OPERATING AND SERVICE MANUAL

2160A

POWER SUPPLY EXTENDER

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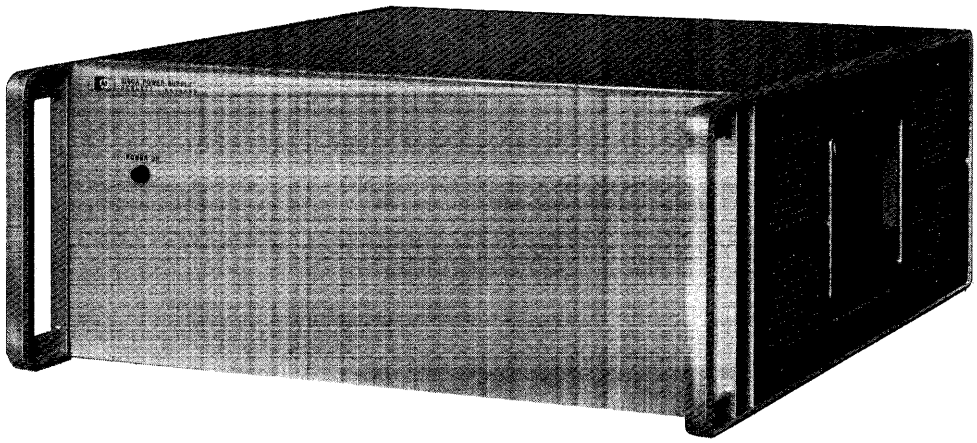

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CERTIFICATION

The Hewlett-Packard Company certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when it was shipped from the factory. The Hewlett-Packard Company further certifies that its calibration measurements are traceable to the U.S. National Bureau of Standards to the extent allowed by the Bureau's calibration facility.

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OPERATING AND SERVICE MANUAL

2160A

POWER SUPPLY EXTENDER

Serial Numbers Prefixed: 817- and 986-

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This manual covers options 001 and 015.

02160-9005

HEWLETT-PACKARD COMPANY
11000 WOLFE ROAD, CUPERTINO, CALIFORNIA, U.S.A.

PRINTED: AUG 1973

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

SECTION I
GENERAL INFORMATION

1-1. INTRODUCTION.

1-2. The Hewlett-Packard 2160A Power Supply Extender, figure 1-1, provides additional current for the HP 2115A Computer and HP 2161A Power Supply combination and for the HP 2116 family of computers. Section I of this manual provides information on current requirements for the extender and applicable units. Specifications and options available with the power supply extender are also described. Section II provides installation and operating instructions, and section III contains the theory of operation. Maintenance information and replacement parts data is contained in sections IV and V, respectively.

1-3. GENERAL DESCRIPTION.

1-4. The power supply extender connects to the computer through two interconnecting cables and acts as a slaved extension of the computer power supply. The power supply extender provides an additional 20 amperes at +4.5 volts and 10 amperes at -2 volts. The extender is required when certain combinations of peripheral interface cards are used in the computer. The internal power supply of the computer is adequate for a full complement of plug-in options if all the options have low current requirements. Additional current from the power supply extender is required, however, if options with high current requirements are used. Paragraph 1-6 provides a further discussion of current requirements.

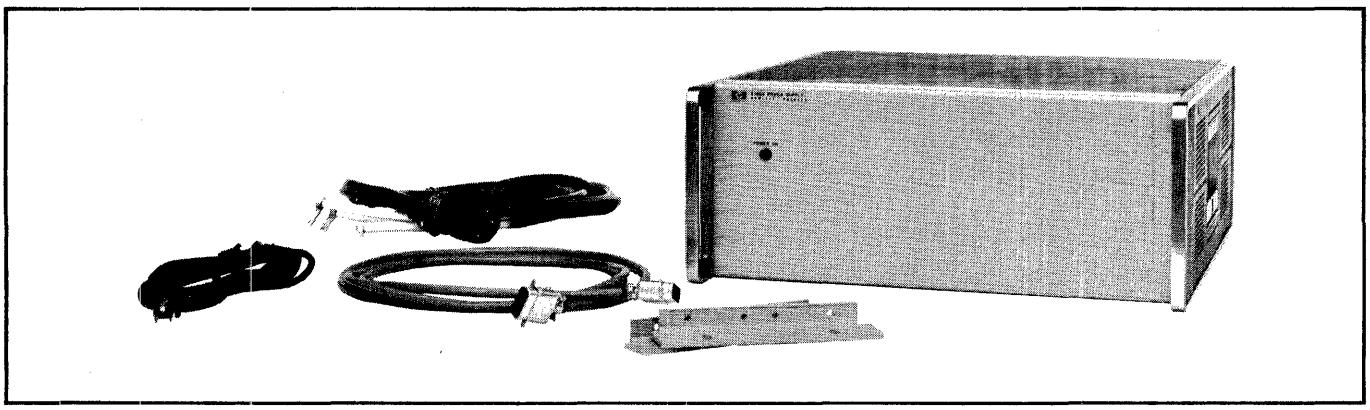
1-5. HP 2160A Power Supply Extenders with serial numbers prefixed 986- have changes incorporated which comply with the latest International Electrotechnical Commission (IEC) requirements. Specifications, installation, operation, and maintenance data is otherwise identical for all models. The external view of the power supply extender in figure 1-1 shows a model with serial number prefix 817-. An exterior view of a model with serial number prefix 986- would show a white POWER ON indicator and a different type of power cable.

1-6. CURRENT REQUIREMENTS.

1-7. Table 1-1 lists the current available from the internal -2 volt and +4.5 volt power supplies of the HP 2115A Computer/HP 2161A Power Supply combination, and for the HP 2116 family of computers. The "Current Available For Options" figures in table 1-1 are obtained by subtracting the current required by the applicable computer from the current available from the power supplies, in the following manner.

a. Subtract the computer -2 volt power supply current requirement from the current available from the -2 volt power supply to find the amount of current available from the -2 volt power supply for options. Example: An HP 2116B Computer with 16k memory is to be used. This requires 15.7 amperes from the -2 volt power supply which can furnish 22.5 amperes. Thus 6.8 amperes of current is still available for options from the -2 volt power supply.

b. Add the current supply capabilities of both (-2 volt and +4.5 volt) power supplies, then subtract the current required by the computer from the +4.5 volt power supply. From this difference, subtract the current available from the -2 volt power supply for options (found in step "a"). This difference remaining is the amount of measurable current available from the +4.5 volt power supply for options. Example: The -2 volt and +4.5 volt power supplies in the HP 2116B Computer can furnish 45.0 amperes total measurable current. The HP 2116B Computer with 16k memory



2137-1

Figure 1-1. HP 2160A Power Supply Extender and Accessories

Table 1-1. Internal/External Power Supply Requirements

REQUIREMENTS	SUPPLY CURRENT (AMPERES)	
	-2V	+4.5V
CURRENT AVAILABLE FROM POWER SUPPLIES		
HP 2115A Computer/HP 2161A Power Supply	25.0	*25.0
HP 2115A Computer/HP 2161A Power Supply with HP 2160A Power Supply Extender	35.0	**35.0
HP 2116 family Computer power supplies	22.5	***22.5
HP 2116 family Computer power supplies with HP 2160A Power Supply Extender	32.5	†32.5
CURRENT REQUIRED BY COMPUTER WITH NO PROCESSOR OR INPUT/ OUTPUT OPTIONS		
HP 2115A Computer/HP 2161A Power Supply with 4K Memory or 8K Memory	15.0	26.0
HP 2116A Computer with 4K Memory	13.5	24.0
HP 2116A Computer with 8K Memory	14.0	28.0
HP 2116B Computer with 8K Memory	15.2	26.4
HP 2116B Computer with 16K Memory	15.7	28.4
HP 2116C Computer with 8K Memory	14.3	23.0
HP 2116C Computer with 16K Memory	15.6	24.2
HP 2116C Computer with 24K Memory	16.9	25.4
HP 2116C Computer with 32K Memory	18.2	26.6
CURRENT AVAILABLE FOR OPTIONS		
HP 2115A Computer/HP 2161A Power Supply with 4K Memory or 8K Memory	10.0	††14.0
HP 2115A Computer/HP 2161A Power Supply with 4K Memory or 8K Memory and HP 2160A Power Supply Extender	20.0	††24.0
HP 2116A Computer with 4K Memory	9.0	††12.0
HP 2116A Computer with 8K Memory	8.5	†† 8.5
HP 2116A Computer with 4K Memory and HP 2160A Power Supply Extender	19.0	††22.0
HP 2116A Computer with 8K Memory and HP 2160A Power Supply Extender	18.5	††18.5
HP 2116B Computer with 8K Memory	7.3	††11.3
HP 2116B Computer with 16K Memory	6.8	†† 9.8
HP 2116B Computer with 8K Memory and HP 2160A Power Supply Extender	17.3	††21.3
HP 2116B Computer with 16K Memory and HP 2160A Power Supply Extender	16.8	††19.8
HP 2116C Computer with 8K Memory	8.2	††13.8

Table 1-1. Internal/External Power Supply Requirements (Continued)

REQUIREMENTS	SUPPLY CURRENT (AMPERES) -2V	SUPPLY CURRENT (AMPERES) +4.5V
CURRENT AVAILABLE FOR OPTIONS (Continued)		
HP 2116C Computer with 16K Memory	6.9	††13.9
HP 2116C Computer with 24K Memory	5.6	††14.0
HP 2116C Computer with 32K Memory	4.3	††14.1
HP 2116C Computer with 8K Memory and HP 2160A Power Supply Extender	18.2	††23.8
HP 2116C Computer with 16K Memory and HP 2160A Power Supply Extender	16.9	††23.9
HP 2116C Computer with 24K Memory and HP 2160A Power Supply Extender	15.6	††24.0
HP 2116C Computer with 32K Memory and HP 2160A Power Supply Extender	14.3	††24.1

NOTES:

* Plus the current drawn from the -2 volt power supply by the computer with memory and options. Maximum available measurable current is 50 amperes.

** Plus the current drawn from the -2 volt power supply by the computer with memory and options. Maximum available measurable current is 70 amperes.

*** Plus the current drawn from the -2 volt power supply by the computer with memory and options. Maximum available measurable current is 45 amperes.

† Plus the current drawn from the -2 volt power supply by the computer with memory and options. Maximum available measurable current is 65 amperes.

†† Plus the current drawn from the -2 volt power supply by selected options.

An inspection of the current values in the columns above will show that the -2 volt and +4.5 volt power supplies in the HP 2160A Power Supply Extender are both 10 ampere capacity power supplies. Capacity of both supplies is shown in the total measurable current figure designated in notes above.

draws an apparent 28.4 amperes from the +4.5 volt power supply. Subtraction of these values leaves an apparent 16.6 amperes total available current from the +4.5 volt power supply. From this figure the 6.8 ampere current availability from the -2 volt power supply should be subtracted. Thus, 9.8 amperes is available from the +4.5 volt power supply for options as shown in table 1-1.

1-8. Table 1-2 lists the current required by certain processor Input/Output options. (Refer to Volume Three, Input/Output System Operation, of the applicable computer manual, for a complete listing of Input/Output option current requirements.) To determine if the computer internal power supply is adequate for the options to be used, or if an HP 2160A Power Supply Extender must be added, proceed as follows: (See the example in paragraph 1-9.)

a. Refer to table 1-2 and add the current required in each of the -2 volt and +4.5 volt columns for the selected options.

b. Add the sum of the -2 volt power supply currents obtained in step "a" to the value in the +4.5 volt column of table 1-1 for the applicable computer with memory under the CURRENT AVAILABLE FOR OPTIONS column. Record this new sum as current available from the +4.5 volt power supply.

c. Again refer to the currents listed for the applicable computer with memory in the CURRENT AVAILABLE FOR OPTIONS column in table 1-1. If the -2 volt power supply current sum of step "a" is higher than that listed in table 1-1, or if the +4.5 volt power supply current sum is higher than that recorded in step "b", an HP 2160A Power Supply extender is required. The current sums cannot then exceed those listed for the computer with memory (as applicable) and an HP 2160A Power Supply Extender together.

1-9. The following example illustrates the use of table 1-1 and table 1-2 in determining the total current required

Table 1-2. Current Required by Options or Accessories

OPTION OR ACCESSORY		SUPPLY CURRENT REQUIRED (AMPERES)	
		-2V	+4.5V
	PROCESSOR OPTIONS		
12569A	Memory Parity Check (HP 2116A-002)	0.50	0.53
12570A	Memory Test (HP 2116A-003)	0.48	0.91
12571A	HP 2150A-001 I/O Expansion, for HP 2115A or HP 2116A Computer	*0.80	*3.00
12572A	HP 2150A-002 Second Additional 4K Memory, for HP 2115A or HP 2116A Computer	*0.60	*1.50
12574A	HP 2150A-004 Extender Memory Parity Check, for HP 2115A or HP 2116A Computer	*0.03	*0.00
12578A	Direct Memory Access (HP 2116B)	0.72	6.20
12578A-001	Direct Memory Access (HP 2115A and HP 2116A)	0.72	6.20
12579A	Extended Arithmetic Unit (HP 2115A, HP 2116A/B)	3.30	4.68
12580A	Memory Parity Check (HP 2115A)	0.50	0.91
12581A	Memory Protect (HP 2116B)	0.90	1.80
12586A	Power Fail with Auto Restart (HP 2115A)	0.04	0.25
12591A	Memory Parity Check (HP 2116B)	0.65	0.90
12594A	HP 2151A I/O Expansion, for HP 2115A	*0.80	*2.76
12596A	HP 2151A I/O Expansion, for HP 2116 Computer family	*0.80	*2.76
12598A	Memory Parity Error with Interrupt (HP 2114B)	0.13	0.86
12612A	HP 2150B-001 I/O Expansion, for HP 2116B Computer	*0.90	*3.90
12613A	HP 2150B-002 Second Additional 8K Memory, for HP 2116B Computer	*0.90	*0.90
	INPUT/OUTPUT OPTIONS		
12531B	Teleprinter Input/Output, Buffered	0.05	0.76
12538A	Magnetic Tape Input/Output (7 Channel, HP 2020A/B)	4.20	6.00
12539B	Time Base Generator	0.42	1.10
12540A	Data-Phone Interface (103A)	0.90	1.40
12554A	General Purpose Duplex Register	0.07	1.11
12559A	Magnetic Tape Input/Output (9 Channel, HP 3030G)	0.24	2.58
12584B	Teleprinter Multiplexor	0.10	1.10
12584B-001	Teleprinter Multiplexor with Auto Disconnect	0.20	2.20

Table 1-2. Current Required by Options or Accessories (Continued)

OPTION OR ACCESSORY	SUPPLY CURRENT REQUIRED (AMPERES)	
	-2V	+4.5
INPUT/OUTPUT OPTIONS (Continued)		
12597A-002 Tape Reader Interface	0.05	0.75
12597A-003 Tape Punch Interface	0.05	0.75

NOTES:

*The HP 2160A Power Supply Extender cannot be used to provide additional power for the HP 2150A/B Memory and I/O Extender or HP 2151A I/O Extender alone. Current for added interfaces in the I/O extenders must come from power supplies in the I/O extenders.

by selected options. In this example an extender is needed; the following steps correspond to the steps in paragraph 1-8.

a. Add option current requirements.

