	
		SUPPLIES OK	SUPPLIES BAD
	Note: Perform step 5 for each of the ICs on the indicated logic PCA, one at a time.		
5	Remove socketed IC on either logic one PCA or logic two PCA as determined in step 4.	Install new IC on logic PCA; return any ICs previously removed from logic PCA.	Repeat step 5 for another IC. If all ICs removed, return to original logic PCA and install new logic PCA in computer.

2-60. PWO AND CLOCK FAILURE ISOLATION

PWO should reach at least 4.4 Vdc a fraction of a second after you switch the power on, but not instantly.

- If PWO reaches at least 4.4 Vdc instantly, the PWO circuitry on the logic one PCA is bad.
- If PWO never reaches 4.4 Vdc, either the PWO circuitry on the logic one PCA is bad, an IC somewhere in the system is holding the line low, or the line is shorted somewhere in the system. To isolate the failure, refer to table 2-13.

> Note: Before table 2-13 can be used, all power supply voltages must be within their acceptable ranges as specified in table 2-3.

All four clock waveforms should be pulse trains swinging between 0V and at least 10V. A clock signal is bad if it does not reach 10V, its duty cycle is incorrect, or it is always constant.

- If the duty cycle is incorrect, the clock circuitry on the logic one PCA is bad.
- If a clock signal does not reach 10V or is always constant, either the clock circuitry on the logic one PCA is bad, an IC somewhere in the computer is holding the line low or constant, or the line is shorted somewhere in the computer. To isolate the failure, refer to table 2-13.

Table 2-13. PWO and Clock Failure Isolation

STEP	ACTION	DIAGNOSIS/REPAIR	
		LINE OK	LINE BAD
1	Disconnect logic two PCA from logic one PCA. Check line at test point on logic one PCA.	Reconnect logic two PCA to logic one PCA. Proceed to step 2, removing ICs on logic two PCA only.	Proceed to step 2, removing ICs on logic one PCA only. Do not remove any RAM ICs since they cannot cause these lines to fail.
Note: Do step 2 for each of the ICs on the logic PCA, one at a time.			
2	Remove IC. Check line.	Replace IC with new one, and return all ICs previously removed from logic PCA.	Repeat step 2 for another IC. If all ICs removed, return to original logic PCA and install new logic PCA in computer.

2-61. TROUBLESHOOTING WITH THE SHORT HP-IB TEST

The short version of the HP-IB Test checks the HP-IB switch settings, the control lines, and the data lines.

2-62. How to Run the Short HP-IB Test

Before running the short HP-IB test, make sure that the HP-IB Service ROM is installed in the computer and that the HP-IB switches on the backpanel are set to select code 7, address 21 (see figures 2-17 and 2-18). Press [H] if the service ROM is in control or type in {HPIB x} if the BASIC system is in control. The parameter x must be an odd integer.

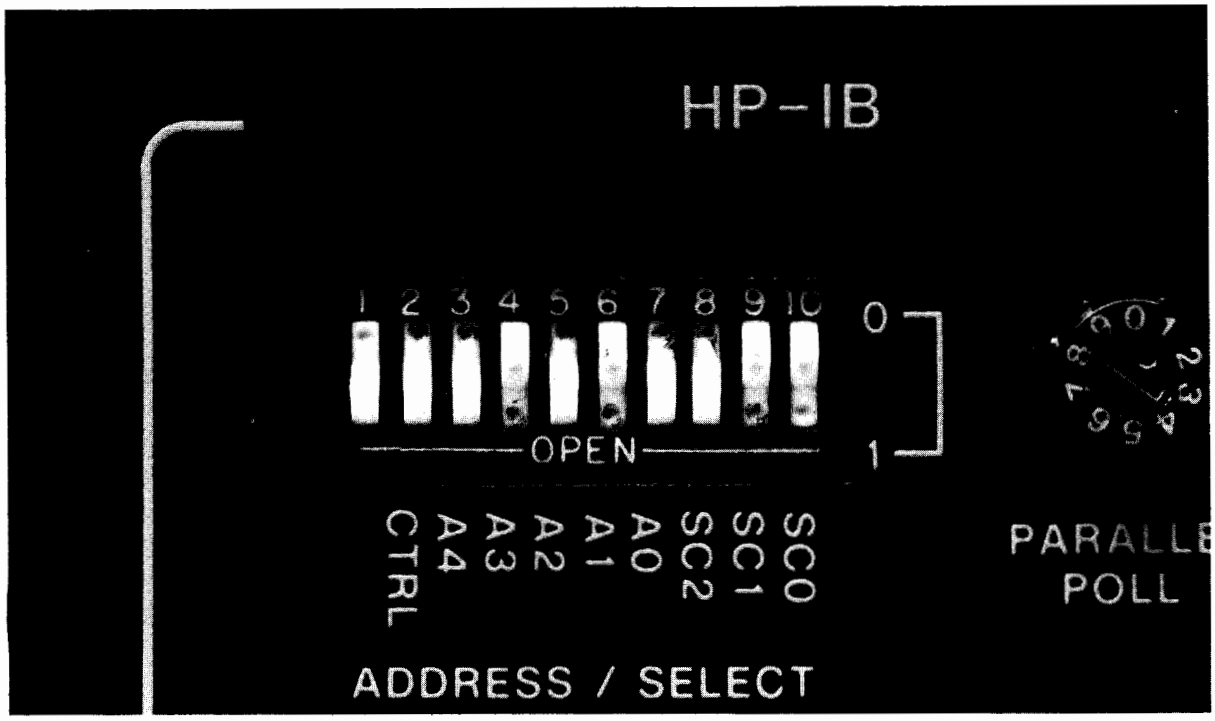


Figure 2-17. HP-IB Switch Setting

2-63. Results of the Short HP-IB Test

One of the following messages appears:

- {HPIB SHORT TEST DONE} indicates that the HP-IB circuitry is probably OK.

- {HPIB BAD #} indicates that the HP-IB select code is not set to 7 if # = a. Any other value for # indicates that either the translator IC or the processor IC may be bad. Try replacing them one at a time. If the same error message occurs after both are replaced, replace the logic two PCA.

- {CONTROL LINE BAD} indicates that either the translator IC or the processor IC may be bad. Try replacing them one at a time. If the same error message occurs after both are replaced, replace the logic two PCA.

- {DATA LINE BAD} indicates that either the translator IC or the processor IC may be bad. Try replacing them one at a time. If the same error message occurs after both are replaced, replace the logic two PCA.

- {SWITCHES BAD} indicates that the HP-IB switch on the back panel assembly may be be bad. Check the switch settings. Replace the HP-IB PCA. If the same message occurs, replace the logic two PCA.

2-64. TROUBLESHOOTING WITH THE LONG HP-IB TEST

The long version of the HP-IB Test contains all of the tests of the short test. It also exercises most of the functions of the interface to provide a very thorough test.

2-65. How to Run the Long HP-IB Test

Before running the long HP-IB Test, perform the following steps:

a. Set the segments of S1 on the HP 82937A HP-IB Interface module PCA to non-controller, select code 6, address 20 (see figure 2-18).

b. Install the HP 82937A HP-IB Interface module into one of the module ports on the HP-87 backpanel.

c. Connect the HP 82937A HP-IB Interface module cable to the HP-IB connector on the backpanel of the computer.

To run the long HP-IB Test press [I] if the service ROM is in control or type in {HPIB s} if the BASIC system is in control. The parameter s must be an even integer to access this test.

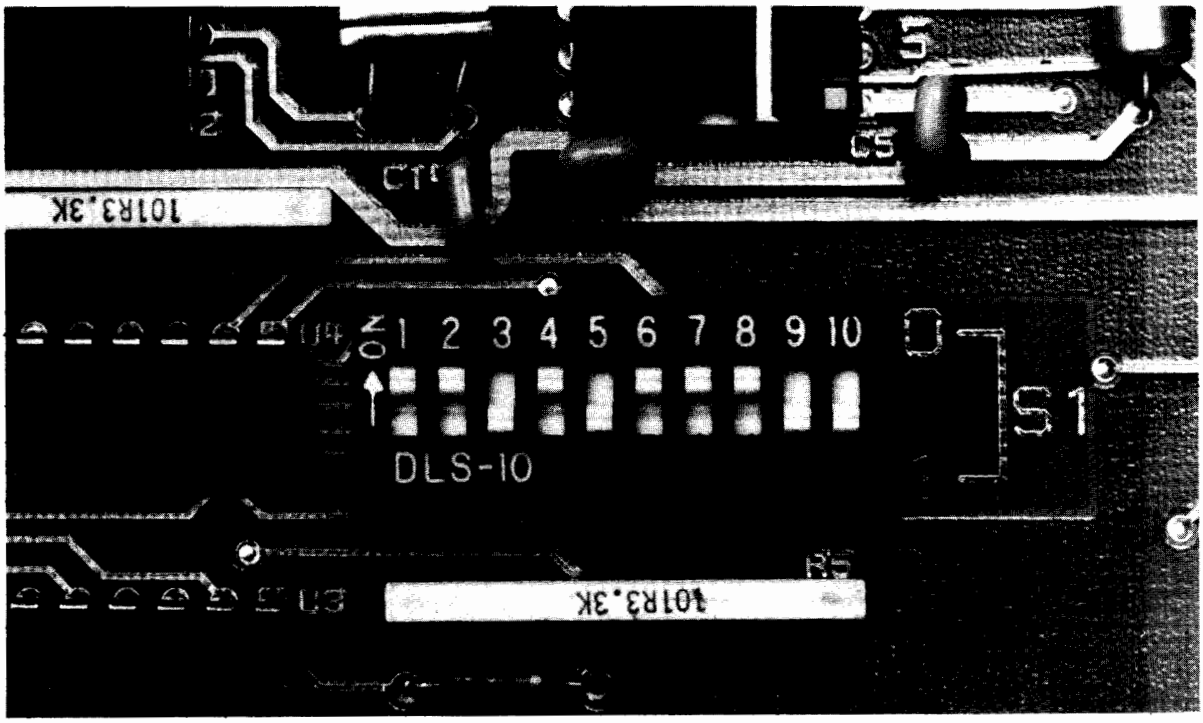


Figure 2-18. S1 Setting on the HP 82937A PCA

2-66. Results of the Long HP-IB Test

One of the following messages will be displayed:

- {HPIB LONG TEST DONE} indicates that the HP-IB circuitry is probably OK.
- The other messages are identical to the short test except for various letters. However, for the purposes of assembly-level service they can be ignored and you you should respond as described in paragraph 2-63.

2-67. TROUBLESHOOTING WITH THE EXTERNAL RAM TEST

The External RAM Test checks the RAM controller IC and the RAM ICs in the HP 82907A/8A/9A Memory Modules. The check is performed in the same way that the RAM Test checks the internal RAM controller and ICs.

When run under the control of the service ROMs, this test checks the address register in the RAM controller. When run under the control of the BASIC system, the address register is not checked. Therefore, running the External RAM Test under the control of the service ROMs provides a more complete check than running the test under the control of the BASIC system.

2-68. How to Run the External RAM Test

a. With the power to the computer off, insert the memory module into one of the module ports in the back panel.

b. Switch the computer on.

c. When the {SERVICE ROM} message appears, press [L]. If the BASIC system is in control, you can run the External RAM Test by typing in {XRAM}.

2-69. Results of the External RAM Test

Any of the following messages may appear:

- {XRAM OK} indicates that the RAM controller and the RAM ICs in the Memory Module are probably OK.
- {NO XRAM OR XRAM BAD!} indicates one of the following conditions:
  - No Memory Module is plugged in a module port, or the service ROMs do not recognize that one is plugged in. If plugging the memory module into a different module port results in the message {XRAM OK}, replace the I/O PCA.
  - The RAM controller in the Memory Module is bad.
- {XRAM CONTROL BAD!} indicates that the RAM controller in the Memory Module is probably bad.
- {XRAM n BAD!} indicates that the RAM IC (in the Memory Module) designated by the number n is probably bad.

2-70. TROUBLESHOOTING WITH THE BEEPER TEST

The Beeper Test causes the beeper to sound three short tones of the same frequency followed by a scale of eight longer tones of increasing frequency. The test performs no internal checks.

2-71. How to Run the Beeper Test

To run the Beeper Test, press [E] if the Service ROM is in control, or type in {BEEPER} if the BASIC system is in control.

2-72. Results of the Beeper Test

After sounding the three short tones and the scale, the message {BEEPER TEST ENDS} appears. If the beeper is not functioning properly, replace the keyboard controller. If this does not solve the problem, replace the speaker.

2-73. USING THE QA TEST

The QA Test is similar to the Heat Test (refer to paragraph 2-25). It executes all the IC checks of the Heat Test and then loads RAM with known data. After x seconds have elapsed, the data is read out of RAM and compared with the original data.

2-74. How to Run the QA Test

To run the QA Test, press [Q] if the service ROM is in control, or type in {QA x} if the BASIC system is in control. To terminate the test press any key.

2-75. Results of the QA Test

- When the QA Test is begun, the message {QA TEST BEGINS} is displayed and the CRT is turned on full.

- If a problem is found during the IC checks, the CRT goes blank, the appropriate message indicating the bad IC is displayed, and the test is terminated.

- If the data read from RAM is not the same as the known data read into RAM, the message {RAM REFRESH BAD} is displayed and the test is terminated. This message indicates that the RAM controller is probably bad.

- If no problem is found, the QA Test runs until you terminate it or for four hours (default). To terminate the test press any key. The message {QA TEST ENDS} will be displayed.

SECTION
III

Disassembly and Reassembly

3-1. INTRODUCTION

This section describes how to access, remove, and replace the major assemblies of an HP-87 and the parts of the top and bottom cases. These assemblies are identified in figure 1-1--which shows the inside of an HP-87 with the top case removed--and in the exploded view in the Replaceable Parts section. The exploded view also identifies the parts of the top and bottom cases.

3-2. SAFETY CONSIDERATIONS

WARNING

Lethal voltages are exposed when the top case of the HP-87 is removed. At certain points these voltages are present not only while power is on, but also for up to several days after power has been turned off. Electrical and mechanical failures may cause dangerous voltages to be present at points that normally are safe. For your own safety, read and heed Safety Considerations in section 1.

Removing the top case can be dangerous if it is done while the power is on or if the brightness control has been disconnected or broken. The danger lies in accidentally touching a high voltage area on the CRT PCA while lifting the top case off of the bottom case. This area is shown in figure 3-1.

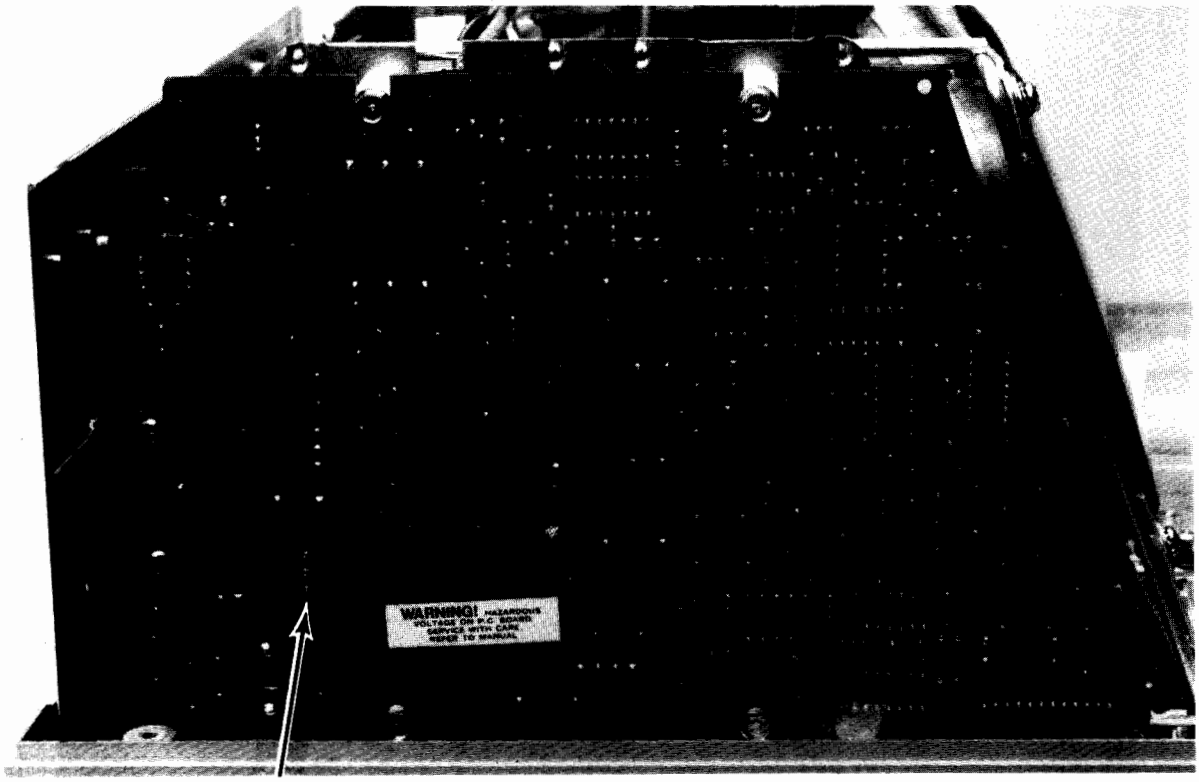


Figure 3-1. High-Voltage Area on CRT PCA

3-3. REMOVING AND TIGHTENING SCREWS

The main tools you will need to remove and replace major HP-87 assemblies are two Pozidriv screwdrivers, #1 and #2. All screws used in the HP-87 have Pozidriv heads, not phillips heads. Although phillips screwdrivers will work, they can easily strip the screw heads. Pozidriv screwdrivers require much less effort to remove and insert screws.

Due to the nature of the plastic used in HP-87 parts, the threads in screw holes can easily be stripped if you overtighten the screws. All screws should be tightened only until they feel snug; if you strip the threads by overtightening the screws, you will have to replace the part. Also, try to engage screws--especially small screws--in the original threads; if a screw cuts new threads, they can easily be stripped.

3-4. CABLE INTERCONNECTIONS

The HP-87 assemblies are electrically connected with two types of ribbon cable. The first type is used to connect the keyboard assembly to the logic one PCA and has thin metallized-film connectors that must be handled as described in paragraphs 3-5 through 3-7. The second type of cable is terminated in pin connectors that require no more than normal careful handling.

3-5. SPECIAL HANDLING FOR KEYBOARD ASSEMBLY CABLES

These ribbon cables can be connected and disconnected with your fingers; no special tool is required. However, if you insert a cable into its connector without properly aligning it first, it will not make the proper electrical connection. Furthermore, it will be very difficult to remove the cable, and doing so may damage it.

3-6. Connecting a Cable

Note: When the contacts of a cable are split, have come loose from their backing, or otherwise deteriorated, use a new cable when reassembling the computer.

To connect a cable properly:

a. Carefully align the contacts of the cable with the contacts of its connector, as shown in figure 3-2. The cable contacts must face the connector contacts.

b. Press the end of the cable into the connector gently but firmly.

c. Make sure that the cable contacts are properly aligned with the connector contacts and that neither edge of the cable is folded over. Figure 3-3 shows a cable connected properly. Figure 3-4 shows a cable misaligned, and figure 3-5 shows a cable connected with an edge folded over.

3-7. Removing a Trapped Cable

To remove an improperly connected cable from its connector:

a. Insert a spare cable of the same type and width into the connector between the trapped cable and the connector contacts. (See figure 3-6.) The contacts of the spare cable should face the contacts of the trapped cable, not the contacts of the connector.

b. Pull the two cables together out of the connector.

