MODULAR POWER SUPPLIES

A, C, AND E SERIES

MODELS 62003A-62048A,

62003C-62048C, AND 62003E-62048E

OPERATING AND SERVICE MANUAL

FOR SERIALS 1210A-00101 AND ABOVE*

*For Serials Above 1210A-00101, a change page may be included.

Hewlett-Packard

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SECTION I
GENERAL INFORMATION

1-1 DESCRIPTION

1-2 Hewlett-Packard modular power supplies are completely solid-state, employing high-reliability transistors and integrated circuits. The power supplies are packaged in three uniform height and depth cases that are fractions of the standard 19-inch rack width. The supplies can be bench-operated or rack-mounted individually or in any combination to full rack width or less. The modular power supplies are of the Constant Voltage/Current Limiting type, furnishing full-rated output voltage at the maximum rated output current. The output voltage can be adjusted between ±0.5 V or ±5% (whichever is greater) of nominal while providing full-rated output current. The supply and load are fully protected from current overloads by a self-restoring current cutback circuit that causes the output current to cutback linearly from approximately 103% to approximately 10% of rated output as the load varies from slightly above the maximum rated value to a complete short circuit. The current limit (cutback) activation point is adjustable anywhere between the 103% and 10% limits.

1-3 Either the positive or negative output terminal may be grounded at the rear terminals.

1-4 SCOPE

1-5 This manual provides installation procedures, operating instructions, principles of operation, maintenance data, and replaceable parts information for the thirty-three Hewlett-Packard modular power supplies listed in the following chart. Note that the last two digits in the model number indicate the nominal output voltage of the supply. The —A suffix supplies are 1/8-rack width units while the —C and —E models are 1/4-rack width units.

1-6 SCHEMATICS

1-7 The modular power supplies covered in this manual are of similar design differing mainly in component values rather than in circuit operation. Hence, in general, the information presented in the manual applies to all of the power supply models with any significant differences among the supplies described as applicable. Thus, the schematic diagrams at the rear of the manual depict groups of similar supplies with five

DC OUTPUT		MODEL
NOMINAL VOLTAGE (Minimum Adj. Span)	CURRENT AT 50°C	
3V (±0.5V)	2A	62003A
	4.25A	62003C
	8.5A	62003E
4V (±0.5V)	2A	62004A
	4A	62004C
	8A	62004E
5V (±0.5V)	2A	62005A
	4A	62005C
	8A	62005E
6V (±0.5V)	1.75A	62006A
	3.75A	62006C
	7.5A	62006E
10V (±0.5V)	1.5A	62010A
	3.25A	62010C
	6.5A	62010E
12V (±0.60V)	1.5A	62012A
	3.0A	62012C
	6.0A	62012E
15V (±0.75V)	1.25A	62015A
	2.5A	62015C
	5.0A	62015E
18V (±0.90V)	1.0A	62018A
	2.25A	62018C
	4.5A	62018E
24V (±1.20V)	.75A	62024A
	1.75A	62024C
	3.75A	62024E
28V (±1.40V)	.7A	62028A
	1.5A	62028C
	3.25A	62028E
48V (±2.40V)	.45A	62048A
	1.0A	62048C
	2.0A	62048E

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schematics provided to illustrate all 33 models. Each schematic, of course, identifies the supplies for which it applies and includes notes and tables to identify the difference (mainly in component values) among the supplies illustrated in the common schematic.

1-8 SPECIFICATIONS

1-9 Detailed specifications for the power supplies are given in Table 1-1.

Table 1-1. Specifications

INPUT:
115Vac ±10%, single phase, 48-63 Hz. See Options 101, 102, and 103.

OUTPUT:
See Paragraph 1-5.

LOAD REGULATION:
Less than 0.01% or 1 mV whichever is greater for a full load to no load change in output current.

LINE REGULATION:
Less than 0.01% or 1 mV whichever is greater for a 10% change in the specified input voltage.

RIPPLE AND NOISE:
Less than 1 mV rms and 2 mV p-p (up to 20 MHz).

TEMPERATURE RANGES:
Operating: 0 to 50°C ambient. Output current derated linearly for temperatures greater than 50° with 50% of maximum output current at 71°C ambient.
Storage: –55°C to +85°C
Cooling: Convection cooled.

TEMPERATURE COEFFICIENT:
Less than 0.01% output voltage change per degree Centigrade over the operating range from 0 to 50°C after 30 minutes warmup.

THERMAL PROTECTION:
Heat sink mounted thermostat opens ac line if supply overheats due to high ambient temperature. Thermostat automatically closes (reset) when temperature cools to safe operating level.

STABILITY:
Less than 0.1% total drift for 8 hours after an initial warm-up time of 30 minutes at constant ambient, constant line voltage, and constant load.

TRANSIENT RECOVERY TIME:
Less than 50 μsec for output recovery to within 15 mV of nominal output voltage following a load change from full to half load (or vice versa).

OVERLOAD PROTECTION:
A current limit circuit cuts back current linearly to approximately 10% of rated output current when supply is short-circuited. Automatically resets when overload removed. Current limit activation point adjustable (screwdriver control) but preset at factory to activate at 104 ±1% of maximum rated output current at nominal output voltage.

OUTPUT CONTROL:
Screwdriver adjustment accessible through hole in front panel. Minimum adjustment range is ±0.5 V or ±5%, whichever is greater.

ERROR SENSING:
Error sensing normally accomplished locally at rear terminals. Provision included at rear terminal strip for remote sensing with correction for load lead voltage drops of up to 0.5 V total. Load protected if sensing terminals inadvertently opened.

MOUNTING:
Three mounting surfaces provided for mounting in the upright position. For mounting orientations other than upright, adequate cooling is required. See Section II.

DIMENSIONS:

A– suffix models: 1.91" W x 5.03" H x 12.25" D (48 mm W x 128mm H x 311mm D)
C– & E– suffix models: 3.94" W x 5.03" H 12.25" D (100 mm W x 128mm H x 311mm D)

WEIGHT (net/shipping):

A– suffix Models: 6 lbs (2, 7 kg)/8 lbs (3, 6 kg)
C– suffix Models: 10 lbs (4, 5 kg)/12 lbs (5, 4 kg)
E– suffix Models: 13 lbs (5, 9 kg)/16 lbs (7, 3 kg)

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1-10 OPTIONS

1-11 Options are factory modifications of a standard instrument that are requested by the customer. The following options are available for the instruments covered by this manual. Where necessary, detailed coverage of the options are included in the manual.

OPTION NO.	DESCRIPTION
011	**Overvoltage Protection "Crowbar":** A completely separate circuit for protecting delicate loads against power supply failure or operator error. The crowbar circuit monitors the output voltage and within 10 μsec imposes a virtual short-circuit (conducting SCR or triac) across the power supply output if the preset overvoltage margin is exceeded. The crowbar circuit is contained on a printed wiring board that is mounted inside the power supply. The activation (trip) voltage of the crowbar is adjustable (screwdriver adjustment) over the following minimum range: from +0.5 Vdc above minimum rated output voltage to +2 Vdc above maximum rated output voltage.
101	**220 Vac, single phase input:** Supply is normally shipped with a 120 Vac (nominal) transformer . Option 101 replaces this transformer with a 220 Vac (nominal) transformer and allows operation from a 190-233 Vac, 48-63 Hz single phase input.
102	**240 Vac, single phase input:** Supply is normally shipped with a 120 Vac (nominal) transformer. Option 102 replaces this transformer with a 240 Vac (nominal) transformer and allows operation from a 208-254 Vac, 48-63 Hz, single phase input.
103	**120 Vac/240 Vac, single phase input:** Supply is normally shipped with a 120 Vac (nominal) transformer. Option 103 replaces this transformer with a 120 Vac/240 Vac (nominal) multi-tap transformer and allows field-changeable operation from 104-127 Vac or 208-254 Vac, 48-63 Hz single phase input.
104	**System Control:** This option allows the user to control the supply's overvoltage protection "crowbar" circuit as well as output voltage. The 104 option includes the same internal, adjustable overvoltage protection crowbar as provided with the 011 option. In addition, the 104 option crowbar includes external (from a rear terminal strip) pulse control capability that allows the crowbar to be either externally triggered or which provides an output pulse to indicate that the crowbar has triggered. The crowbar pulse specifications are: Input Trigger Pulse: Voltage: 8 — 15 V Width (between 90% point at leading edge and 10% point at falling edge): 5 μsec — 2 msec Output Pulse: Voltage: 2 — 12 V Width (between 90% point at leading edge and 10% point at falling edge): 2 — 20 μsec Load Impedance: 1 KΩ (min.) In addition to the crowbar trigger external access, the 104 option also includes access (from a rear terminal strip) to the summing point of the supply to enable the dc output voltage to be remotely programmed to zero (±15 mVdc max.) with a contact closure.

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1-12 ACCESSORIES

1-13 The accessories listed below may be ordered with the power supply or separately from your local Hewlett-Packard field sales office (refer to list at rear of manual for addresses).

HP Part No.	Description
62410A	Rack Mounting Tray for mounting any combination of supplies. 19" wide, 5-1/4" high, and 17" deep. (Refer to Section II for details.)
62411A	Rack Tray Blank Front Panel, 10-1/2" wide, 5-3/16" high, 1/8" thick.
62412A	Rack Tray Blank Rear Panel, mounts on rear of rack mounting tray and allows installation of custom input/output connectors or other hardware.
62415A	Rack Tray AC Distribution Panel mounts on rear of rack mounting tray and includes ac input terminal strip and line card.
62414A	Rack Tray Slides provide easy access to rack mounting tray and its supplies.
62413A	Rack Mounting Tray Cooling Unit provides forced air cooling of rack-mounted supplies.

1-14 INSTRUMENT/MANUAL IDENTIFICATION

1-15 Hewlett-Packard power supplies are identified by a two-part serial number. The first part is the serial number prefix, a number-letter combination that denotes the date of a significant design change and the country of manufacture. The first two digits indicate the year (10 = 1970, 11 = 1971, etc.), the second two digits indicate the week, and the letter "A" designates the U.S.A. as the country of manufacture. The second part is the power supply serial number; a different sequential number is assigned to each power supply, starting with 00101.

1-16 If the serial number on your instrument does not agree with those on the title page of the manual, Change Sheets supplied with the manual or Manual Backdating Changes define the differences between your instrument and the instrument described by this manual.

1-17 ORDERING ADDITIONAL MANUALS

1-18 One manual is shipped with each power supply. Additional manuals may be purchased from your local Hewlett-Packard field office (see list at rear of this manual for addresses). Specify the model number, serial number prefix, and HP Part number provided on the title page.

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SECTION II
INSTALLATION

2-1 INITIAL INSPECTION

2-2 Before shipment, this instrument was inspected and found to be free of mechanical and electrical defects. As soon as the instrument is unpacked, inspect for any damage that may have occurred in transit. Save all packing materials until the inspection is completed. If damage is found, a claim should be filed with the carrier immediately. Also, a Hewlett-Packard Sales and Service office should be notified.

2-3 Mechanical Check

2-4 This check should confirm that there are no broken connectors and that the panel surfaces are free of dents and scratches.

2-5 Electrical Check

2-6 The instrument should be checked against its electrical specifications. Section V includes an "in-cabinet" performance check to verify proper instrument operation.

2-7. INSTALLATION DATA

2-8 The instrument is shipped ready for bench operation. It is necessary only to connect the instrument to a source of power and it is ready for operation.

2-9 Location

2-10 This instrument is air cooled. Sufficient space should be allotted so that a free flow of cooling air can reach the instrument when it is in operation. At least 1/2-inch clearance at the bottom of the unit is recommended to permit proper air flow. The supply should be used in an area where the ambient temperature does not exceed 50°C. If operated at an ambient greater than 50°C, the supply's output current must be linearly derated down to 50% at 71°C.

NOTE

If the power supply must be operated in a restricted air flow environment, the supply's power consumption (and heat dissipation requirements) can be minimized by operating at low line input voltage. Consult your nearest HP sales engineer for more information on the cooling requirements for your specific operation

2-11 Mounting Orientation

2-12 Figure 2-1 shows outline and dimension information for each modular power supply size. As shown, holes are provided on three surfaces of the supplies any of which can be used to install the supply in the upright position. If the top mounting holes are used; however, be sure that a rigid top support is employed to support the weight of the unit(s). Note that if any other orientation other than upright is required, adequate air flow must be provided; see your nearest HP sales engineer for additional information.

2-13 Rack Mounting

2-14 The modular power supplies can be readily mounted in any combination in a standard 19-inch rack using the Hewlett-Packard Rack Mounting Tray, Model 62410A. The supplies are mounted upright and attached to the tray using the two (A— suffix models) or four (C— and E— suffix models) 10-32 threaded mounting holes located in the bottom of the supply case. The maximum number of supplies that can be mounted in the tray depends on the types of supplies used. For example, if all 1/8-width (A— suffix) supplies are employed, eight modular power supplies can be mounted in the tray. Of course, the tray does not have to be filled to capacity.