		-2V (AMP)	+4.5V (AMP)
12578A	Direct Memory Access	0.72	6.20
12579A	Extended Arithmetic Unit	3.30	4.68
12581A	Memory Protect	0.90	1.80
12598A	Memory Parity Error with Interrupt	0.13	0.86
12531B	Teleprinter Input/Output Buffered	0.05	0.76
12538B	Magnetic Tape Input/Output	4.20	6.00
	Totals	9.30	20.30

b. Total -2 volt power supply current required by options: 9.30A

HP 2116B Computer, with 16K memory, +4.5 volt power supply current available for options: 9.80A

Total +4.5 volt power supply current available for options: 19.10A

c. It can be seen that the 9.3-ampere requirement from the -2 volt supply exceeds the 6.8-ampere current availability by 2.5 amperes. Therefore, the HP 2160A Power Supply will be needed. The +4.5 volt power supply current requirement should also be considered, as explained in the next step.

d. The total +4.5 volt supply current required by the options (20.30A) is larger than the total in step "b" (19.10A), therefore an HP 2160A Power Supply Extender is also necessary to furnish the required current listed in step "a" (20.30A) for the +4.5 volt power supply.

1-10. IDENTIFICATION.

1-11. Hewlett-Packard uses a serial number located on the rear panel to identify each unit. The first group of digits is a serial number prefix used to identify a particular unit configuration. This prefix number does not change unless unit changes are made. The serial number prefix may consist of either three or four digits. If the serial number prefix contains four digits, a code letter between the serial number prefix and serial number indicates the country in which the equipment was manufactured. The last five digits identify each specific unit. If the serial number prefix on your unit does not agree with those on the title page of this manual, there are differences between your unit and the unit described in this manual. These differences are described in manual supplements available at the nearest HP Sales and Service Office.

1-12. Printed-circuit card revisions are identified by a letter and a revision code stamped on the card. The letter code identifies the version of the etched trace pattern on the unloaded card. The revision code refers to the electrical characteristics of the loaded card. If the revision code stamped on the printed-circuit card does not agree with the revision code shown on the schematic diagram in this manual, there are differences between your unit and the unit described in this manual. These differences are described in manual supplements available at the nearest HP Sales and Service Office.

1-13. SPECIFICATIONS.

1-14. Table 1-3 lists specifications for the HP 2160A Power Supply Extender.

1-15. STANDARD ACCESSORIES AND SERVICE ITEMS.

1-16. The standard accessories and service items supplied with the power supply extender are:

a. Interconnecting Control Cable, 12 feet (365,8 cm), (part no. 02150-6018).

b. Interconnecting DC Power Cable, 6 feet (183,9 cm), (part no. 02160-6001).

Table 1-3. HP 2160A Power Supply Extender, Specifications

ITEM	CHARACTERISTIC
Power Requirement	115V ±10%, 47- to 66-Hz, single phase, 3A (maximum) 230V ±10%, 47- to 66-Hz, single phase, 1.5A (maximum)
Grounding Provisions	Through three-prong power connector
DC Outputs	20A at +4.50 ±0.14V dc, ripple < 10mV RMS 10A at -2.0 ±0.1V dc, ripple < 10mV RMS
Power Fail Output	True signal, >1.5V peak-to-peak
Temperature Range	0° to 55°C (32° to 132°F)
Relative Humidity	95% at 40°C (104°F)
Heat Dissipation	1180 BTU/hr
Cooling Provisions	Intake: Fan at rear panel Exhaust: Sides
Mounting	Standard 19-inch (483 mm) rack
Width	16-3/4 inches (426 mm) without rack-mount kit
Panel Height	6-3/4 inches (172 mm)
Depth	18-3/4 inches (464 mm) including handles
Weight	43 pounds (19,5 Kg)

c. AC Power Cable, 7-1/2 feet (228,6 cm), (817- serial number prefix part no. 8120-0078; 986- serial number prefix part no. 8120-1348).

d. Rack-Mounting Kit (part no. 5060-0776).

e. Operating and Service Manual (part no. 02160-9005).

1-17. OPTIONS.

1-18. Options to a standard Hewlett-Packard unit are identified by a three-digit suffix following the model designation (0000A-000) of the unit. Option 001 for the HP 2160A Power Supply Extender must be specified when ordering the unit for connection to the HP 2115A Computer/HP 2161A Power Supply combination. This option provides a different interconnecting cable than that used with the 2116 family of computers. Instead of the 02160-6001 DC Power Cable, the 02115-6019 DC Power Cable is supplied. Instructions for installing this option are included in section II.

1-19. The HP 2160A Power Supply Extender is normally shipped ready for operation from a 115-volt 47- to 66-hertz single-phase power source. Option 015 allows the unit to be operated from a 220-volt or 240-volt (230-volt nominal) 47- to 66-hertz single-phase source. When the option is installed, it may be identified by the 230-volt ac label affixed to the rear panel of the unit. Internal changes are made and the input power fuse rating is different when the 230-volt option is ordered. The detachable power cable that is required in the United States is shipped with the unit. (Refer to paragraph 1-16, step "c" for cable part numbers.) When the unit passes through customs into the destination country, the sales office in the destination country will exchange the detachable power cable for the required cable.

SECTION II
INSTALLATION AND OPERATION

2-1. INTRODUCTION.

2-2. This section provides information on unpacking and inspection, installation, and operation of the HP 2160A Power Supply Extender.

2-3. UNPACKING AND INSPECTION.

2-4. Carefully unpack the unit and retain packaging materials until after inspection of the equipment. No special unpacking precautions are necessary. If the shipping carton is damaged upon receipt, request that the carrier's agent be present when the unit is unpacked. Inspect the unit for damage (scratches, dents, broken parts, etc.). If the unit is damaged and fails to meet specifications, notify the carrier and the nearest Hewlett-Packard Sales and Service Office immediately. (Sales and Service Offices are listed at the back of this manual.) Retain the shipping container and the padding material for the carrier's inspection. The Hewlett-Packard Sales and Service Office will arrange for the repair or replacement of the damaged unit without waiting for any claims against the carrier to be settled.

2-5. INSTALLATION.

2-6. Installation procedures are provided below for the HP 2160A Power Supply Extender with the HP 2115A Computer/HP 2161A Power Supply combination and with the HP 2116 family of computers. Instructions are also included for connections when I/O extenders are used as part of the system. Mounting instructions, power considerations, and shipping instructions are also included below.

2-7. RACK OR BENCH MOUNTING.

2-8. The power supply extender may be mounted on a bench or in a standard 19-inch (483 mm) rack. To mount the unit in a rack, follow the instructions provided in the rack-mounting kit furnished with the unit. All necessary interconnecting cables are furnished for the basic unit. When rack-mounting the power supply extender, plan to place the unit within four feet of the computer to enable dc power cable connections to be made.

2-9. POWER REQUIREMENTS.

2-10. The power supply extender operates from a 115-volt 47- to 66-hertz single-phase source, or a 230-volt (nominal) 47- to 66-hertz single-phase source (with option 015) and requires 345 watts of power.

CAUTION

If a 230-volt label (for option 015) is not affixed to the rear panel, do not plug the unit into a 230-volt receptacle until further investigation has been made to determine if option 015 has been installed.

2-11. The power supply extender is protected from power overloads by a 5-ampere slow-blow type fuse (serial numbers prefixed 817-), or 5-ampere fast-acting fuse (serial numbers prefixed 986-) for 115-volt 47- to 66-hertz operation. A 3-ampere fast-acting fuse is provided for 230-volt 47- to 66-hertz operation. The fuse is located in a fuse holder mounted on the rear panel. Check the ampere rating of the fuse supplied with the unit before applying power.

2-12. A detachable three-conductor power cord is supplied with the unit for connection to the power source. Refer to paragraphs 1-15 and 1-19 for power cable differences. If the unit must be operated from a two-contact outlet, use a three-conductor to two-conductor adapter and connect the adapter ground wire to a suitable ground.

WARNING

The ground wire is for the protection of operating and maintenance personnel. Do not defeat its purpose. Ensure that solid contact with ground is made.

2-13. SHIPPING INSTRUCTIONS.

2-14. If the unit is to be shipped to Hewlett-Packard for service or repair, attach a tag to the unit identifying the owner and indicating the service or repair to be accomplished. Include the model number and full serial number of the unit.

2-15. Place the unit in the original container if available. If the original container is not available, a suitable container and packing material can be purchased from a local Hewlett-Packard Sales and Service Office.

2-16. If the original container is not used, wrap the unit in heavy paper and place it in an inner container. Place adequate packing material around all sides of the unit and place

a cardboard strip over the front panel. Place the unit and inner container in a heavy carton or wooden box and bind with strong tape or metal bands. Mark the shipping container "FRAGILE".

Note

In any correspondence, identify the unit by model number and serial number prefix. Refer any questions to the nearest Hewlett-Packard Sales and Service Office.

2-17. INSTALLATION PROCEDURE.

2-18. Paragraphs 2-19 and 2-20 provide installation instructions for the HP 2160A Power Supply Extender with the HP 2115A Computer/HP 2160A Power Supply combination. Option 001 is necessary for connection with the HP 2115A Computer. Refer to paragraph 1-18 for a description of this option. Paragraphs 2-21 through 2-23 provide instructions for connection of the power supply extender with the HP 2116 family of computers.

WARNING

Before installing any of the equipment described below, disconnect all power cables involved with equipment described. Failure to head this warning could result in injury or death to personnel performing the installation.

2-19. HP 2160A INSTALLATION WITH HP 2115A/ HP 2161A. See figure 2-1 for the interconnecting diagram of the power supply extender and HP 2115A Computer/ HP 2161A Power Supply cabling and proceed as follows:

a. Connect the 02115-6019 DC Power Cable supplied with option 001 for the HP 2160A to the three power input terminals of the HP 2115A Computer. Connect the three lug terminals (see figure 4-3) in exactly the same manner as the original 02115-6019 DC Power Cable which connects from the HP 2161A Power Supply to the HP 2115A Computer. To accomplish this, remove the retaining nuts from the power cable lug terminals in the HP 2115A Computer and stack the lug terminals of the additional dc power cable from the HP 2160A Power Supply Extender on top of their respective counter-parts as follows:

(1) White-red lead (+4.5V) lugs together on positive side of capacitor C2.

(2) White lead (-2V) lugs together on negative side of capacitor C1.

(3) White-black lead (ground) lugs together on chassis ground bolt.

b. Replace the retaining nuts for the dc power cable lugs and secure both dc power cables in place.

c. Connect the plug connector of the 02115-6019 DC Power Cable supplied with the HP 2160A to J2 on the power supply extender.

d. Connect the 02150-6018 Control Cable as shown in figure 2-1.

e. Remove jumper W1 located on Power Control Board A2 of the HP 2161A Power Supply. This puts the thermal cutout circuit of the HP 2160A in series with that of the HP 2161A.

f. Connect the ac power cable to the HP 2160A Power Supply Extender as shown in figure 2-1. This completes the installation.