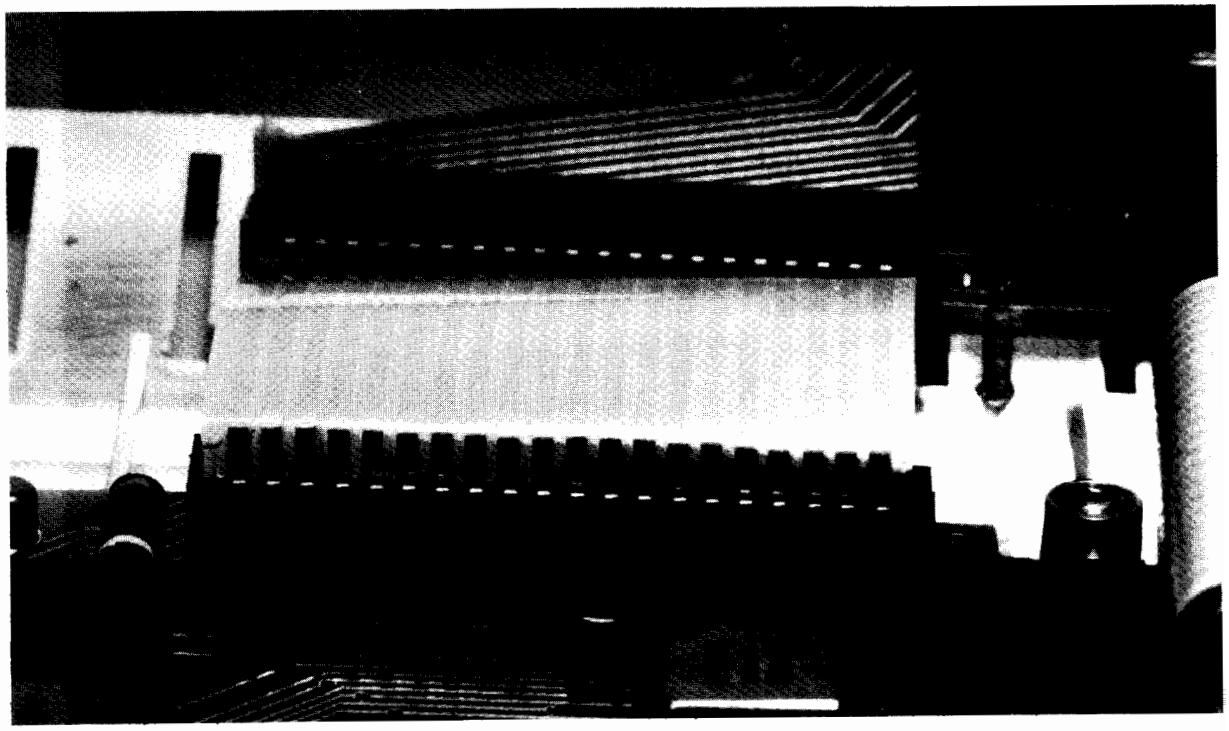


Figure 3-2. Aligning Cable Contacts

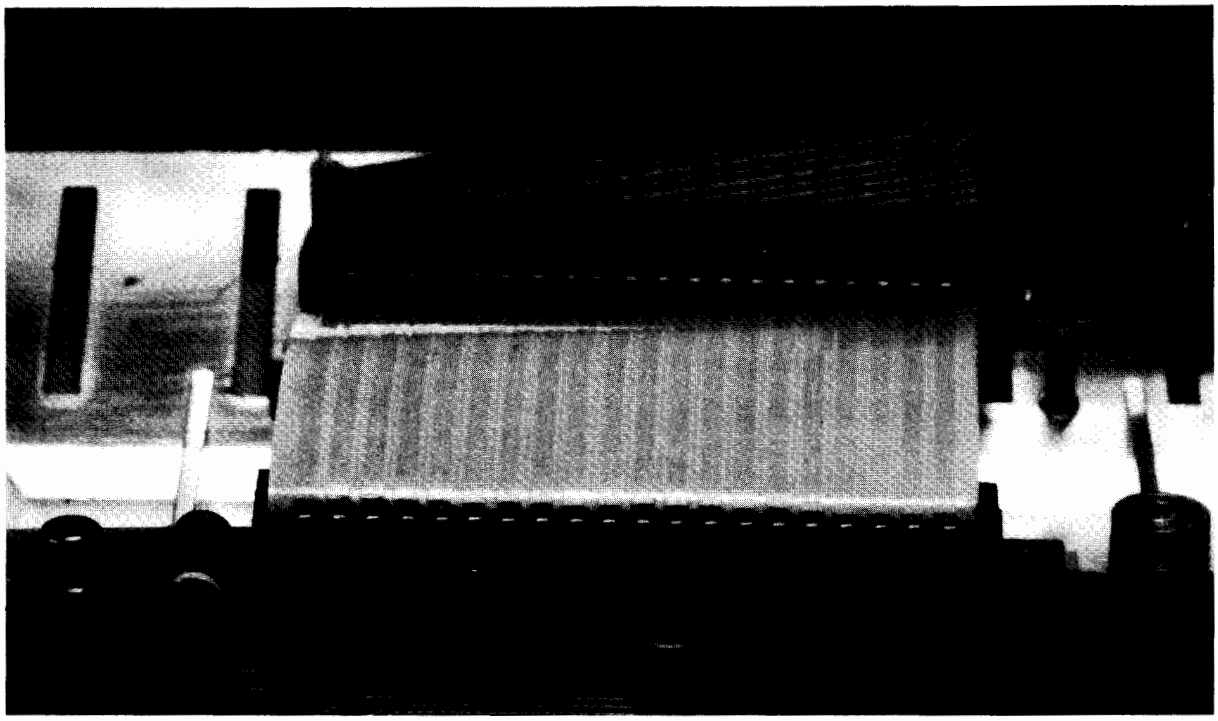


Figure 3-3. Cable Connected Properly

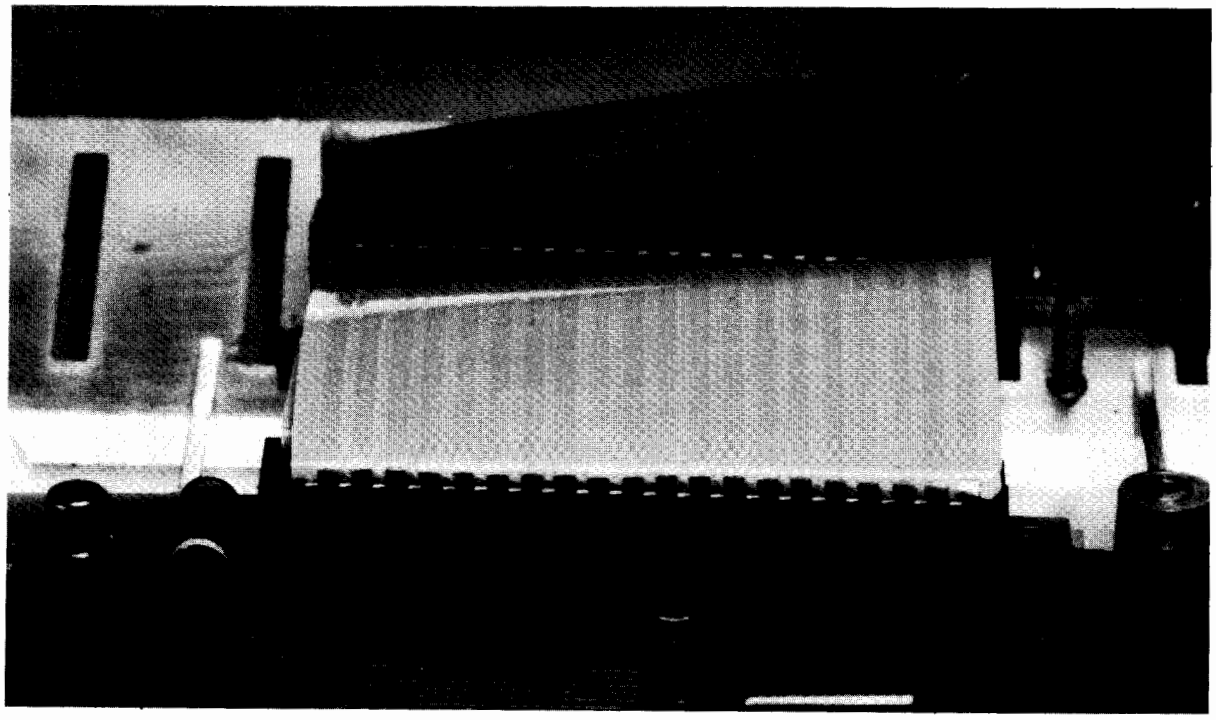


Figure 3-4. Cable Misaligned

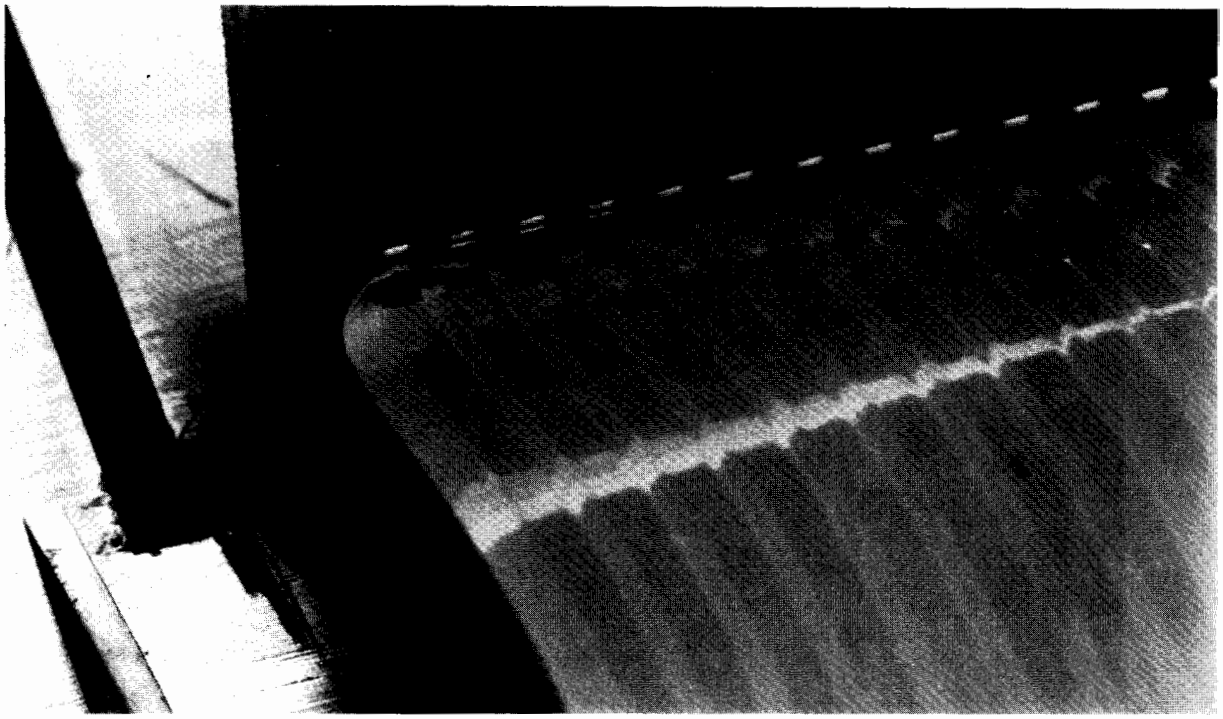


Figure 3-5. Cable Connected With Edge Folded Over

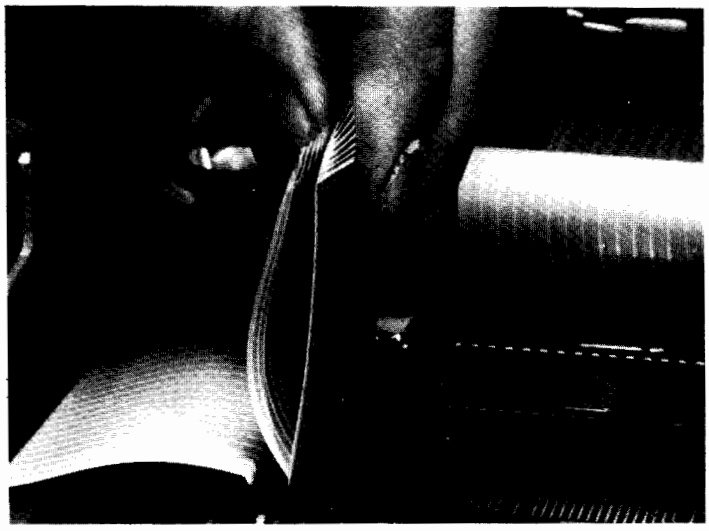


Figure 3-6. Removing a Trapped Cable

3-8. REPLACING ASSEMBLIES AND CASE PARTS

The disassembly and reassembly procedures are grouped as follows:

1. Separating the top case from the bottom case.
2. Replacing the keyboard assembly.
3. Replacing a key cap.
4. Replacing the space bar.
5. Replacing a plunger and a spring.
6. Replacing the [CAPS LOCK] key mechanism.
7. Replacing key contacts.
8. Replacing a keyboard hinge.
9. Cleaning key contacts.
10. Replacing the logic one PCA.
11. Replacing the logic two PCA.
12. Replacing the power supply PCA.
13. Replacing the CRT PCA.
14. Replacing the CRT assembly.
15. Replacing the back panel assembly.

16. Replacing the I/O PCA.

17. Replacing the HP-IB PCA.

18. Replacing parts of the top case assembly.

19. Replacing parts of the bottom case assembly.

20. Attaching the top case to the bottom case.

WARNING

Before working on the computer with the top cover off, remove objects from your shirt pocket that could fall out and strike the CRT. The CRT can implode if it is dropped, hit by a tool or other object, or subjected to stress exceeding the glass strength.

CAUTION

Avoid touching the metallized inside surface of the top and bottom cases with your fingers. Do not allow substances such as solder flux to touch the metallized surfaces. Contamination of these surfaces could degrade the EMI (electromagnetic interference) characteristics of the computer.

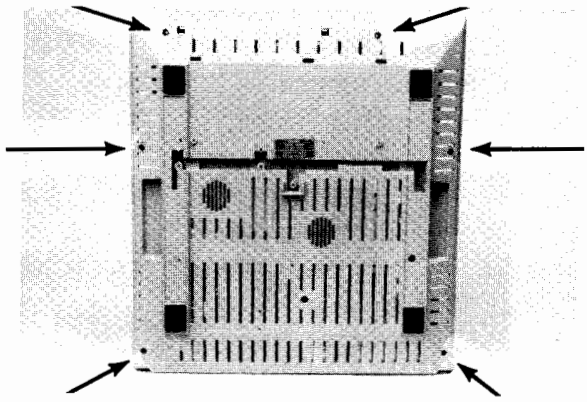
1. SEPARATING THE TOP CASE FROM THE BOTTOM CASE

> CAUTION
> If the power is on while the case is removed, the metallized inside surface of the top case could short traces on the CRT PCA. This could blow the fuse and/or damage other components.

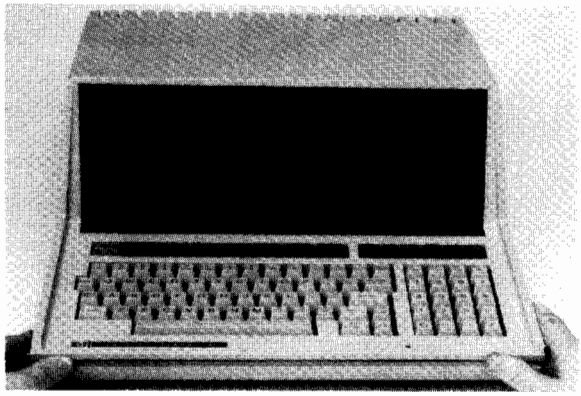
a. Disconnect the power cord from the back panel.

b. Remove any plug-in modules from the I/O ports.

c. Remove the six screws in the bottom case after tilting the computer on its back panel.



d. Separate the front of the top case from the front of the bottom case. To do so, rotate the computer back down and place your thumbs on the front edge of the top case. Push upward until the cases separate slightly.

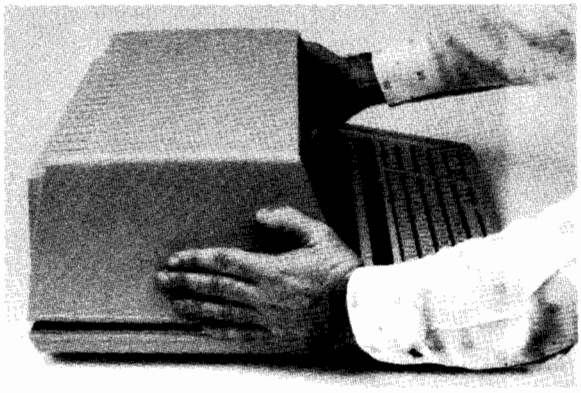


WARNING

In the next step, be careful not to allow the fingers of your left hand to curl under the top case. If they do, they could contact the high-voltage area on the CRT PCA. (This area is shown in figure 3-1.) If the brightness control is disconnected or broken, high voltage may be present there.

Also, be sure to lift the top case straight up. If you do not, the metallized inside surface of the top case could be scratched, thereby degrading the EMI characteristics, or it could contact the high-voltage area on the CRT PCA.

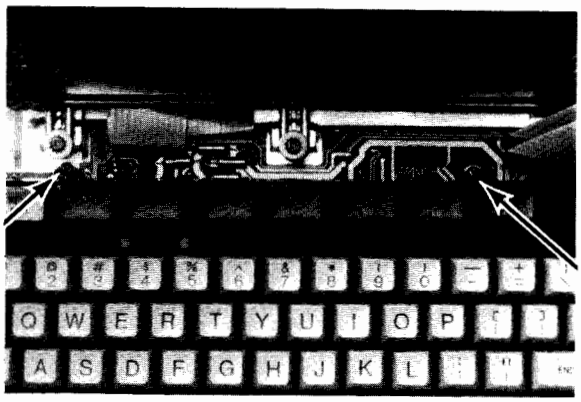
e. Lift the top case off of the computer. To do so, place your hands on the sides of the computer near the back. Press inward on the sides of the top case and lift it straight up.



2. REPLACING THE KEYBOARD ASSEMBLY

a. Remove the two screws securing the keyboard to the bottom case.

b. Rotate the back of the keyboard forward.



c. Lift the keyboard out of the bottom case. To do so, grasp its ends and lift up and slightly forward until the keyboard hinge pins snap out of their retainers in the bottom case. With the keyboard still inclined, lift it straight up until the two cables disconnect from the logic one PCA.

d. Disconnect the two cables from the keyboard assembly, and connect them to the new keyboard assembly.

e. Connect the other ends of the cables to the logic one PCA.

f. Snap the keyboard hinge pins into the retainers in the bottom case.

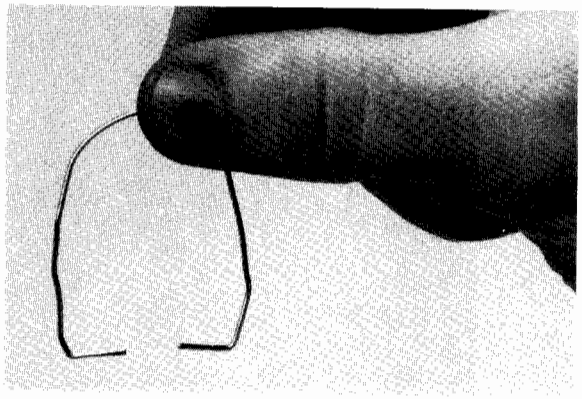
g. Rotate the back of the keyboard down.

h. Insert and tighten the two screws securing the bottom case.

Note: Be sure to run the System Test (or at least the Keyboard Test) from the System Service ROM after installing the top case. If any key catches on the top case, loosen the four screws securing the keyboard hinges to the keyboard PCA and adjust the position of the keyboard.

3. REPLACING A KEYCAP

Note: Make a tool to remove key caps by bending a paper clip as shown in the photograph.



a. If the key cap to be removed is along the outside of the keyboard, remove the key caps between the one to be removed and the outside of the keyboard. This provides clearance for the paper clip, preventing the key cap from being scratched.

b. Insert the paper clip over the key and hook the clip in the corners of the key cap.

c. Pull firmly upward to remove the key cap.

d. Install the new key cap by pressing it firmly into place. It is a press fit; it will not snap. If you have removed several key caps, see figure 3-7 for the correct key positions.

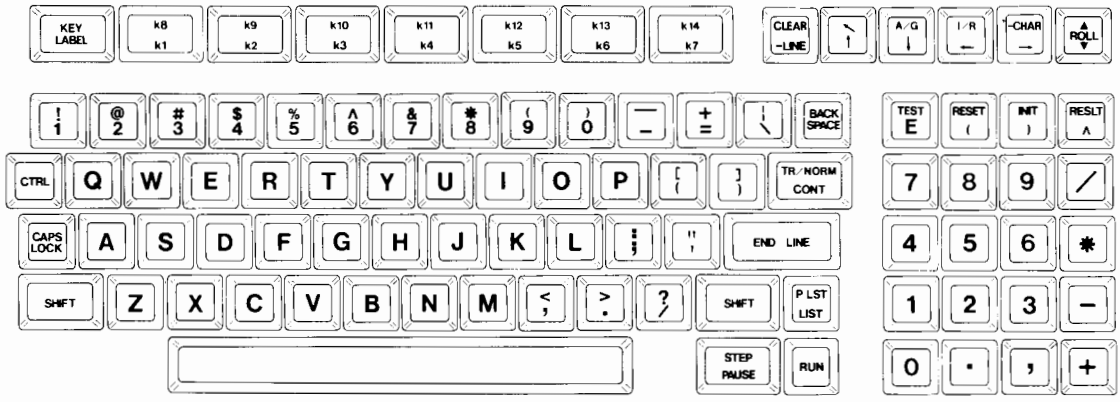


Figure 3-7. HP-87 Keyboard

4. REPLACING THE SPACE BAR

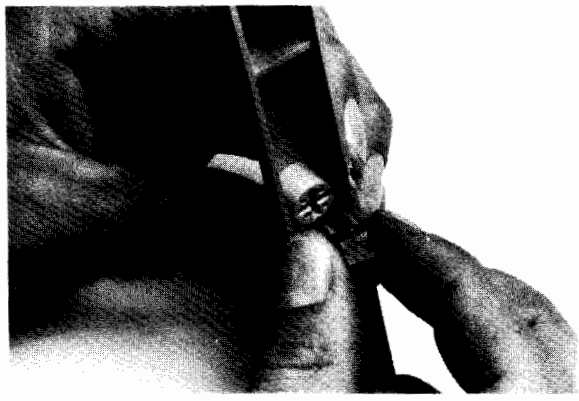
a. Pull the space bar up, by hooking your thumbs under the ends of the bar, until the bar separates from its plunger.

b. Slide the bar along the hinge rod and gently press the bracket inward until it clears the rod.

c. If the adapter from the space bar remained in the plunger instead in the space bar:

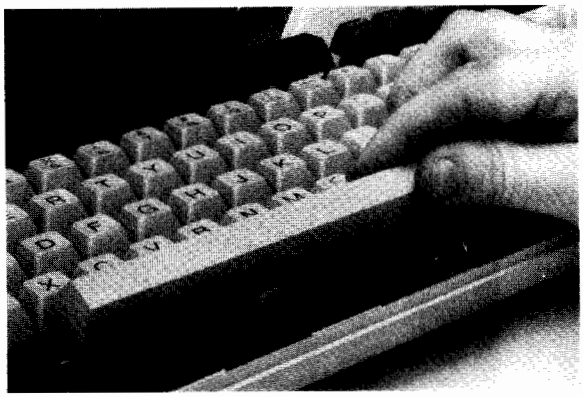
(1) Pull the adapter out of the plunger with your fingers.

(2) Insert the adapter into the boss in the space bar. The adapter should be positioned so that it angles toward the edge of the space bar away from the brackets.



(3) Press the adapter firmly into place with your thumb.

d. Position the space bar over the keyboard. It should be oriented with the brackets toward the front.



e. Hook one end of the hinge rod in the hole in the bracket.

f. Hook the other end in the rear hole of the bracket after sliding the bar along the rod.

g. Position the space bar with its adapter over its plunger, then press down on the center of the bar as far as it will go. It is a press fit; it will not snap.

5. REPLACING A PLUNGER AND SPRING

Note: After the plunger has been removed, it should not be reinserted. Discard it and install a new plunger.

This procedure does not apply to the plunger and spring for the [CAPS LOCK] key. To replace them, see the procedure 6.

a. Remove the key cap or space bar as described above.

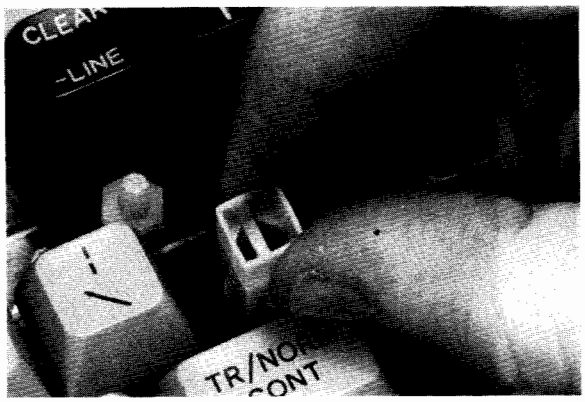
b. Grasp the plunger firmly using long-nose pliers with serrated tips.

> CAUTION
> In the next step, be sure to pull the plunger straight up. If you pull it up at an angle, the plunger housing could be damaged.

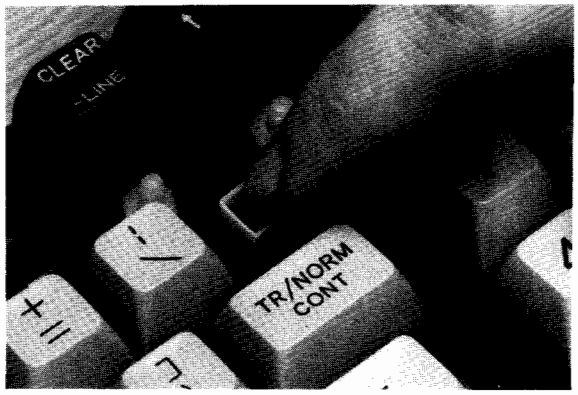
c. Pull up to remove the plunger.

d. Remove the old key spring and replace it with a new one. For all keys except the space bar, insert a short spring (28 mm; 1.1 in.). For the space bar, insert a long spring (35 mm; 1.4 in.).

e. Place a new plunger over the spring. The plunger should be oriented such that the slots in its sides face the left and right of the keyboard and the bar inside points toward the front and back of the keyboard.