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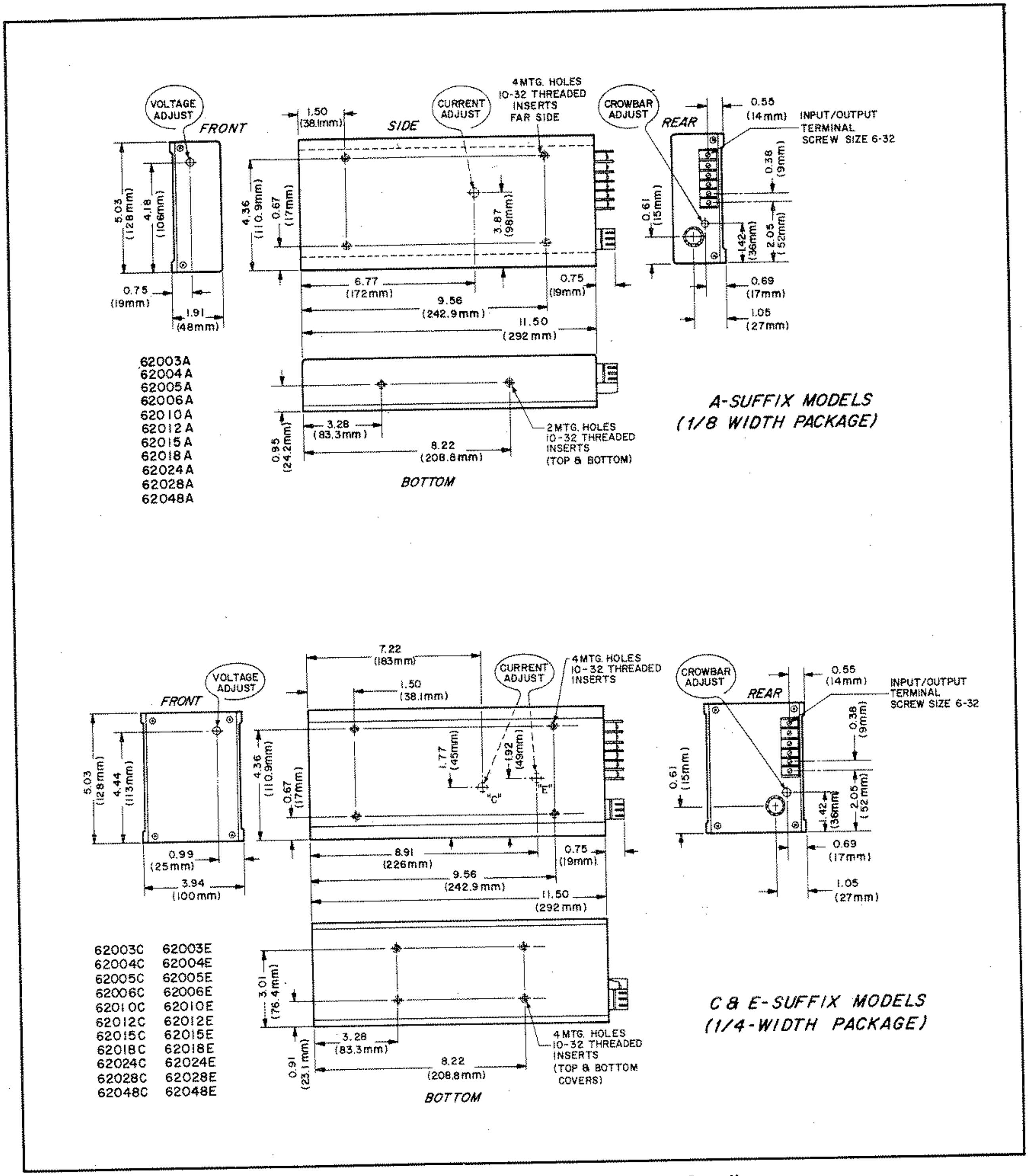

Figure 2-1. Outline Diagrams, Modular Power Supplies

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2-15 INPUT POWER REQUIREMENTS

2-16 The modular power supplies may be operated from a nominal 120 Vac, 220 Vac, or 240 Vac, 48-63 Hz, power source. The standard supply (no options) is shipped from the factory wired for 120 Vac (nominal) operation and requires the following maximum input current and power at high line (127 Vac) voltage input:

MODEL	AC INPUT at 127 Vac	
	CURRENT (Max.)	POWER (Max.)
62003A	.30A	31W
62003C	.77A	74W
62003E	1.38A	143W
62004A	.33A	34W
62004C	.78A	76W
62004E	1.42A	149W
62005A	.37A	37W
62005C	.80A	79W
62005E	1.53A	160W
62006A	.36A	37W
62006C	.80A	79W
62006E	1.56A	161W
62010A	.39A	39W
62010C	.98A	97W
62010E	1.87A	192W
62012A	.47A	47W
62012C	1.00A	100W
62012E	1.89A	191W
62015A	.45A	46W
62015C	.99A	97W
62015E	1.82A	181W
62018A	.42A	42W
62018C	.97A	95W
62018E	1.93A	196W
62024A	.39A	39W
62024C	.93A	88W
62024E	1.95A	198W
62028A	.44A	44W
62028C	.91A	86W
62028E	1.87A	190W
62048A	.47A	47W
62048C	.97A	95W
62048E	2.00A	193W

2-17 220/240 VOLT OPERATION

2-18 As applicable, Options 101, 102, and 103 (installed at the factory) permit the supply to be operated from a 120, 220, or 240 Vac (nominal) input line. Option 101 provides for 220 Vac operation while Option 102 allows 240 Vac operation. Option 103, however, provides for either 120 Vac or 240 Vac operation at the selection of the user as described below.

2-19 Option 103 Power Transformer Connections, A– suffix Models. For the A– suffix models, the primary connections of the supply are changed at the inboard side of the rear power input terminals. For 120 Vac operation (as shipped), two leads are soldered from each of the ac input terminals as shown in Figure 2-2B. To connect the supply for 240 Vac operation, unsolder the wht/blk/yel and wht/blk/grn leads and twist them together with a wire terminal as shown in Figure 2-2A.

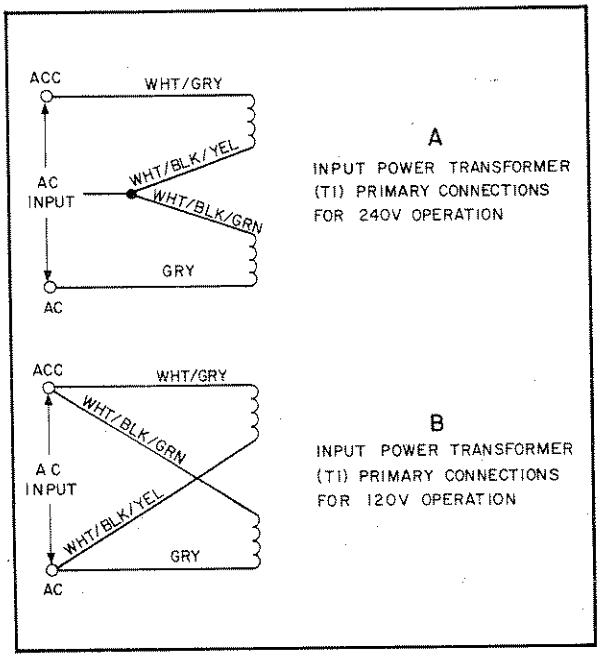

Figure 2-2. Primary Connections For 120/240 Vac Operation (Option 103) – A Suffix Models Only

2-20 Option 103 Power Transformer Connections, –C and E– Suffix Models. For the C– and E– suffix models, the appropriate power transformer 120/240 V terminals must be connected as shown in Figure 2-3. Notice that the transformer connections are changed at the transformer terminals shown in the illustration.

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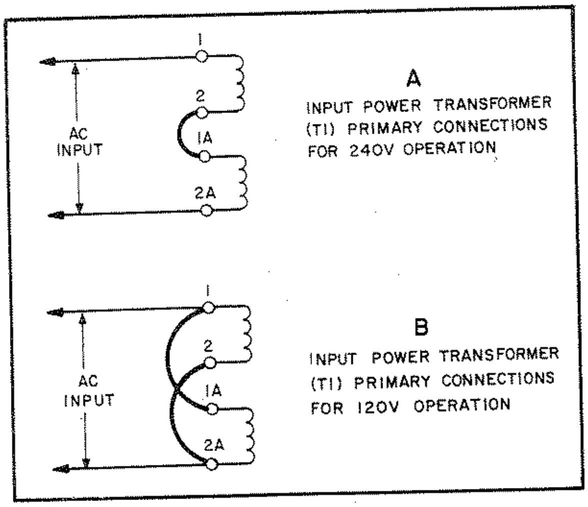

Figure 2-3. Primary Connections For 120/240 Vac Operation (option 103) —C and —E Suffix Models Only

2-21 REPACKAGING FOR SHIPMENT

2-22 To insure safe shipment of the instrument, it is recommended that the package designed for the instrument be used. The original packaging material is reusable. If it is not available, contact your local Hewlett-Packard field office to obtain the materials. This office will also furnish the address of the nearest service office to which the instrument can be shipped. Be sure to attach a tag to the instrument which specifies the owner, model number, full serial number, and service required, or a brief description of the trouble.

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SECTION III
OPERATING INSTRUCTIONS

3-1 TURN-ON CHECKOUT PROCEDURE

3-2 The following checkout procedure describes the use of the voltage control and ensures that the supply is operational.

a. Before connecting input power to unit, connect external voltmeter across +S and −S terminals at rear terminal board.

b. Connect unit to input power source using AC, ACC, and ground terminals at rear. (Use proper wire size in accordance with the input AC current rating.)

c. Observe output voltage of supply on external meter. Output is factory set to nominal voltage. If desired, VOLTAGE ADJUST (screwdriver control, accessible through cutout on front panel) potentiometer can be used to set output to any voltage within adjustment span (±0.5 V or ±5% as applicable).

NOTE

The current limit may require readjustment if the output voltage is set away from nominal. Refer to Paragraph 3-8.

d. To verify operation of current limit circuit, remove voltmeter and disconnect input power. Connect short across output terminals of supply and reconnect input power. Using clip-on milliammeter (HP Model 428B, or equivalent) observe that short circuit output current is approximately 3% to 15% of rated output current.

e. Remove short and milliammeter. *Before connecting actual load to supply, read the following paragraphs.*

3-3 OPERATION

3-4 The supply can be operated in one of two operating modes; normal or remote sensing. Auto-Series, Auto-Parallel, Auto-Tracking and remote programming operation are not feasible with this supply. The following paragraphs describe both of those modes plus supplementary operating information. More theoretical descriptions regarding the operational features of power supplies in general are given in application note 90A, DC Power Supply Handbook (available at no charge from your local HP sales office).

3-5 Normal Operating Mode

3-6 The power supply is shipped with the rear terminal straps connected for Constant Voltage/Current Limiting, local sensing, operation. This strapping pattern is illustrated in Figure 3-1. Before connecting a load to the supply, check the rear terminals to ensure that the connections are correct and that the connecting straps are tightened securely.

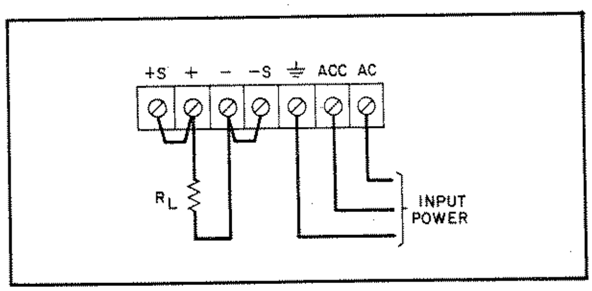

Figure 3-1. Normal Strapping

3-7 Current Limit

3-8 Figure 3-2 shows typical current limiting characteristics for all HP modular supplies. As indicated on the drawing, the current limit point varies in accordance with the output voltage. As received from the factory, the initial current limit point is set to 104 ±1% of the current rating with the output voltage at its nominal value. This same current limit setting is recommended for all output voltages within the adjustment span because: (1) the current limit crossover point must be at least 3% higher than the maximum expected operating current to prevent performance degradation; and (2) a current limit setting of higher than 105% of rating creates the possibility of excessive internal heating as specified in the caution note of Figure 3-2. Hence, the current limit potentiometer (accessible through a

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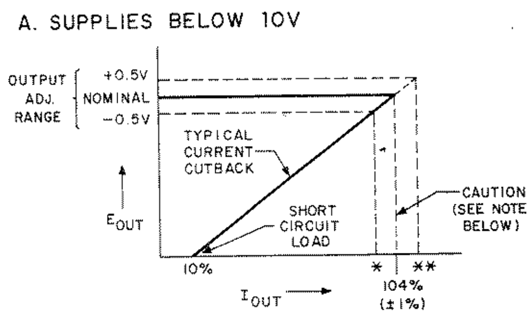
cutout in the side panel) may have to be readjusted to satisfy the above two requirements if the user intends to operate at an output voltage which is above or below nominal. For example, if the user has a supply of 10 Volts or above and requires an output voltage of +5% above nominal, the initial current limit point would be factory set to approximately 109% of rating. This violates the 105% current limit constraint mentioned previously and, thus, the current limit potentiometer would have to be adjusted (described in Section V) so that the current limit point is moved to 104 ±1% at the upper voltage limit rather than at nominal voltage.