2-20. HP 2160A INSTALLATION WITH HP 2115A/ HP 2161A AND HP 2150A OR HP 2151A. Connect the HP 2160A Power Supply Extender to the HP 2115A Computer/HP 2161A Power Supply as described in steps "a" through "e" of paragraph 2-19 if this has not been accomplished. See figure 2-2 for an interconnecting diagram and proceed as follows:

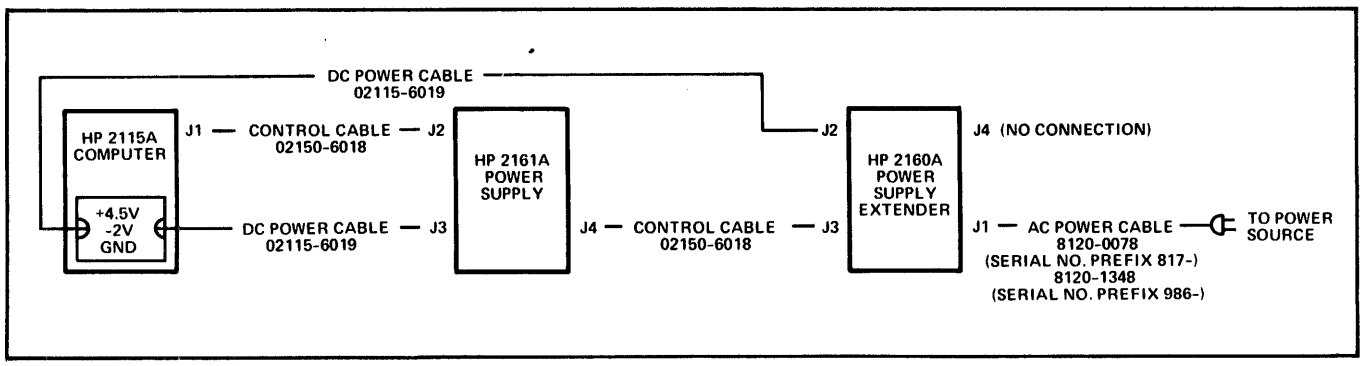


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Figure 2-1. HP 2160A Interconnections with HP 2115A/HP 2161A

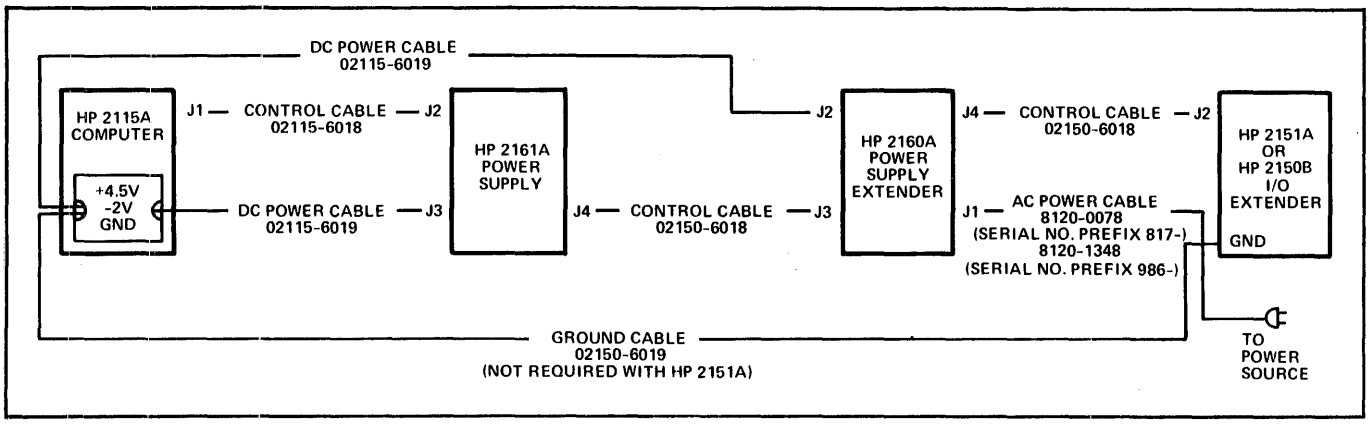

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Figure 2-2. HP 2160A Interconnections with HP 2115A/HP 2161A and HP 2150A or HP 2151A

a. Install the 02150-6018 Control Cable between the power supply extender and the HP 2150A or HP 2151A Extender as shown in figure 2-2.

b. If the HP 2150A I/O and Memory Extender is being used, the ground cable supplied with the HP 2150A must be installed as shown in figure 2-2. Refer to the HP 2161A manual and to the applicable extender manuals for further changes required when using the I/O or I/O and memory extenders.

c. Connect the ac power cable to the HP 2160A Power Supply Extender as shown in figure 2-2. The installation is complete when the changes mentioned in step "b" have been made.

2-21. HP 2160A INSTALLATION WITH HP 2116 FAMILY COMPUTERS. Figure 2-3 illustrates the interconnecting diagram, with cable part numbers, for connection of the HP 2160A Power Supply Extender to the HP 2116A, HP 2116B, or HP 2116C Computer. To connect the power supply extender to any of the HP 2116 family computers, perform the following steps:

a. Remove the right side-panel (as you face the computer) from the computer (see figure 2-4). This will expose the three power supply output terminals inside the computer.

b. Remove the three braided straps from the output terminals in the computer (marking each for proper identification). Put the 02160-6001 DC Power Cable (see figure 4-2), in place, positioning the lugs as shown in figure 2-4.

Note

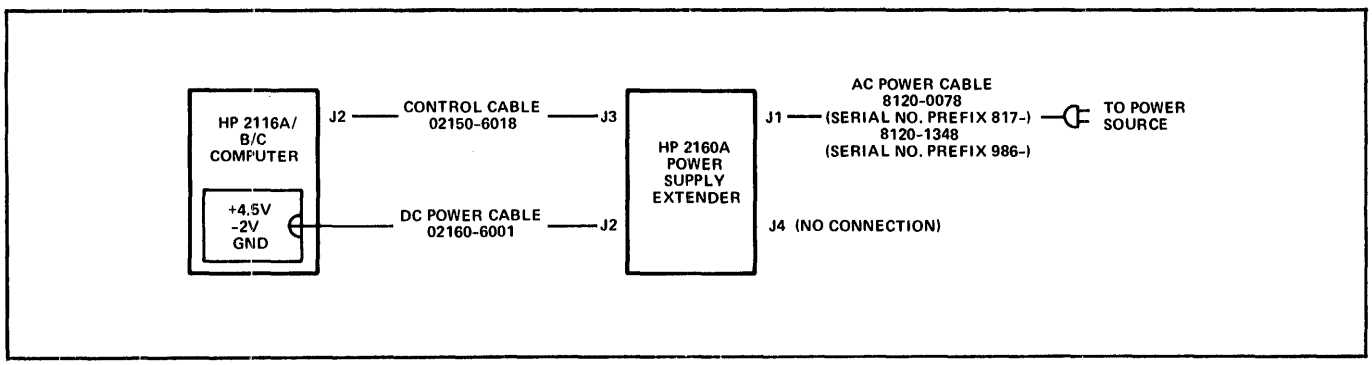
If force is needed to bend the dc power cable terminal wires into position, do not turn on computer power until sure of proper terminal hook-up. The terminal wires are staggered in length to indicate proper installation sequence.

c. Put the braided straps back in position on top of the dc power cable terminal lugs and secure each lug and braided strap with two of the 5/8-inch, no. 4-40 screws provided.

d. Replace the computer side-panel.

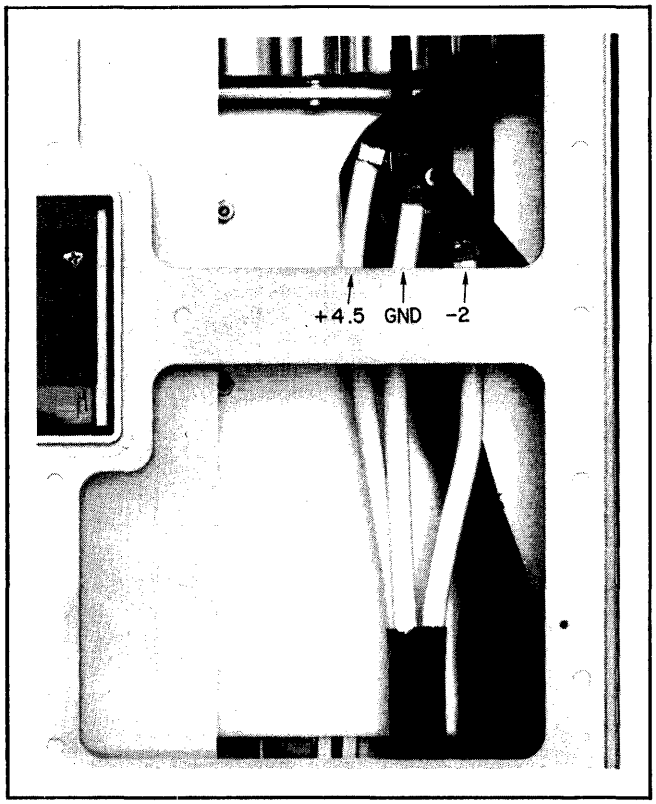
e. Connect the other end of the 02160-6001 DC Power Cable to connector J2 on the power supply extender (see figure 2-6).

f. Attach the 02150-6018 Control Cable (see figure 4-1) to connector J2 on the back of the computer as shown in figure 2-5.



2137-10

Figure 2-3. HP 2160A Interconnections with HP 2116A, B or C



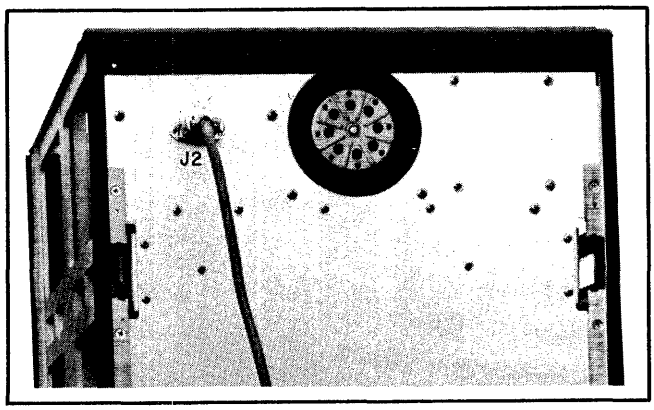
2137-2

Figure 2-4. HP 2116 Computer (Right Side View), Power Supply Terminal Connection Points

g. Connect the other end of the 02150-6018 Control Cable to connector J3 on the power supply extender (see figure 2-6).

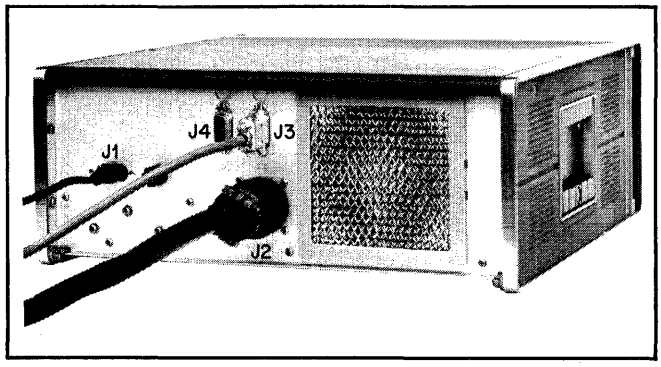
h. Remove the thermal cutout circuit jumper wire from the terminal board inside the HP 2116 Computer as shown in figure 2-7. This will put the HP 2160A Power Supply Extender thermal cutout switch in series with the computer circuits.

i. Connect the ac power cable to the HP 2160A Power Supply Extender as shown in figure 2-3. This completes the installation.



2137-3

Figure 2-5. HP 2116 Computer (Rear View), Control Cable Connection Point



2137-4

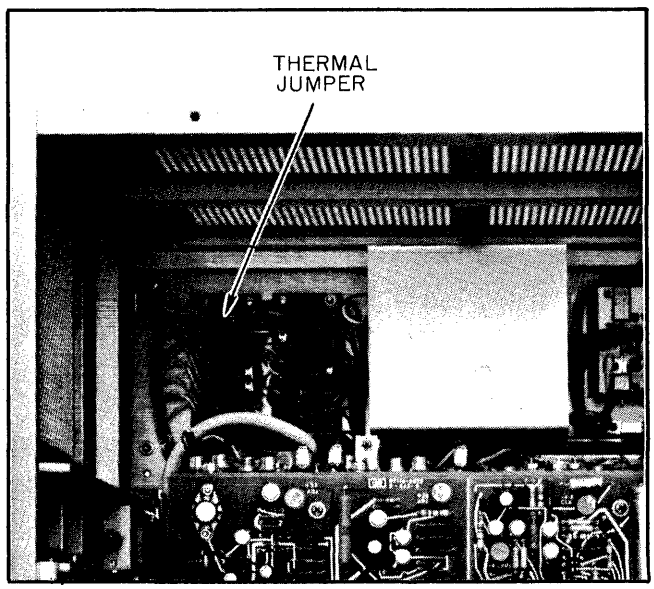
Figure 2-6. HP 2160A Power Supply Extender, Rear Panel Cable Connection Points

2-22. HP 2160A INSTALLATION WITH HP 2116A AND HP 2150A OR HP 2151A. Connect the HP 2160A Power Supply Extender to the HP 2116A Computer as described in steps "a" through "h" of paragraph 2-21 if this has not been accomplished. See figure 2-8 and proceed as follows:

a. Install the 02150-6018 Control Cable (see figure 4-1) between the power supply extender and the HP 2150A or HP 2151A Extender as shown in figure 2-8.

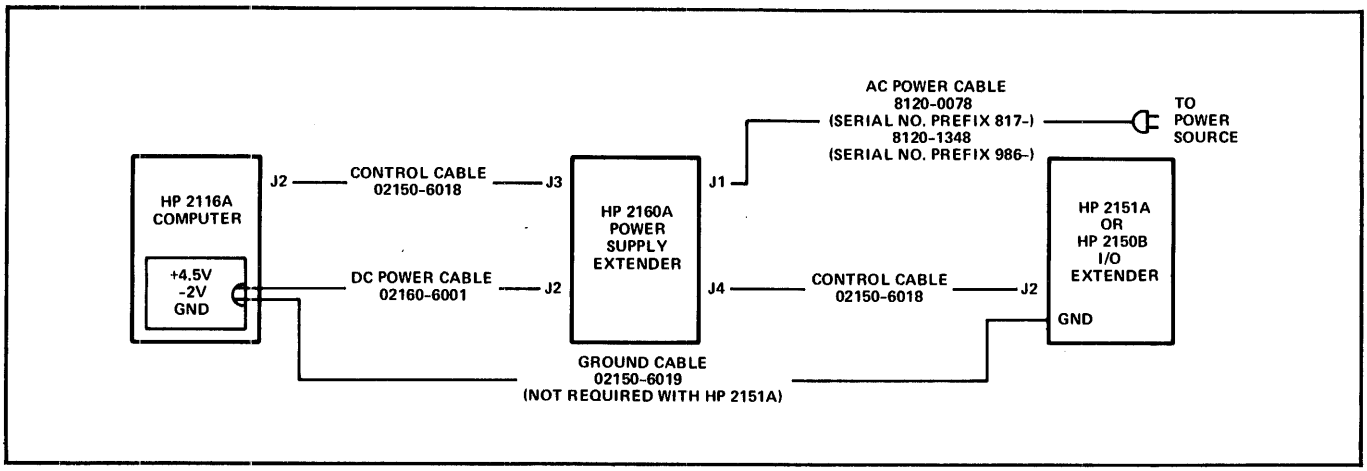
b. If the HP 2150A I/O and Memory Extender is being used, the ground cable supplied with the HP 2150A must be installed as shown in figure 2-8. Refer to the Operating and Service Manual for the HP 2150A I/O and Memory Extender or HP 2151A I/O Extender for further changes required when using the I/O or I/O and memory extenders.

c. Connect the ac power cable to the HP 2160A Power Supply Extender as shown in figure 2-8. The installation is complete when the changes mentioned in step "b" have been made.