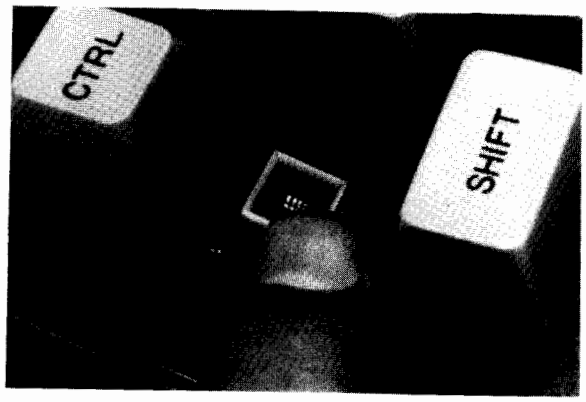
f. Press the plunger down with your finger until it snaps into place.



6. REPLACING THE [CAPS LOCK] KEY MECHANISM

a. Remove the key cap as described above.

b. Place your finger over the plunger, and pry the wire away from plunger using a small flat-blade screwdriver.



c. Lift off and discard the plunger and spring.

d. Remove the straight retaining wire from the bottom of the plunger housing using needle-nose pliers. You may have to release the wire form beneath the plunger housing by prying it toward the rear of the keyboard.

e. Remove the C-shaped wire from the plunger housing.

f. Insert a new C-shaped wire into the plunger housing. The long arm should be down and located in the shallow channel in the base of the housing.

g. Insert a new straight retaining wire between the arms of the other wire, then release it so that it drops to the bottom of the plunger housing.

h. Pry both ends of the straight wire under the corners of the plunger housing.

i. Place a new, long spring around the contacts in the plunger housing.

j. Place a new plunger over the spring. The plunger should be oriented such that the raised area on one of its sides face the rear of the keyboard.

k. Press the plunger down into the housing while prying the C-shaped wire away from the plunger using a small, flat-blade screwdriver.

l. Release the wire so that it engages in the slot in the side of the plunger. Press down on the plunger a few times to make sure that the mechanism is working properly.

7. REPLACING KEY CONTACTS

a. Remove the key cap, plunger, and spring as described above.

b. Unsolder the key contacts from the back of the keyboard PCA.

> CAUTION
> In the next step, be sure to pull the contacts straight up. If you pull them up at an angle, the plunger housing could be damaged.

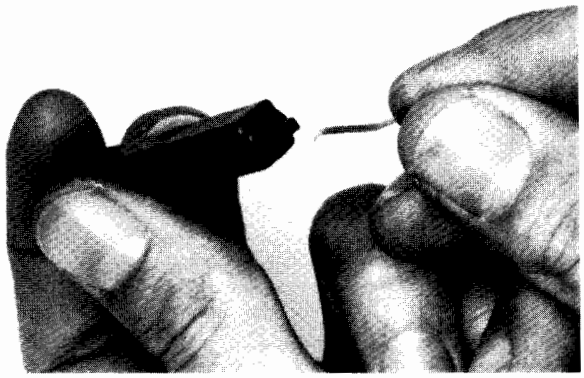
c. Remove the key contacts, one at a time, by pulling them straight up using needle-nose pliers with serrated tips.

d. Remove all solder from the two holes in the keyboard PCA.

e. Remove any bits of plastic, loose solder, or other particles from the inside of the plunger housing.

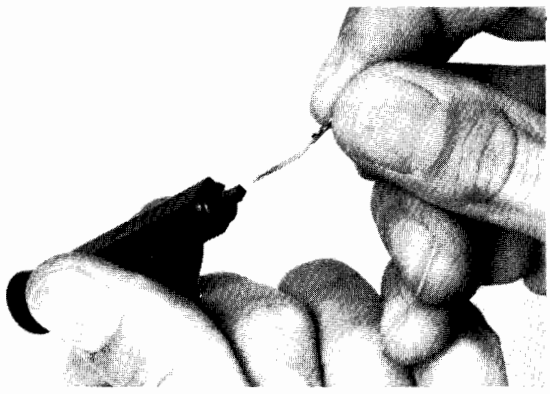
> CAUTION
> Wear white gloves while handling the key contacts in the next two steps. If key contacts are contaminated with dirt or oils, they might not make proper electrical contact when closed.

f. Insert a solid key contact into one of the rectangular holes next to the plunger in the bottom of the key contact insertion tool. The contact should be inserted so that it is bent toward the plunger in the tool.

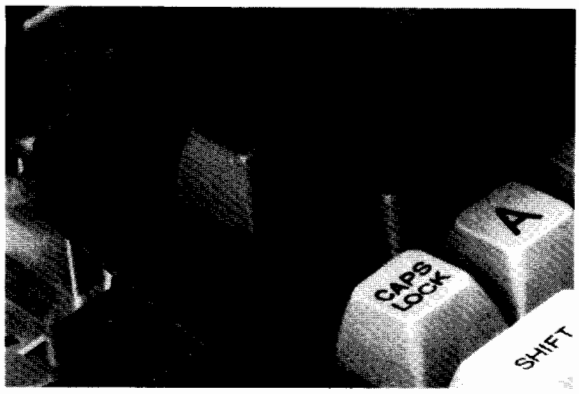


g. Push the contact into the tool as far as it will go. When fully inserted, the solder tail of the contact will reach the end of the plunger in the tool.

h. Insert a slotted key contact into the other rectangular hole in the tool. Again, the contact should be inserted so that it is bent toward the plunger. Push the contact into the tool as far as it will go.



i. Insert the tool into the plunger housing. The tool should be oriented so that the contacts are facing the left and right of the keyboard, not the front and rear.



j. Press the tool down until it bottoms out in the plunger housing.

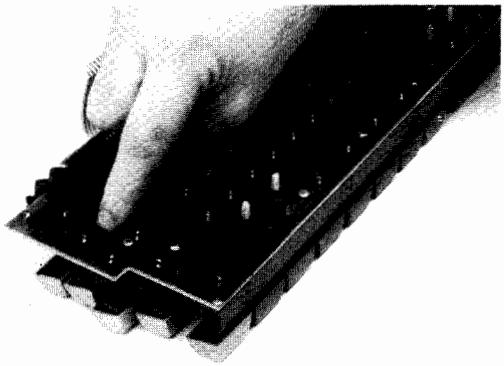
k. Solder the contacts to the keyboard PCA.

8. REPLACING A KEYBOARD HINGE

a. Remove the two screws securing the hinge to the keyboard PCA.

b. Position a new hinge beneath the keyboard PCA. The pin in the middle of the hinge should be engaged in the hole in the keyboard PCA.

c. Insert and tighten the screws.

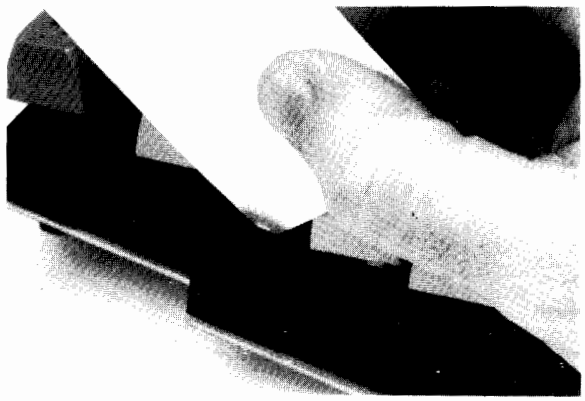


9. CLEANING KEY CONTACTS

a. Remove the key cap, plunger, and spring as described in procedures 3 and 5.

b. Dampen the corner of a thin cardboard sheet (such as a business card) with Freon TE, TF, or TMS PLUS.

c. Insert the dampened corner between the key contacts, and move it up and down a few times.

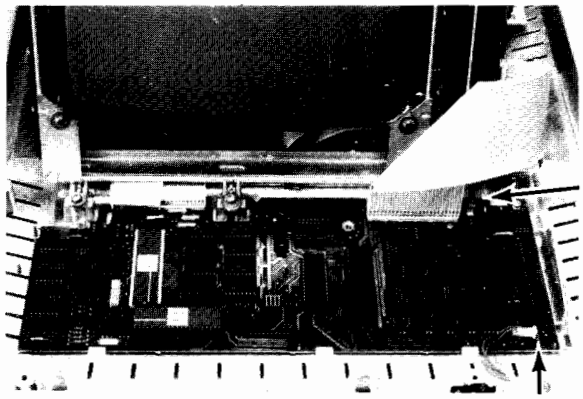


10. REPLACING THE LOGIC ONE PCA

With the keyboard assembly removed (procedure 2):

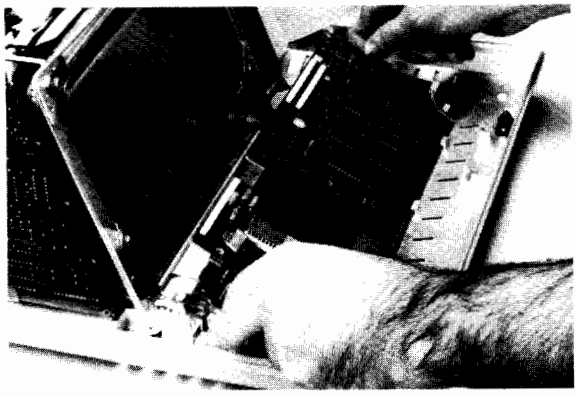
a. Disconnect the cables from the logic one PCA to the CRT PCA, the power supply PCA, and the logic two PCA.

b. Disconnect the two small connector plugs from the logic one PCA. One is at the upper right and the other is at the lower right.



c. Remove the two screws securing the logic one PCA to the bottom case.

d. Lift the logic one PCA out by rocking it forward.



e. Make sure the insulator is correctly positioned in the bottom case.

f. Place the new logic one PCA in the bottom case. To do so, hook the front edge of the logic one PCA under the hooks in the bottom case, then set the back down.

g. Insert and tighten the two screws securing the logic one PCA to the bottom case.

h. Connect the two small plugs to the logic one PCA. Be sure that the wires to the speaker pass under the CRT frame. Also be sure that the plug from the power light is connected so that the wires come out of the plug toward the front of the computer. The power light will not turn on if the plug is connected backwards.

i. Arrange the power light wires down against the logic one PCA and the bottom case.

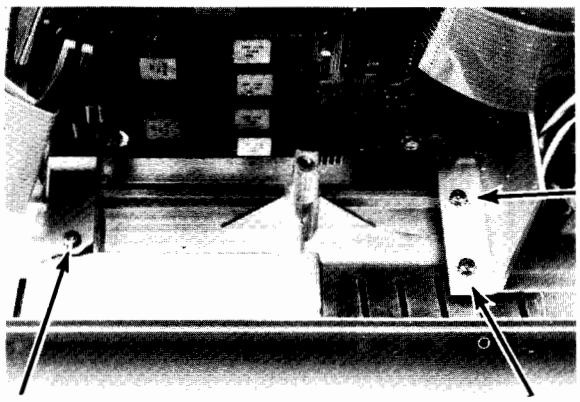
j. Connect to the logic one PCA the cables from the CRT PCA, the power supply PCA, and the logic two PCA.

11. REPLACING THE LOGIC TWO PCA

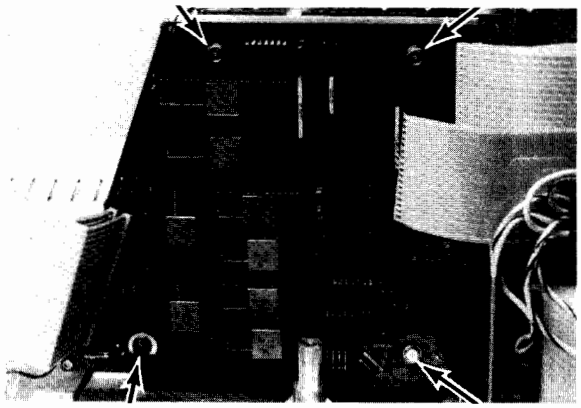
With the top cover removed (procedure 2):

a. Disconnect the cables from the logic two PCA to the logic one PCA, the I/O PCA, and the HP-IB PCA.

b. Loosen the three screws holding the logic two PCA mounting bracket to the bottom case. Loosening these screws lets you lift the logic two PCA so you can remove the screws in the next step.



c. Remove the four screws securing the logic two PCA to the mounting bracket.



d. Remove the ground strap from the PCA.

e. Remove the logic two PCA.

f. Place the new logic two PCA in position.

g. Insert and tighten the four screws securing the logic two PCA to the mounting bracket. (Be sure to recon- the ground strap.)

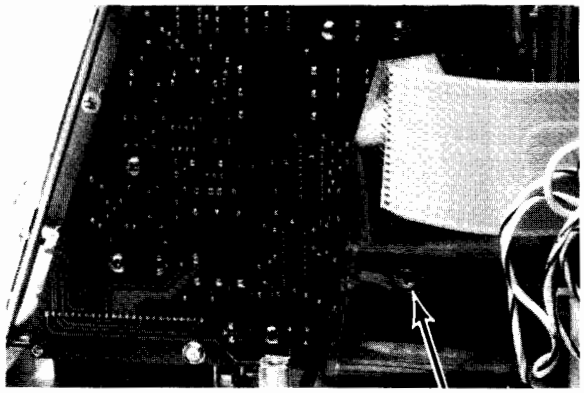
h. Tighten the three screws securing the mounting bracket to the bottom case.

12. REPLACING THE POWER SUPPLY PCA

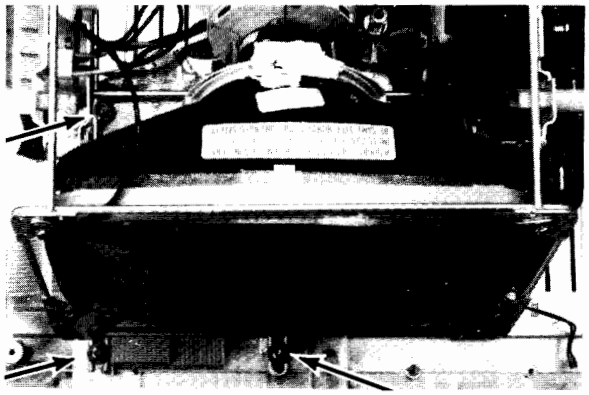
With the logic two PCA removed (procedure 11):

a. Remove the three screws securing the logic two PCA mounting bracket to the bottom case. Remove the mounting bracket.

b. Remove the screw holding the ground strap to the power supply PCA.



c. Loosen the three screws holding the CRT frame to the bottom case. This will allow you to lift the CRT assembly and the power supply PCA to gain access to the mounting screws.



d. Remove the four screws securing the power supply PCA to the CRT frame.

e. Disconnect the ribbon cable from the power supply PCA to the logic one PCA and the plug on the right side of the power supply PCA.

f. Remove the power supply PCA by lifting it up.

g. Connect the ribbon cable and the three-socket plug to the new power supply PCA.

h. Place the new power supply PCA into position and secure it to the CRT frame with the four screws.

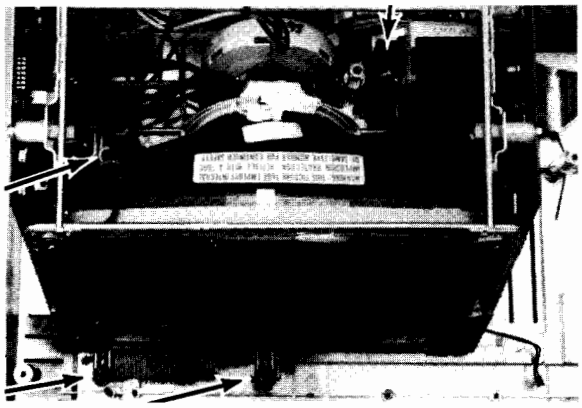
i. Tighten the three screws securing the CRT frame.

13. REPLACING THE CRT PCA

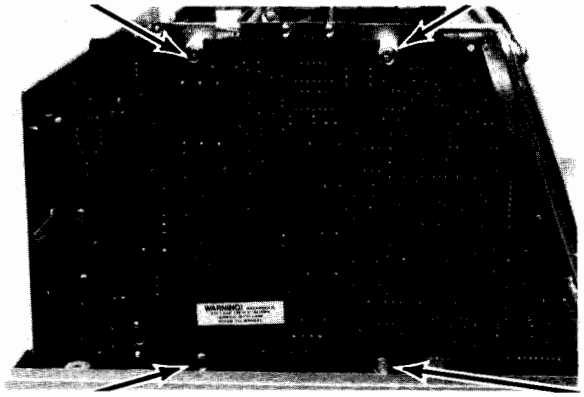
With the keyboard assembly removed (procedure 2):

a. Discharge the CRT anode wire by lifting up the rubber gasket and inserting a screwdriver until it touches the wire prongs. Then short the screwdriver to the CRT frame.

b. Loosen the four screws and washers securing the CRT frame to the bottom case.



c. Remove the four screws securing the CRT PCA to the CRT frame.



d. Disconnect the five plugs on the CRT PCA from their connectors.

e. Disconnect the cable connecting the CRT PCA to the logic one PCA.

f. Disconnect the anode wire from the CRT by first lifting up the rubber gasket to gain access to the wire prongs. Use small needle-nose pliers to compress the prongs and lift them straight out.

g. Remove the CRT PCA.

h. Connect the CRT anode wire on the new CRT PCA to the CRT by compressing the wire prongs with a small needle-nose pliers and inserting them in the hole in the CRT.

i. Connect the ribbon cable between the CRT PCA and the logic one PCA.

j. Connect the four plugs from the CRT and the one plug from the brightness control to their respective connectors on the new CRT PCA.

k. Place the new CRT PCA in position and secure it to the CRT frame with the four screws. Don't forget to re-attach the ground strap.

l. Tighten the four screws holding the CRT frame to the bottom case.

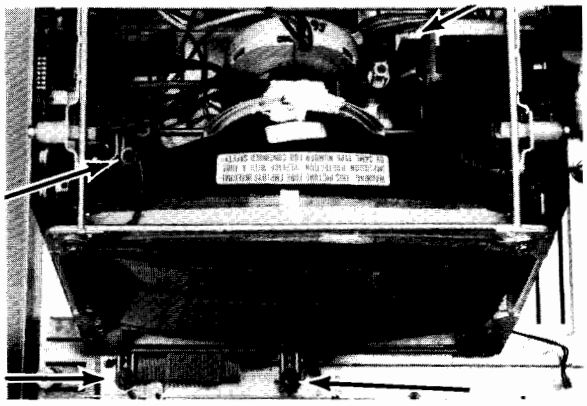
14. REPLACING THE CRT ASSEMBLY

With the power supply PCA and the CRT PCA removed (procedures 12 and 13):

a. Discharge the CRT anode wire as described in procedure 13, step a.

b. Remove the four screws and washers securing the CRT frame to the bottom case.

c. Lift out the CRT assembly.



d. Place the new CRT assembly in position and secure it with the four screws and washers. Do not tighten the screws completely since you will need to lift the CRT frame in order to mount the CRT PCA on the CRT frame.

15. REPLACING THE BACK PANEL ASSEMBLY

With the top case removed (procedure 1):

a. Turn the computer around so that the back panel is facing you.

b. Disconnect the power plug from the power supply PCA.

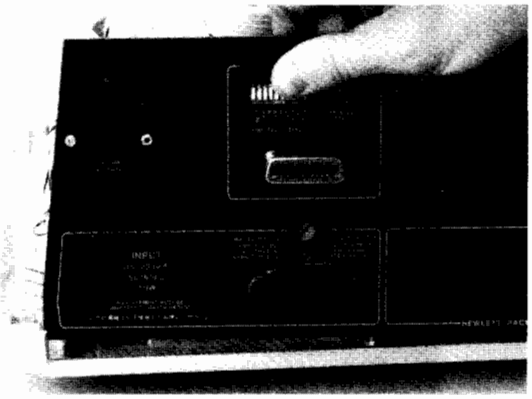
c. Disconnect the two cables connecting the I/O PCA to the logic two PCA.

d. Disconnect the two cables connecting the HP-IB PCA to the logic two PCA from the logic two PCA.

e. Remove the three screws securing the back panel assembly to the bottom case.

f. Remove the screw securing the CRT chassis to the back panel assembly.

g. Lift the left side of the back panel assembly up and the right side out until it clears the shaft of the brightness control.



h. Place the right side of the new back panel assembly in position so that the shaft of the brightness control passes through the hole. Then place the left side of the assembly in the bottom case.

i. Disconnect the old I/O PCA from the old back panel assembly and install it on the new back panel assembly. (See procedure 16).

j. Connect the two ribbon cables on the new HP-IB PCA to the logic two PCA.

k. Connect the power plug to the power supply PCA.

l. Insert and tighten the three screws securing the back panel assembly to the bottom case.

m. Insert and tighten the screw securing the CRT chassis to the back panel assembly.

16. REPLACING THE I/O PCA

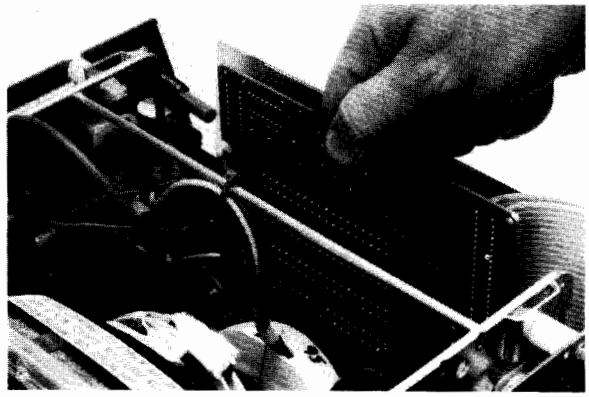
With the top case removed (procedure 1):

a. Turn the computer around so that the back panel is facing you.

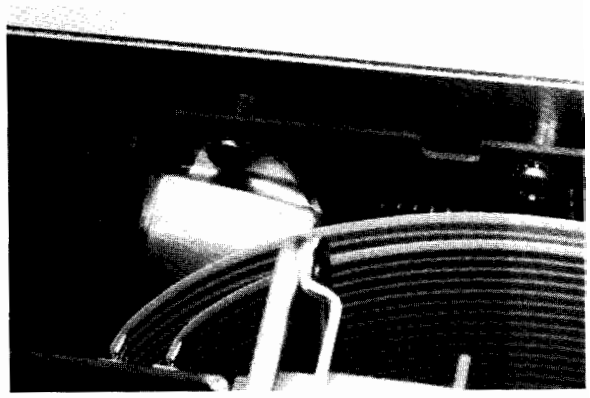
b. Disconnect the two cables between the I/O PCA and the logic two PCA.

c. Remove the two screws securing the I/O PCA to the back panel assembly.

d. Slide the I/O PCA up and out of its mounting bracket.



e. Remove the screw and washer securing the ground strap to the I/O PCA.



f. Reconnect the ground strap to the new I/O PCA.

g. Insert the new I/O PCA into it mounting bracket.

h. Connect the two cables between the I/O PCA and the logic two PCA.