NOMINAL OUTPUT	*	**
3V	89%	119%
4V	93%	115%
5V	95%	113%
6V	97%	111%

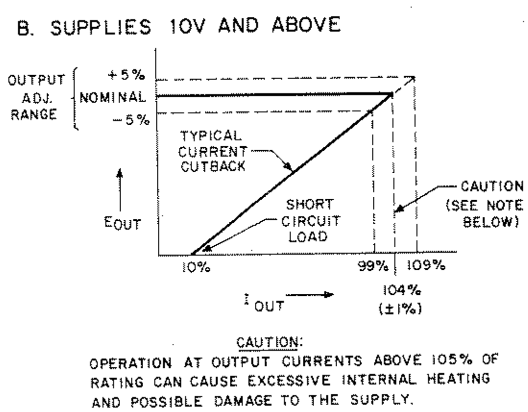


Figure 3-2. Typical Current Limiting Characteristics

3-9 Connecting Load

3-10 Each load should be connected to the proper supply output terminals using separate pairs of connecting wires. This will minimize mutual coupling effects between loads and will retain full advantage of the low output impedance of the power supply. Each pair of connecting wires should be as short as possible and twisted or shielded to reduce noise pickup. (If a shield is used, connect one end to power supply ground terminal and leave the other end unconnected.)

3-11 If load considerations require that the output power distribution terminals be remotely located from the power supply, then the power supply output terminals should be connected to the remote distribution terminals via a pair of twisted or shielded wires and each load separately connected to the remote distribution terminals. For this case, remote sensing should be used (Paragraph 3-13).

3-12 Positive or negative voltages can be obtained from this supply by grounding either one of the output terminals or one end of the load.

3-13 Remote Sensing (See Figure 3-3)

3-14 Remote sensing is used to maintain good regulation at the load by reducing the degradation in regulation that would occur due to the voltage drop in the leads between the power supply and the load. Remote sensing is accomplished by utilizing the strapping pattern shown in Figure 3-3. The power supply should be turned off before changing strapping patterns. The leads from the sensing terminals to the load will carry much less current than the load leads and it is not required that these leads be as heavy as the load leads. However, they must be twisted or shielded to minimize noise pick-up.

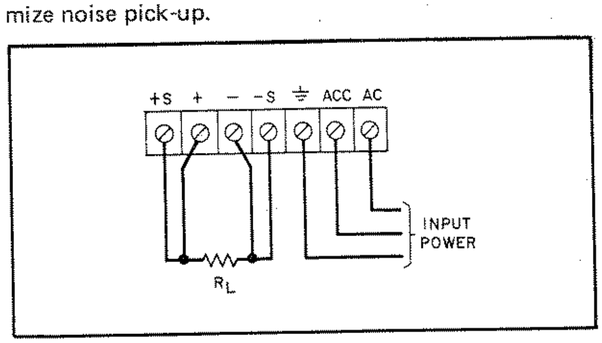


Figure 3-3. Remote Sensing

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3-15 For reasonable load lead lengths, remote sensing greatly improves the performance of the supply. However, if the load is located a considerable distance from the supply, added precautions must be observed to obtain satisfactory operation. Notice that the voltage drop in the load leads subtracts directly from the available output voltage and also reduces the amplitude of the feedback error signals that are developed within the unit. Because of these factors it is recommended that the total drop in both load leads not exceed 0.5 V. If a larger drop must be tolerated, please consult your local HP sales engineer.

NOTE

Due to the voltage drop in the load leads, it may be necessary to readjust the current limit. Refer to Paragraph 3-8.

3-16. It should be noted that a problem can occur in obtaining maximum rated output voltage (nominal +0.5 V) from a lower voltage supply (below 10 V) even if the total voltage drop in both load leads is maintained at 0.5 Volt. This problem is most likely to occur when the input ac is at low line. To counteract this effect, the user can maintain the ac input at a higher line voltage or reduce the voltage drop in the load leads by using larger diameter wires.

3-17 SPECIAL OPERATING PRECAUTIONS

3-18 Temperature

3-19 The normal operating temperature for this supply is from 0 to 50°C, ambient. Beyond 50°C, the output current is linearly derated to 50% at 71°C. Additional information on temperature is given in Section II.

NOTE

During normal operation of the supply, the case of the unit may become hot to the touch. This is a normal occurrence and no cause for alarm.

3-20 Mounting Orientation

3-21 The supply should be mounted and operated in the upright position as instructed in Section II. If the supply must be operated in an orientation other than upright, an adequate flow of cooling air must be maintained. Contact your nearest HP sales engineer for details.

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SECTION IV
PRINCIPLES OF OPERATION

4-1 OVERALL DESCRIPTION

4-2 Figure 4-1 is a simplified schematic of the power supply indicating all of its major circuits. Except for minor variations (discussed later in Section IV) the Hewlett-Packard modular supplies covered by this manual are as shown in Figure 4-1. Notice that each stage of the supply has been designated according to function. These functional designations also appear on the applicable schematic at the rear of the manual so that both diagrams can be correlated.

4-3 The ac input voltage is reduced to the proper level by the power transformer and fed to the rectifier-filter where it is converted to raw (unregulated) dc. The raw dc voltage is adjusted by the series regulator so that a regulated, constant voltage is available across the output terminals of the supply.

4-4 The series regulator, part of a feedback loop, alters its conduction in accordance with the feedback control signals obtained from the driver. The driver, in turn, is controlled by feedback signals originated in

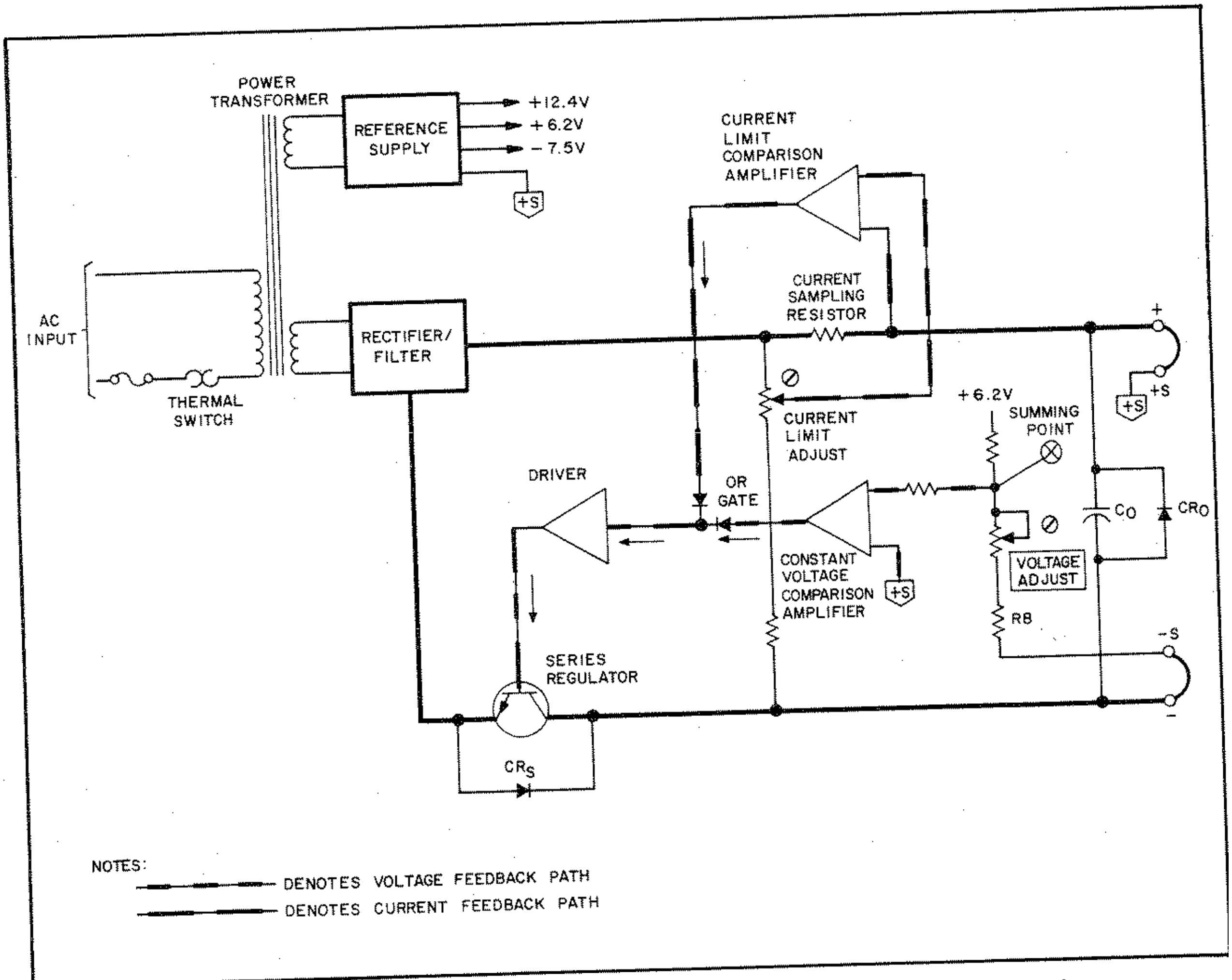

Figure 4-1. Typical Modular Power Supply, Simplified Schematic

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the voltage comparison amplifier, during constant voltage operation, or the current limiting amplifier during current limit operation.

4-5 The reference supply provides regulated bias voltages which are used by the internal circuitry throughout the main power supply.

4-6 DETAILED DESCRIPTION

4-7 The following paragraphs describe in detailed terms, the operation of each of the supply's major circuits. Throughout this discussion, refer to both the simplified schematic of Figure 4-1 and the appropriate schematic diagram at the rear of the manual.

4-8 Feedback Loop

4-9 The voltage comparison amplifier, together with the driver and series regulator, comprises the constant voltage feedback loop. This feedback loop maintains a constant output voltage during normal (constant voltage) operation. To accomplish this, the voltage comparison amplifier continuously monitors the output voltage of the supply. It detects instantaneous changes in the output and applies an amplified error signal to the series regulator (via the driver) which is of the correct phase and amplitude to counteract the change.

4-10 The feedback loop also prevents the output current from exceeding a preset current limit value. Current limiting operation is initiated by the current limit comparison amplifier which conducts if the output current that flows through the current sampling resistance exceeds a value established by the current limit-adjust potentiometer. When conducting, this amplifier sends a turn-down signal to the series regulator, via the driver.

4-11 An output capacitor, C_O, connected across the output of the supply, helps to stabilize the feedback loop regardless of the type of load that is imposed.

4-12 Constant Voltage Comparison Amplifier

4-13 This circuit consists of the VOLTAGE ADJUST potentiometer R7 and a differential amplifier stage (U2 and associated components). An integrated circuit is used for the differential amplifier for increased reliability and to minimize differential voltages due to mis-matched transistors and thermal differentials.

4-14 The voltage comparison amplifier continuously compares the output voltage of the supply with the voltage drop between the –S terminal and the circuit's summing point (junction at voltage divider R5, R7, and R8). If these two voltages are momentarily unequal, an error voltage is generated whose amplitude is proportional to the difference. The error signal ultimately alters the conduction of the series regulator which, in turn, alters the output current so that the output voltage becomes equal to the voltage at the summing point. Hence, through feedback action, the difference between the two inputs to U2 is held at nearly zero volts.

4-15 The inverting input of the comparison amplifier (pin 2 of U2) is connected, through jumper W1 to the constant voltage summing point. (As indicated on NOTE 7 of each schematic, W1 is connected either to the junction of R5, R7 for supplies below 10 V or to the junction of R7, R8 for supplies 10 V and above.) The non-inverting input to the comparison amplifier (pin 3 of U2) is connected directly to the output voltage sensing terminal (+S) of the supply. Instantaneous changes in the output voltage, or changes at the summing point due to rotation of the voltage pot, produce a difference voltage between the two inputs of the comparison amplifier. This difference voltage is amplified and appears at the output of the amplifier, at pin 6.

4-16 Capacitor C12 and resistor R10 couple rapid output voltage variations to the input of U2 while slower (dc) changes are coupled to U2 via resistor R8. Diodes CR11 and CR12 prevent excessive voltage excursions from over-driving the comparison amplifier; RC network R12,C13 provide degenerative feedback to help stabilize the feedback loop.

4-17 Driver

4-18 The driver amplifies the error signal from the constant voltage or current limit comparison amplifiers to a level sufficient to drive the series regulating transistor(s). Inverting stage Q2 receives its input signal from the OR-gate diode (CR13 or CR14) that is conducting at the time. During normal (constant voltage) operation, CR13 is forward biased and CR14 is reverse biased. The reverse is true during current limiting operation.

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4-19 Stage Q2 provides mainly voltage amplification of the feedback signal while emitter follower Q3 provides most of the current gain. Some models; e.g. 62048A, contain only one driver stage (Q2) instead of two.

4-20 Feedback capacitor C18 provides degenerative feedback to Q3 to prevent oscillation and C19 helps shape the high frequency rolloff of the feedback loop response curve. R28 provides a leakage current path for transistor Q3.

4-21 Series Regulator

4-22 The series regulator, or series control element, acts as a variable resistance connected in series with the load. Its conduction is controlled by the feedback signals from the driver so that the output voltage is maintained constant or the current limit is not exceeded. A diode (CR_S on Figure 4-1) connected across the regulator, protects the series element(s) from possible damage by a reverse current flow.

4-23 Many modular power supplies employ one series transistor as indicated on Figure 4-1. However, higher power units (such as Models 62003E thru 62048E) use two regulating transistors, connected in parallel to minimize power dissipation. Approximately half of the output current flows through each transistor.