2137-5

Figure 2-7. HP 2116 Computer (Inside Top View), Thermal Jumper Location



2137-11

Figure 2-8. HP 2160A Interconnections with HP 2116A and HP 2150A or HP 2151A

2-23. HP 2160A INSTALLATION WITH HP 2116B OR HP 2116C AND HP 2150B OR HP 2151A. Refer to the basic instructions for connecting the HP 2160A Power Supply Extender to the HP 2116B or HP 2116C Computer as described in steps "a" through "h" of paragraph 2-21 if this has not been accomplished. See figure 2-9 and proceed as follows:

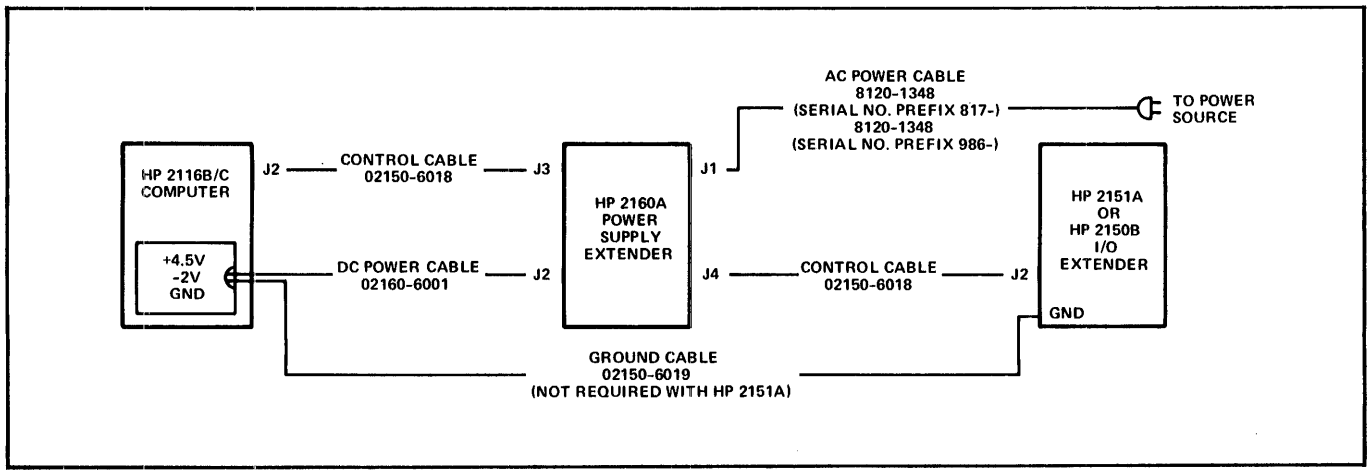
a. Install the 02150-6018 Control Cable (see figure 4-1) between the power supply extender and the HP 2150B or HP 2151A Extender as shown in figure 2-9.

b. If the HP 2150B I/O and Memory Extender is being used, the ground cable supplied with the HP 2150B must be installed as shown in figure 2-9. Refer to the HP 2116B or C Installation and Maintenance Manual, Volume II, and the HP 2150B I/O and Memory Extender or HP 2151A I/O Extender Manual for further changes required when using the I/O or I/O and memory extenders.

c. Connect the ac power cable to the HP 2160A Power Supply Extender as shown in figure 2-9. The installation is complete when the changes mentioned in step "b" have been made.

2-24. OPERATION.

2-25. The HP 2160A Power Supply Extender is controlled and receives drive signals for regulation from the computer power supply. The only operator indicator is the POWER ON light on the front panel. This indicator is red for models with serial numbers prefixed 817- and white for models with serial numbers prefixed 986-. Operation of the power supply extender does not require the attention of the computer user.



2137-12

Figure 2-9. HP 2160A Interconnections with HP 2116B or HP 2116C and HP 2150B or HP 2151A

SECTION III
THEORY OF OPERATION

3-1. INTRODUCTION.

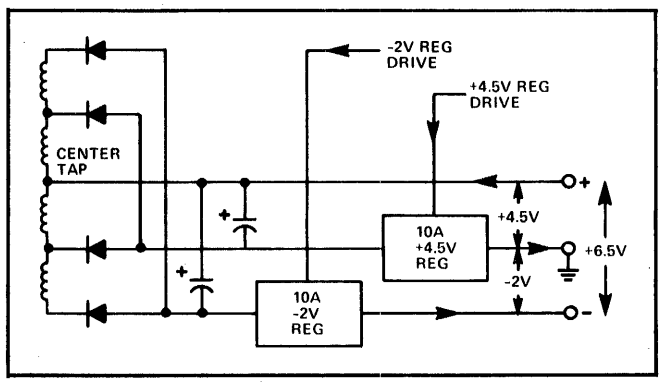
3-2 This section provides a functional description of HP 2160A Power Supply Extender operation (paragraph 3-3). A brief discussion of the interface signals is also provided. Circuit descriptions for the power supply extender are provided in paragraph 3-7.

3-3. FUNCTIONAL DESCRIPTION.

3-4. The primary purpose of the power supply extender is to provide supplementary -2 volt and +4.5 volt current for the computer power supplies to which it is connected. The -2 volt and +4.5 volt regulators in the power supply extender are controlled by the same drive signals that control regulation of the computer internal power supply. The two output voltages of the power supply extender and the corresponding output voltages of the computer internal power supply (+4.5 volts and -2 volts) are connected together and appear as a single source to the computer. In this manner the power supply extender and the computer power supply, in effect, operate in parallel.

3-5. Figure 3-1 illustrates the method by which the -2 volt and +4.5 volt supplies are interconnected within the power supply extender to provide current (in the manner described in paragraph 1-6) while using standard circuits to obtain the required voltages. The secondary windings of the transformer, the associated rectifier circuits, and the two series regulators constitute two separate power supplies; one at 6.5 volts and the other at 4.5 volts, with the positive terminals tied together. The negative terminal of the 4.5-volt supply is connected to ground, which forces the positive or common terminal of both supplies to become +4.5 volts. The negative terminal of the 6.5-volt supply therefore becomes -2 volts. This is the method used to establish the +4.5 volt and -2 volt supply voltage levels in the power supply extender.

3-6. The main outputs (-2 volts and +4.5 volts) from the power supply extender are available for connection to the HP 2115A or HP 2116 family of computers at connector J2. The thermal switch, power on, and regulator drive signals are received from the computer at connector J3 of the power supply extender in addition to +18 volt (HP 2115A) or +23.3 volt (HP 2116) power for operation. An External Power Fail (HP 2115A) or Extender Power Fail, EPF, (HP 2116) signal is coupled between J3 of the power supply extender and connector J4 of the HP 2161A Power Supply (when using the HP 2115A Computer) or J2 of the HP 2116 family of computers. An External Power On (HP 2115A) or Extender Power Up, EPO, (HP 2116) signal is routed to the computer through the power supply extender from the I/O or I/O and memory extenders when used. The power on signal from the computer is also routed through



2137-6

Figure 3-1. -2 Volt and +4.5 Volt Power Supply Interconnection, Simplified Schematic Diagram

the power supply extender from J3 to J4 for connection to the I/O extenders.

3-7. CIRCUIT DESCRIPTIONS.

3-8. Refer to the schematic diagram, figure 4-7, for the circuit discussions that follow. Primary power and fusing circuits of the power supply extender are discussed in paragraph 3-9 with details of the power-on circuits. The +20, -20, -5.11, and -9 volt bias supply rectifiers and regulators, used to generate voltages for internal use, all mount on supply regulator card A1 within the power supply extender. These are discussed in paragraph 3-11. The -9 volt bias supply also has components on the chassis and on resistor board A2. The +4.5 volt rectifier and series regulator circuits, and the -2 volt rectifier and series regulator circuits mount side by side on the heat sink assembly, the diode resistor board, and on card A1. Capacitors C5 and C6 for the above mentioned circuits mount on the chassis. These output power supplies are discussed in paragraph 3-13 through 3-16. The current sense and power fail circuits for the +4.5 volt and -2 volt power supplies both mount on card A1 and are discussed in paragraphs 3-17 and 3-20, respectively. The thermal switch circuit discussed in paragraph 3-23 mounts on the heat sink assembly.

3-9. PRIMARY POWER CIRCUITS AND FUSING.

3-10. The primary and secondary circuits of the power supply extender are both fused. The primary of transformer T1 may be connected for 115-volt operation or for 230-volt operation (option 015) as shown on the schematic. Fan B1 and POWER ON lamp DS1 are connected so that they need not be changed in the circuit for the different input voltages. When the computer begins operation, it applies -18 volts (HP 2115A) or -22.6 volts (for HP 2116 family computers) to connector J3, pin 5, of the power supply

extender. This energizes relay K1 which applies power to components of the entire unit.

3-11. INTERNAL BIAS SUPPLIES.

3-12. All bias voltages for internal use are generated within the power supply extender except the +18 volts (HP 2115A) or +23.3 volts (HP 2116) which is supplied by the applicable computer internal power supply. The 53.6-volt ac (center-tapped) and 12-volt ac secondary windings of transformer T1 furnish the necessary voltages for the +20, -20, -5.11, and -9 volt bias supply circuits. The 53.6-volt ac output from T1 is applied through fuses F7 and F8 to positive and negative full-wave rectifier circuits (A1CR12 through A1CR15). Each rectifier circuit consists of two rectifiers connected to a common center-tapped transformer winding. Capacitors A1C5 and A1C6 filter the two resulting rectified dc voltages. Resistors A1R26 and A1R27 discharge the two filter capacitors when the power supply extender is turned off. Resistors A1R25, A1R28, and A1R5 with Zener diodes A1CR10, A1CR11, and A1CR6, respectively, provide the +20, -20, and -5.11 volt outputs to the power supply extender circuits. The 12-volt ac output winding of T1 is applied to full-wave bridge rectifier circuit A1CR1 through A1CR4, which produces a rectified 13.5 volts dc. The positive terminal of this supply is connected to +4.5 volts, causing the negative terminal to become -9 volts. Capacitor C4 filters the -9 volt output. Resistor A2R3 provides a discharge path for C4 when the power supply extender is turned off. Resistor A2R2 limits the turn-on surge current through rectifier diodes A1CR1 through A1CR4.

3-13. OUTPUT VOLTAGE SUPPLIES.

3-14. Secondary winding terminals 1 through 5 of transformer T1, the associated rectifiers, and series regulating elements Q2, Q3, Q5, and Q6 form the +4.5 volt and -2 volt power supplies. These supplies are interconnected as described in paragraph 3-3. The regulator circuits for these supplies are on card A1. The individual circuits are described below.

3-15. POSITIVE 4.5-VOLT SUPPLY. The +4.5V Drive signal enters the power supply extender at connector J3, pin 8, and is applied to the base of transistor A1Q3 of +4.5 volt supply differential amplifier A1Q2 and A1Q3. This drive signal controls the base-emitter voltage drop of A1Q3, thereby regulating the emitter current of A1Q3. The sum of the emitter currents of A1Q3 and A1Q2 flows through A1R29 and is essentially constant. Therefore, varying the emitter current of A1Q3 will also cause the emitter current of A1Q2 to vary, but in opposite fashion. The output of A1Q2 is applied through resistor A1R2 to the base of emitter-follower A1Q1, then through diode A1CR5 to the base of +4.5 volt regulator driver transistor Q1. Diode A1CR5 increases the collector-emitter voltage of transistor A1Q2. The output of Q1 is applied equally to the bases of both regulator transistors Q2 and Q3 to control their level of operation. The emitters of transistors Q2 and Q3 are connected through current balancing resistors R7 and R8 to ground. The +4.5 volt output is provided from the transformer center tap.

3-16. NEGATIVE 2-VOLT SUPPLY. The -2 volt Drive signal enters the power supply extender at connector J3, pin 9, and is applied to the base of transistor A1Q9, the first half of -2 volt supply differential amplifier A1Q8 and A1Q9. Operation of the -2 volt supply is essentially the same as that of the +4.5 volt supply with the exception of the output current flow path. The -2 volt supply output current is taken from the emitters of regulator transistors Q5 and Q6 through current-balancing resistors R10 and R11, which are tied together. The +4.5 volt and -2 volt regulators are interrelated by way of the common connection to the center tap of the secondary winding of transformer T1 (which is also the +4.5-volt output).

3-17. CURRENT SENSE CIRCUITS.

3-18. In the +4.5 volt supply, current sense transistor A1Q4, while normally turned off, monitors the voltage drop across emitter-balancing resistor R7. If the voltage drop increases, indicating a low impedance load or short circuit, A1Q4 is turned on. When A1Q4 conducts, it removes the drive signal from the base of A1Q1, thereby turning off regulator transistors Q2 and Q3. This initiates shut-down of the +4.5 volt supply which causes the overload to be transferred to the computer internal +4.5 volt power supply. The added load on the +4.5 volt computer power supply will cause it to also go into current limiting, which will then shut down the entire computer power supply system.

3-19. Operation of the -2 volt supply current sense circuit is the same as that of the +4.5 volt supply.

3-20. POWER FAIL CIRCUITS.

3-21. In the +4.5 volt supply, transistor A1Q5 is turned on during normal power supply extender operation to monitor the collector-emitter drop across regulator transistor Q3. In this manner it detects any fluctuations of line voltage in order to control the power fail option in the computer. If the collector-emitter drop of regulator transistor Q3 decreases below a lower set limit, indicating a failure of line voltage, transistor A1Q5 will shut off. This will turn on transistor A1Q6 by causing the base voltage to go in a positive direction. With A1Q6 turned on, a positive signal is applied to the computer to operate the power fail option.

3-22. Operation of the -2 volt supply power fail circuit is the same as that of the +4.5 volt supply.

3-23. THERMAL SWITCH.

3-24. Thermal switch S1 is connected between pins 1 and 2 of connector J3 on the power supply extender. When the power supply extender is installed as an integral part of a computer system, thermal switch S1 is put in series with the computer thermal cut-out circuit. If the temperature of the thermal switch, inside the power supply extender, exceeds 75 +0, -2°C, thermal switch S1 opens. When the switch opens it causes both the power supply extender and the computer internal power supply to shut down.