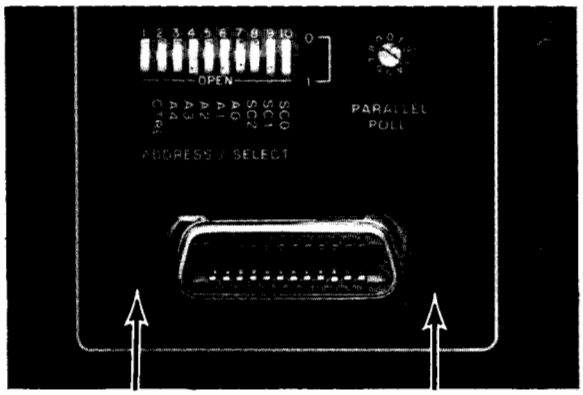
i. Insert and tighten the two screws securing the I/O PCA to the back panel assembly.

17. REPLACING THE HP-IB PCA

With the top cover removed (procedure 1):

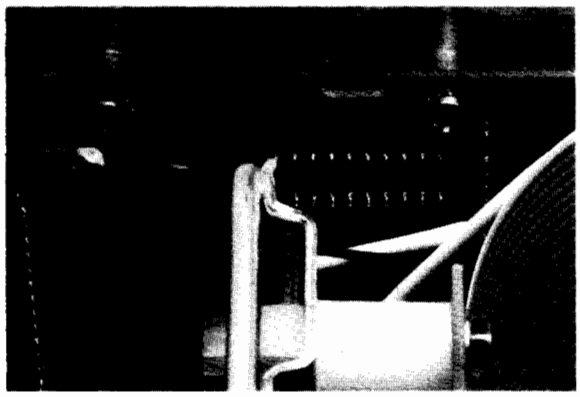
a. Turn the computer around so that the back panel faces you.

b. Remove the two screws securing the HP-IB connector to the back panel assembly.



c. Disconnect the two cables from the I/O PCA. This will provide better access to the screws securing the HP-IB PCA to the back panel assembly.

d. Remove the two screws and and washers securing the HP-IB PCA to the back panel assembly.



e. Disconnect the two cables between the HP-IB PCA and the logic two PCA.

f. Remove the HP-IB PCA.

g. Secure the new HP-IB PCA to the back panel assembly with the two screws and washers.

h. Connect the two cables from the HP-IB PCA to the logic two PCA.

i. Connect the two cables from the I/O PCA to the logic two PCA.

j. Install and tighten the two screws securing the HP-IB connector to the back panel assembly.

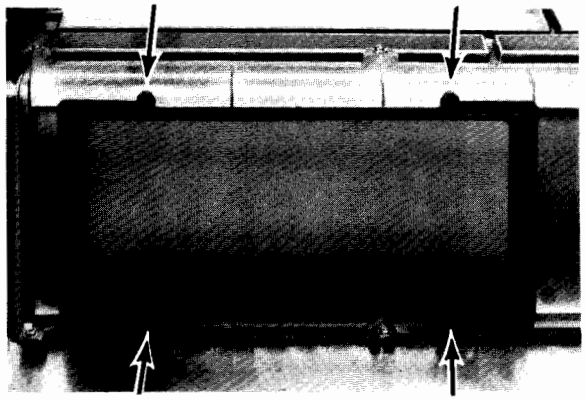
18. REPLACING PARTS OF THE TOP CASE ASSEMBLY

With the top case removed (procedure 1):

> CAUTION
> Wear white gloves while replacing parts of the top case assembly. If the metallized inside surface of the top case is contaminated with grease or dirt, the EMI (electromagnetic interference) characteristics of the computer may be degraded.

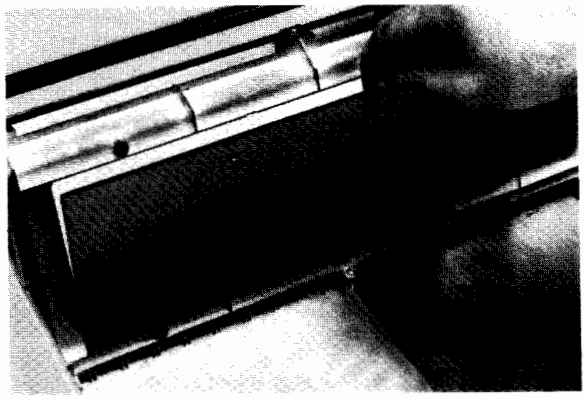
o To replace the CRT window:

a. Remove the four screws securing the lens retainer.



b. Remove the lens retainer.

c. Lift out the CRT window lens.

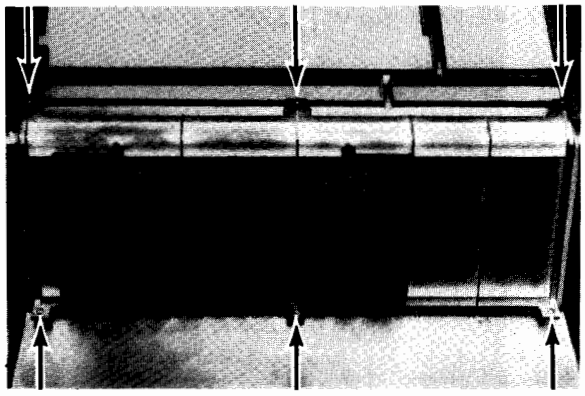


d. Place the new CRT window lens in position.

e. Place the CRT lens retainer in position and secure it with the four screws.

o To replace the bezel:

a. Remove the six screws securing the bezel to the top cover assembly.



b. Remove the CRT window lens from the old bezel and insert it into the new bezel as described above.

c. Place the new bezel into the top cover assembly, then insert and tighten the six screws.

19. REPLACING PARTS OF THE BOTTOM CASE ASSEMBLY

With the top case assembly removed (procedure 1):

> CAUTION
> Wear white gloves while replacing parts of the bottom case assembly. If the metallized inside surface of the bottom case is contaminated with grease or dirt, the EMI (electromagnetic interference) characteristics of the computer may be degraded.

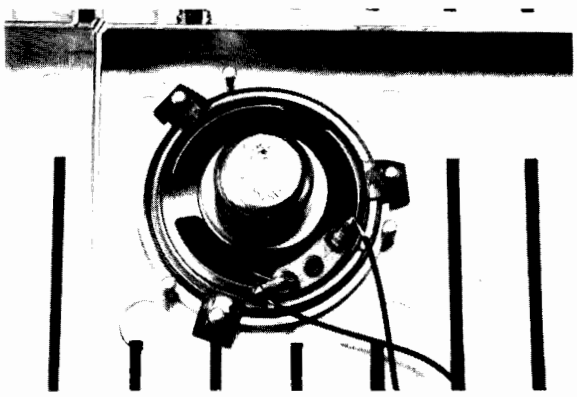
- To replace the speaker:

  a. Disconnect the speaker plug from the logic one PCA.

  b. Remove the CRT assembly as described in procedure 14.

  c. Break each of the three retaining clips off of the pins using pliers or diagonal cutters, being careful not to break the pins.

  d. Place the new speaker in the bottom case with the speaker's terminals toward the channel in the bottom case.



e. Insert a new retaining clip over each pin and press them all the way down using a small nutdriver.

f. Connect the speaker plug to the logic one PCA.

o To replace the brightness control:

a. Remove the back panel assembly as described in procedure 15.

b. Remove the nut securing the brightness control to its mounting post in the bottom case. Use a 1/2-inch nutdriver.

c. Push the shaft of the control through the hole in its mounting post.

d. Pull the control to the left until its plug comes off the connector.

e. Insert the plug of the new control over the CRT frame.

f. Engage the tip of the connector pins into the plug, then press the plug onto the connector with your finger.

g. Insert the shaft of the new control into the hole in its mounting post. Be sure that the locating tab on the control enters the slot in the post.

h. Insert and tighten the nut securing the control to the post.

i. Install the back panel assembly in the bottom case as described in procedure 15.

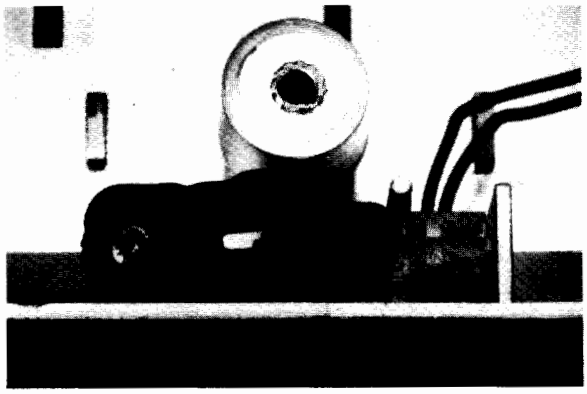
o To replace the power light:

a. Remove the keyboard assembly as described in procedure 2.

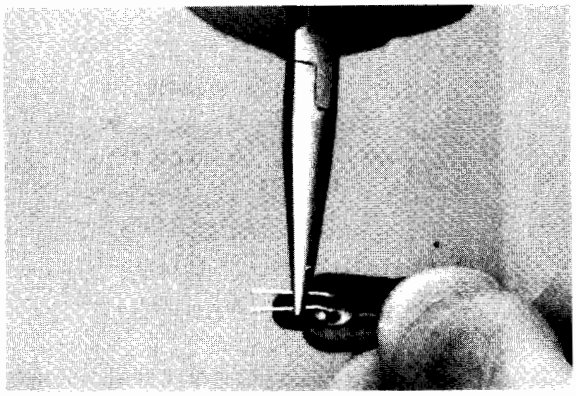
b. Disconnect the power light plug from the logic one PCA.

c. Remove the screw securing the power light holder to the bottom case.

d. Lift out the power light holder and pull the plug off the LED.

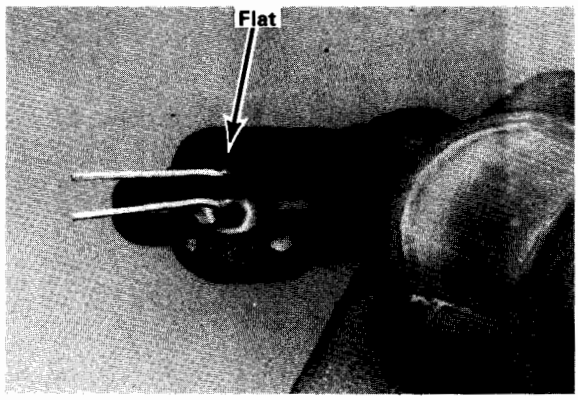


e. Pull the LED out of the holder using pliers.

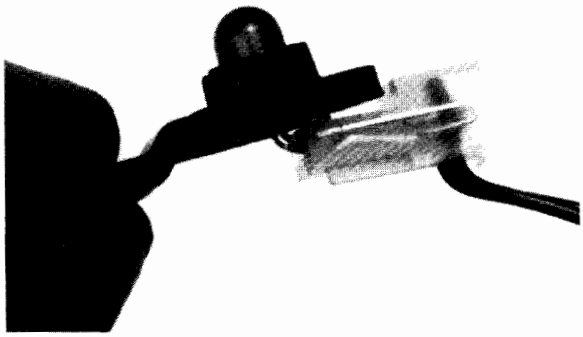


f. Insert a new LED into the holder. The flat on the LED should be aligned with the flat on the base of the holder.

g. Push the LED in until its base is flush with the base of the holder.



h. Insert about 3/4 of the length of the LED leads into either of the plugs. Bend the plug away from the screw hole in the holder. The plug should be positioned so that when the holder is in position the wires will come down out of the holder, not up.

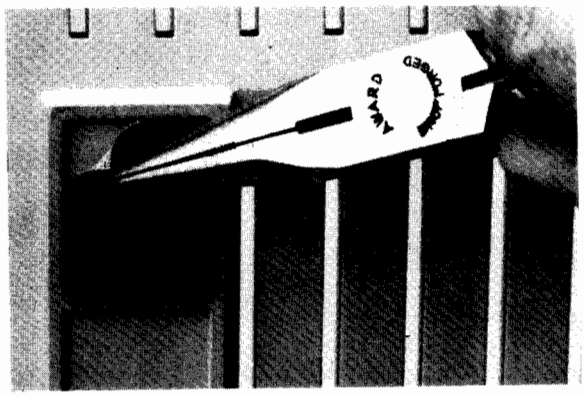


i. Position the holder in the bottom case and insert the screw. Before tightening it, orient the holder so that the plug is positioned between the two ribs in the bottom case. Tighten the screw.

j. Connect the other plug to the logic one PCA. The plug should be positioned so that the wires come out of the plug toward the front of the computer. The power light will not turn on if the plug is connected backwards.

k. Arrange the power light wires down against the logic one PCA and the bottom case.

o To replace a foot: tilt the computer onto its back panel, peel off the old foot with needle-nose pliers, then press a new foot into place.



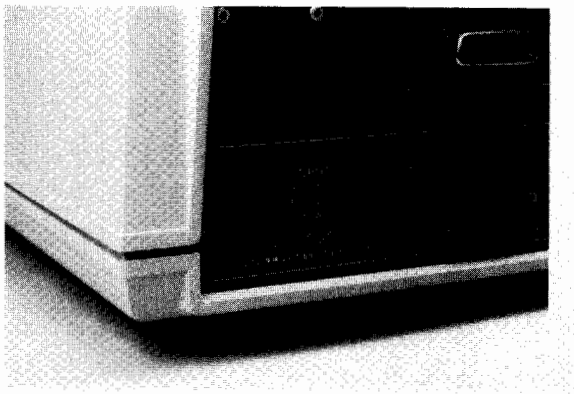
20. ATTACHING THE TOP CASE TO THE BOTTOM CASE

a. Make sure the power cord is disconnected from the back panel.

b. Make sure the grounding spring is correctly attached to the CRT assembly.

> CAUTION
> In the next step, be careful to lower the top case straight down onto the bottom case. If you do not, the metallized inside surface of the top case may be scratched, which might degrade the EMI characteristics of the computer.

c. Place the top case in position on the bottom case. Make sure that the back panel is just inside the top case, not outside.



d. Wiggle the top case and gently press it down until the cases close together. When closed properly, there should be a gap of about 1.6 mm (1/16 in.) between the edges of the cases.

e. Insert and tighten the six screws in the bottom case after tilting the computer onto its back panel.

Section
IV

Replaceable Parts

This section lists the replaceable parts and assemblies of the HP-87. This section also contains exploded view drawings of the HP-87, the keyboard assembly, and the back panel assembly.

Assemblies or parts listed without an HP part number are identified for reference only and cannot be ordered as named. Such items are either supplied as part of the assemblies under which they are listed, or can be obtained by ordering the indicated parts included in the assembly.

Table 4-1. Keyboard Assembly Replaceable Parts

FIGURE AND INDEX NUMBER	HP PART NUMBER	DESCRIPTION	QTY
4-2-26	00087-60905	ASSEMBLY, keyboard	1
4-2-27	2200-0103	SCREW, machine, 4-40 x 0.25 inch	2
4-2-28	8120-2843	CABLE, ribbon	2
4-2-29	00085-40031	HINGE, keyboard	2
4-2-30	0624-0314	SCREW, tapping, 4-20 x 0.375 inch	4
4-2-31	0380-1462	SUPPORT, PC board	4
	0371-2369	CAP, key, [LABEL KEY]	1
	0371-2370	CAP, key, [k1 k8]	1
	0371-2371	CAP, key, [k2 k9]	1
	0371-2372	CAP, key, [k3 k10]	1
	0371-2373	CAP, key, [k4 k11]	1
	0371-2374	CAP, key, [k5 k12]	1
	0371-2375	CAP, key, [k6 k13]	1
	0371-2376	CAP, key, [k7 k14]	1
	0371-0092	CAP, key, [↑\]	1
	0371-2381	CAP, key, [↓ A/G]	1
	0371-2378	CAP, key, [← I/R]	1
	0371-2379	CAP, key, [→-CHAR]	1

Table 4-1. Keyboard Assembly Replaceable Parts (Continued)

FIGURE AND INDEX NUMBER	HP PART NUMBER	DESCRIPTION	QTY
	0371-0137	CAP, key, [ROLL]	1
	0371-2377	CAP, key, [-LINE CLEAR]	1
	0371-0119	CAP, key, [1 !]	1
	0371-0103	CAP, key, [2@]	1
	0371-0104	CAP, key, [3 #]	1
	0371-0105	CAP, key, [4 $]	1
	0371-0106	CAP, key, [5 %]	1
	0371-0063	CAP, key, [6 -]	1
	0371-0130	CAP, key, [7 &]	1
	0371-0070	CAP, key, [8 *]	1
	0371-0071	CAP, key, [9 (]	1
	0371-0072	CAP, key, [0)]	1
	0371-0073	CAP, key, [-_]	1
	0371-0074	CAP, key, [= +]	1
	0371-0075	CAP, key, [\ |]	1
	0371-0076	CAP, key, [BACK SPACE]	1
	0371-2380	CAP, key, [E TEST]	1
	0371-0141	CAP, key, [(RESET]	1
	0371-0140	CAP, key, [) INIT]	1

Table 4-1. Keyboard Assembly Replaceable Parts (Continued)

FIGURE AND INDEX NUMBER	HP PART NUMBER	DESCRIPTION	QTY
	0371-0097	CAP, key, [^ RESLT]	1
	0371-0131	CAP, key, [CTRL]	1
	0371-0101	CAP, key, [Q]	1
	0371-0090	CAP, key, [W]	1
	0371-0120	CAP, key, [E]	1
	0371-0100	CAP, key, [R]	1
	0371-0079	CAP, key, [T]	1
	0371-0108	CAP, key, [Y]	1
	0371-0080	CAP, key, [U]	1
	0371-0085	CAP, key, [I]	1
	0371-0125	CAP, key, [O]	1
	0371-0123	CAP, key, [P]	1
	0371-0143	CAP, key, [([]	1
	0371-0065	CAP, key, [)]]	1
	0371-2368	CAP, key, [CONT TR/NORMAL]	1
	0371-0124	CAP, key, [7]	1
	0371-0117	CAP, key, [8]	1
	0371-0118	CAP, key, [9]	1
	0371-0078	CAP, key, [/]	1

Table 4-1. Keyboard Assembly Replaceable Parts (Continued)

FIGURE AND INDEX NUMBER	HP PART NUMBER	DESCRIPTION	QTY
	0371-0127	CAP, key, [CAPS LOCK]	1
	0371-0142	CAP, key, [A]	1
	0371-0099	CAP, key, [S]	1
	0371-0121	CAP, key, [D]	1
	0371-0088	CAP, key, [F]	1
	0371-0087	CAP, key, [G]	1
	0371-0086	CAP, key, [H]	1
	0371-0084	CAP, key, [J]	1
	0371-0083	CAP, key, [K]	1
	0371-0082	CAP, key, [L]	1
	0371-0132	CAP, key, [; :]	1
	0371-0128	CAP, key, [' "]	1
	0371-0153	CAP, key, [END LINE]	1
	0371-0114	CAP, key, [4]	1
	0371-0115	CAP, key, [5]	1
	0371-0116	CAP, key, [6]	1
	0371-0077	CAP, key, [*]	1
	0371-0147	CAP, key, [SHIFT], right offset stem	1

Table 4-1. Keyboard Assembly Replaceable Parts (Continued)

FIGURE AND INDEX NUMBER	HP PART NUMBER	DESCRIPTION	QTY
	0371-0107	CAP, key, [Z]	1
	0371-0089	CAP, key, [X]	1
	0371-0122	CAP, key, [C]	1
	0371-0091	CAP, key, [V]	1
	0371-0064	CAP, key, [B]	1
	0371-0126	CAP, key, [N]	1
	0371-0081	CAP, key, [M]	1
	0371-0066	CAP, key, [,]	1
	0371-0067	CAP, key, [. >]	1
	0371-0068	CAP, key, [/ ?]	1
	0371-0146	CAP, key, [SHIFT], left offset stem	1
	0371-0134	CAP, key, [LIST PLST]	1
	0371-0111	CAP, key, [1]	1
	0371-0112	CAP, key, [2]	1
	0371-0113	CAP, key, [3]	1
	0371-0133	CAP, key, [-]	1
	0371-0154	CAP, key, [SPACE BAR]	1
4-1-1		o ADAPTER	1

Table 4-1. Keyboard Assembly Replaceable Parts (Continued)

FIGURE AND INDEX NUMBER	HP PART NUMBER	DESCRIPTION	QTY
	0371-0148	CAP, key, [PAUSE STEP]	1
	0371-0135	CAP, key, [RUN]	1
	0371-0110	CAP, key, [0]	1
	0371-0129	CAP, key, [.]	1
	0371-0109	CAP, key, [,]	1
	0371-0102	CAP, key, [+]	1
4-1-2	1251-5794	CONNECTOR, ribbon cable, 11-pin	2
4-1-3	1535-4040	CONTACT, key, slotted	92
4-1-4	1535-4041	CONTACT, key, solid	92
4-1-5	1535-4043	PLUNGER, key	91
4-1-6	1535-4042	PLUNGER, key, [CAPS LOCK]	1
4-1-7	1150-1415	SPRING, key, 28 mm (1.1 in.)	90
4-1-8	1150-1416	SPRING, key, 35 mm (1.4 in.)	2
4-1-9	1460-1782	WIRE, cam, [CAPS LOCK] plunger	1
4-1-10	1460-1783	WIRE, retaining, [CAPS LOCK] plunger	1