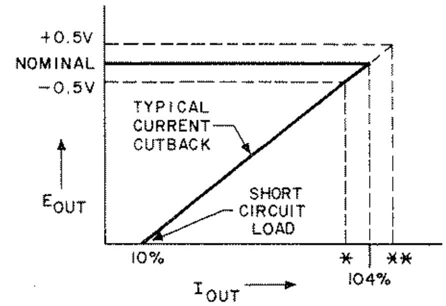
4-24 Current Limit Comparison Amplifier

4-25 This circuit consists of current limit adjust potentiometer R18 and a differential amplifier stage (U3 and associated components). Stage U3 is similar in appearance and operation to the constant voltage comparison amplifer, U2.

4-26 The current limit comparison amplifier effectively monitors the output current of the supply by monitoring the IR drop across current sampling resistor R15. The voltage drop across R15 is compared with a reference voltage established by the setting of current limit potentiometer R18. During constant voltage operation, the output of U3 is not positive enough to forward bias OR gate diode CR14. However, if the output current increases to approximately 104% of the rated value, the input to pin 2 of U3 is driven momentarily less positive. If this occurs, a positive going output signal from U3 forward biases CR14 and reverse biases CR13. This feedback signal then decreases the conduction of the series regulator.

4-27 The current limiting circuit contains a current "cutback" feature which protects the series regulating transistor(s) against excessive overloads. As the load resistance decreases, the output current is cut back linearly, from the initial current limit point, to approximately 10% of the rated current under short circuit conditions (see Figure 4-2). Cutback action is made possible by R18 and R19, which are connected across the output of the supply. If the load resistance decreases after the initial current limiting point, the resultant drop in output voltage causes a decrease in the current flowing through R18 and R19. This, in turn, causes U3 to conduct even harder further reducing the conduction of the series regulator.

A. SUPPLIES BELOW 10V



NOMINAL OUTPUT	*	**
3V	89%	119%
4V	93%	115%
5V	95%	113%
6V	97%	111%

B. SUPPLIES 10V AND ABOVE

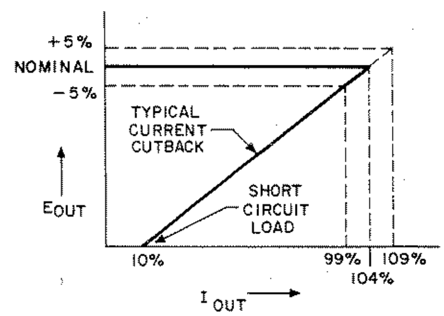


Figure 4-2. Typical Current Limiting Characteristics

4-28 As described in Section III, the cutback point for the supply can vary from approximately 3% to 15% of the rated output current. Resistors R20 and R21 determine the actual cutback point.

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4-29 Reference Supply

4-30 The reference supply is a small regulated bias source which is similar to the main power supply. It contains a series regulator (Q1) and a comparison amplifier (U1). The three reference voltages are all derived from raw dc obtained from a full-wave rectifier (CR1 and CR2) and filter capacitor C1. The +6.2V and −7.5V outputs are developed across Zener diodes VR1 and VR2. The reference Zener diode (VR2) is temperature compensated. Resistor R4 limits the current through VR2 to establish an optimum bias level.

4-31. The regulating circuit consists of U1, Q1, and associated components. The voltage across the reference zener (+6.2 V with respect to +S) and the voltage at the junction of divider R2 and R3 are compared and any differences are detected by U1. The error voltage is then amplified and applied to series regulator Q1 to counteract the difference and maintain the +12.4 V output constant. Output capacitor C3 stabilizes the reference regulator feedback loop to prevent oscillation.

4-32 Zener diode VR1 provides an additional reference voltage of −7.5 V. This voltage is not as tightly regulated as the other two reference voltages since it is not controlled by the regulator circuit. The unregulated +23 V, taken directly from the rectifier, is used only by Option 011 or 104 crowbar circuits.

4-33 Additional Protection Features

4-34 The supply contains several "special purpose" components which protect the supply in the event of unusual circumstances. One of these is the output diode (CR9 or U5; refer to applicable schematic). Connected across the output terminals, this diode prevents internal damage from reverse voltages that might be applied during system operation when one power supply is turned on before another. The output diode can withstand currents equal to the maximum current rating of the supply for time periods of short duration (approximately 3 minutes); or up to half the current rating of the supply for longer time periods.

4-35 The series regulator diode (CR8 or U5) protects the regulating transistor(s) from the effects of a reverse current which would occur if an external voltage were applied across an unenergized supply.

4-36 Sensing protection resistors R32 and R33 prevent the load from receiving full rectifier voltage if the connections between the output terminals and the sensing terminals (+S and −S) are removed inadvertently.

4-37 Thermal switch TC1 opens if the heat sink temperature exceeds a safe value. With TC1 open, the ac input path to the supply is broken, shutting down the supply. The switch automatically resets after the supply has cooled to a temperature below that at which it originally opened. The opening and closing temperatures for the switch are given in the individual parts list for each supply.

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SECTION V
MAINTENANCE

5-1 INTRODUCTION

5-2 Upon receipt of the power supply, the performance check of Paragraph 5-6 can be made. This check is suitable for incoming inspection. Section III contains a quick but less comprehensive checkout procedure which can be used in lieu of the performance check, if desired.

5-3 If a fault is detected in the power supply while making the performance check or during normal operation, proceed to the troubleshooting procedures (Paragraph 5-37). After troubleshooting and repair (Paragraph 5-54) repeat the performance check to ensure that the fault has been properly corrected and that no other faults exist. Before performing any maintenance checks, turn on the power supply and allow a half-hour warm-up.

5-4 TEST EQUIPMENT REQUIRED

5-5 Table 5-1 lists the test equipment required to perform the various procedures described in this section.

Table 5-1. Test Equipment Required

TYPE	REQUIRED CHARACTERISTICS	USE	RECOMMENDED MODEL
Digital Voltmeter	Sensitivity: 100μV full scale (min.). Input impedance: 10 megohms (min.).	Measure DC voltages: calibration procedures	HP 3450A
Variable Voltage Transformer	Range: 90–130Vac. Equipped with voltmeter accurate within 1 Volt	Vary AC input	---
Oscilloscope	Sensitivity: 100μV/cm. Differential input.	Display transient response and ripple/ noise waveforms; current limit adjustment.	HP140B plus 1400B plug-in. 1402A plug-in for noise measurements.
Repetitive Load Sw.	Rate: 60Hz, 2μsec. rise and fall time.	Measure transient response.	See Figure 5-4.
Resistive Load	Value: See Paragraph 5-11. Tolerance: ±5%	Power supply load resistor. (Fixed resistor or Rheostat).	James G. Biddle "Lubri-Tact" Rheostat 411G23CS or 411G85CS.
Current Sampling Resistor (Shunt)	Value: See Paragraph 5-13. Accuracy: 1% (minimum)	Measure output current	Simpson Portable Shunt, 06704.

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5-6 PERFORMANCE TEST

5-7 The following test can be used as an incoming inspection check and appropriate portions of the test can be repeated to check the operation of the instrument after repairs. The tests are performed using the nominal 120VAC, 60Hz, input power for the unit. If the correct result is not obtained for a particular check, proceed to troubleshooting (Paragraph 5-37).

5-8 Measurement Techniques

5-9 Connecting Monitoring Device. For the following Constant Voltage measurements, the measuring device must be connected across the rear sensing terminals of the supply in order to achieve valid indications. A measurement made across the load includes the impedance of the leads to the load and such lead lengths can easily have an impedance that is greater than the supply impedance, thus invalidating the measurement. To avoid mutual coupling effects, each monitoring device must be connected directly to the sensing terminals by separate pairs of leads.

5-10 Avoid Current Limiting. When measuring the constant voltage performance specifications, the current limit point should be set at least 3% above the maximum output current which the supply will draw, since the onset of current limiting action will cause a drop in output voltage, increased ripple, and other changes not properly ascribed to the constant voltage operation of the supply. The current limit potentiometer is factory set to its proper value when the supply is providing nominal output voltage. If an output voltage other than nominal is selected, read Paragraph 3-8 and then proceed to the current limit adjustment procedure, Paragraph 5-72.

5-11 Selecting A Load Resistor. Constant voltage specifications are checked with a "full" load resistance connected across the supply. The resistance and wattage of the load resistor, therefore, must permit operation of the supply at its rated output voltage and current. For example, a supply that is rated at 4 ± 0.5 volts and 4 amperes would require a load resistance of 1 ohm at the nominal output voltage (4V). If the output voltage were set to one of the adjustment limits (4.5V or 3.5V), the load resistance would have to increase or decrease accordingly, to allow the unit to provide its rated current of 4 amperes. The wattage rating of the 1 ohm resistor would be 4 watts, minimum.

5-12 Either a fixed or variable resistor (rheostat) can be used as the load resistance. A rheostat is very useful when measuring the output current of the supply and also is a convenience if the user is testing a number of modular power supplies of different ratings. A rheostat of the type recommended in Figure 5-1 is adequate for any supply covered by this manual. If a fixed resistor is used for output current measurements, its tolerance must be accounted for in evaluating the test results.

5-13 Output Current Measurements. For accurate output current measurements a current sampling resistor should be inserted between the load resistor and the output of the supply. An accurate voltmeter is then placed across the sampling resistance and the output current at any time can be calculated by dividing the voltage across the sampling resistor by its ohmic value. The total resistance of the series combination (sampling resistor and load resistor) should be equal to the full load resistance as determined in the preceding paragraphs. Of course, if the value of the sampling resistance is very low when compared to the full load resistance, the value of the sampling resistance may be ignored. The meter shunt recommended in Table 1-1, for example, has a resistance of only 5 milliohms and can be neglected when calculating the load resistance of the supply.

5-14 Figure 5-1 shows a four terminal meter shunt. The load current is fed to the extremes of the wire leading to the resistor while the sampling terminals are located as close as possible to the resistance portion itself.

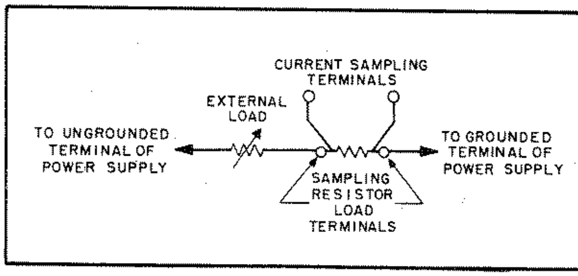

Figure 5-1. Current Sampling Resistor Connections

5-15 Rated Output

5-16 Voltage. To ensure that the supply will furnish the maximum rated output voltage, proceed as follows:

a. Connect digital voltmeter across +S and −S terminals of supply observing correct polarity.

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b. Apply input power to supply.

c. With no load connected, set output voltage of supply to any value desired within adjustment span. This output voltage can be used for all remaining constant voltage tests.

d. With supply off, connect full load resistance across + and – output terminals of supply (see Paragraph 5-11).

e. Reconnect input power to supply. Voltmeter should read output voltage set in Step c (within tolerances of load resistor and meter).

5-17 **Current.** To ensure that the supply will furnish the maximum rated output current, proceed as follows:

a. Connect test setup shown in Figure 5-2. Select load and current sampling resistor values according to Paragraphs 5-11 and 5-13.

b. Apply input power to supply and adjust R_L until digital voltmeter indicates a voltage drop which is proportional to the maximum rated output current.

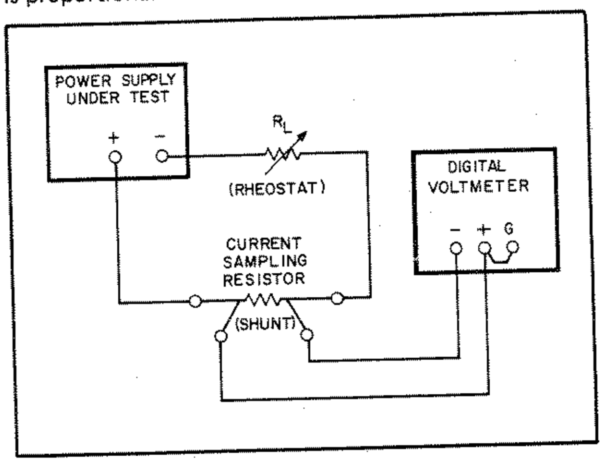

Figure 5-2. Output Current, Test Setup

5-18 Load Regulation

Definition: The change ΔE_{OUT} in the static value of DC output voltage resulting from a change in load resistance from open circuit to a value which yields maximum rated output current (or vice versa).

5-19 To check the constant voltage load regulation, proceed as follows:

a. Connect full load resistance across rear output terminals (Paragraph 5-11).

b. Connect digital voltmeter across ±S terminals.

c. Turn on supply and obtain desired output voltage. Record voltage read on voltmeter.

d. Disconnect load resistance.

e. Reading on digital voltmeter should not vary from reading recorded in step c by more than 0.01% or 1mV, whichever is greater.

5-20 Line Regulation

Definition: The change, ΔE_{OUT}, in the static value of DC output voltage resulting from a change in AC input voltage over the specified range from low line (usually 104 Volts) to high line (usually 127 Volts), or from high line to low line.

5-21 To test the line regulation, proceed as follows:

a. Connect variable auto transformer between input power source and power supply power input terminals.

b. Connect load resistance and digital voltmeter across output of supply.

c. Adjust variable auto transformer for low line input.

d. Turn on setup. Read and record output voltage on digital voltmeter.

e. Adjust variable auto transformer for high line input.

f. Reading on digital voltmeter should not vary from reading recorded in step d by more than 0.01% or 1mV, whichever is greater.