SECTION IV
MAINTENANCE

4-1. INTRODUCTION.

4-2. This section provides preventive maintenance, troubleshooting, and repair information for the HP 2160A Power Supply Extender. Diagrams for parts location and a schematic are also provided to aid in maintaining the equipment.

4-2. PREVENTIVE MAINTENANCE.

4-4. The power supply extender is designed so that a minimum amount of maintenance is necessary. Table 4-1 provides a schedule for periodic inspection and cleaning of the unit. There are no mechanical or electrical adjustments that must be made in the power supply extender.

Table 4-1. Preventive Maintenance Schedule

ROUTINE	SCHEDULE
Inspection (paragraph 4-5)	Quarterly
Cleaning (paragraph 4-7)	Monthly

4-5. INSPECTION.

4-6. The power supply extender should be inspected according to the schedule in table 4-1 for signs of mechanical and electrical defects. Inspect interconnecting and power cables for fraying or chaffing. Inspect connectors for damaged or corroded pins. Repair or replace cables or connectors if they are damaged. Visually inspect the assemblies and components of the power supply extender for signs of overheating, leakage, frayed insulation on wiring, or other signs of deterioration. Inspect the primary and secondary fuses to ensure, if replacement has been necessary, that properly rated fuses are installed. See the schematic diagram (figure 4-7) and replaceable parts lists in section V for fuse types and part numbers.

4-7. CLEANING.

4-8. Power supply extender cleaning should be accomplished according to the schedule in table 4-1. Dust, moisture, grease, and foreign material should be removed to ensure troublefree operation. Accumulated dust and loose dirt may be removed with a stiff-bristle brush or compressed air. Remove moisture with a clean, dry cloth or cotton swab. Grease and oil may be removed with a cloth or cotton swab saturated with a diluted lacquer solution or similar cleaning compound. It is important to ensure that moisture does not accumulate around high current components and circuits. The cooling fan air filters must be removed and cleaned at least once every 30 days when the power supply extender is being operated in a relatively clean-air environment. When being operated in a dusty environment, the filters must be removed and cleaned at least once every 7 days.

4-9. TROUBLESHOOTING.

4-10. If the power supply extender should fail to function properly, the troubleshooting procedure provided in table 4-2 will be helpful in isolating the faulty circuit.

WARNING

This equipment has dangerous line voltage present at various points within the chassis. Use extreme caution when working on the equipment with the cover removed. Failure to heed this warning could result in injury or death.

4-11. If the power supply extender does not fail completely but one (or both) of the output voltages is incorrect, proceed with the following steps:

a. Remove all of the I/O interface cards from the computer.

b. Using an accurate voltmeter, such as an HP 412A, monitor the voltage drop across emitter balance resistors R7, R8, R10, and R11 in the power supply extender. The drop across any one of the resistors should not exceed 0.93 volts at any time.

c. Insert the I/O interface cards one at a time and note any change in the voltage drop across the emitter balance resistors. If the drop across any one of these resistors exceeds 0.93 volts, the respective circuit will go into current limiting. If the power supply extender goes into current limiting, proceed to table 4-2 and perform steps "a" and "b" of the final check. If one of the emitter balance resistors shows a drop much larger than any of the others and its respective output voltage is incorrect, normal electronics troubleshooting techniques must be used to locate the low impedance source.

4-12. If highly intermittent power failures in the computer are experienced while operating with the power supply extender, the -9 volt bias supply could be faulty. If the computer power supplies are attempting to deliver slightly above rated load with the -9 volt bias in the 2160A disabled,

Table 4-2. HP 2160A Power Supply Extender, Troubleshooting Procedure

STEP	EXTERNAL SYMPTOM	PREPARATION	PROCEDURE		
1	Power light off, outputs ok.		Check resistor R1 and lamp DS1 on the chassis.		
2	Power light off, no output.		Fuse F1 good?	NO	Replace fuse; if it blows again, check for a short.
				YES	Go to next check.
			Line voltage at J1?	NO	Check power cord and line voltage supply source.
				YES	Go to next check.
			-18V (2115A) or -22.6V (2116) at J3, pin 5?	NO	Check interconnecting cables and computer power supply operation.
				YES	Go to next check.
			Relay K1 contacts closed?	NO	Check relay coil and related wiring.
				YES	Go to next check.
			Check all primary power wiring to transformer T1 and relay K1 located in the power supply extender chassis.		
3	Power light on, no output.		Power Fail in effect?	YES	If Power Fail option is installed, PRESET light will be on. Press PRESET switch; if normal operation resumes, failure was temporary. If light remains on, proceed with next step.
				NO	Go to next check.
		Remove all I/O interface cards.	Will the computer operate?	YES	Perform the check in paragraph 4-11.
				NO	Go to next check.
		Disconnect plug connector from power supply extender connector J2.	Will the computer operate?	NO	Problem is somewhere in the computer circuitry. Refer to volume two of applicable computer manual.
				YES	Problem is in the HP 2160A Power Supply Extender, go to next check.
			Does thermal cut-out circuit have continuity from pin 1 to pin 2 of connector J3?	NO	Over-heat problem. Check cooling fan, air filter (change if necessary), and transistors on the heat sink unit where switch S1 is mounted.
				YES	Go to next check.
			All fuses good (F2 thru F8)?	NO	Replace fuses; if they blow again, check the respective circuits for shorts and low impedances.
				YES	Go to next check.

Table 4-2. HP 2160A Power Supply Extender, Troubleshooting Procedure (Continued)

<table>
<tr><th>STEP</th><th>EXTERNAL SYMPTOM</th><th>PREPARATION</th><th colspan="3">PROCEDURE</th></tr>
<tr><td rowspan="8">3 (cont)</td><td rowspan="8"></td><td rowspan="3">Reconnect the cable to connector J2 of the power supply extender. Turn on computer power and continue with the following checks (I/O interface cards still removed).</td><td rowspan="2">Bias voltages all present? (+20V, -20V, -5.11V, and -9V.)

Note
-9V will increase to about -15V when the +4.5V supply fails.</td><td>NO</td><td>Check components and circuit of the respective bias supplies.</td></tr>
<tr><td>YES</td><td>Go to next check</td></tr>
<tr><td rowspan="6"></td><td rowspan="2">+18V (2115A) or +23.3V (2116) at connector J3, pin 7?</td><td>NO</td><td>Check interconnecting cables and operation of the computer power supply.</td></tr>
<tr><td>YES</td><td>Go to next check</td></tr>
<tr><td rowspan="2">Raw dc voltages present at rectifiers? (Remove regulator card A1 and measure approximately -10V at pin U and approximately -12V at pin H of connector XA1.)</td><td>NO</td><td>Check for bad rectifiers, open or shorted secondary winding of T1, or bad resistors and capacitors in the rectifier circuits.</td></tr>
<tr><td>YES</td><td>Reinstall regulator card A1 and proceed to the next check.</td></tr>
<tr><td colspan="3">If the computer internal power supply and power supply extender regulated output voltages are still not present, and troubleshooting checks in this table have not indicated the problem area, perform the following steps.

a. Temporarily place a short across capacitor C54 on printed-circuit card A301 (logic supply regulator) of the computer internal power supply. If the +4.5 and -2V supplies in the power supply extender are functioning properly, they will both begin normal operation.

b. If one, or both, of the supplies fail to operate when the capacitor is shorted, there is a circuit problem that did not show up in the checks of this table and a component-by-component check may be necessary.

Note

When checking for faulty components, check particularly for shorted current sense transistors A1Q4 and A1Q10 and for shorted or open differential amplifier transistors A1Q2, A1Q3, A1Q8, and A1Q9.</td></tr>
</table>

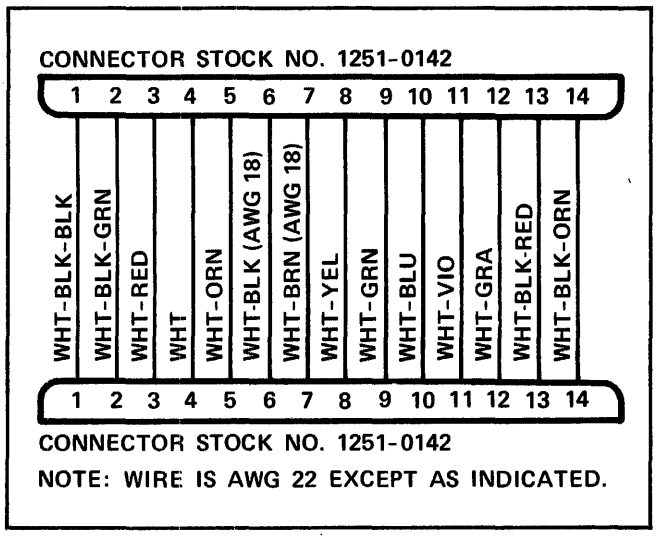
there will not be an extender power fail at the computer. Check the series resistor (R7, R8, R10, R11) voltages in the 2160A.

4-13. REMOVAL AND REPLACEMENT.

4-14. When disassembling the power supply extender to replace parts or wiring, refer to the parts location diagrams, the point-to-point wiring list and wiring diagram, and the replaceable parts lists in section V for component placement, wiring, and values.

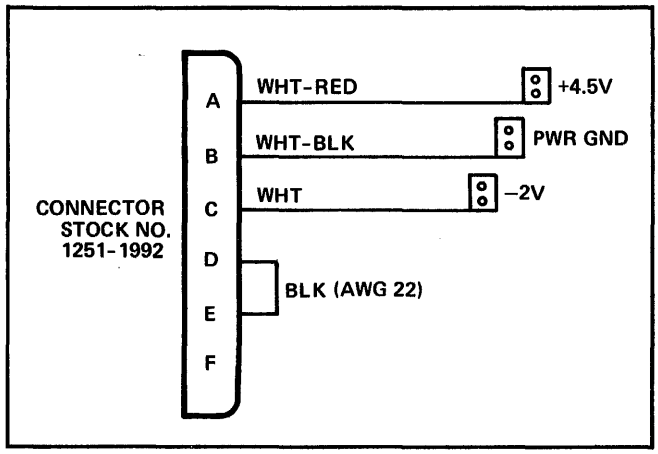
4-15. If transistors on the heat sink assembly, or diodes on the diode-resistor subdeck must be changed, ensure that silicone grease such as Dow-Corning no. 340 Silicone Heat Sink Compound is used between the new component and its mounting assembly to ensure good thermal contact. If it becomes necessary to replace capacitors A1C5 and A1C6 on the supply regulator card, use silicone rubber to affix the parts firmly to the board. This material (part no. 0470-0251) may be ordered through Hewlett-Packard Sales and Service Offices listed at the back of this manual.

4-16. Refer to figures 4-1 through 4-4 and to table 4-3 for wiring information. Replace wires with the same size and color as on the original installation.



2137-14

Figure 4-1. 02150-6018 Control Cable, Wiring Diagram



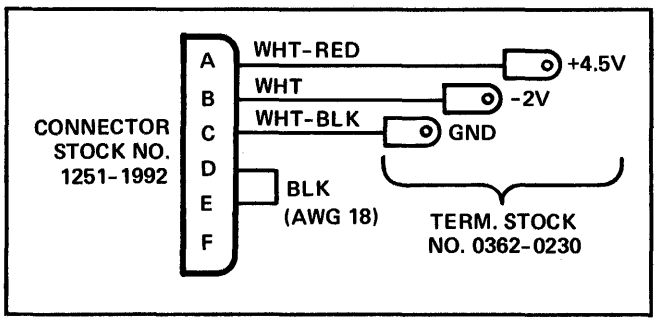
2137-15

Figure 4-2. 02160-6001 DC Power Cable, Wiring Diagram

4-17. DIAGRAMS.

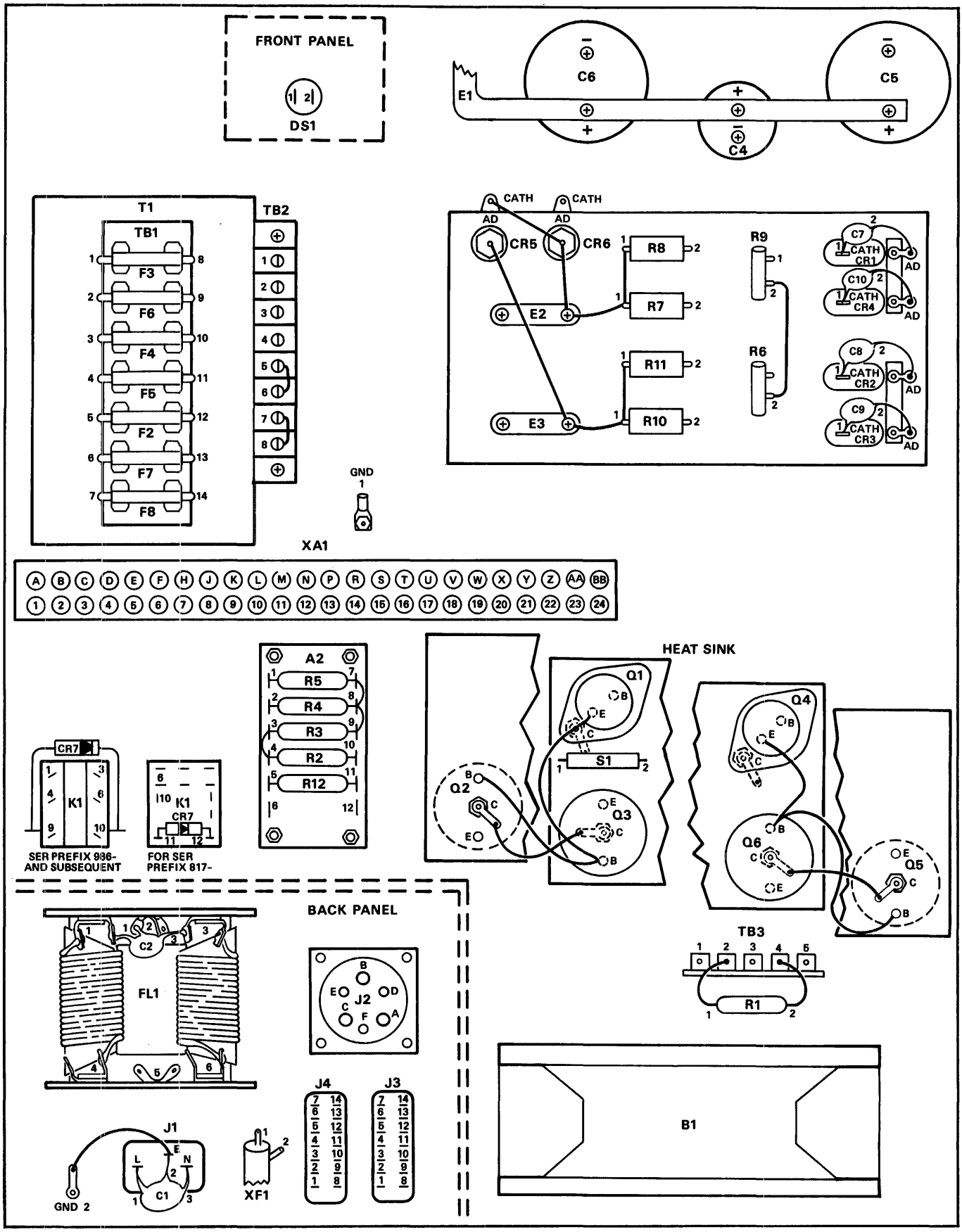
4-18. Figure 4-5 shows the location of assemblies and chassis mounted components within the power supply extender. Figure 4-6 is a parts location diagram for supply regulator card A1. Figure 4-7 is the schematic diagram for models of the power supply extender with serial numbers prefixed 817- or 986-. Option 015 information is also provided on the diagram.