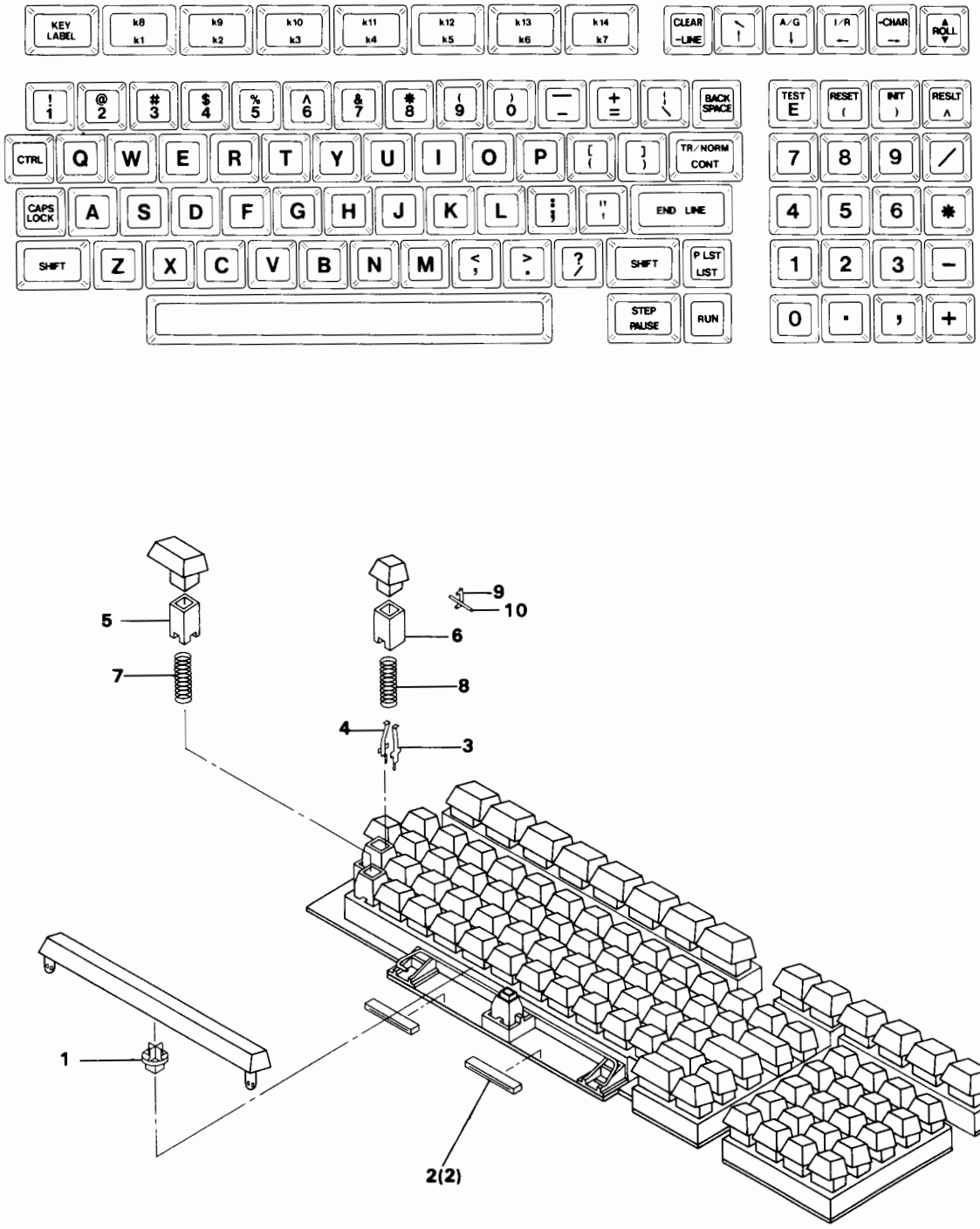


Figure 4-1. Keyboard Assembly Exploded View

Table 4-2. HP-87 Replaceable Parts

FIGURE AND INDEX NUMBER	HP PART NUMBER	DESCRIPTION	QTY
4-2-1	00085-60025	ASSEMBLY, power light	1
4-2-2	00085-40019	HOLDER	1
4-2-3	1990-0524	LED	1
		ASSEMBLY, topcase	
4-2-4	2200-0147	SCREW, machine, 4-40 x 0.625 inch	6
4-4-1	4040-1998	BEZEL	1
4-4-2	4040-2011	COVER	1
4-4-3	2200-0589	SCREW, machine, 4-40 x 0.312 inch	6
4-4-4	2190-0891	WASHER, flat matallic, #4	6
4-4-5	00087-40001	RETAINER-LENS	1
4-4-6	1000-0621	LENS, glass	1
4-4-7	0624-0532	SCREW, tapping, 2-38 x 0.437 inch	4
4-4-8	3050-0098	WASHER, flat metallic, #2	4
4-4-9	2200-0139	SCREW, machine, 4-40 x 0.25 inch	5
4-4-10	8160-0366	GROUND STRIP, RFI	1
4-4-11	1400-1087	STIFFENER	1
4-2-5	00087-60908	ASSEMBLY, logic one PC	1

Table 4-2. HP-87 Replaceable Parts (Continued)

FIGURE AND INDEX NUMBER	HP PART NUMBER	DESCRIPTION	QTY
	00087-60901	BOARD, logic one PC	1
	1MC2-0101	IC, CRT controller	1
	1MB2-0001	IC, keyboard controller	1
	1MB1-0001	IC, CPU	1
	1MC4-0002	IC, memory controller	1
	5081-5552	IC, RAM	1
	1258-0187	JUMPER, 4-contact	2
	1258-0124	JUMPER, 1-contact	1
4-2-6	0340-1002	INSULATOR	1
4-2-7	0624-0314	SCREW, tapping 4-20 x 0.375 inch	2
4-2-8	00087-~~60907~~ 69009 J2	ASSEMBLY, logic two PC	1
	00087-60902	BOARD, logic two PC	1
	1MB5-0101	IC, translator	1
	1MA8-0101	IC, I/O Buffer	1
	1MA7-0056	IC, ROM 0	1
	1MA7-0082	IC, ROM 1	1
	1MA7-0058	IC, ROM 2	1
	1MA7-0059	IC, ROM 3	1

Table 4-2. HP-87 Replaceable Parts (Continued)

FIGURE AND INDEX NUMBER	HP PART NUMBER	DESCRIPTION	QTY
	1MA7-0071	IC, ROM 4	1
	1MA7-0072	IC, ROM 5	1
	1820-2437	IC, HP-IB Microprocessor	1
4-2-9	8120-3426	CABLE, ribbon, 24-pin (power supply PCA)	1
4-2-10	8120-3427	CABLE, ribbon, 24-pin (I/O PCA)	1
4-2-11	8120-3428	CABLE, ribbon, 17-pin (HP-IB PCA)	1
4-2-12	8120-3429	CABLE, ribbon, 17-pin (HP-IB PCA)	1
4-2-13	8120-3431	CABLE, ribbon, 24-pin (logic two PCA)	1
4-2-14	8120-3425	CABLE, ribbon, 12-pin (CRT PCA)	1
4-2-15	8120-3430	CABLE, ribbon, 24-pin (logic two PCA to I/O PCA)	2
4-2-16	00087-00002	BRACKET, logic two	1
4-2-17	0380-1302	GROMMET-SPACER	12
4-2-18	0624-0480	SCREW, tapping, #8	12
4-2-19	2190-0563	WASHER, lock, ext. tooth, #6	3

Table 4-2. HP-87 Replaceable Parts (Continued)

FIGURE AND INDEX NUMBER	HP PART NUMBER	DESCRIPTION	QTY
4-2-20	0624-0403	SCREW, tapping, 6-19 x 0.375 inch	3
4-2-21	00087-69004	ASSEMBLY, power supply	1
4-2-22	00087-60025	ASSEMBLY, speaker	1
4-3-1	00087-60030	ASSEMBLY, P/PS ground	1
4-2-23	00087-60903	ASSEMBLY, I/O PCA	1
4-2-24	00085-60027	CONTROL, brightness	1
4-2-25	00087-60906	ASSEMBLY, backpanel	1
4-3-2	00087-60016	ASSEMBLY, transformer	1
4-3-3	00087-60904	ASSEMBLY, HP-IB PCA	1
4-3-4	2360-0113	SCREW, machine, 6-32 x 0.25 inch	2
4-3-5	2200-0778	SCREW, machine, 4-40 x 0.312 inch	2
4-3-6	2200-0558	SCREW, machine 4-40 x 2.25 inch	4
4-3-7	2190-0411	WASHER, lock, external teeth, #4	7
4-3-8	0590-0199	NUT, hex, w/lockwasher, 4-40	5
4-3-9	0590-0305	NUT, hex, w/lockwasher, 6-32	2

Table 4-2. HP-87 Replaceable Parts (Continued)

FIGURE AND INDEX NUMBER	HP PART NUMBER	DESCRIPTION	QTY
4-3-10	0380-0643	STANDOFF, hex, 0.255 inch	2
4-3-11	2110-0569	NUT, fuse holder	1
4-3-12	1400-1147	BRACKET, transformer	1
4-3-13	1400-1148	BRACKET, transformer	1
4-3-14	0905-0090	O-ring	1
4-3-15	8160-0335	STRIP, conducting, 1 x 4.5 inch	1
4-3-16	9135-0038	FILTER, line	1
4-3-17	3101-0402	SWITCH, ON/OFF	1
4-2-32	00087-69003	ASSEMBLY, CRT PCA	1
4-2-33	00087-60909	ASSEMBLY, CRT	1
4-2-34	2190-0142	WASHER, flat, metallic, #6	7
4-2-35	2190-0563	WASHER, locking, external tooth, #6	12
4-2-36	2360-0195	SCREW, machine, 6-32 x 0.312 inch	9
4-2-37	2360-0203	SCREW, tapping, 6-32 x 0.625 inch	3
4-2-38	1460-1725	SPRING, extension	1

Table 4-2. HP-87 Replaceable Parts (Continued)

FIGURE AND INDEX NUMBER	HP PART NUMBER	DESCRIPTION	QTY
4-2-39	1130-0565	STRAP, grounding	1
4-2-40	2110-0020	FUSE (115V)	1
4-2-40	2110-06393	FUSE (230V)	1
4-2-41	2110-0565	FUSE CAP (115V)	1
4-2-41	2110-0567	FUSE CAP (230V)	

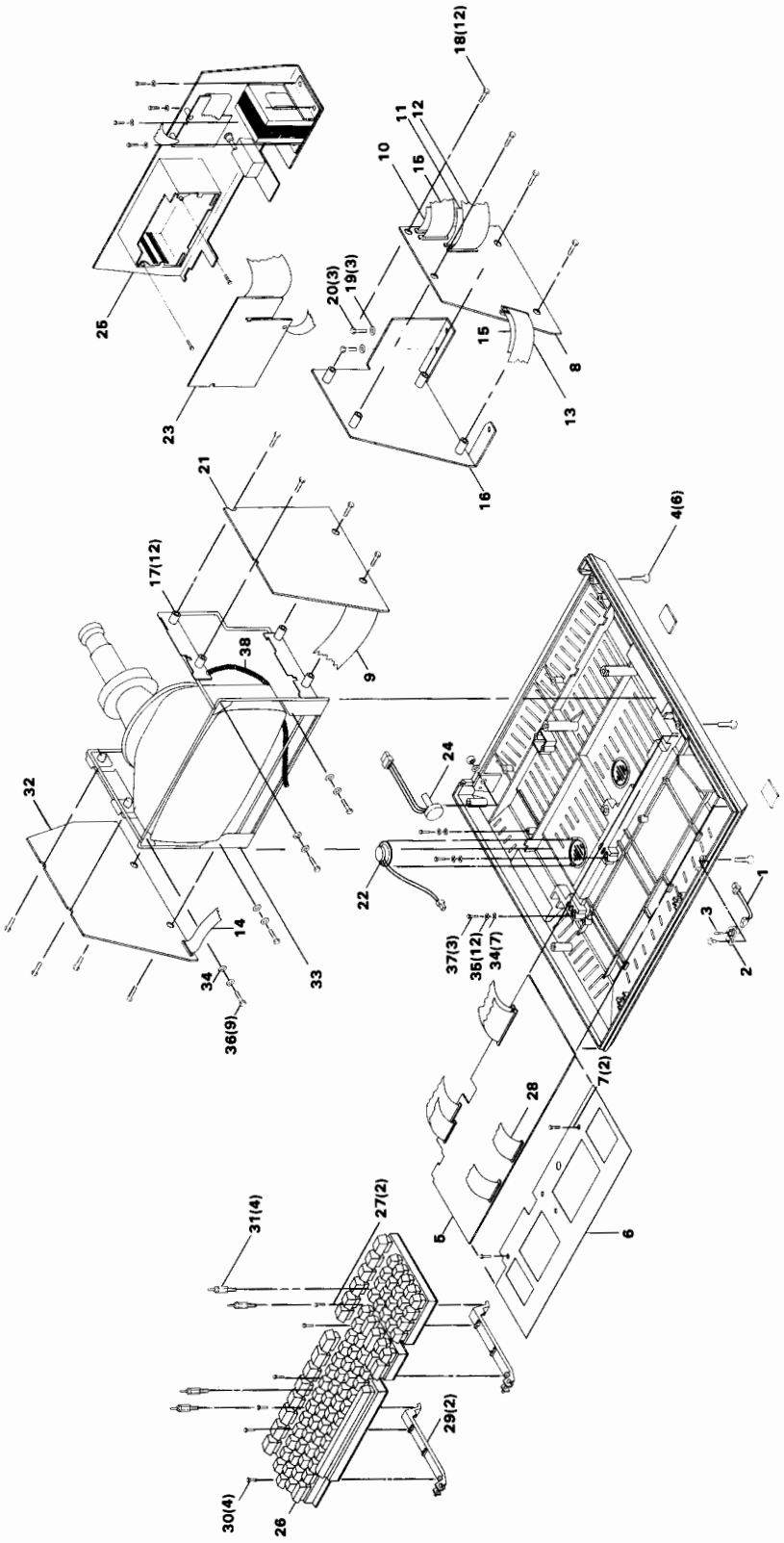


Figure 4-2. HP-87 Exploded View

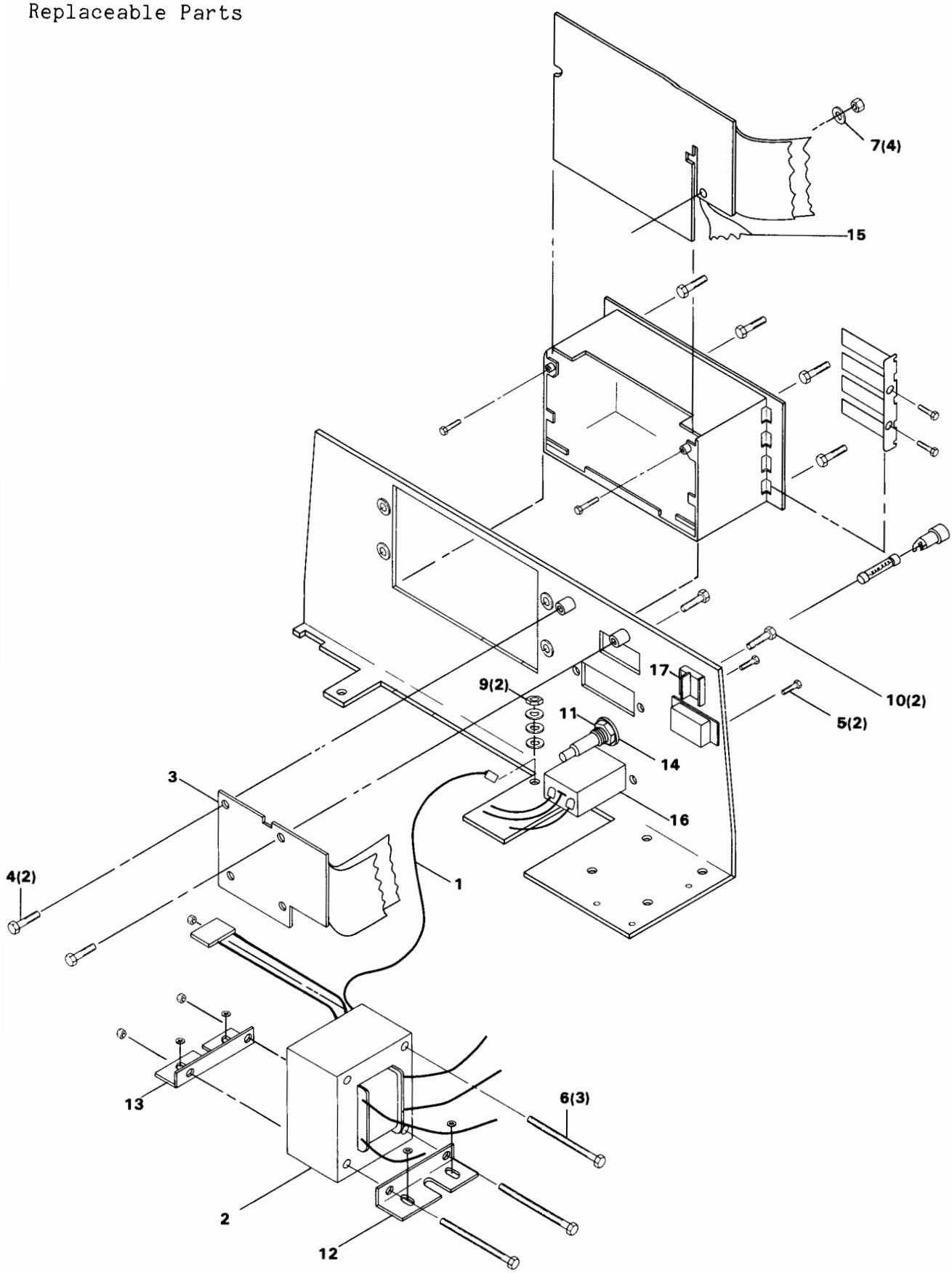


Figure 4-3. Back Panel Exploded View

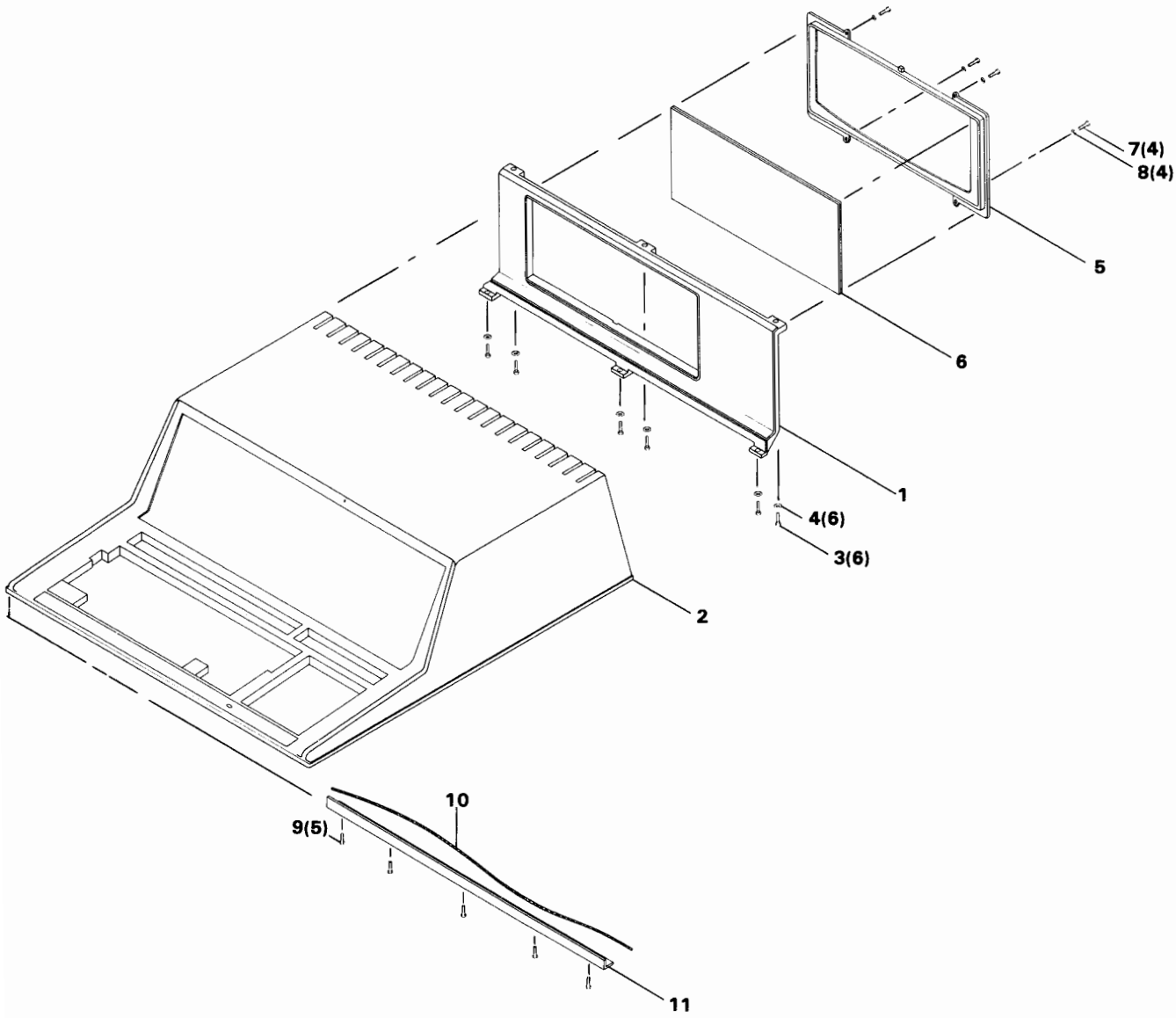


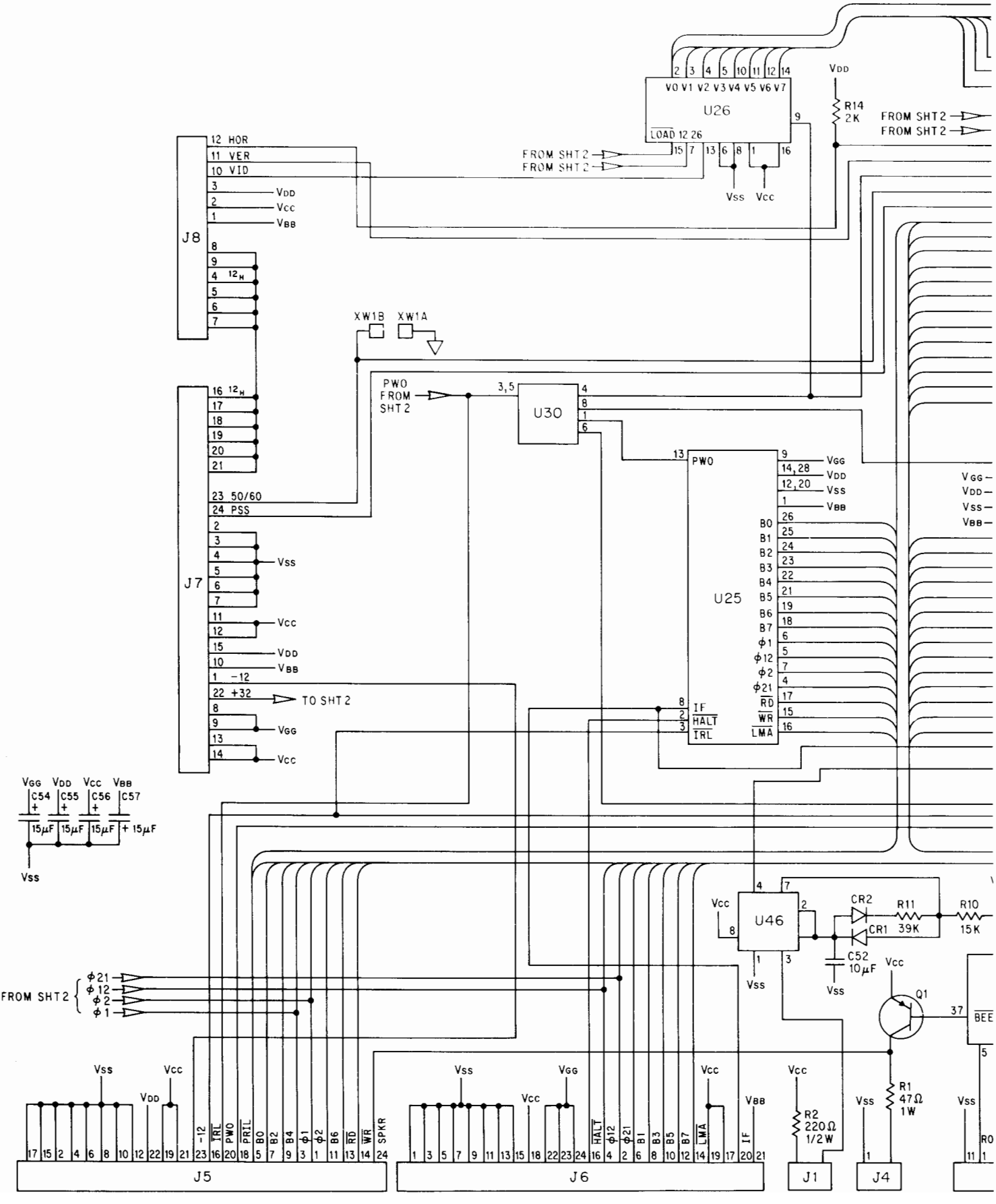
Figure 4-4. Top Cover Assembly Exploded View