5-22 Ripple and Noise

Definition: The residual AC voltage which is superimposed on the DC output of a regulated power supply. Ripple and noise may be specified and measured in terms of its RMS peak-to-peak value.

5-23 Ripple and noise measurement can be made at any input AC line voltage combined with any DC output voltage and load current within rating.

5-24 Figure 5-3A shows an incorrect method of measuring p-p ripple. Note that a continuous ground loop exists from the third wire of the input power cord of

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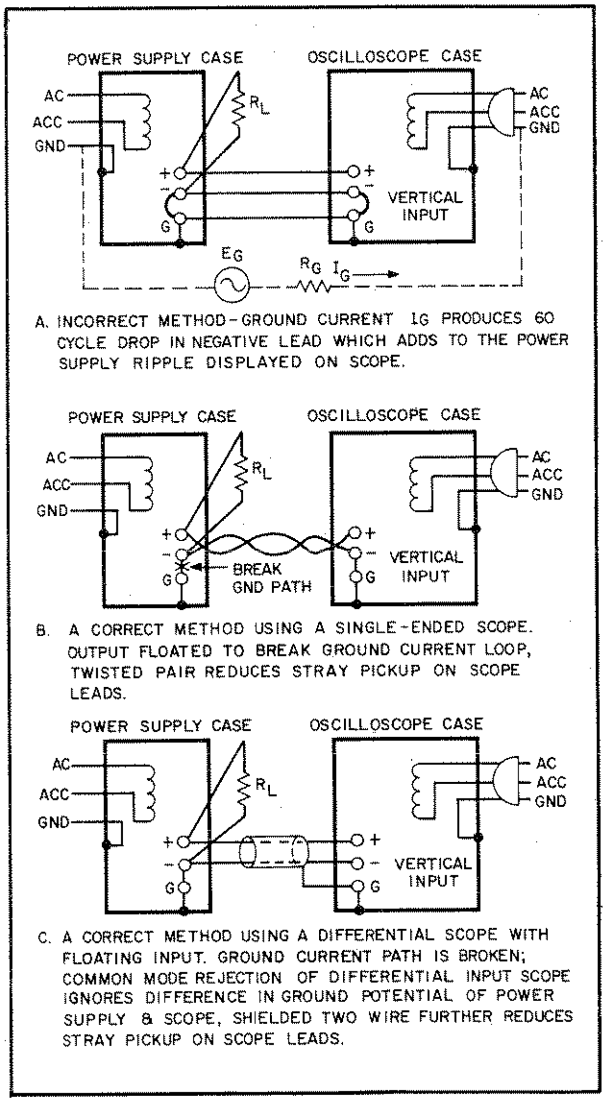
the supply to the third wire of the input power cord of the oscilloscope via the grounded power supply case, the wire between the negative output terminal of the power supply and the vertical input of the scope, and the grounded scope case. Any ground current circulating in this loop as a result of the difference in potential E_G between the two ground points causes an IR drop which is in series with the scope input. This IR drop, normally having a 60Hz line frequency fundamental, plus any pickup on the unshielded leads interconnecting the power supply and scope, appears on the face of the CRT. The magnitude of this resulting signal can easily be much greater than the true ripple developed between the plus and minus output terminals of the power supply, and can completely invalidate the measurement.



A. INCORRECT METHOD-GROUND CURRENT I_G PRODUCES 60 CYCLE DROP IN NEGATIVE LEAD WHICH ADDS TO THE POWER SUPPLY RIPPLE DISPLAYED ON SCOPE.

B. A CORRECT METHOD USING A SINGLE-ENDED SCOPE. OUTPUT FLOATED TO BREAK GROUND CURRENT LOOP, TWISTED PAIR REDUCES STRAY PICKUP ON SCOPE LEADS.

C. A CORRECT METHOD USING A DIFFERENTIAL SCOPE WITH FLOATING INPUT. GROUND CURRENT PATH IS BROKEN; COMMON MODE REJECTION OF DIFFERENTIAL INPUT SCOPE IGNORES DIFFERENCE IN GROUND POTENTIAL OF POWER SUPPLY & SCOPE, SHIELDED TWO WIRE FURTHER REDUCES STRAY PICKUP ON SCOPE LEADS.

Figure 5-3. Ripple and Noise, Test Setup

5-25 The same ground current and pickup problems can exist if an RMS voltmeter is substituted in place of the oscilloscope in Figure 5-3. However, the oscilloscope display, unlike the true RMS meter reading, tells the observer immediately whether the fundamental period of the signal displayed is 8.3 milliseconds (1/120Hz) or 16.7 milliseconds (1/60Hz). Since the fundamental ripple frequency present on the output of an HP supply is 120Hz (due to full-wave rectification), an oscilloscope display showing a 120Hz fundamental component is indicative of a "clean" measurement setup, while the presence of a 60Hz fundamental usually means that an improved setup will result in a more accurate (and lower) value of measured ripple.

5-26 Figure 5-3B shows a correct method of measuring the output ripple of a constant voltage power supply using a single-ended scope. The ground loop path is broken by floating the power supply output. Note that to ensure that no potential difference exists between the supply and the oscilloscope, it is recommended that whenever possible they both be plugged into the same ac power buss. If the same buss cannot be used, both ac grounds must be at earth ground potential.

5-27 Either a twisted pair or (preferably) a shielded two-wire cable should be used to connect the output terminals of the power supply to the vertical input terminals of the scope. When using a twisted pair, care must be taken that one of the two wires is connected to the grounded input terminal of the oscilloscope. When using shielded two-wire, it is essential for the shield to be connected to ground at one end only to prevent ground current flowing through this shield from inducing a signal in the shielded leads.

5-28 To verify that the oscilloscope is not displaying ripple that is induced in the leads or picked up from the grounds, the (+) scope lead should be shorted to the (—) scope lead at the power supply terminals. The ripple value obtained when the leads are shorted should be subtracted from the actual ripple measurement.

5-29 In most cases, the single-ended scope method of Figure 5-3B will be adequate to eliminate non-real components of ripple so that a satisfactory measurement may be obtained. However, in more stubborn cases, (or if high frequency noise up to 20MHz must be measured), it may be necessary to use a differential scope with floating input as shown in Figure 5-3C. If desired, two single-conductor shielded cables may be substituted in

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place of the shielded two-wire cable with equal success. Because of its common mode rejection, a differential oscilloscope displays only the difference in signal between its two vertical input terminals, thus ignoring the effects of any common mode signal produced by the difference in the ac potential between the power supply case and scope case. Before using a differential input scope in this manner, however, it is imperative that the common mode rejection capability of the scope be verified by shorting together its two input leads at the power supply and observing the trace on the CRT. If this trace is a straight line, then the scope is properly ignoring any common mode signal present. If this trace is not a straight line, then the scope is not rejecting the ground signal and must be realigned in accordance with the manufacturer's instructions until proper common mode rejection is attained.

5-30 Ripple and/or noise output measurement procedures are given in the following steps. If a high frequency noise measurement is desired, an oscilloscope with sufficient bandwidth (20MHz) must be used. To measure the ripple/noise output, proceed as follows:

a. Connect oscilloscope or RMS voltmeter as shown in Figures 5-3B or 5-3C.

b. Connect input power and observe oscilloscope.

c. The observed ripple should be less than 1mVrms and 2mV p-p.

5-31 Load Transient Recovery

Definition: The time "X" for output voltage recovery to within "Y" millivolts of the nominal output voltage following a "Z" amp step change in load current – where:

"X" = 50µsec, "Y" = 15mV, and "Z" is the specified load current change, equal to half of the current rating of the supply. The nominal output voltage is defined as the DC level half way between the static output voltage before and after the imposed load change.

5-32 Transient recovery time may be measured at any input line voltage combined with any output voltage and load current within rating.

5-33 Reasonable care must be taken in switching the load resistance on and off. A hand-operated switch in series with the load is not adequate, since the resulting one-shot displays are difficult to observe on most oscilloscopes, and the arc energy occurring during switching action completely masks the display with a noise burst. Transistor load switching devices are expensive if reasonably rapid load current changes are to be acheived.

5-34 A mercury-wetted relay, as connected in the load switching circuit of Figure 5-4 should be used for loading and unloading the supply. When this load switch is connected to a 60Hz AC input, the mercury-wetted relay will open and close 60 times per second. Adjustment of the 25K control permits adjustment of the duty cycle of the load current switching and reduction in jitter of the oscilloscope display. This relay may also be used with a 50Hz ac input.

5-35 The maximum load ratings listed in Figure 5-4 must be observed in order to preserve the mercury-wetted relay contacts. Switching of larger load currents can be accomplished with mercury pool relays; with this technique fast rise times can still be obtained, but the large inertia of mercury pool relays limits the maximum repetition rate of load switching and makes the clear display of the transient recovery characteristic on an oscilloscope more difficult.

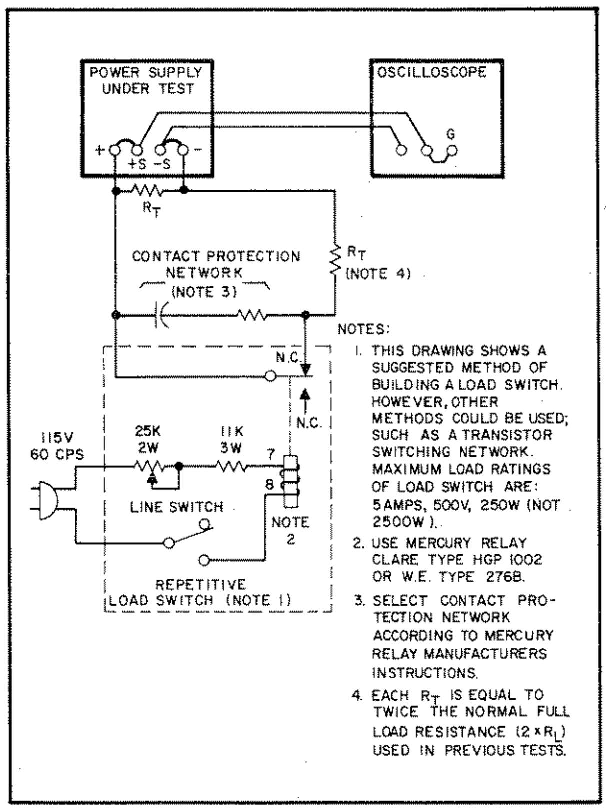

Figure 5-4. Transient Recovery Time, Test Setup

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5-36 To check the transient recovery time, proceed as follows:

a. Connect test setup shown in Figure 5-4. Both load resistors (R_T) are twice normal value of full load resistance.

b. Turn on supply and close the line switch on the repetitive load switch setup.

c. Set the oscilloscope for internal sync and lock on either the positive or negative load transient spike.

d. Set the vertical input of the oscilloscope for ac coupling so that small dc level changes in the output voltage of the power supply will not cause the display to shift.

e. Adjust the horizontal positioning control so that the trace starts at a point coincident with a major graticule division. This point is then representative of time zero.

f. Adjust the vertical centering on the scope so that the tail ends of the no load and full load waveforms are symmetrically displaced about the horizontal center line of the oscilloscope. This center line now represents the nominal output voltage defined in the specification.

g. Increase the sweep rate so that a single transient spike can be examined in detail.

h. Adjust the sync controls separately for the positive and negative going transients so that not only the recovery waveshape but also as much as possible of the rise time of the transient is displayed.

i. Starting from the major graticule division representative of time zero, count to the right 50μsec and vertically 15mV. Recovery should be within these tolerances; as illustrated in Figure 5-5.

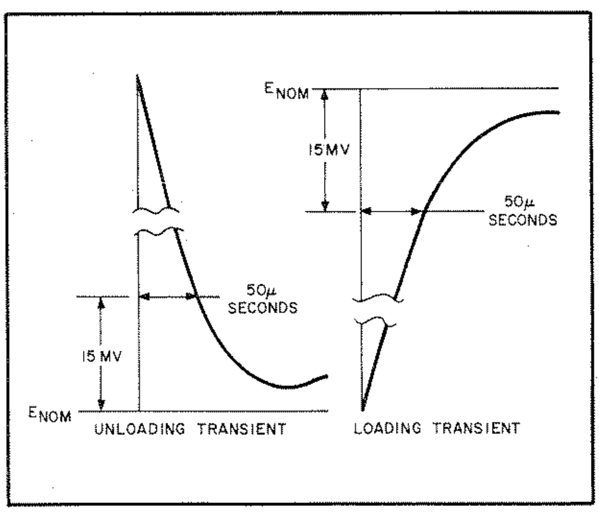

Figure 5-5. Transient Recovery Time Waveforms

5-37 TROUBLESHOOTING

5-38 Before attempting to troubleshoot this instrument, ensure that the fault is with the instrument itself and not with an associated circuit. The performance test enables this to be determined without having to remove the covers from the supply.

5-39 A good understanding of the principles of operation is a helpful aid in troubleshooting, and it is recommended that the reader review Section IV of the manual before attempting to troubleshoot the unit in detail. Once the principles of operation are understood, refer to the initial troubleshooting procedures in Paragraph 5-41 to locate the symptom and probable cause.

5-40 Various lettered test points are located at critical points on the PC board to assist in troubleshooting. These test points are also included on the schematic diagrams at the rear of the manual.