4-19. When viewing the power supply extender from the front, the component side of card A1 is toward the front as the assembly mounts in receptacle connector XA1. The alphabetical pin numbers of the 48-pin connector are toward the front of the unit with pin letters reading sequentially from right to left (see figure 4-4). Numerical pin numbers are toward the rear of XA1 and also run sequentially from right to left.



2137-16

Figure 4-3. 02115-6019 DC Power Cable (Option 001), Wiring Diagram



2137-13

Figure 4-4. HP 2160A Power Supply Extender, Wiring Diagram

Table 4-3. Point-to-Point Wiring List

FROM	TO	COLOR	FROM	TO	COLOR	FROM	TO	COLOR
A2-1	C6(-)	blu	CR4-ad	CR1-ad	bus bar	K1-6	TB2-8	blk
A2-2	C5(-)	orn	CR4-cath	C10-1	*	K1-10	FL1-1	gra
A2-3	C4(-)	grn	CR4-cath	TB1-9	vio	K1-11	A2-5	wht-brn
A2-3	A2-4	bus wire	CR5-ad	E3	clear	K1-11	CR7-ad	*
A2-4	A2-3	bus wire	CR5-cath	CR6-ad	bare	K1-12	CR7-cath	*
A2-5	K1-11	wht-brn	CR6-ad	CR5-cath	bare	K1-12	J2-D	brn
A2-7	C6(+)	red	CR6-ad	E2	bare	Q1-B	XA1-V	wht-blk-yel
A2-7	A2-8	bus wire	CR6-cath	E1	red	Q1-C	C4(-)	grn
A2-8	A2-7	bus wire	CR7-ad	K1-11	*	Q1-E	Q3-B	brn
A2-8	A2-9	bus wire	CR7-cath	K1-12	*	Q2-B	R6-1	brn
A2-9	A2-8	bus wire	DS1-1	TB3-2	gra	Q2-B	Q3-B	brn
A2-10	XA1-BB	wht-red-yel	DS1-2	TB3-1	wht-gra	Q2-C	C5(-)	orn
A2-11	J3-5	wht-grn	E1	C4(+)	bus	Q2-C	Q3-C	orn
A2-11	J4-5	wht-grn	E1	C5(+)	bus	Q2-E	R7-2	wht-yel-blu
B1	TB3-1	*	E1	C6(+)	bus	Q3-B	Q1-E	brn
B1	TB3-4	*	E1	CR6-cath	red	Q3-B	Q2-B	brn
C1-1	J1-L	*	E1	J2-A	wht	Q3-C	Q2-C	orn
C1-2	J1-E	*	E1	XA1-P	red	Q3-E	R8-2	wht-brn-yel
C1-3	J1-N	*	E2	CR6-ad	bare	Q4-B	XA1-L	wht-brn-grn
C2-1	FL1-1	*	E2	J2-B	wht	Q4-C	C4(-)	grn
C2-2	FL1-2	*	E2	R7-1	bare	Q4-E	Q6-B	gra
C2-3	FL1-3	*	E2	XA1-N	blk	Q5-B	Q6-B	gra
C4(+)	E1	bus bar	E3	CR5-ad	clear	Q5-B	R9-1	gra
C4(+)	XA1-Z	red	E3	J2-C	wht	Q5-C	C6(-)	blu
C4(-)	A2-3	grn	E3	R10-1	bare	Q5-C	Q6-C	blu
C4(-)	Q1-C	grn	E3	XA1-D	vio	Q5-E	R10-2	wht-yel-grn
C4(-)	Q4-C	grn	FL1-1	C2-1	*	Q6-B	Q4-E	gra
C4(-)	XA1-K	grn	FL1-1	K1-10	gra	Q6-B	Q5-B	gra
C5(+)	E1	bus bar	FL1-2	C2-2	*	Q6-C	Q5-C	blu
C5(+)	TB2-4	red	FL1-2	J1-E	blk	Q6-E	R11-2	wht-brn-gra
C5(-)	A2-2	orn	FL1-3	C2-3	*	R1-1	TB3-2	*
C5(-)	CR3-ad	orn	FL1-3	TB3-1	wht-gra	R1-2	TB3-4	*
C5(-)	Q2-C	orn	FL1-4	XF1-2	wht-brn-gra	R6-1	Q2-B	brn
C5(-)	XA1-U	orn	FL1-6	J1-N	wht	R6-1	XA1-W	brn
C6(+)	E1	bus bar	GND1	T1	(wht)*	R6-2	J3-7	wht-vio
C6(+)	A2-7	red	GND2	J1-E	blk	R6-2	J4-7	wht-vio
C6(-)	A2-1	blu	J1-E	C1-2	*	R6-2	R9-2	wht-vio
C6(-)	CR4-ad	blu	J1-E	FL1-2	blk	R7-1	E2	bare
C6(-)	Q5-C	blu	J1-E	GND2	blk	R7-1	R8-1	bare
C6(-)	XA1-H	blu	J1-L	C1-1	*	R7-2	Q2-E	wht-yel-blu
C7-1	CR1-cath	*	J1-L	XF1-1	gra	R7-2	XA1-S	wht-yel-blu
C7-2	CR1-ad	*	J1-N	C1-3	*	R8-1	R7-1	bare
C8-1	CR2-cath	*	J1-N	FL1-6	wht	R8-2	Q3-E	wht-brn-yel
C8-2	CR2-ad	*	J2-A	E1	wht	R8-2	XA1-R	wht-brn-yel
C9-1	CR3-cath	*	J2-B	E2	wht	R9-1	Q5-B	gra
C9-2	CR3-ad	*	J2-C	E3	wht	R9-1	XA1-B	gra
C10-1	CR4-cath	*	J2-D	K1-12	brn	R9-2	R6-2	wht-vio
C10-2	CR4-ad	*	J2-E	J3-6	wht-orn	R9-2	XA1-X	wht-vio
CR1-ad	C7-2	*	J2-E	J4-6	wht-orn	R10-1	E3	bare
CR1-ad	CR4-ad	bus bar	J3-1	S1-2	yel	R10-1	R11-1	bare
CR1-cath	C7-1	*	J3-2	S1-1	blu	R10-2	Q5-E	wht-yel-grn
CR1-cath	TB1-8	brn	J3-3	XA1-M	wht-gra	R10-2	XA1-F	wht-yel-grn
CR2-ad	C8-2	*	J3-4	J4-4	wht	R11-1	R10-1	bare
CR2-ad	CR3-ad	bus bar	J3-5	A2-11	wht-grn	R11-2	Q6-E	wht-brn-gra
CR2-cath	C8-1	*	J3-6	J2-E	wht-orn	R11-2	XA1-E	wht-brn-gra
CR2-cath	TB1-10	wht	J3-7	R6-2	wht-vio	S1-1	J3-2	blu
CR3-ad	C5(-)	orn	J3-8	XA1-T	wht-red	S1-2	J3-1	yel
CR3-ad	C9-2	*	J3-9	XA1-C	wht-red-vio	T1#	TB2-8	(blk)*
CR3-ad	CR2-ad	bus bar	J4-3	XA1-M	wht-gra	T1#	TB2-7	(blk-grn)*
CR3-cath	C9-1	*	J4-4	J3-4	wht	T1#	TB2-5	(blk-red)*
CR3-cath	TB1-11	wht-vio	J4-5	A2-11	wht-grn	T1#	TB2-6	(blk-yel)*
CR4-ad	C6(-)	blu	J4-6	J2-E	wht-orn	T1#	TB1-3	(blu)*
CR4-ad	C10-2	*	J4-7	R6-2	wht-vio	T1#	TB1-1	(grn)*

*Denotes component leadwire. T1#Denotes transformer on early units.

Table 4-3. Point-to-Point Wiring List (Continued)

FROM	TO	COLOR	FROM	TO	COLOR	FROM	TO	COLOR
T1#	TB1-4	(orn)*	TB1-9	CR4-cath	vio	XA1-B	R9-1	gra
T1#	TB1-6	(red)*	TB1-10	CR2-cath	wht	XA1-C	J3-9	wht-red-vio
T1#	TB1-7	(red)*	TB1-11	CR3-cath	wht-vio	XA1-D	E3	vio
T1#	TB2-4	(red)*	TB1-12	XA1-Y	wht-blu	XA1-E	R11-2	wht-brn-gra
T1#	TB2-3	(red-yel)*	TB1-13	XA1-1	wht-red-gra	XA1-F	R10-2	wht-yel-grn
T1#	TB1-5	(vio)*	TB1-14	XA1-2	wht-red-grn	XA1-H	C6(-)	blu
T1#	TB2-2	(vio)*	TB2-2	T1#	(vio)*	XA1-K	C4(-)	grn
T1#	GND1	(wht)*	TB2-2	T1**	(blu)*	XA1-L	Q4-B	wht-brn-grn
T1#	TB1-2	(yel)*	TB2-2	XA1-AA	wht-red-blu	XA1-M	J3-3	wht-gra
T1**	TB2-4	(blk)*	TB2-3	T1#	(red-yel)*	XA1-M	J4-3	wht-gra
T1**	TB1-5	(blu)*	TB2-3	T1**	(red-yel)*	XA1-N	E2	blk
T1**	TB2-2	(blu)*	TB2-3	XA1-12	blk	XA1-N	XA1-12	bus wire
T1**	TB1-4	(brn)*	TB2-4	C5(+)	red	XA1-P	E1	red
T1**	TB1-1	(grn)*	TB2-4	T1#	(red)*	XA1-R	R8-2	wht-brn-yel
T1**	TB1-6	(orn)*	TB2-4	T1**	(blk)*	XA1-S	R7-2	wht-yel-blu
T1**	TB1-3	(red)*	TB2-5	T1#	(blk-red)*	XA1-T	J3-8	wht-red
T1**	TB2-5	(red-wht-blk)*	TB2-5	T1**	(red-wht-blk)*	XA1-U	C5(-)	orn
T1**	TB2-3	(red-yel)*	TB2-5	TB2-6	bus bar	XA1-V	Q1-B	wht-blk-yel
T1**	TB1-7	(vio)*	TB2-5	TB3-1	wht-gra	XA1-W	R6-1	brn
T1**	GND1	(wht)*	TB2-6	T1#	(blk-yel)*	XA1-X	R9-2	wht-vio
T1**	TB2-8	(wht-blk)*	TB2-6	T1**	(wht-blk-yel)*	XA1-Y	TB1-12	wht-blu
T1**	TB2-6	(wht-blk-yel)*	TB2-6	TB2-5	bus bar	XA1-Y	XA1-21	bus wire
T1**	TB2-7	(wht-grn)*	TB2-7	T1#	(blk-grn)*	XA1-Z	C4(+)	red
T1**	TB1-2	(yel)*	TB2-7	T1**	(wht-grn)*	XA1-Z	XA1-22	bus wire
TB1-1	T1#	(grn)*	TB2-7	TB2-8	bus bar	XA1-AA	TB2-2	wht-red-blu
TB1-1	T1**	(grn)*	TB2-7	TB3-4	wht-grn-gra	XA1-AA	XA1-23	bus wire
TB1-2	T1#	(yel)*	TB2-8	K1-6	blk	XA1-BB	A2-10	wht-red-yel
TB1-2	T1**	(yel)*	TB2-8	T1#	(blk)*	XA1-BB	XA1-24	bus wire
TB1-3	T1#	(blu)*	TB2-8	T1**	(wht-blk)*	XA1-1	TB1-13	wht-red-gra
TB1-3	T1**	(red)*	TB3-1	B1	*	XA1-2	TB1-14	wht-red-grn
TB1-4	T1#	(orn)*	TB3-1	DS1-2	wht-gra	XA1-12	TB2-3	blk
TB1-4	T1**	(brn)*	TB3-1	FL1-3	wht-gra	XA1-12	XA1-N	bus wire
TB1-5	T1#	(vio)*	TB3-1	TB2-5	wht-gra	XA1-21	XA1-Y	bus wire
TB1-5	T1**	(blu)*	TB3-2	DS1-1	gra	XA1-22	XA1-Z	bus wire
TB1-6	T1#	(red)*	TB3-2	R1-1	*	XA1-23	XA1-AA	bus wire
TB1-6	T1**	(orn)*	TB3-4	B1	*	XA1-24	XA1-BB	bus wire
TB1-7	T1#	(red)*	TB3-4	R1-2	*	XF1-1	J1-L	gra
TB1-7	T1**	(vio)*	TB3-4	TB2-7	wht-grn-gra	XF1-2	FL1-4	wht-brn-gra
TB1-8	CR1-cath	brn						

*Denotes component leadwire.
T1#Denotes transformer on early units.
T1**Denotes transformer on later units.