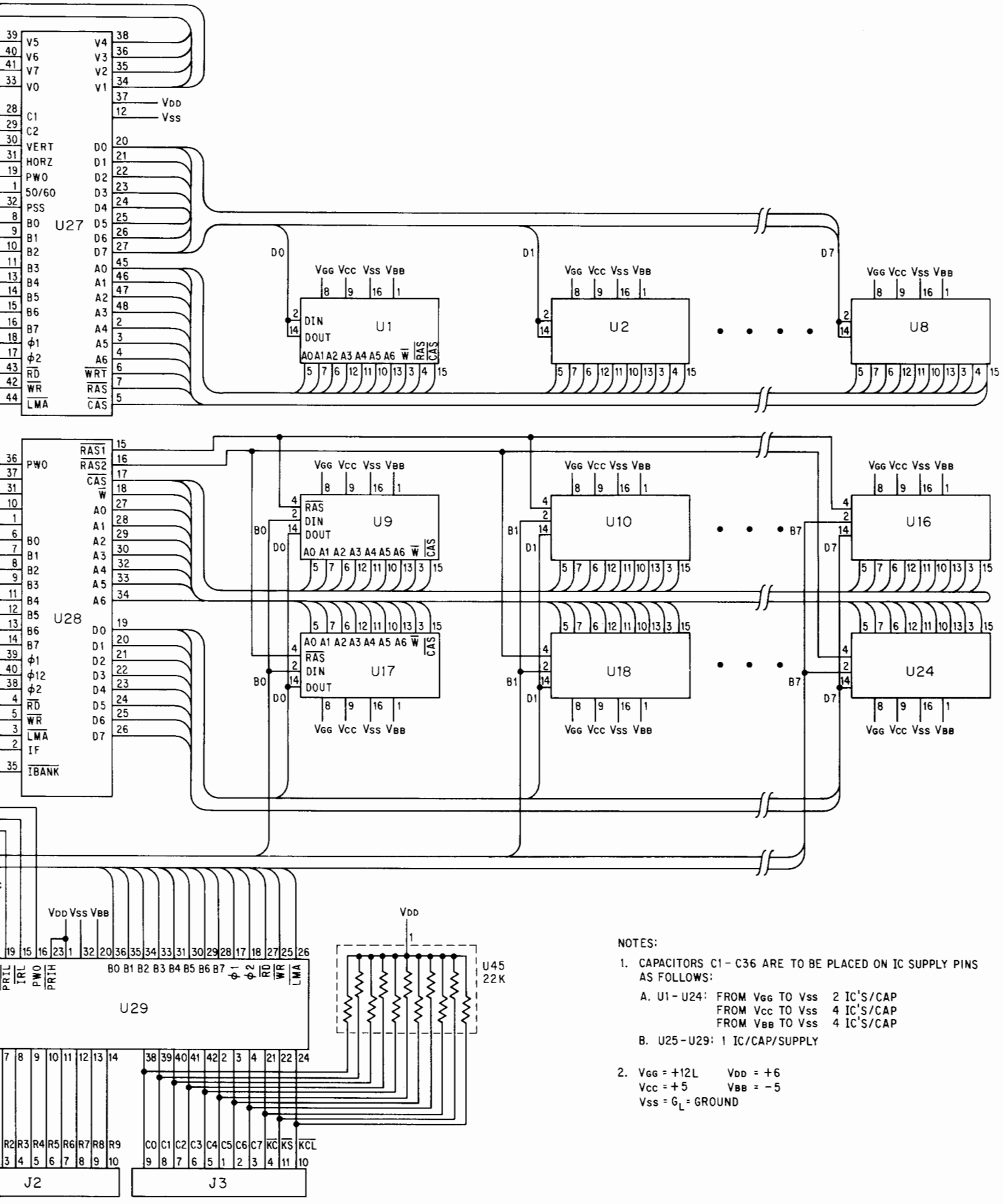
Section
V

Schematic Diagrams

This section contains the schematic diagrams for the printed-circuit assemblies of the HP-87.

HP-87
Schematic Diagrams



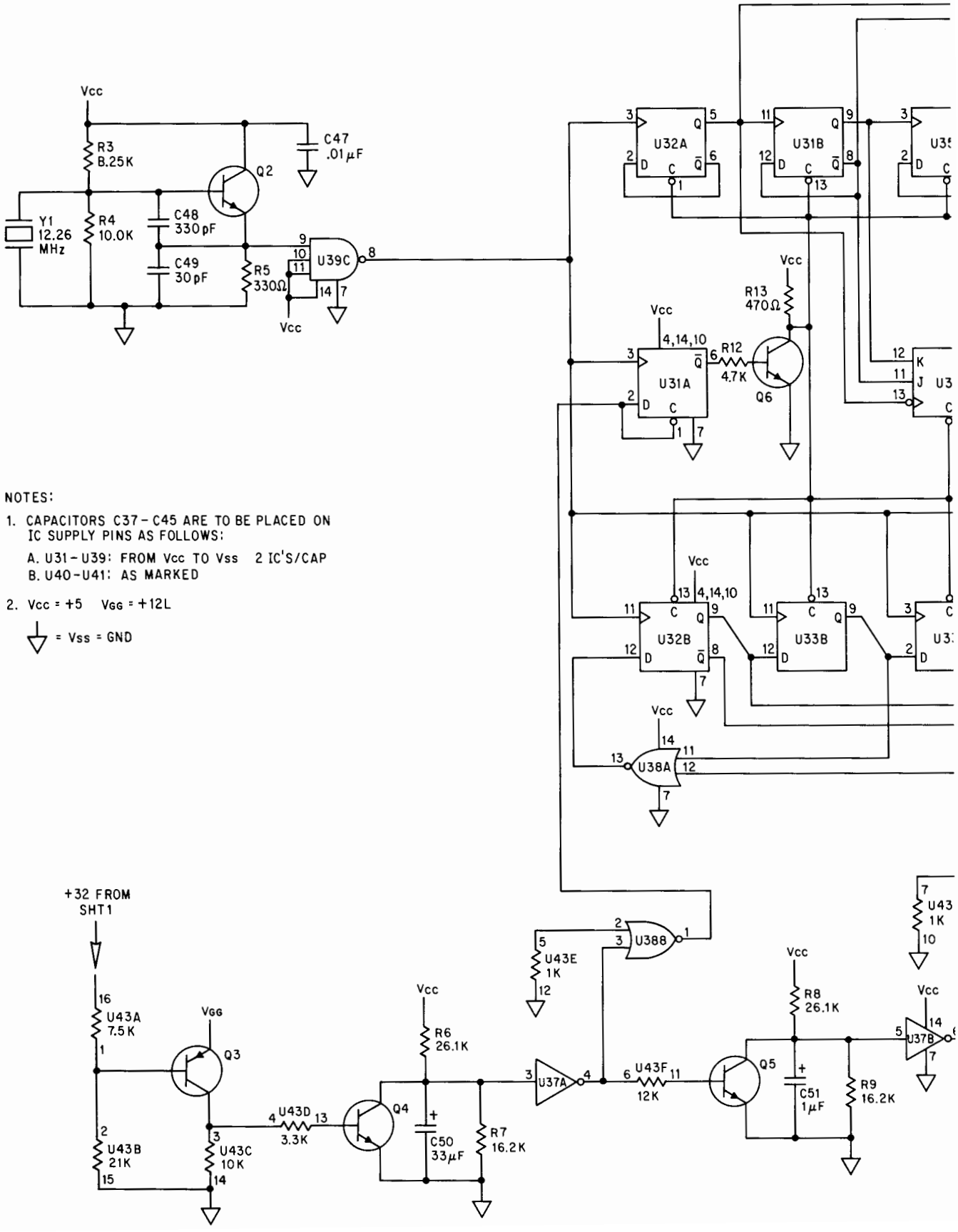


NOTES:

1. CAPACITORS C1 - C36 ARE TO BE PLACED ON IC SUPPLY PINS AS FOLLOWS:
   A. U1 - U24: FROM V_{GG} TO Vss 2 IC'S/CAP
   FROM Vcc TO Vss 4 IC'S/CAP
   FROM V_{BB} TO Vss 4 IC'S/CAP
   B. U25 - U29: 1 IC/CAP/SUPPLY

2. V_{GG} = +12L V_{DD} = +6
   Vcc = +5 V_{BB} = -5
   Vss = G_L = GROUND

Figure 5-1. Logic One PCA Schematic Diagram (Sheet 1)


Vcc
R3
8.25K
C47
.01μF
Q2
Y1
12.26
MHz
R4
10.0K
C48
330pF
C49
30pF
R5
330Ω
U39C
Vcc
U32A
U31B
R13
470Ω
U31A
4,14,10
R12
4.7K
Q6
NOTES:
1. CAPACITORS C37 - C45 ARE TO BE PLACED ON IC SUPPLY PINS AS FOLLOWS:
A. U31 - U39: FROM Vcc TO Vss 2 IC'S/CAP
B. U40 - U41: AS MARKED
2. Vcc = +5 VGG = +12L
= Vss = GND
U32B
U33B
U38A
+32 FROM SHT1
U43A
7.5K
VGG
Q3
U43B
21K
U43C
10K
U43D
3.3K
Q4
R6
26.1K
C50
33μF
R7
16.2K
U43E
1K
U38B
U37A
U43F
12K
Q5
R8
26.1K
C51
1μF
R9
16.2K
U37B
U43
1K

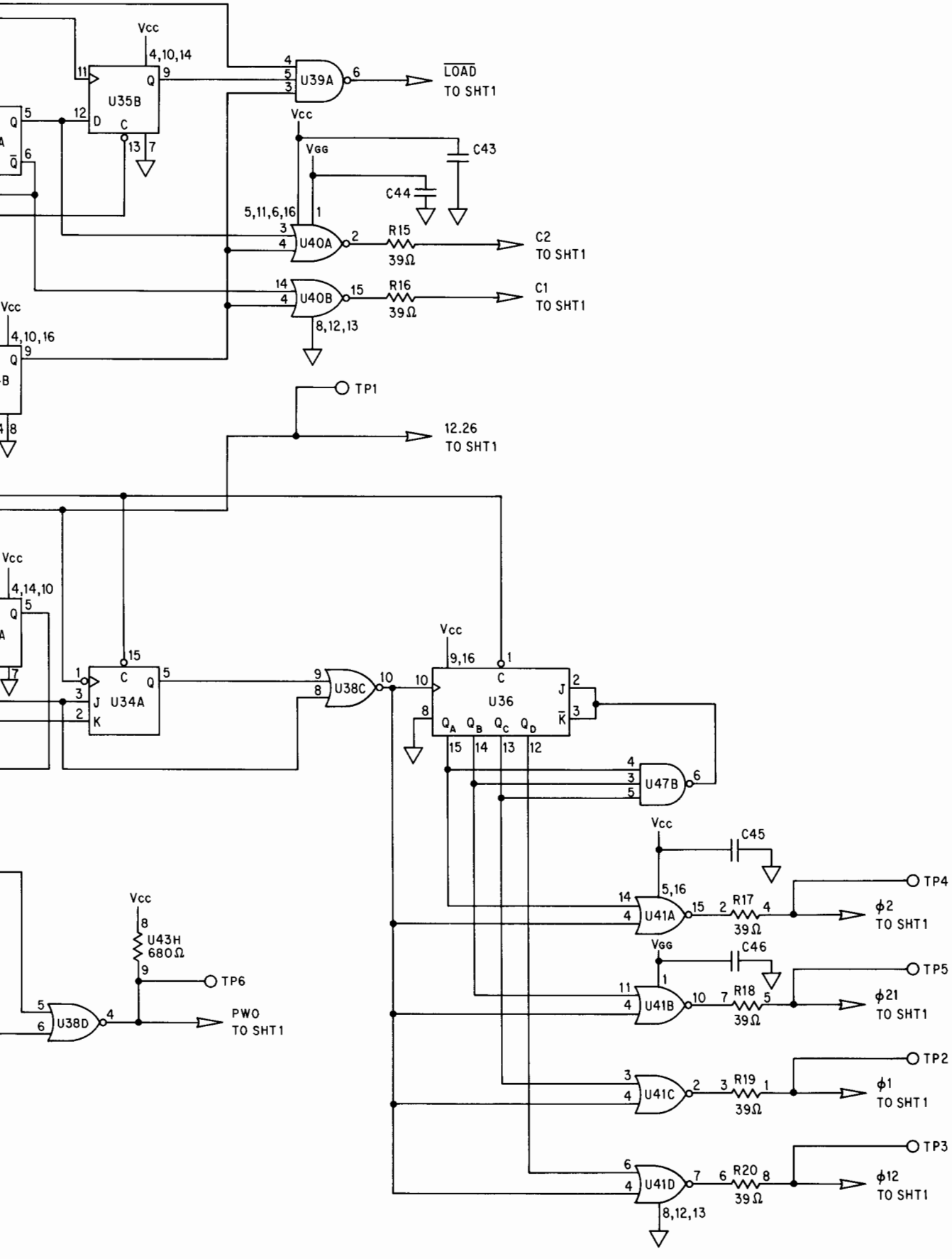
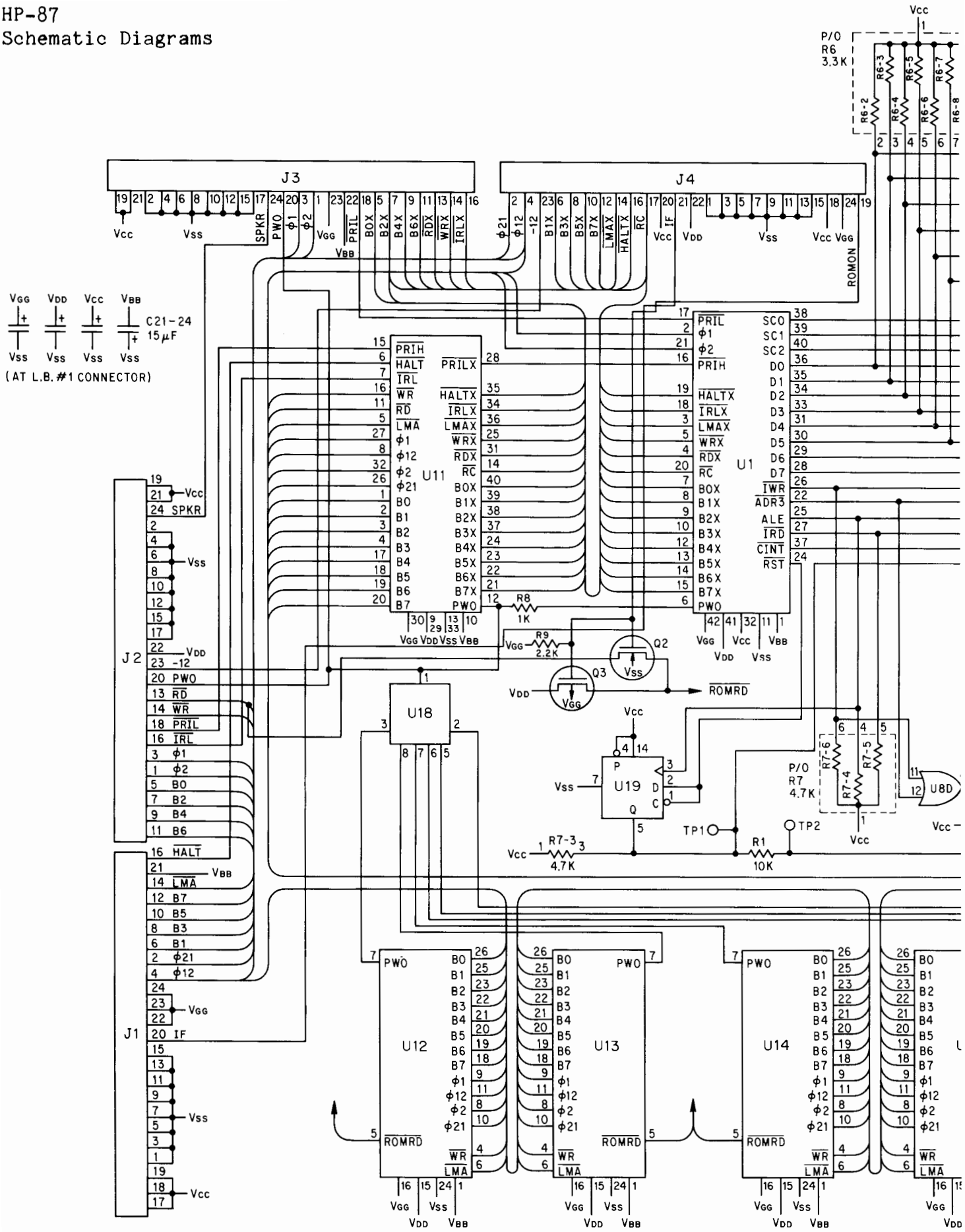
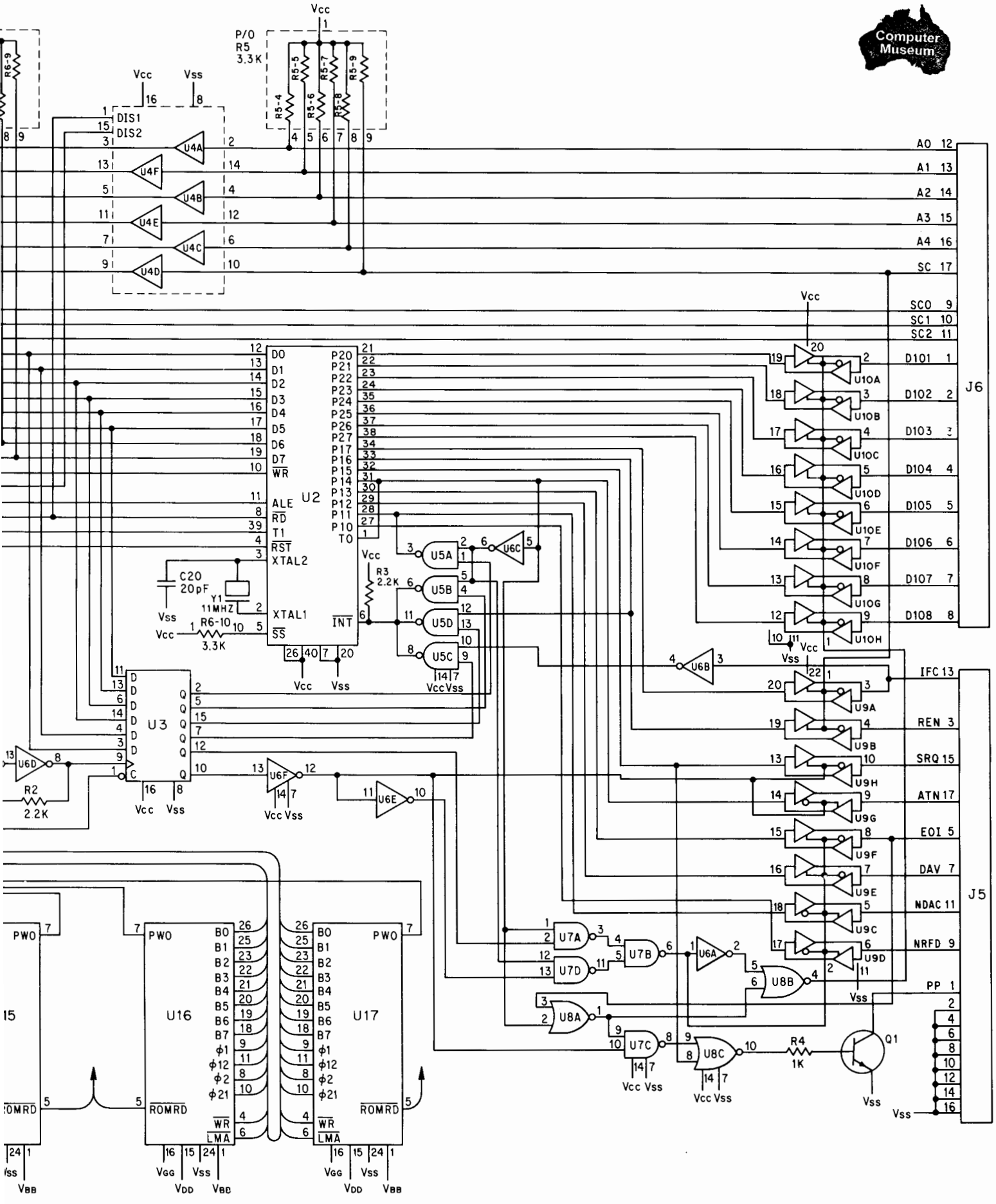


Figure 5-2. Logic One PCA Schematic Diagram (Sheet 2)