5-41 Initial Troubleshooting Procedures

5-42 If a malfunction occurs, proceed as follows:

(1) Disconnect input power and remove all loads from unit.

(2) Ensure that +S and −S terminals are strapped securely to proper output terminals.

(3) Measure output voltage across sensing terminals and proceed to Table 5-2 to locate your symptom and appropriate isolation procedures.

5-43 Open Fuse Troubleshooting

5-44 Although an open line fuse can be caused by fatigue or line transients, it is recommended that the unit be first checked for internal shorts before replacing the fuse. To accomplish this test, follow the below steps in sequence:

(1) Visually inspect the unit for charred components, foreign matter, and obvious shorts.

(2) With power removed, connect an ohmmeter between + output terminal and test point F on the P.C. board. Reading should not be less than the value of R31 (between 200 and 5,600 ohms, depending upon the model number) after filter capacitor C9 becomes charged. If resistance is less than R31, check C9, CR3, 4, 5, 6, (or U4), Q4, (Q5), CR8 (or U5), CR9 (or U5) or C11 for short.

(3) Connect ohmmeter across reference supply filter capacitor (test points B and N). Reading should

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be at least 5,000 ohms. If less, check C1, CR1, or CR2 for short.

(4) Connect ohmmeter across power transformer (ACC terminal and test point F). Reading should be at least 10 Megohms. If it is less, check T1 for shorts or leakage.

(5) If the previous steps prove satisfactory, or if a trouble was found and corrected, replace line fuse and reconnect input power.

5-45 Current Limit Troubleshooting

5-46 Improper activation of the current limit protection circuit can be caused by one of two conditions: (1) a failure within the supply; or (2) activation of the optional crowbar SCR (option 011 or 104). Table 5-5 shows the recommended method of isolating the trouble to either the supply itself or the crowbar. Failures within the main supply are covered in Table 5-5 while crowbar problems are referenced to a separate table.

5-47 Excessive Ripple Troubleshooting

5-48 If excessive ripple or noise is encountered, the frequency of the ripple should be determined as the first step in isolating the trouble. Ripple or spikes occuring at the line or twice the line frequency, are usually caused by problems in the reference supply or the main rectifier area of the supply. Refer to the next paragraph if this problem occurs. Higher frequency noise ("hash") occurring at a fixed frequency are

Table 5-2. Initial Troubleshooting

SYMPTOM	CHECK	RESPONSE – PROBABLE CAUSE
Low output voltage (less than 1.5V)	Check fuse F1	a. Fuse blown, Internal short – proceed to Paragraph 5-43. b. Fuse good. Series regulator loop or reference supply defective – proceed to Table 5-3.
High output voltage (above maximum rating)	–––	a. Series regulator loop defective – proceed to Table 5-4.
High ripple	Check operating setup for ground loops	a. Refer to paragraph 5-24 for ground loop information. b. If setup is free of ground loops, reference supply or main rectifier may be defective – proceed to Paragraph 5-47. c. Supply may be operating too close to current limit crossover point – read Paragraph 5-10, then Paragraph 5-45.
Will not current limit	–––	a. OR-gate diode CR14 open or current limit amplifier U3 defective.
Poor load or line regulation	Check reference voltages (12.4V, 6.2V, and 7.5V)	a. Voltages incorrect (beyond ±10% tolerance). Check reference supply as indicated in Table 5-3, Steps 2 and 3. b. Voltages correct (within ±10%). Supply may be current limiting – read Paragraph 5-10.
Oscillation and/or poor load transient recovery time	–––	a. Higher frequency oscillations (above 50kHz) can be caused by an open C13, C14, or C18. b. A defective output capacitor (C11) or feedback capacitor (C19) can cause oscillations in one of many frequency ranges. c. Oscillations occuring only in the current limiting mode, can be caused by an open C15 or C16. Oscillation near the current limiting crossover point are caused by an open CR15.

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Table 5-3. Low Output Voltage Troubleshooting

STEP	ACTION	RESPONSE	PROBABLE CAUSE
1	Check input voltage to reference supply; voltage between test points B (+) and N should read 30 ± 6Vdc.	a. Normal voltage b. Abnormal	a. Proceed to Step 2. b. CR1 or CR2 open or shorted. TC1, T1 open.
2	Check +12.4V reference. Voltage between test points P (+) and +S should be 12.4 ±1.3Vdc	a. Normal voltage b. Abnormal	a. Proceed to Step 3. b. Q1 or R1 open.
3	Check +6.2V and −7.5V references. Voltage between test points R or N and +S should be 6.2 ±0.7Vdc, or 7.5 ±0.8Vdc, respectively.	a. Normal voltage b. Abnormal	a. Proceed to Step 4. b. Check applicable zener diode, VR1 or VR2.
4	Check raw dc input to main power supply. Voltage between test point F and +S are different for each model and are given in a table opposite the appropriate schematic.	a. Normal voltage b. Abnormal voltage (beyond ±20%)	a. Proceed to Step 5. b. CR3—CR6 (or U4) open. C9 shorted or T1 open
5	To eliminate the current limit circuit as a possible source of the trouble, measure voltage drop across applicable OR-gate diode (CR14), Test points C to G.	a. T.P. C negative with respect to G (−1.8V). b. T.P. C positive with respect to G (0.7V).	a. Unit in Constant Voltage mode, proceed to Step 6. b. Unit in current limiting mode, proceed to current limit troubleshooting, Table 5-5. **CAUTION** Do not perform Steps 6 and 7 if unit is in the current limit mode. If the output is shorted, performing Steps 6 and 7 will damage the series regulator.
6	Check conduction capability of series regulator by shorting driver transistor Q3, emitter-to-collector.	a. Output voltage increases b. Output voltage remains low.	a. Proceed to Step 7. b. Series regulator transistor(s) Q4 (Q5) open. Wiring to heat sink open.

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Table 5-3. Low Output Voltage Troubleshooting (Continued)

STEP	ACTION	RESPONSE	PROBABLE CAUSE
	NOTE: Q3 not included on 62048A. To check series regulator, perform action of Step 7.		
7	Check conduction of drive Q3 by shorting collector of Q2 (T.P. D) to +S terminal	a. Output voltage increases. b. Output voltage remains low.	a. Proceed to Step 8. b. Driver transistor Q3 open.
8	Check conduction of Q2 by shorting T.P. D to +S.	a. Output voltage increases b. Output voltage remains low.	a. Proceed to Step 9. b. Driver Q2 open.
9	Check turn-up capability of U2 by shorting pin 2 of U2 to +S.	a. Output voltage increases b. Output voltage remains low.	a. U2 is good. Check for defective input circuit component; R5, R7, R8, R11, CR11, or CR12. b. Check for open CR13, or defective feedback capacitor C13 or C14. If these components are good, replace defective U2.

Table 5-4. High Output Voltage Troubleshooting

STEP	ACTION	RESPONSE	PROBABLE CAUSE
1	Check turn-off of series regulator by shorting base-to-emitter of Q4 (shortout R30).	a. Output voltage decreases. b. Output voltage remains high.	a. Proceed to Step 2. b. Series regulator transistor(s) Q4 (Q5) shorted. Protection diode (CR8 or U5) shorted.
2	Check turn-off of drivers Q2 and Q3 by shorting base of Q2 (T.P.G) to +S.	a. Output voltage decreases b. Output voltage remains high.	a. Proceed to Step 3. b. Driver transistor Q2 or Q3 shorted. C18 or C19 shorted.
3	Check turn-off capability of U2 by shorting summing point (at pad W1) of U2 to − output terminal.	a. Output voltage decreases b. Output voltage remains high	a. U2 is good. Check for defective input circuit component; R5, R7, or R8. b. Check VR1 for −7.5V bias. If OK, check for open CR13 or shorted C13, C14, CR11 or CR12. If these components are good, replace defective U2.

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Table 5-5. Current Limit Troubleshooting

STEP	ACTION	RESPONSE	PROBABLE CAUSE
1	If unit is equipped with Option 011 or 104 crowbar, disconnect crowbar SCR by lifting one end of R13 or R14 (resistor in series with SCR) on crowbar P.C. board. If unit does not have crowbar option, proceed directly to Step 2.	a. Output voltage goes high. b. Output voltage goes to normal. c. Output voltage remains low.	a. Crowbar fired due to high output voltage condition – proceed to Table 5-4. b. Crowbar defective – proceed to Table 5-6. c. Internal short or current limit circuit defective – proceed to Step 2.
2	Remove input power and connect ohmmeter across + and – output terminals.	a. Resistance less than value of R19 (see schematic). b. Resistance more than value of R19.	a. Capacitor C11 or protection diode CR9 (U5) shorted. b. Proceed to Step 3.
3	Check for presence of –7.5V across Zener diode VR1.	a. Voltage incorrect b. Voltage correct	a. VR1 defective b. CR14 shorted, U3 defective.

Table 5-6. Crowbar Troubleshooting (Option 011 or 104)

SYMPTOM	PROBABLE CAUSE
Crowbar always on, won't reset	a. CR5 (or CR6) shorted. If shorted, check Q4 for open.
Crowbar won't trip	a. Q1 open or shorted. b. Q2 (or Q3) open or shorted. c. R45 (crowbar adjust) open. d. CR4 (if used) shorted. e. +23V bias missing.
Crowbar trips but won't latch (oscillates on and off)	a. CR3 (if used) open
Crowbar trip point shifts or is susceptible to external noise	a. VR1 defective b. R45 intermittent c. C1, C2 open
Crowbar circuit prevents supply from reaching proper voltage, but SCR is not fired.	a. Q4 shorted.

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covered under the sympton "Oscillation" in Table 5-2. Random frequency noise is most often caused by a defective reference diode, VR2. A defective I.C. (U1 or U2) can also cause this problem.

5-49 If a line frequency ripple problem exists, check the ripple at the dc input to the reference supply across test points B and N. It should be less than 600mV p-p. If it is significantly greater than 600mV, check C1, CR1, and CR2. If it is less than 600mV, check the ripple between test point R and +S (+6.2V). The ripple at T.P. R should be less than 1mV p-p. If it is greater than 1mV, check VR2, Q1, and U1, in that order.

5-50 If the ripple is not excessive in the reference supply, check the ripple across the main filter capacitor (T.P. F to +S). It should be less than 200mV p-p at no load or less than 3V p-p at full load. If the ripple here is significantly larger, check C9, CR3-CR6 (or U4), and C4, in that order.

5-51 Spikes occurring at a 120Hz rate can be caused by an open C4 (or C5) if included. Try repositioning the leads in the rectifier area (CR3-CR6, or U4) if the spike problem persists.

5-52 Crowbar Troubleshooting (Units with Option 011 or 104 Only)

5-53 The following table provides continued troubleshooting information for both option 011 and 104. Operating instructions, circuit descriptions and schematics for both crowbars are contained in the applicable Appendix; A or B.

5-54 REPAIR AND REPLACEMENT

5-55 Cover Removal

5-56 **A Suffix Supplies.** To remove the wrap-around cover on "A" series supplies, remove two screws each from the front and rear of the package and lift cover away from unit. If unit is equipped with an optional crowbar, sufficient lead length is provided so that the cover can be placed beside the unit.

5-57 **C and E Suffix Supplies.** To remove the covers for both the "C" and "E" series supplies, proceed as follows:

a. On right side of package, remove two screws approximately 5 inches to rear of the front edge of package. This loosens top and bottom L-shaped covers.

b. To remove top-front cover remove four screws on front of unit; one per corner.

c. To remove bottom-rear cover, remove four screws at rear of unit; one per corner.

5-58 Main P.C. Board Removal

5-59 **A Suffix Boards.** To remove the main P.C. board in "A" series supplies, proceed as follows:

a. Remove cover (previously described).

b. Remove two screws about 1/2-inch from rear edge holding terminal strip bracket.

c. Remove two screws about 3-inches from rear edge holding P.C. board.

d. Push P.C. board toward bottom of unit until top edge clears top slot in side cover.

e. Pull board from top slot then out of bottom slot and rotate for access to circuit side.

f. Ensure that leads are not pinched when reassembling.

5-60 **C and E Suffix Boards.** To remove P.C. board for these supplies, proceed as follows:

a. Loosen right cover and remove top-front cover (previously described).

b. Remove bottom-rear cover.

c. Remove left side cover by removing two screws about 5 inches back from front edge and two screws holding terminal strip bracket.

d. Board and series regulating transistor(s) are now exposed for servicing or removal.

5-61 Series Regulator Replacement

5-62 To remove and replace a series regulating transistor, proceed as follows:

a. Remove covers (previously described).

b. Remove collector screws and unsolder base and emitter leads.

c. To replace transistor, follow the below reassembly order, as viewed from bottom of heat sink: Collector screw, flat washer, shoulder washer, heat sink, silicon grease (Dow DC-3, HP 6040-0209, or HP 8500-0059), mica insulator, more silicon grease, transistor, electrical lug (on one collector screw), lockwasher and nut. (On "A" series transistors, the base and emitter pins have associated insultor bushings.)

5-63 Capacitor Replacement (A Suffix Supplies)

5-64 Due to space limitations in "A" series supplies, some of the filter and output capacitors (C9 and C11)

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are secured with nylon cable ties. These ties must be cut to remove C9 or C11. Replacement capacitors include these ties when ordered from Hewlett-Packard. Cable ties can also be ordered separately. Both C9 and C11 require Panduit type SST-2, or HP 1400-0265, cable ties. The ties can be installed with a special tool, such as a Panduit GS-2B, or with a pair of long nose pliers.