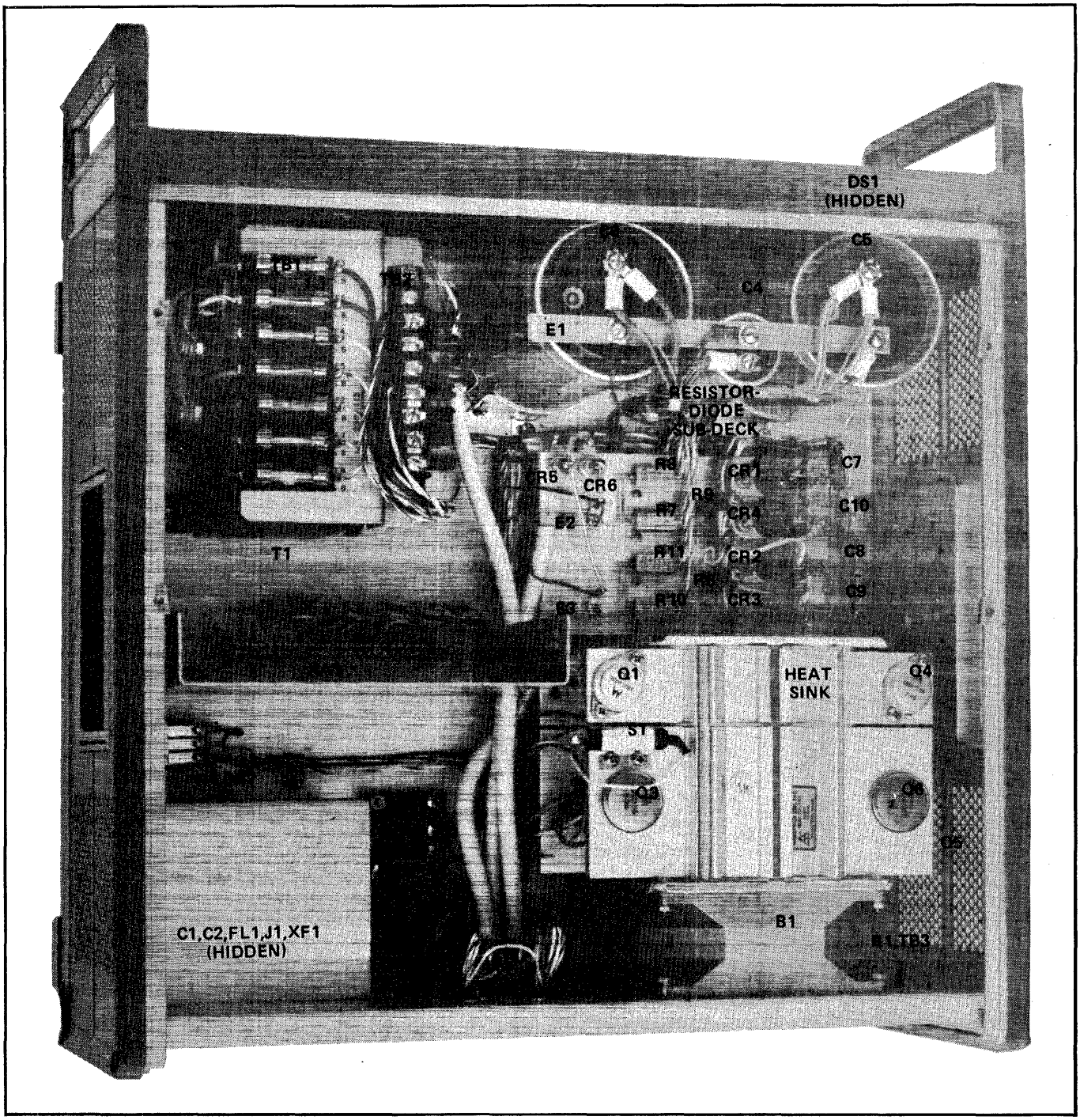


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Figure 4-5. HP 2160A Power Supply Extender, Parts Location Diagram

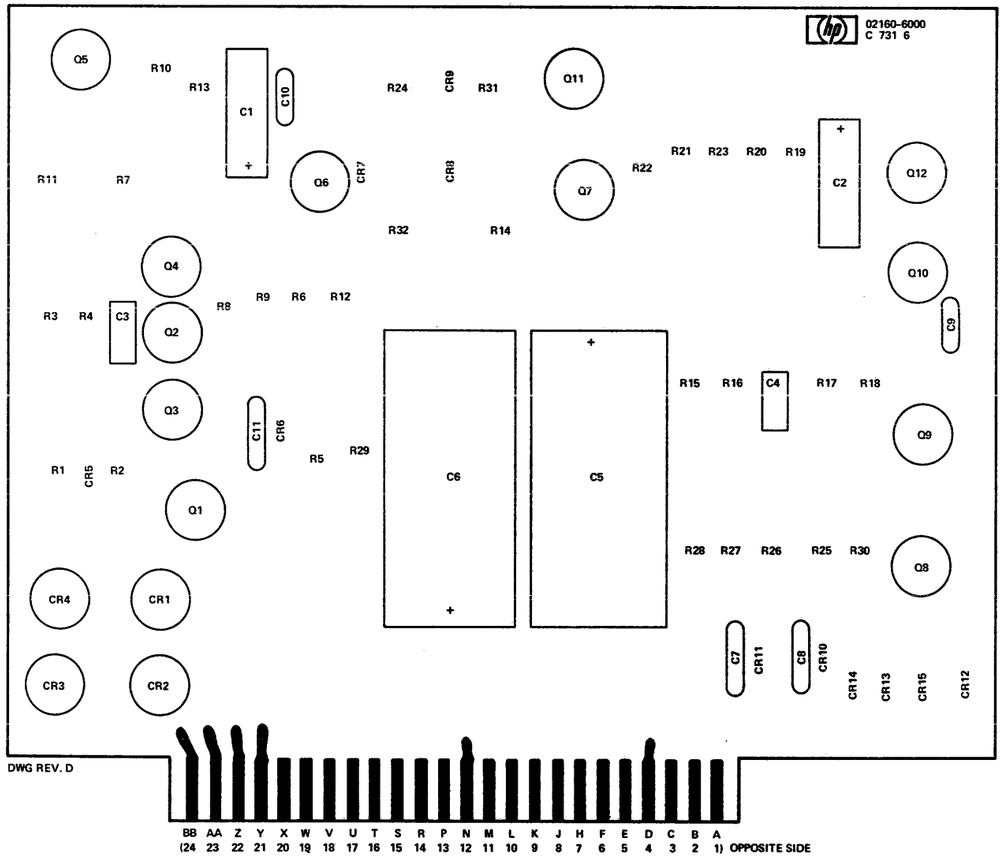
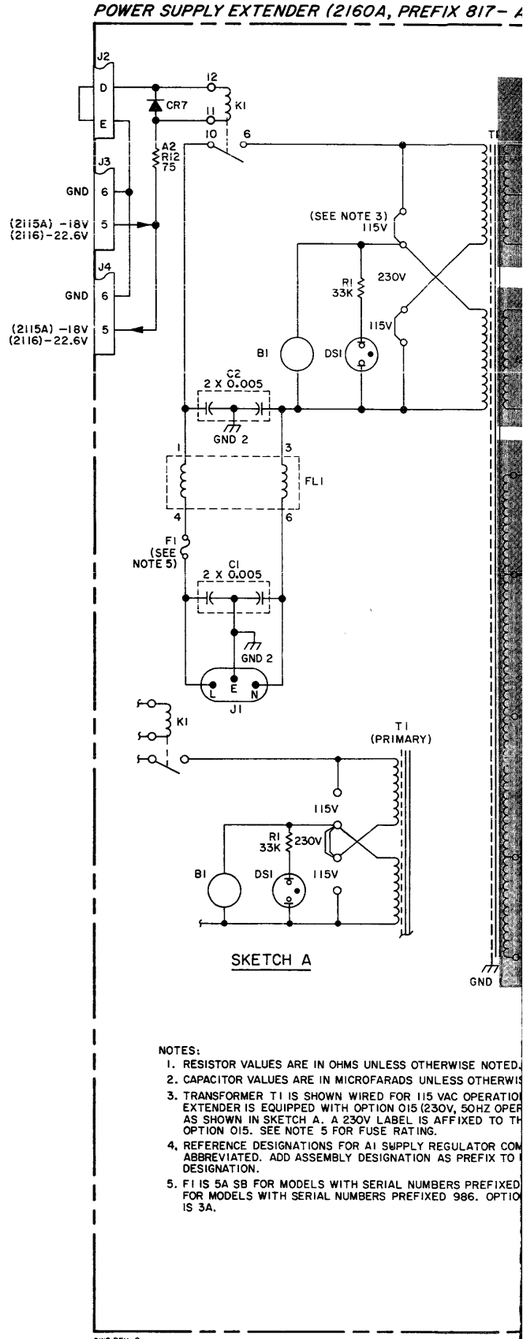


Figure 4-6. Supply Regulator Card A1, Parts Location Diagram



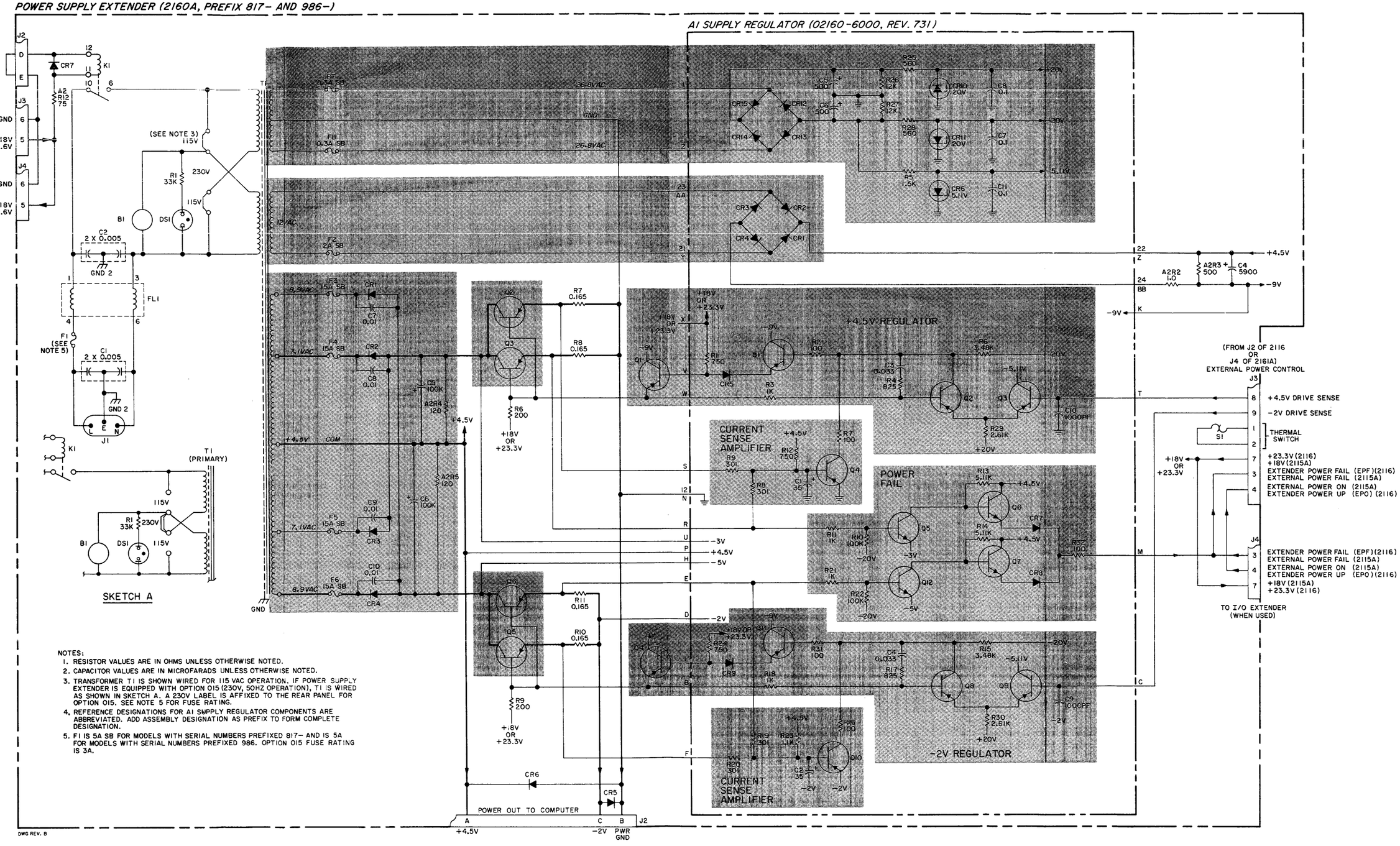


Figure 4-7. HP 2160A Power Supply Extender, Schematic Diagram

SECTION V
REPLACEABLE PARTS

5-1. INTRODUCTION.

5-2. This section provides information for ordering replacement parts for the HP 2160A Power Supply Extender. Table 5-1 lists parts in alphanumeric order of the reference designations for the entire power supply extender. Part numbers and descriptions for each reference designation are included. Table 5-2 lists parts for the printed-circuit card (A1). Table 5-3 lists parts for resistor board A2. Parts location information for the power supply extender is contained in figures 4-5 and 4-6.

5-3. Tables 5-1 through 5-3 list the following information for each part.

a. Reference designation (alphanumeric order).

b. Hewlett-Packard part number

c. Description of the part. (Refer to table 5-5 for an explanation of abbreviations used in the DESCRIPTION column.)

d. Typical manufacturer of the part in a five-digit code; refer to list of manufacturers in table 5-4.

e. Manufacturer's part number.

5-4. ORDERING INFORMATION.

5-5. To order replacement parts, address the order or inquiry to the nearest Hewlett-Packard Sales and Service Office. (Refer to the list at the end of this manual for addresses.) Specify the following information for each part ordered:

a. Equipment model and serial number.

b. Hewlett-Packard stock number for each part.

c. Description of each part.

d. Circuit reference designation (if applicable).