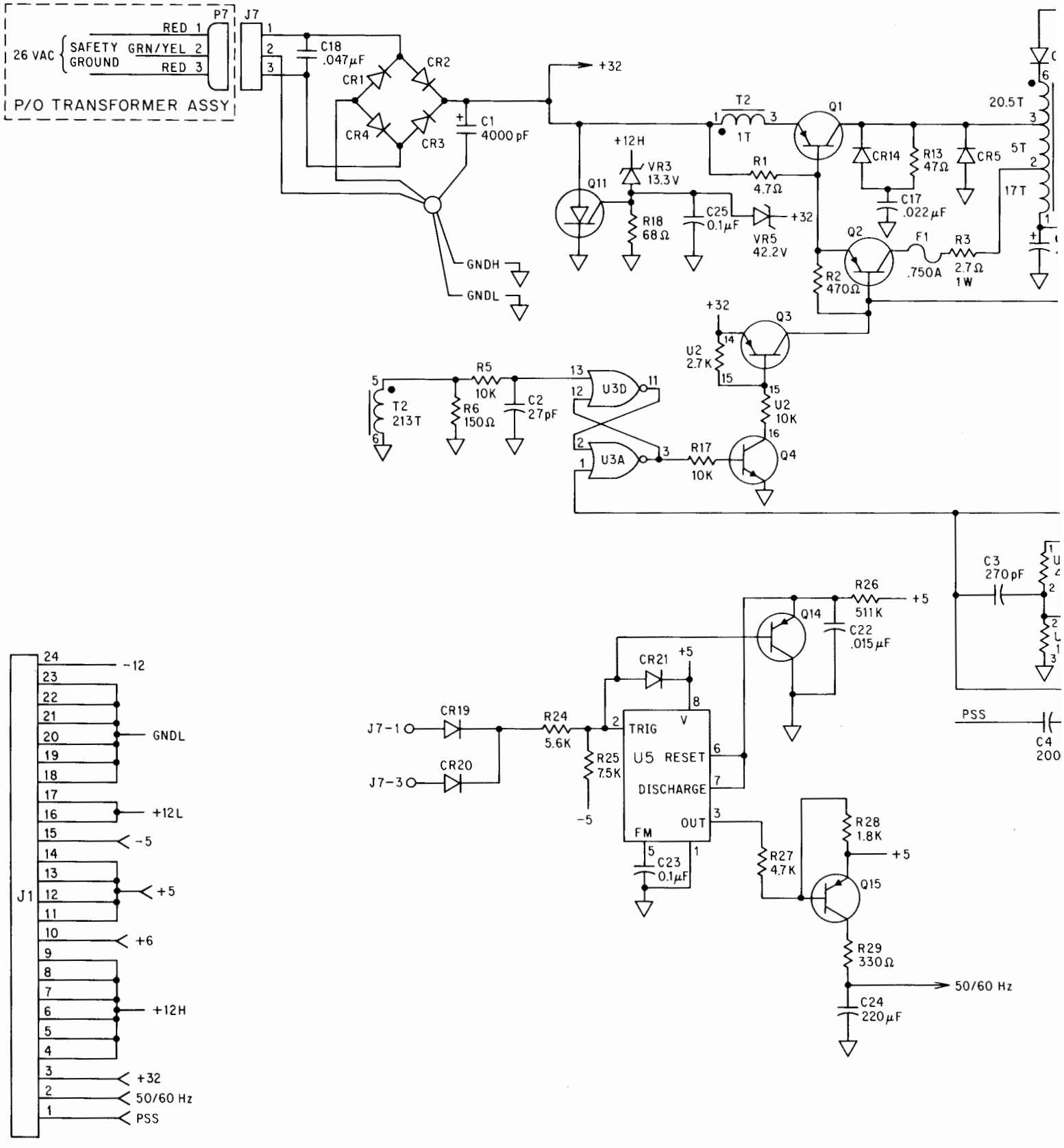
NOTES:

1. CAPACITORS C1 - C12 ARE PLACED ON SUPPLY PINS OF U1, U11 - U17 2 1C'S/CAP/SUPPLY
   C13 ON Vcc OF U1
   C14 - C16 ON Vcc OF U2, U9, U10
   C17 - C19 ON Vcc OF U3, U8 2 1C'S/CAP



2. V_{GG} = +12L V_{DD} = +6 V_{CC} = +5
V_{BB} = −5 V_{SS} = GL = GROUND

Figure 5-3. Logic Two PCA Schematic Diagram


P7
RED 1
26 VAC
SAFETY GRN/YEL 2
GROUND
RED 3
P/O TRANSFORMER ASSY
J7
C18 .047μF
CR1
CR2
CR3
CR4
C1 4000 pF
+32
GNDH
GNDL
T2
1T
Q1
20.5T
5T
17T
CR14
R13 47Ω
CR5
C17 .022μF
+12H
VR3 13.3V
Q11
R18 68Ω
C25 0.1μF
VR5 42.2V
R1 4.7Ω
Q2
F1 .750A
R3 2.7Ω 1W
R2 470Ω
Q3
U2 2.7K
U2 10K
T2 213T
R5 10K
R6 150Ω
C2 27pF
U3D
U3A
R17 10K
Q4
C3 270pF
R26 511K
+5
Q14
C22 .015μF
CR21
CR19
CR20
J7-1
J7-3
R24 5.6K
R25 7.5K
-5
U5
TRIG
V
RESET
DISCHARGE
FM
OUT
C23 0.1μF
R27 4.7K
R28 1.8K
Q15
R29 330Ω
50/60 Hz
C24 220μF
PSS
C4
J1
24 -12
23
22
21
20 GNDL
19
18
17
16 +12L
15 -5
14
13
12 +5
11
10 +6
9
8
7
6 +12H
5
4
3 +32
2 50/60 Hz
1 PSS

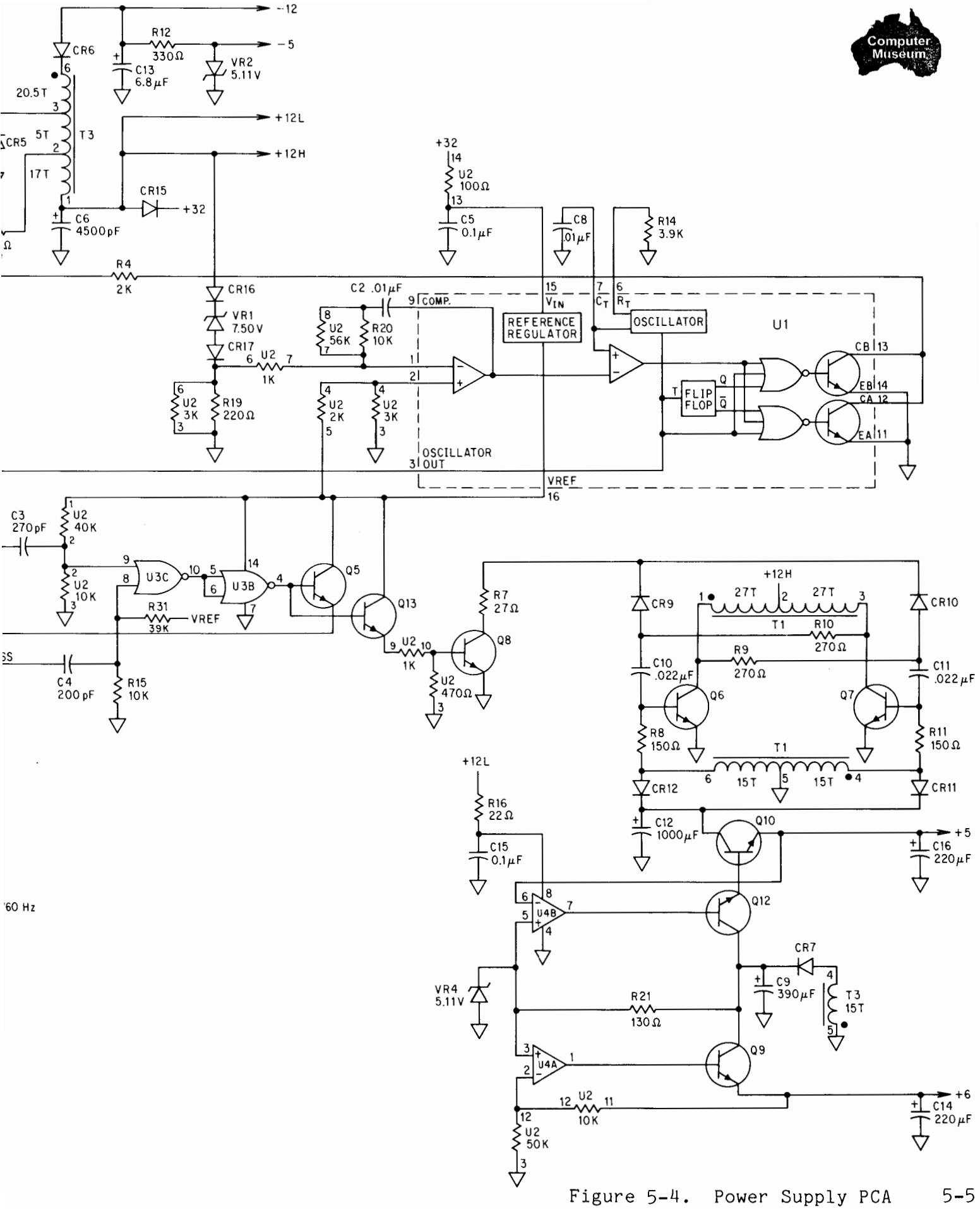
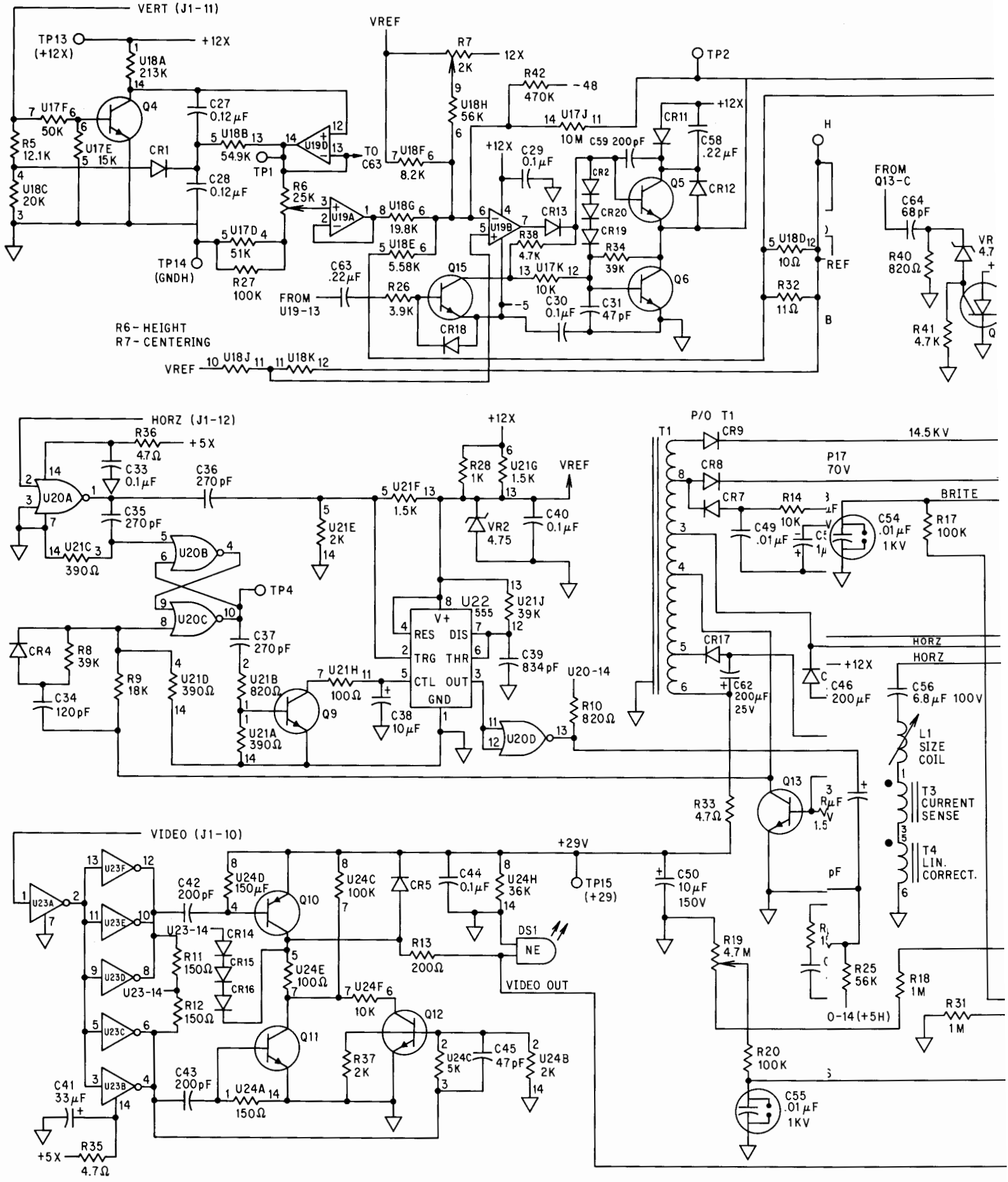