5-65 To replace the capacitor, proceed as follows:

a. Thread pointed end of tie through holes in P.C. board from top. Ensure that gripping teeth are on inside of loop being formed.

b. Insert capacitor in proper position on board. Head of cable tie should face inside of unit.

c. Tighten cable tie with tool or pliers. Cut excess about 1/4-inch from head.

d. Solder and trim capacitor leads.

5-66 Crowbar Board Removal

5-67 **A Suffix Supplies.** To remove the crowbar board (optional) on "A" series supplies, first remove the cover. Next, remove one number six and one number eight screw holding the crowbar board. If the SCR is replaced, use the same silicon grease recommended for the series regulating transistor.

5-68 **C and E Suffix Supplies.** For "C" and "E" series supplies, the crowbar board is removed as follows:

a. Loosen right side cover.

b. Remove top-front cover.

c. Remove one self-tapping screw from center of bottom-rear cover.

d. Loosen other self-tapping screw and rotate board upward to gain access to components.

e. To remove board, remove second self-tapping screw completely.

f. If SCR is replaced, use silicon grease recommended previously for series regulator.

5-69 Semiconductor Replacement

5-70 Table 5-7 contains replacement data for the semiconductors used in the modular supplies described by this manual. When replacing a semiconductor, use a Hewlett-Packard part or an exact commercial replacement part, if applicable. In cases where neither of these parts are immediately available and a part is needed for emergency operation or troubleshooting verification, the first or second alternate part (see Table 5-7) can be tried with at least a 90% probability of success. Also, the user has the option of hand selecting the alternate part by using the device characteristics listed in Table 5-7.

5-71 Notice that these alternate replacements apply only to the HP modular power supplies and their use in any other Hewlett-Packard instrument is not authorized because of inclusion in this table.

5-72 Current Limit Adjustment

5-73 The current limiting point for the supply is factory set to 104 ± 1% of the current rating with the output voltage set at nominal. As described in Paragraph 3-8, the current limit may require readjustment at output voltages other than nominal. The current limit should also be checked and adjusted, if necessary, after replacement of R15, R17 (if used), R18, or R19. Proceed as follows to check and adjust the current limit:

a. Connect setup shown in Figure 5-6.

b. With R_L at maximum, set output voltage to desired value.

c. Decrease R_L until current limit is reached (substantial increase in 120Hz ripple observed on scope). Reading on voltmeter is equivalent to current limit point.

d. If current limit of Step c is not 104 ± 1% of maximum current rating, change current limit by first increasing R_L.

e. Next, use insulated tool to increase current limit setting (turn R18 clockwise).

f. Again decrease R_L until voltmeter reads value equivalent to 104 ± 1% of maximum output current.

g. Decrease current limit setting (R18 ccw) until supply current limits (ripple increases on scope).

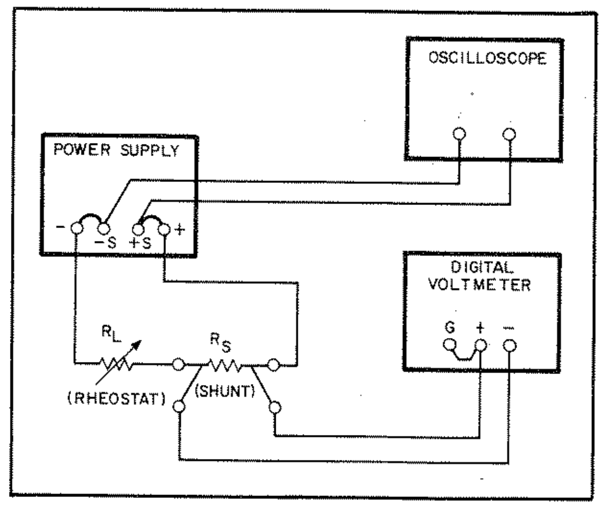

Figure 5-6. Current Limit Adjustment Setup

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Table 5-7. Semiconductor Replacement Data

REFERENCE DESIGNATOR	CHARACTERISTICS	HP PART NO.	EXACT COMMERCIAL REPLACEMENT	FIRST/ SECOND ALTERNATE
U1, U2, U3	BVCEO = 18V; I = 3mA; 0.5W, GAW = 84db; ft = 1MHz	1820-0223	LM301AH Nat. Semi.	———
Q1	BVCEO = 175V; I = 1A; 1W, GAW = 25 (min.); ft = 10MHz	1854-0095	40346 RCA	2N3440/2N3439
Q2	BVCEO = 100V; I = 1A; 1W, GAW = 50 (min.); ft = 100MHz	1853-0037	———	2N3634/2N3636
Q2	BVCER = 70V; I = 0.7A; 1W, GAW = 35-200; ft = 60MHz	1853-0041	———	2N4036/2N4314
Q2	BVCEO = 40V; I = 0.4A, 0.31W, GAW = 90-180; ft = 90MHz	1853-0099	———	2N2907A/2N3906
Q3	BVCEO = 120V; I = 0.5A; 1W, GAW = 35 (min.); ft = 150MHz	1854-0271	MM2258 Moto.	2N3500
Q3	BVCEO = 50V; I = 1A; 0.8W, ICBO = 10nA (max.); ft = 50MHz	1854-0244		2N1711A/2N2102A
Q3, 4, 5	BVCER = 80V; I = 15A; 175W, GAW = 50-90; ft = 500kHz	1854-0563	———	2N3055/2N5038
U4	PIV = 100V; I = 15A; 150W, Isurge = 150A	1906-0039	SCPAI Semtech	21PT10 Int. Rect. (Discrete Diodes)
U4	PIV = 200V; I = 10A @ 100°C, 100W, Isurge = 100A	1906-0041	IN4436/T/F	21PT10 Int. Rect. (Discrete Diodes)
U5	PIV = 100V; I = 15A; 150W, Isurge = 150A	1906-0040	SCDAI Semtech	21PT 10 Int. Rect. (Discrete Diodes)
VR1	7.5V, 0.4W	1902-0064	1N5236B	1N5236A
VR2	6.2V, 0.25W	1902-1221	1N825	1N825A
CR1,2,3,4,5,6	PIV = 200V; I = 1A; Irev. = 5μA	1901-0327	1N5059	———
CR3,4,5,6	PIV = 200V; I = 3A; Irev. = 1mA	1901-0416	1N4999	———

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SECTION VI
REPLACEABLE PARTS

6-1 INTRODUCTION

6-2 This section contains information for ordering replacement parts. Table 6-4 lists parts in alphanumeric order by reference designators and provides the following information:

a. Reference Designators. Refer to Table 6-1.

b. Description. Refer to Table 6-2 for abbreviations.

c. Total Quantity (TQ). Given only the first time the part number is listed except in instruments containing many sub-modular assemblies, in which case the TQ appears the first time the part number is listed in each assembly.

d. Manufacturer's Part Number or Type.

e. Manufacturer's Federal Supply Code Number. Refer to Table 6-3 for manufacturer's name and address.

f. Hewlett-Packard Part Number.

g. Recommended Spare Parts Quantity (RS) for complete maintenance of one instrument during one year of isolated service.

h. Parts not identified by a reference designator are listed at the end of Table 6-4 under Mechanical and/or Miscellaneous. The former consists of parts belonging to and grouped by individual assemblies; the latter consists of all parts not immediately associated with an assembly.

6-3 ORDERING INFORMATION

6-4 To order a replacement part, address order or inquiry to your local Hewlett-Packard sales office (see lists at rear of this manual for addresses). Specify the following information for each part: Model, complete serial number, and any Option or special modification (J) numbers of the instrument; Hewlett-Packard part number; circuit reference designator; and description. To order a part not listed in Table 6-4, give a complete description of the part, its function, and its location.

Table 6-1. Reference Designators

A	= assembly	E	= miscellaneous electronic part
B	= blower (fan)		
C	= capacitor	F	= fuse
CB	= circuit breaker	J	= jack, jumper
CR	= diode	K	= relay
DS	= device, signaling (lamp)	L	= inductor
		M	= meter

Table 6-1. Reference Designators (Continued)

P	= plug	V	= vacuum tube, neon bulb, photocell, etc.
Q	= transistor		
R	= resistor		
S	= switch	VR	= zener diode
T	= transformer	X	= socket
TB	= terminal block	Z	= integrated circuit or network
TS	= thermal switch		

Table 6-2. Description Abbreviations

A	= ampere	mfr	= manufacturer
ac	= alternating current	mod.	= modular or modified
assy.	= assembly	mtg	= mounting
bd	= board	n	= nano = 10^{-9}
bkt	= bracket	NC	= normally closed
°C	= degree Centigrade	NO	= normally open
		NP	= nickel-plated
cd	= card	Ω	= ohm
coef	= coefficient	obd	= order by description
comp	= composition		
CRT	= cathode-ray tube	OD	= outside diameter
CT	= center-tapped	p	= pico = 10^{-12}
dc	= direct current	P.C.	= printed circuit
DPDT	= double pole, double throw	pot.	= potentiometer
		p-p	= peak-to-peak
DPST	= double pole, single throw	ppm	= parts per million
elect	= electrolytic	pvr	= peak reverse voltage
encap	= encapsulated		
F	= farad	rect	= rectifier
°F	= degree Farenheit	rms	= root mean square
fxd	= fixed	Si	= silicon
Ge	= germanium	SPDT	= single pole, double throw
H	= Henry		
Hz	= Hertz	SPST	= single pole, single throw
IC	= integrated circuit		
		SS	= small signal
ID	= inside diameter	T	= slow-blow
incnd	= incandescent	tan.	= tantulum
k	= kilo = 10^3	Ti	= titanium
m	= milli = 10^{-3}	V	= volt
M	= mega = 10^6	var	= variable
μ	= micro = 10^{-6}	ww	= wirewound
met.	= metal	W	= Watt

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Table 6-3. Code List of Manufacturers

CODE	MANUFACTURER	ADDRESS
00629	EBY Sales Co., Inc.	Jamaica, N.Y.
00656	Aerovox Corp.	New Bedford, Mass.
00853	Sangamo Electric Co. S. Carolina Div.	Pickens, S.C.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Ind.	Beverly Hills, Calif.
01281	TRW Semiconductors, Inc.	Lawndale, Calif.
01295	Texas Instruments, Inc.	Dallas, Texas
01686	RCL Electronics, Inc.	Manchester, N.H.
01930	Amerock Corp.	Rockford, Ill.
02107	Sparta Mfg. Co.	Dover, Ohio
02114	Ferroxcube Corp.	Saugerties, N.Y.
02606	Fenwal Laboratories	Morton Grove, Ill.
02660	Amphenol Corp.	Broadview, Ill.
02735	Radio Corp. of America, Solid State and Receiving Tube Div.	Somerville, N.J.
03508	G.E. Semiconductor Products Dept.	Syracuse, N.Y.
03797	Eldema Corp.	Compton, Calif.
03877	Transitron Electronic Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co., Inc.	Cedar Knolls, N.J.
04009	Arrow, Hart and Hegeman Electric Co.	Hartford, Conn.
04072	ADC Electronics, Inc.	Harbor City, Calif.
04213	Caddell & Burns Mfg. Co. Inc.	Mineola, N.Y.
04404	*Hewlett-Packard Co. Palo Alto Div.	Palo Alto, Calif.
04713	Motorola Semiconductor Prod. Inc.	Phoenix, Arizona
05277	Westinghouse Electric Corp. Semiconductor Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	Grand Junction, Colo.
05820	Wakefield Engr. Inc.	Wakefield, Mass.
06001	General Elect. Co. Electronic Capacitor & Battery Dept.	Irmo, S.C.
06004	Bassik Div. Stewart-Warner Corp.	Bridgeport, Conn.
06486	IRC Div. of TRW Inc. Semiconductor Plant	Lynn, Mass.
06540	Amatom Electronic Hardware Co. Inc.	New Rochelle, N.Y.
06555	Beede Electrical Instrument Co.	Penacook, N.H.
06666	General Devices Co.	Indianapolis, Ind.
06751	Semoor Div. Components, Inc.	Phoenix, Arizona
06776	Robinson Nugent, Inc.	New Albany, N.Y.
06812	Torrington Mfg. Co.	Van Nuys, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp.	Elmira, N.Y.
07263	Fairchild Camera and Instrument	Mountain View, Calif.
07387	Birtcher Corp., The	Los Angeles, Calif.
07397	Sylvania Electric Prod. Inc.	Mountainview, Calif.
07716	IRC Div. of TRW Inc.	Burlington, Iowa
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Raytheon Co. Components Div.	Mountain View, Calif.
08484	Breeze Corporations, Inc.	Union, N.J.
08530	Reliance Mica Corp.	Brooklyn, N.Y.
08717	Sloan Company, The	Sun Valley, Calif.
08730	Vemaline Products Co. Inc.	Wyckoff, N.J.
08806	General Elect. Co. Minature Lamp Dept.	Cleveland, Ohio
08863	Nylomatic Corp.	Norrisville, Pa.
08919	RCH Supply Co.	Vernon, Calif.
09021	Airco Speer Electronic Components	Bradford, Pa.
09182	*Hewlett-Packard Co. New Jersey Div.	Rockaway, N.J.
09213	General Elect. Co. Semiconductor Prod. Dept.	Buffalo, N.Y.
09214	General Elect. Co. Semiconductor Prod. Dept.	Auburn, N.Y.
09353	C & K Components Inc.	Newton, Mass.
09922	Burndy Corp.	Norwalk, Conn.
11115	Wagner Electric Corp. Tung-Sol Div.	Bloomfield, N.J.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of Cal. Inc.	So. Pasadena, Calif.
11502	IRC Div. of TRW Inc.	Boone, N.C.
11711	General Instrument Corp.	Newark, N.J.
12136	Philadelphia Handle Co.	Camden, N.J.
12615	U.S. Terminals, Inc.	Cincinnati, Ohio
12617	Hamlin Inc.	Lake Mills, Wisconsin
12697	Clarostat Mfg. Co. Inc.	Dover, N.H.
13103	Thermalloy Co.	Dallas, Texas
14493	*Hewlett-Packard Co.	Loveland, Colo.
14655	Cornell-Dubilier Electronics Div. Federal Pacific Electric Co.	Newark, N.J.
14936	General Instrument Corp. Semiconductor Prod. Group	Hicksville, N.Y.
15801	Fenwal Elect.	Framingham, Mass.
16299	Corning Glass Works	Raleigh, N.C.