5-6. To obtain a part that may not be listed include the following information in the order:

a. Equipment model and serial number.

b. Description of the part.

c. Function and location of the part within the equipment.

Table 5-1. HP 2160A Power Supply Extender, Replaceable Parts

REFERENCE DESIGNATION	HP PART NO.	DESCRIPTION	MFR CODE	MFR PART NO.
A1	02160-6000	Supply Regulator Card	28480	02160-6000
A2	02160-6002	Resistor Board	28480	02160-6002
B1	3160-0072	Fan Assy Tubeaxial, 115 Vac, 50 to 60 Hz	28480	3160-0072
C1,2	0160-3043	Capacitor, Fxd, Cer, dual 0.005 uF, ±20%, 250 VACW	56289	29C147A-CDH
C4	0180-1977	Capacitor, Fxd, Al, 5900 uF, -10% +75%, 50 VDCW	28480	0180-1977
C5,6	0180-1875	Capacitor, Fxd, Al, 100,000 uF, -10% +75%, 20 VDCW	28480	0180-1875
C7 thru C10	0150-0093	Capacitor, Fxd, Cer, 0.01 uF, -10% +80%, 100 VDCW	28480	0150-0093
CR1 thru CR4	1901-0344	Diode, Si, 50V, 50A	28480	1901-0344
CR5,6	1901-0496	Diode, Si, 100 PIV, 12A	04713	MR1121
CR7	1901-0045	Diode, Si, 100 PIV, 0.75A	04713	SR1358-7
*DS1	1450-0048	Lamp, Neon, red	72765	599-124
**DS1	1450-0419	Lamp, Neon, Translucent white	28480	1450-0419
E1	02160-0008	Bus Bar, Capacitor	28480	02160-0008
E2,3	0360-1279	Shorting Strip	28480	0360-1279
*F1	2110-0030	Fuse, 125V, 5A, SB	75915	313005
**F1	2110-0010	Fuse, 250V, 5A, 3AG	00000	OBD
F1	2110-0003	Fuse, 250V, 3A, 3AG (Option 015 only)	00000	OBD
F2	2110-0006	Fuse, 125V, 2A, SB	71400	MDL2
F3 thru F6	2110-0025	Fuse, 32V, 15A, SB	75915	313015
F7,8	2110-0044	Fuse, 250V, 0.3A, SB	00000	OBD
FL1	9100-1834	Line filter, ac, 20A	28480	9100-1834
*J1	1251-0148	Connector, Receptacle, 3 pin male	87930	1065-1
**J1	1251-2357	Connector, Receptacle, 3 pin male, 6A, 250V	82389	EAC-301
J2	1251-1965	Connector, Receptacle, 6 pin	28480	1251-1965
J3,4	1251-0143	Connector, Receptacle, 14 contacts	28480	1251-0143
*K1	0490-0474	Relay, 3 pdt, 10A, 115V ac or 32 Vdc contacts; 12 Vdc, 100-ohm coil	94696	88X324
**K1	0490-0930	Relay, dpdt, 10A contacts; 12 Vdc, 120-ohm coil	28480	0490-0930
Q1,4	1850-0098	Transistor, Ge, PNP	28480	1850-0098
Q2,3,5,6	1850-0198	Transistor, Ge, PNP	04713	2N2156
R1	0686-3335	Resistor, Fxd, Comp. 33K ohms, ±5%, 1/2W	01121	EB3335
R6,9	0816-0031	Resistor, Fxd, WW, 200 ohms, ±10%, 10W	28480	0816-0031
R7,8,10,11	0811-2557	Resistor, Fxd, WW, 0.165 ohms, ±1%, 10W	28480	0811-2557
S1	3103-0004	Thermal Switch, 2A, 115V ac, 75 -2°C	28480	3103-0002
***TI	9100-1225	Transformer, power	28480	9100-1225
TB1	2110-0271	Fuseholder	28480	2110-0271
TB2	0360-1255	Terminal Strip	00000	OBD
TB3	0360-0018	Terminal Board	71785	332-14-05-035
XA1	1251-0335	Connector, 48 pin	28480	1251-0335
XF1	1400-0084	Fuseholder, Post Type	75915	342014

*Serial no. prefix 817- only.
**Serial no. prefix 986- only.
***A replacement power transformer (T1, part number 9100-1225) is equipped with fuseholder TB1, terminal strip TB2, and the associated mounting bracket.

Table 5-2. Supply Regulator Card A1 (02160-6000), Replaceable Parts

REFERENCE DESIGNATION	HP PART NO.	DESCRIPTION	MFR CODE	MFR PART NO.
C1,2	0180-0064	Capacitor, Fxd, Al, 35 uF, -10% +100%, 6 VDCW	56289	30D356G006BB2-DSB
C3,4	0160-0163	Capacitor, Fxd, Mylar, 0.033 uF, ±10%, 200 VDCW	56289	192P33392-PTS
C5,6	0180-1866	Capacitor, Fxd, Al, 500 uF, -10% +75%, 75 VDCW	56289	39D507G075HL4-DSB
C7,8,11	0150-0121	Capacitor, Fxd, Cer, 0.1 uF, -20% +80%, 50 VDCW	56289	5C50B1-CMI
C9,10	0150-0050	Capacitor, Fxd, Cer, 1000 pF, 1000 VDCW	56289	C067B102E102Z-S26-CDH
CR1 thru CR4	1901-0416	Diode, Si, 200 PIV, 3A	28480	1901-0416
CR5,9	1901-0025	Diode, Si, 150 PIV, 0.2A	07263	FD2387
CR6	1902-0041	Diode, Breakdown, 5.11V, 5%, 400 mW	04713	SZ10939-98
CR7,8	1901-0040	Diode, Si, 30V, 0.05A	07263	FDG1088
CR10,11	1902-0556	Diode, Breakdown, 20V, 5%, 1W	28480	1902-0556
CR12 thru CR15	1901-0026	Diode, Si, 200 PIV, 0.75A	04713	SR1358-8
Q1 thru Q3,8,9,11	1853-0001	Transistor, Si, PNP	07263	S-3251
Q4,10	1850-0062	Transistor, Ge, PNP	01295	GA287
Q5,12	1851-0017	Transistor, Ge, NPN	01295	2N1304
Q6,7	1854-0215	Transistor, Si, NPN	04713	SPS3611
R1,24	0761-0058	Resistor, Fxd, Met Ox, 750 ohms ±5%, 1W	28480	0761-0058
R2,7,16,31,32	0757-0198	Resistor, Fxd, Flm, 100 ohms ±1%, 1/2W	28480	0757-0198
R3,11,18,21	0757-0159	Resistor, Fxd, Flm, 1000 ohms ±1%, 1/2W	28480	0757-0159
R4,17	0757-0818	Resistor, Fxd, Flm, 825 ohms ±1%, 1/2W	28480	0757-0818
R5	0761-0015	Resistor, Fxd, Met Ox, 1500 ohms ±5%, 1W	28480	0761-0015
R6,15	0698-3411	Resistor, Fxd, Flm, 3480 ohms ±1%, 1/2W	28480	0698-3411
R8,9,19,20	0757-0808	Resistor, Fxd, Flm, 301 ohms ±1%, 1/2W	28480	0757-0808
R10,22	0758-0053	Resistor, Fxd, Flm, 100K ohms ±5%, 1/2W	28480	0758-0053
R12	0757-0817	Resistor, Fxd, Flm, 750 ohms ±1%, 1/2W	28480	0757-0817
R13,14	0757-0833	Resistor, Fxd, Flm, 5.11K ohms ±1%, 1/2W	28480	0757-0833
R23	0757-0820	Resistor, Fxd, Flm, 1100 ohms ±1%, 1/2W	28480	0757-0820
R25,28	0761-0057	Resistor, Fxd, Met Ox, 560 ohms ±5%, 1W	28480	0761-0057
R26,27	0686-1235	Resistor, Fxd, Comp, 12K ohms ±5%, 1/2W	01121	EB1235
R29,30	0698-0024	Resistor, Fxd, Flm, 2610 ohms ±1%, 1/2W	28480	0698-0024

Table 5-3. Kingman Board Assembly A2 (02160-6002), Replaceable Parts

REFERENCE DESIGNATION	HP PART NO.	DESCRIPTION	MFR CODE	MFR PART NO.
R2	0811-0040	Resistor, Fxd, WW, 1 ohm, 1%, 5W	28480	0811-0040
R3	0811-1858	Resistor, Fxd, WW, 500 ohms, 5%, 5W	28480	0811-1858
R4,5	0811-2138	Resistor, Fxd, WW, 120 ohms, 5%, 5W	28480	0811-2138
R12	0812-0097	Resistor, Fxd, WW, 75 ohms, 5%, 5W	28480	0812-0097

Table 5-4. Code List of Manufacturers

The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 and H4-2, and their latest supplements.

Code No.	Manufacturer	Address
00000	U.S.A. Common	Any supplier of U.S.
01121	Allen Bradley Co.	Milwaukee, Wis.
01295	Texas Instruments, Inc., Transistor Products Div.	Dallas, Texas
04713	Motorola Inc., Semiconductor Products Div.	Phoenix, Arizona
07263	Fairchild Camera & Inst. Corp., Semiconductor Div.	Mountain View, Cal.
28480	Hewlett-Packard Co.	Palo Alto, Cal.
56289	Sprague Electric Co.	North Adams, Mass.
71400	Bussmann Mfg. Division of McGraw-Edison Co.	St. Louis, Mo.
71785	Cinch Mfg. Co. Howard B. Jones Div.	Chicago, Ill.
72765	Drake Mfg. Co.	Harwood Heights, Ill.
75915	Littlefuse, Inc.	Des Plaines, Ill.
82389	Switchcraft, Inc.	Chicago, Ill.
87930	Tower Mfg. Corp.	Providence, R.I.
94696	Magnecraft Electric Co.	Chicago, Ill.

Table 5-5. Reference Designations and Abbreviations

REFERENCE DESIGNATIONS

A	= assembly	K	= relay	TB	= terminal board
B	= motor, synchro	L	= inductor	TP	= test point
BT	= battery	M	= meter	U	= integrated circuit, non-repairable assembly
C	= capacitor	MC	= microcircuit	V	= vacuum tube, photocell, etc.
CB	= circuit breaker	P	= plug connector	VR	= voltage regulator
CR	= diode	Q	= semiconductor device other than diode or microcircuit	W	= cable, jumper
DL	= delay line	R	= resistor	X	= socket
DS	= indicator	RT	= thermistor	Y	= crystal
E	= Misc electrical parts	S	= switch	Z	= tuned cavity, network
F	= fuse	T	= transformer		
FL	= filter				
J	= receptacle connector				

ABBREVIATIONS

A	= amperes	gra	= gray	ph	= Phillips head
ac	= alternating current	grn	= green	pk	= peak
ad	= anode			p-p	= peak-to-peak
Al	= aluminum	H	= henries	pt	= point
AR	= as required	Hg	= mercury	PIV	= peak inverse voltage
adj	= adjust	hr	= hour(s)	PNP	= positive-negative-positive
assy	= assembly	Hz	= hertz	PWV	= peak working voltage
		hdw	= hardware	porc	= porcelain
B	= base	hex	= hexagon, hexagonal	posn	= position(s)
bp	= bandpass			pozi	= pozidrive
blk	= black	ID	= inside diameter		
blu	= blue	IF	= intermediate frequency		
brn	= brown	in.	= inch, inches	rf	= radio frequency
brs	= brass	I/O	= input/output	rdh	= round head
Btu	= British thermal unit	int	= internal	rmo	= rack mount only
Be Cu	= beryllium copper	incl	= include(s)	rms	= root-mean-square
		insul	= insulation, insulated	RWV	= reverse working voltage
C	= collector	impgrg	= impregnated	rect	= rectifier
cw	= clockwise	incand	= incandescent	r/min	= revolutions per minute
ccw	= counterclockwise			RTL	= resistor-transistor logic
cer	= ceramic	k	= kilo (10^3), kilohm		
cmo	= cabinet mount only			s	= second
com	= common	lp	= low pass	SB	= slow blow
crt	= cathode-ray tube			Se	= selenium
CTL	= complementary-transistor logic	m	= milli (10^{-3})	Si	= silicon
		M	= mega (10^6), megohm	scr	= silicon controlled rectifier
cath	= cathode	My	= Mylar	sil	= silver
cd pl	= cadmium plate	mfr	= manufacturer	sst	= stainless steel
Comp	= composition	mom	= momentary	stl	= steel
conn	= connector	mtg	= mounting	spcl	= special
compl	= complete	misc	= miscellaneous	spdt	= single-pole, double-throw
		Met Ox	= metal oxide	spst	= single-pole, single-throw
dc	= direct current	mintr	= miniature	semicond	= semiconductor
dr	= drive				
DTL	= diode-transistor logic	n	= nano (10^{-9})	Ta	= tantalum
depc	= deposited carbon	n.c.	= normally closed or no connection	td	= time delay
dpdt	= double-pole, double-throw			Ti	= titanium
dpst	= double-pole, single-throw	Ne	= neon	tgl	= toggle
		no.	= number	thd	= thread
E	= emitter	n.o.	= normally open	tol	= tolerance
ECL	= emitter-coupled logic	np.	= nickel plated	TTL	= transistor transistor logic
ext	= external	NPN	= negative-positive-negative		
encap	= encapsulated	NPO	= negative-positive zero (zero temperature coefficient)	U(μ)	= micro (10^{-6})
elctlt	= electrolytic	NSR	= not separately replaceable		
		NRFR	= not recommended for field replacement	V	= volt(s)
F	= farads			var	= variable
FF	= flip-flop			vio	= violet
flh	= flat head	OD	= outside diameter	VDCW	= direct current working volts
Flm	= film	OBD	= order by description		
Fxd	= fixed	orn	= orange	W	= watts
filh	= fillister head	ovh	= oval head	WW	= wirewound
		oxd	= oxide	wht	= white
G	= giga (10^9)			WIV	= working inverse voltage
Ge	= germanium	p	= pico (10^{-12})		
gl	= glass	PC	= printed circuit	yel	= yellow
gnd	= ground(ed)				

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