Figure 5-4. Power Supply PCA Schematic Diagram

HP-87
Schematic Diagrams



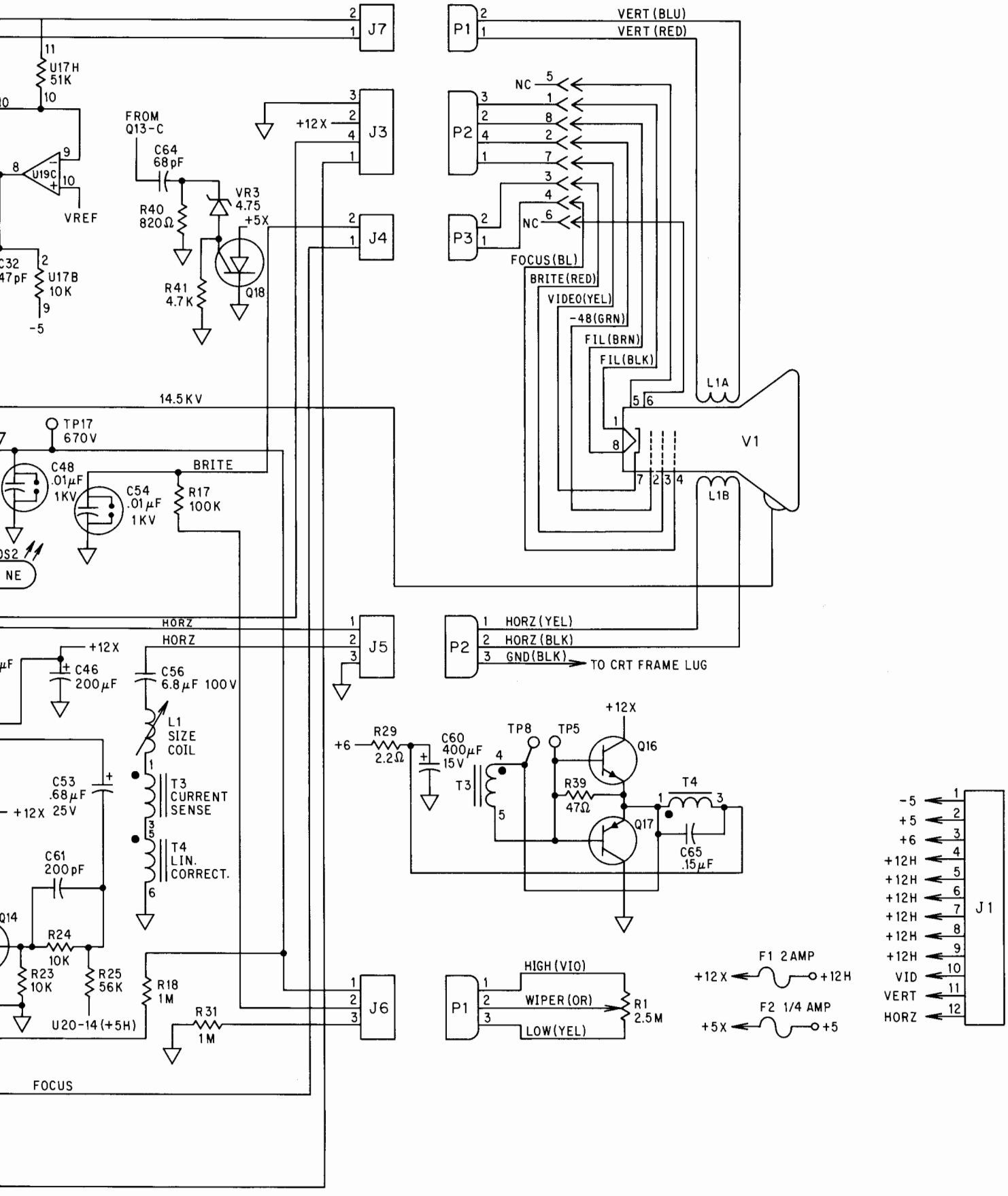


Figure 5-5. CRT PCA Schematic Diagram 5-6

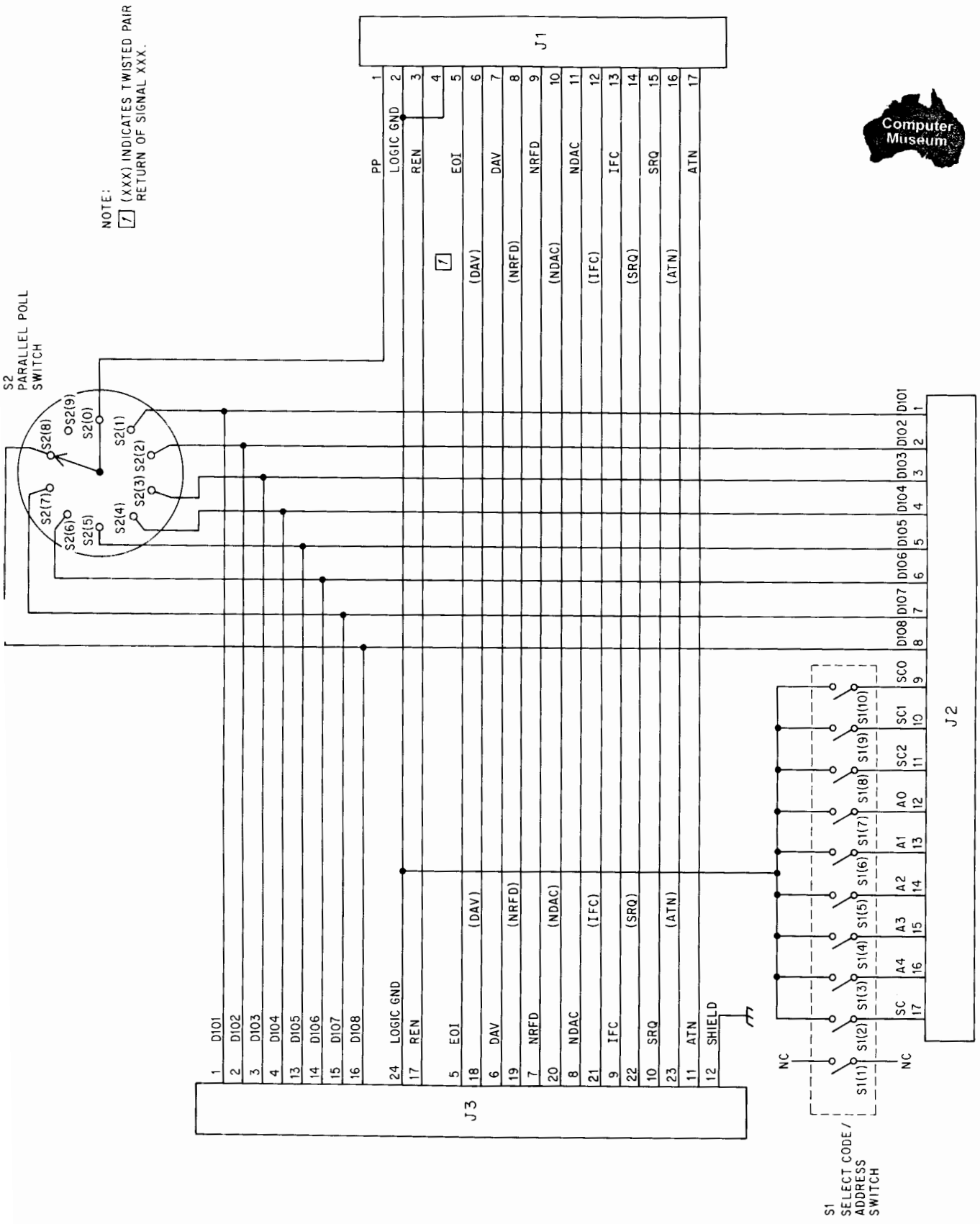


Figure 5-6. HP-IB PCA Schematic Diagram

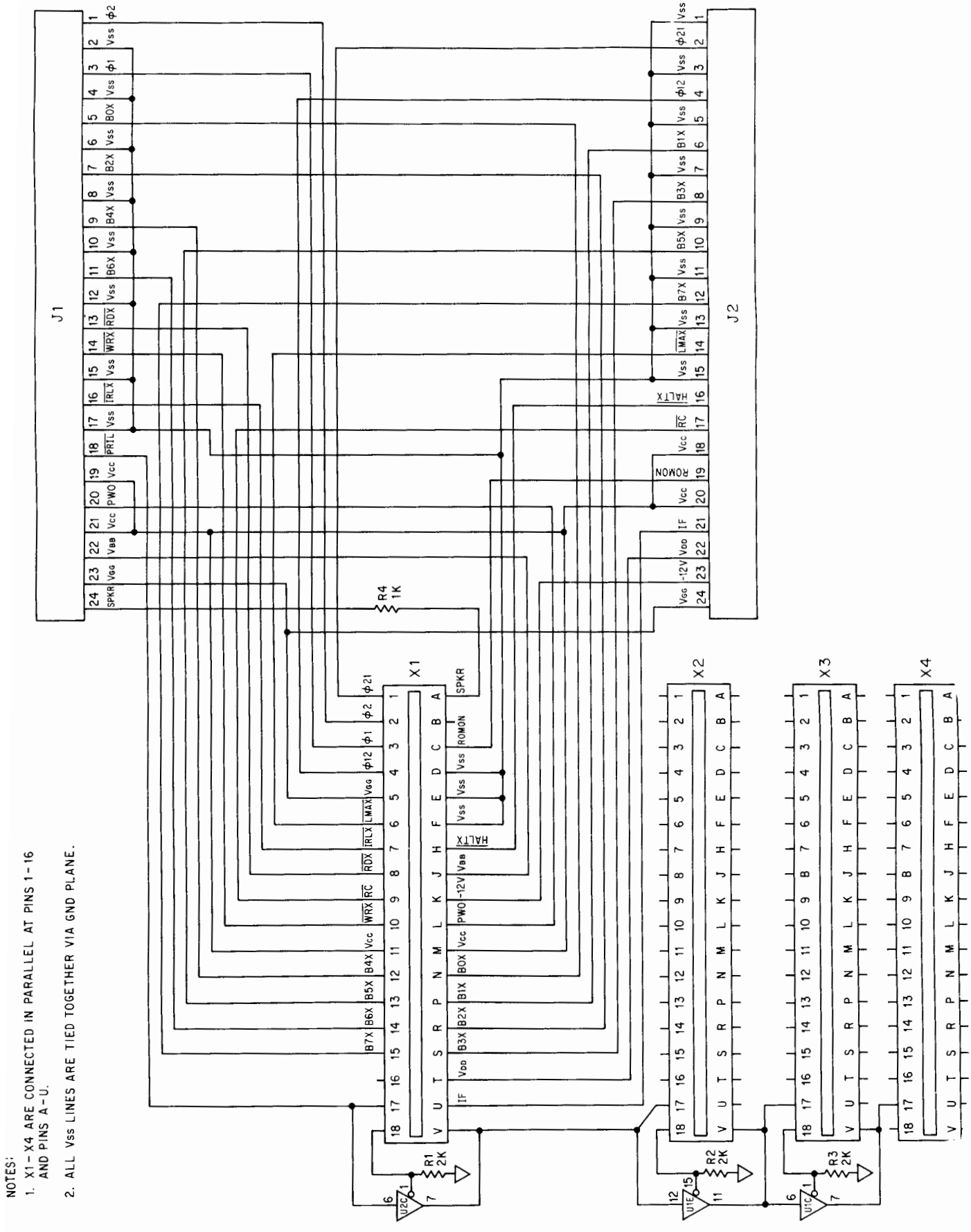


Figure 5-7. I/O PCA Schematic Diagram

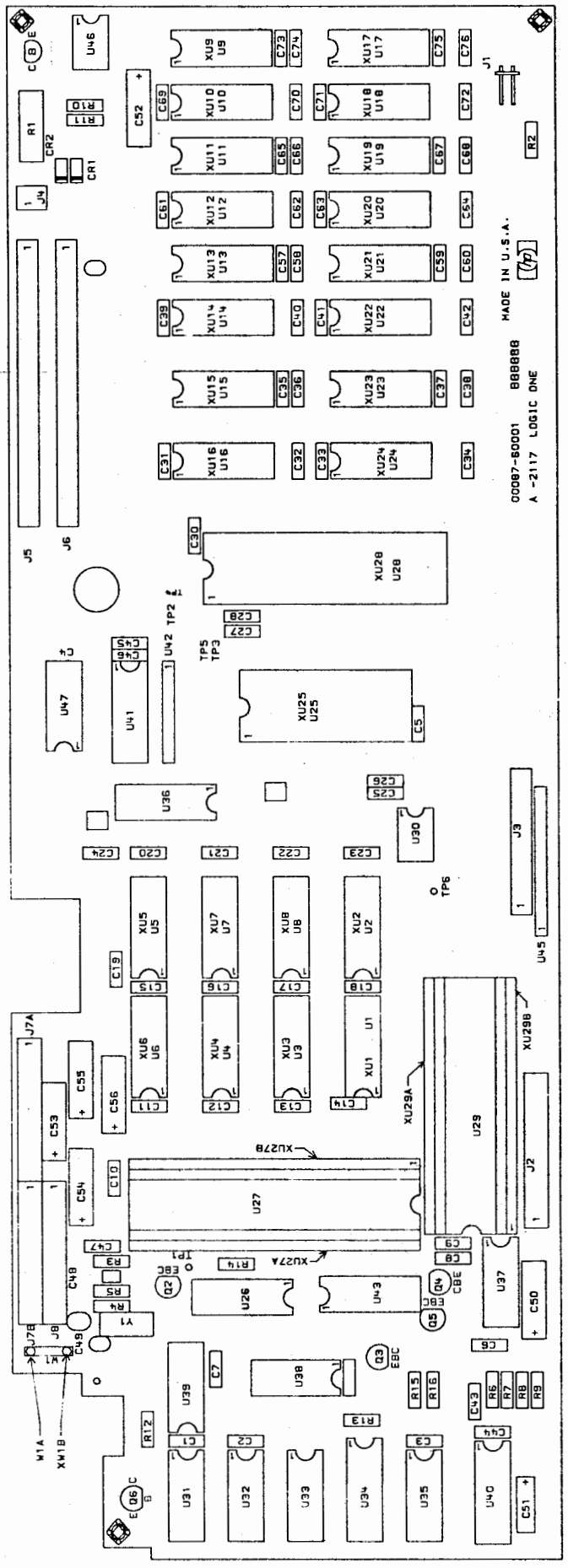


Figure 5-8. Logic One PCA Component Location Diagram, HP-87A

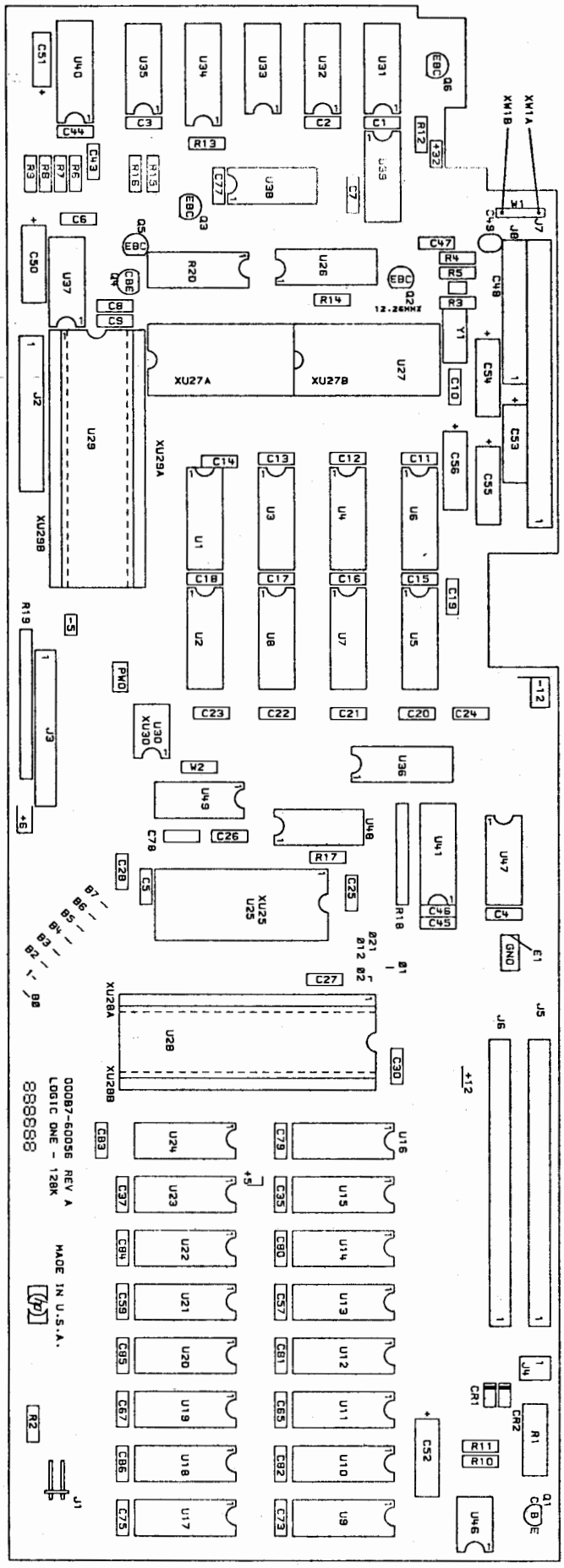


Figure 5-9. Logic One PCA Component Location Diagram, HP-87XM

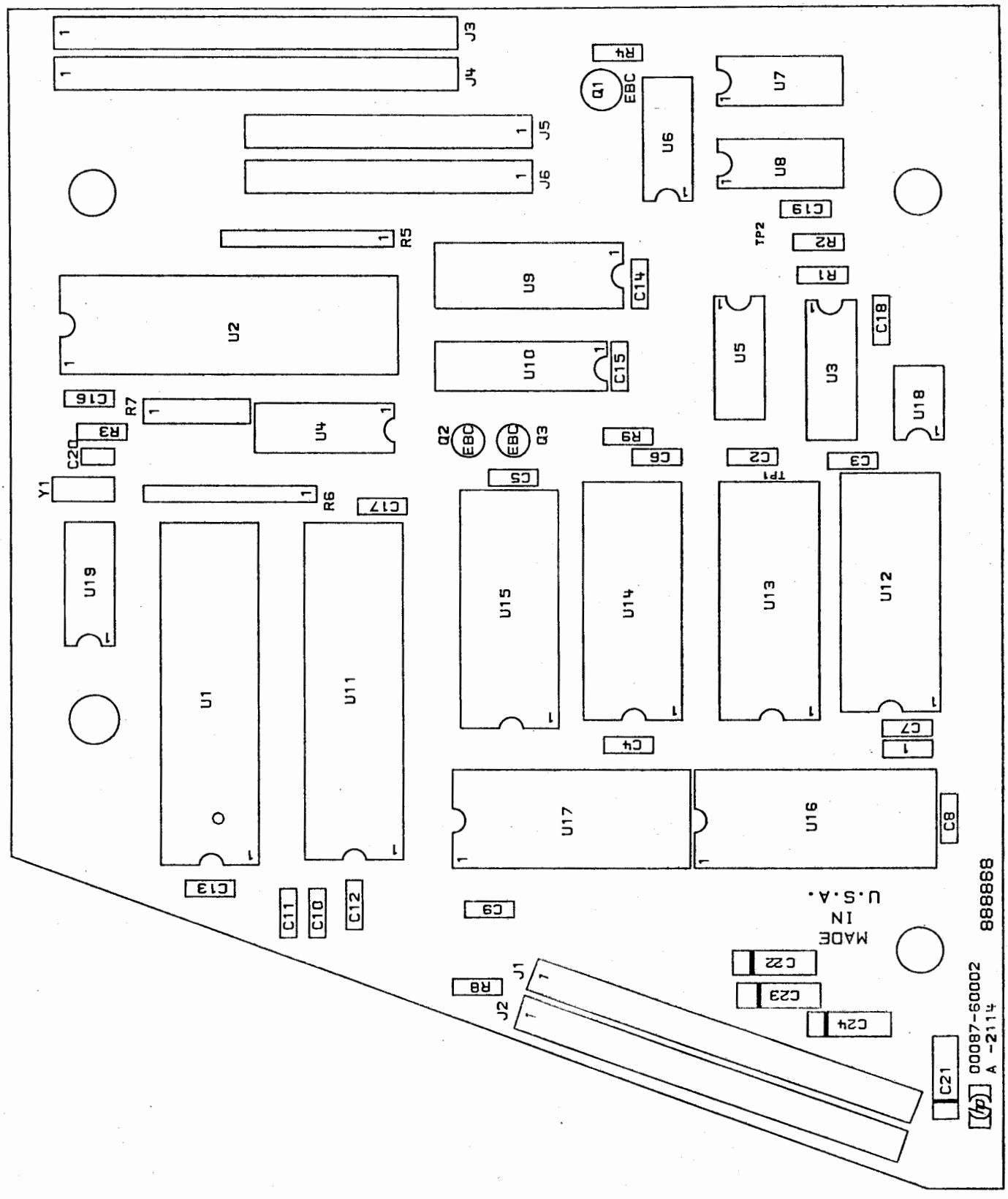


Figure 5-10. Logic Two PCA Component Location Diagram

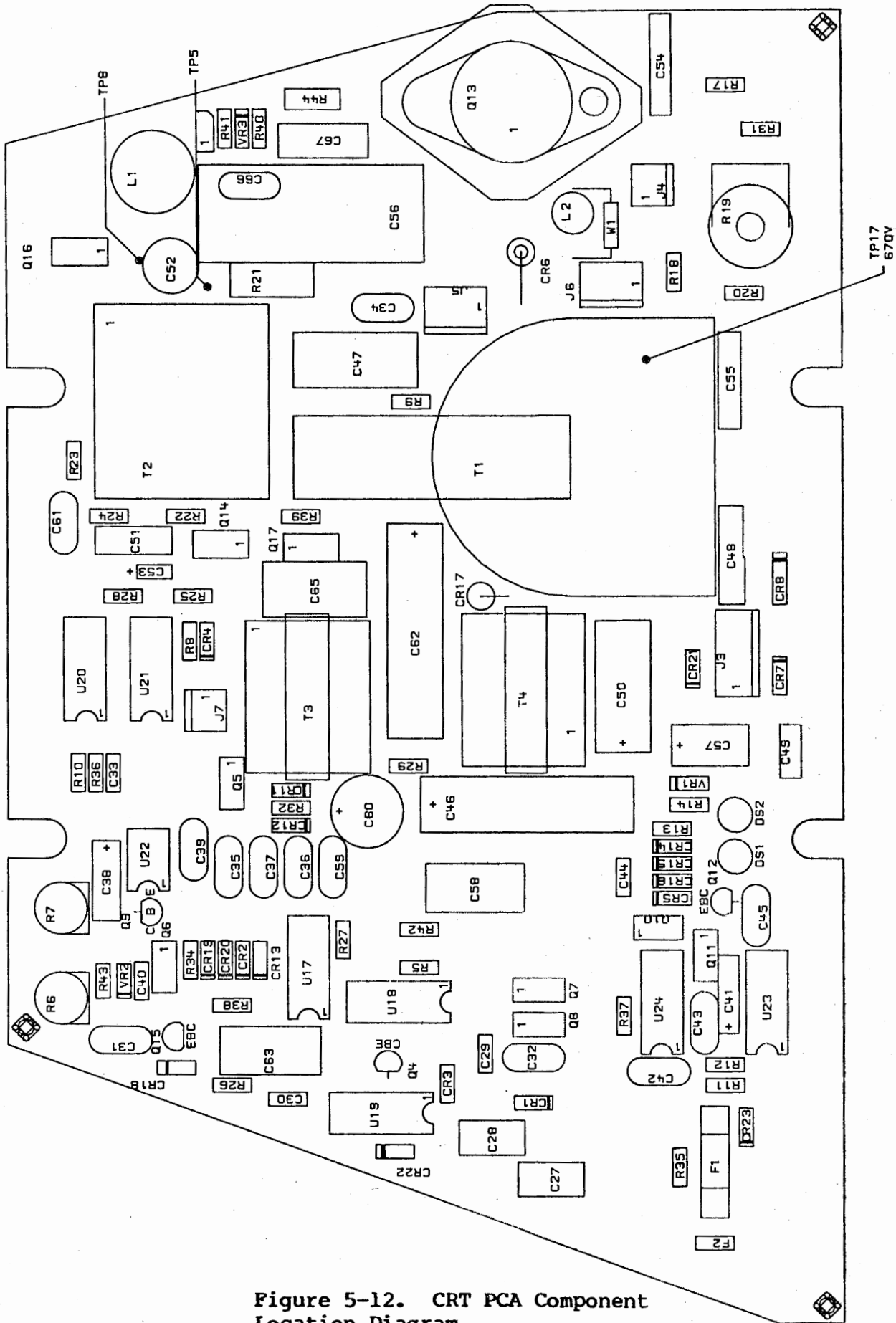


Figure 5-12. CRT PCA Component Location Diagram

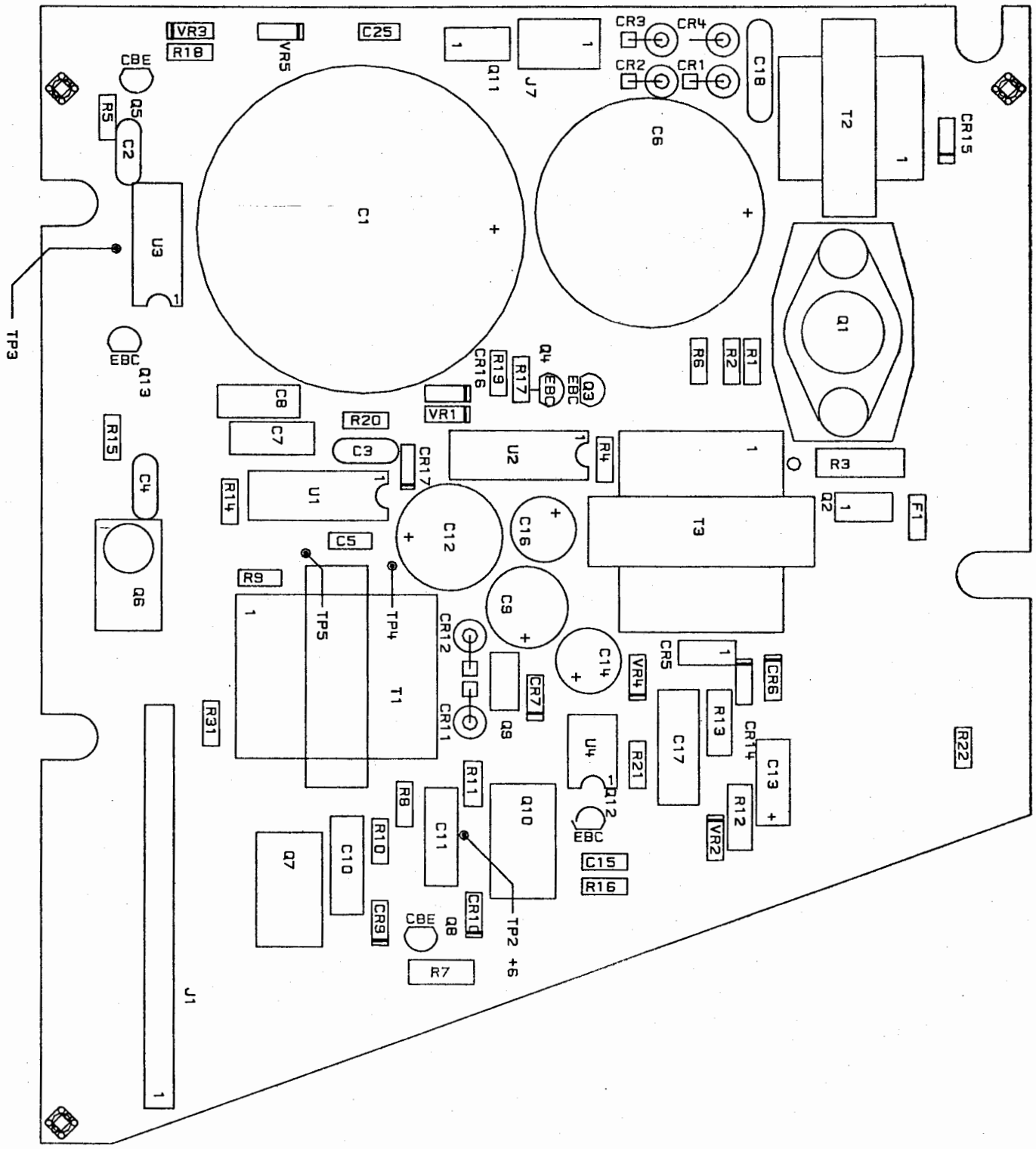


Figure 5-11. Power Supply PCA Component Location Diagram

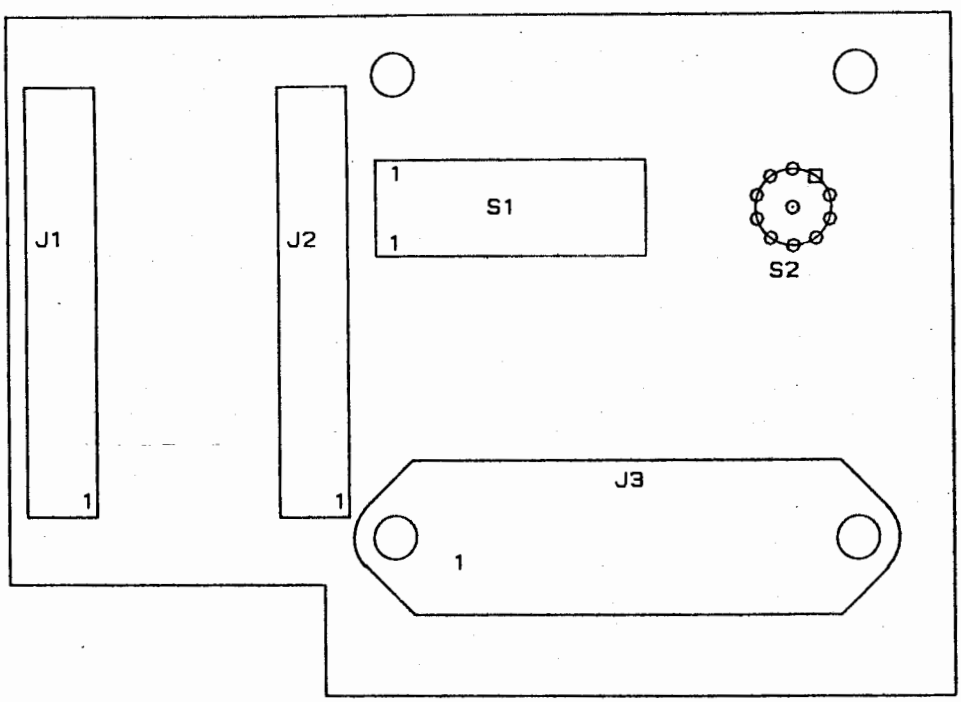


Figure 5-13. HP-IB PCA Component Location Diagram

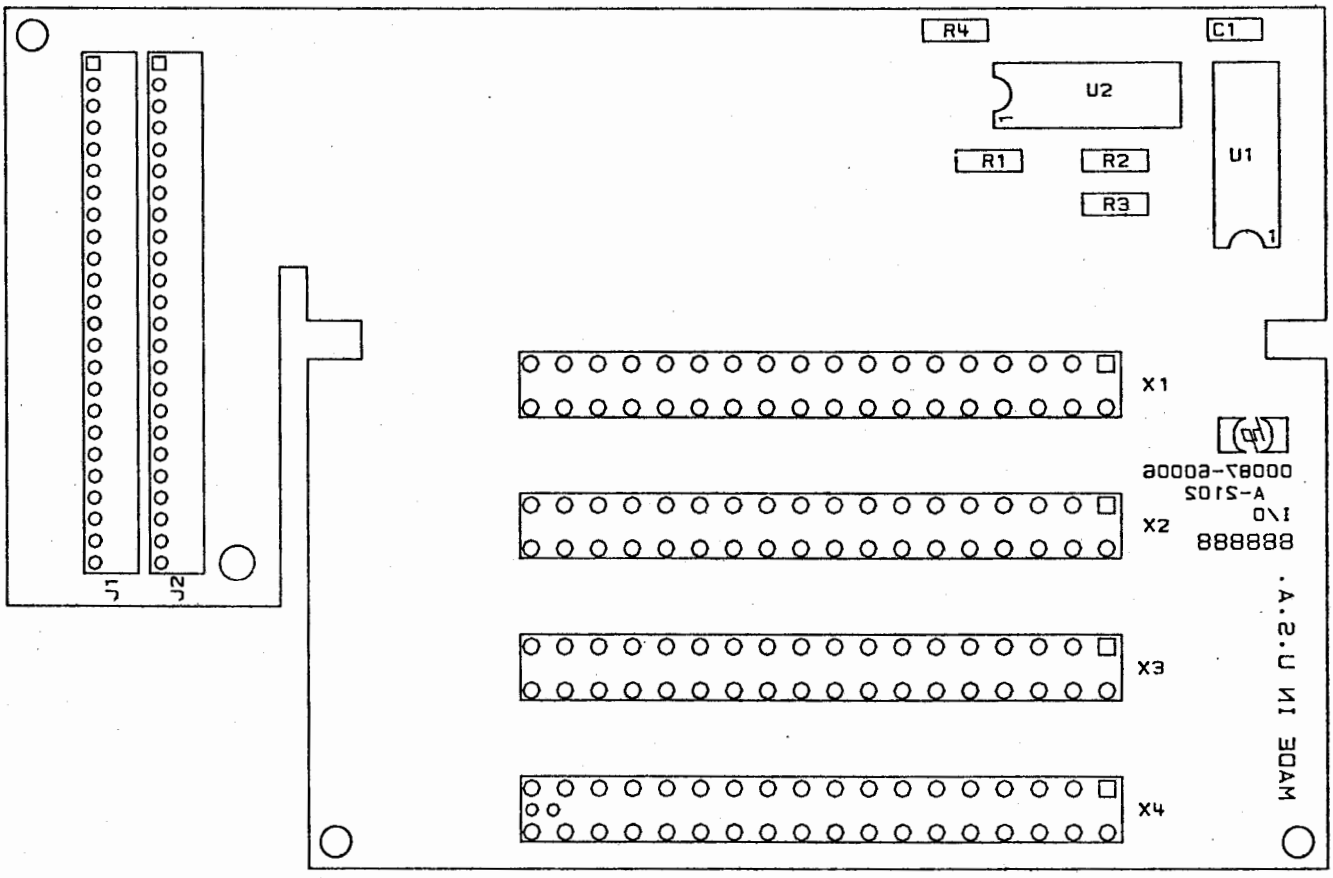


Figure 5-14. I/O PCA Schematic Diagram