*Use Code 28480 assigned to Hewlett-Packard Co., Palo Alto, California

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Table 6-3. Code List of Manufacturers (Continued)

CODE NO.	MANUFACTURER	ADDRESS
16758	Delco Radio Div. of General Motors Corp.	Kokomo, Ind.
17545	Atlantic Semiconductors, Inc.	Asbury Park, N. J.
17803	Fairchild Camera and Instrument Corp Semiconductor Div. Transducer Plant	Mountain View, Calif.
17870	Daven Div. Thomas A. Edison Industries McGraw-Edison Co.	Orange, N. J.
18324	Signetics Corp.	Sunnyvale, Calif.
19315	Bendix Corp. The Navigation and Control Div.	Teterboro, N. J.
19701	Electra/Midland Corp.	Mineral Wells, Texas
21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.
22229	Union Carbide Corp. Electronics Div.	Mountain View, Calif.
22753	UID Electronics Corp.	Hollywood, Fla.
23936	Pamotor, Inc.	Pampa, Texas
24446	General Electric Co.	Schenectady, N. Y.
24455	General Electric Co. Lamp Div. of Consumer Prod. Group	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
24681	LTV Electrosystems Inc Memcor/Components Operations	Huntington, Ind.
26982	Dynacool Mfg. Co. Inc.	Saugerties, N. Y.
27014	National Semiconductor Corp.	Santa Clara, Calif.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
28520	Heyman Mfg. Co.	Kenilworth, N. J.
28875	IMC Magnetics Corp. New Hampshire Div.	Rochester, N. H.
31514	SAE Advance Packaging, Inc.	Santa Ana, Calif.
31827	Budwig Mfg. Co.	Ramona, Calif.
33173	G. E. Co. Tube Dept.	Owensboro, Ky.
35434	Lectrohm, Inc.	Chicago, Ill.
37942	P. R. Mallory & Co. Inc.	Indianapolis, Ind.
42190	Muter Co.	Chicago, Ill.
43334	New Departure-Hyatt Bearings Div. General Motors Corp.	Sandusky, Ohio
44655	Ohmite Manufacturing Co.	Skokie, Ill.
46384	Penn Engr. and Mfg. Corp.	Doylestown, Pa.
47904	Polaroid Corp.	Cambridge, Mass.
49956	Raytheon Co.	Lexington, Mass.
55026	Simpson Electric Co. Div. of American Gage and Machine Co.	Chicago, Ill.
56289	Sprague Electric Co.	North Adams, Mass.
58474	Superior Electric Co.	Bristol, Conn.
58849	Syntron Div. of FMC Corp.	Homer City, Pa.
59730	Thomas and Betts Co.	Philadelphia, Pa.
61637	Union Carbide Corp.	New York, N. Y.
63743	Ward Leonard Electric Co.	Mt. Vernon, N. Y.
70563	Amperite Co. Inc.	Union City, N. J.
70901	Beemer Engrg. Co.	Fort Washington, Pa.
70903	Belden Corp.	Chicago, Ill.
71218	Bud Radio, Inc.	Willoughby, Ohio
71279	Cambridge Thermionic Corp.	Cambridge, Mass.
71400	Bussmann Mfg. Div. of McGraw & Edison Co.	St. Louis, Mo.
71450	CTS Corp.	Elkhart, Ind.
71468	I. T. T. Cannon Electric Inc.	Los Angeles, Calif.
71590	Globe-Union Inc. Centralab Div.	Milwaukee, Wis.
71700	General Cable Corp. Cornish Wire Co. Div.	Williamstown, Mass.
71707	Coto Coil Co. Inc.	Providence, R. I.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71785	Cinch Mfg. Co. and Howard B. Jones Div.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72136	Electro Motive Mfg. Co. Inc.	Willimantic, Conn.
72619	Dialight Corp.	Brooklyn, N. Y.
72699	General Instrument Corp.	Newark, N. J.
72765	Drake Mfg. Co.	Harwood Heights, Ill.
72962	Elastic Stop Nut Div. of Amerace Esna Corp.	Union, N. J.
72982	Erie Technological Products Inc.	Erie, Pa.
73096	Hart Mfg. Co.	Hartford, Conn.
73138	Beckman Instruments Inc. Helipot Div.	Fullerton, Calif.
73168	Fenwal, Inc.	Ashland, Mass.
73293	Hughes Aircraft Co. Electron Dynamics Div.	Torrance, Calif.
73445	Amperex Electronic Corp.	Hicksville, N. Y.
73506	Bradley Semiconductor Corp.	New Haven, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73734	Federal Screw Products, Inc.	Chicago, Ill.
74193	Heinemann Electric Co.	Trenton, N. J.
74545	Hubbell Harvey Inc.	Bridgeport, Conn.
74868	Amphenol Corp. Amphenol RF Div.	Danbury, Conn.
74970	E. F. Johnson Co.	Waseca, Minn.
75042	IRC Div. of TRW, Inc.	Philadelphia, Pa.
75183	*Howard B. Jones Div. of Cinch Mfg. Corp.	New York, N. Y.
75376	Kurz and Kasch, Inc.	Dayton, Ohio
75382	Kilka Electric Corp.	Mt. Vernon, N. Y.
75915	Littlefuse, Inc.	Des Plaines, Ill.
76381	Minnesota Mining and Mfg. Co.	St. Paul, Minn.
76385	Minor Rubber Co. Inc.	Bloomfield, N. J.
76487	James Millen Mfg. Co. Inc.	Malden, Mass.
76493	J. W. Miller Co.	Compton, Calif.

*Use Code 71785 assigned to Cinch Mfg. Co., Chicago, Ill.

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Table 6-3. Code List of Manufacturers (Continued)

CODE NO.	MANUFACTURER	ADDRESS
76530	Cinch	City of Industry, Calif.
76854	Oak Mfg. Co. Div. of Oak Electro/Netics Corp.	Crystal Lake, Ill.
77068	Bendix Corp., Electrodynamics Div.	No. Hollywood, Calif.
77122	Palnut Co.	Mountainside, N.J.
77147	Patton-MacGuyer Co.	Providence, R.I.
77221	Phaostron Instrument and Electronic Co.	South Pasadena, Calif.
77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
77342	American Machine and Foundry Co. Potter and Brumfield Div.	Princeton, Ind.
77630	TRW Electronic Components Div.	Camden, N.J.
77764	Resistance Products Co.	Harrisburg, Pa.
78189	Illinois Tool Works Inc. Shakeproof Div.	Elgin, Ill.
78452	Everlock Chicago, Inc.	Chicago, Ill.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78526	Stanwyck Winding Div. San Fernando Electric Mfg. Co. Inc.	Newburgh, N.Y.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78584	Stewart Stamping Corp.	Yonkers, N.Y.
79136	Waldes Kohinoor, Inc.	L.I.C., N.Y.
79307	Whitehead Metals Inc.	New York, N.Y.
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Co.	Mt. Kisco, N.Y.
80031	Mepco Div. of Sessions Clock Co.	Morristown, N.J.
80294	Bourns, Inc.	Riverside, Calif.
81042	Howard Industries Div. of Msl Ind. Inc.	Racine, Wisc.
81073	Grayhill, Inc.	La Grange, Ill.
81483	International Rectifier Corp.	El Segundo, Calif.
81751	Columbus Electronics Corp.	Yonkers, N.Y.
82099	Goodyear Sundries & Mechanical Co. Inc.	New York, N.Y.
82142	Airco Speer Electronic Components	Du Bois, Pa.
82219	Sylvania Electric Products Inc. Electronic Tube Div. Receiving Tube Operations	Emporium, Pa.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals and Controls Inc. Control Products Group	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83058	Carr Fastener Co.	Cambridge, Mass.
83186	Victory Engineering Corp.	Springfield, N.J.
83298	Bendix Corp. Electric Power Div.	Eatontown, N.J.
83330	Herman H. Smith, Inc.	Brooklyn, N.Y.
83385	Central Screw Co.	Chicago, Ill.
83501	Gavitt Wire and Cable Div. of Amerace Esna Corp.	Brookfield, Mass.

CODE NO.	MANUFACTURER	ADDRESS
83508	Grant Pulley and Hardware Co.	West Nyack, N.Y.
83594	Burroughs Corp. Electronic Components Div.	Plainfield, N.J.
83835	U.S. Radium Corp.	Morristown, N.J.
83877	Yardeny Laboratories, Inc.	New York, N.Y.
84171	Arco Electronics, Inc.	Great Neck, N.Y.
84411	TRW Capacitor Div.	Ogallala, Neb.
86684	RCA Corp. Electronic Components	Harrison, N.J.
86838	Rummel Fibre Co.	Newark, N.J.
87034	Marco & Oak Industries a Div. of Oak Electro/netics Corp.	Anaheim, Calif.
87216	Philco Corp. Lansdale Div.	Lansdale, Pa.
87585	Stockwell Rubber Co. Inc.	Philadelphia, Pa.
87929	Tower-Olschan Corp.	Bridgeport, Conn.
88140	Cutler-Hammer Inc. Power Distribution and Control Div. Lincoln Plant	Lincoln, Ill.
88245	Litton Precision Products Inc, USECO Div. Litton Industries	Van Nuys, Calif.
90634	Gulton Industries Inc.	Metuchen, N.J.
90763	United-Car Inc.	Chicago, Ill.
91345	Miller Dial and Nameplate Co.	El Monte, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat, Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Neb.
91662	Elco Corp.	Willow Grove, Pa.
91929	Honeywell Inc. Div. Micro Switch	Freeport, Ill.
92825	Whitso, Inc.	Schiller Pk., Ill.
93332	Sylvania Electric Prod. Inc. Semi-conductor Prod. Div.	Woburn, Mass.
93410	Essex Wire Corp. Stemco Controls Div.	Mansfield, Ohio
94144	Raytheon Co. Components Div. Ind. Components Oper.	Quincy, Mass.
94154	Wagner Electric Corp. Tung-Sol Div.	Livingston, N.J.
94222	Southco Inc.	Lester, Pa.
95263	Leecraft Mfg. Co. Inc.	L.I.C., N.Y.
95354	Methode Mfg. Co.	Rolling Meadows, Ill.
95712	Bendix Corp. Microwave Devices Div.	Franklin, Ind.
95987	Weckesser Co. Inc.	Chicago, Ill.
96791	Amphenol Corp. Amphenol Controls Div.	Janesville, Wis.
97464	Industrial Retaining Ring Co.	Irvington, N.J.
97702	IMC Magnetics Corp. Eastern Div.	Westbury, N.Y.
98291	Sealectro Corp.	Mamaroneck, N.Y.
98410	ETC Inc.	Cleveland, Ohio
98978	International Electronic Research Corp.	Burbank, Calif.
99934	Renbrandt, Inc.	Boston, Mass.

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Table 6-4. Replaceable Parts

REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
	A-SERIES (62003A thru 62048A)					
	Main Power Supply Board					
C1	fxd, elect. 300μF 40Vdc	1	34D307G040GJ2	56289	0180-1805	1
C2	fxd, mica 390pF 300Vdc	1		28480	0140-0200	1
C3	fxd, mylar .47μF 25Vdc	2		28480	0160-0174	1
C4	fxd, ceramic .05μF 400Vdc	1		28480	0150-0052	1
C9		1				
62003A thru 62010A	fxd, elect. 6000μF 25Vdc			28480	0180-2520	
62012A thru 62028A	fxd, elect. 3000μF 50VDC			28480	0180-2510	
62048A	fxd, elect. 1500μF 100Vdc			28480	0180-2521	
C11		1				1
62003A thru 62024A	fxd, elect. 1400μF 30Vdc			28480	0180-1860	
62028A, 62048A	fxd, elect. 490μF 65Vdc			28480	0180-1856	
C12						1
62003A thru 62028A	fxd, tantalum 4.7μF 35Vdc		150D475X9035B2	56289	0180-0100	
62048A	fxd, tantalum 5μF 65Vdc			28480	0180-1836	1
C13	fxd, mylar .01μF 200Vdc	1	192P10392	56289	0160-0161	1
C14	fxd, mica 10pF 300Vdc	1	RDM15C10053C	00853	0160-2197	1
C15	fxd, mica .47μF 25Vdc			28480	0160-0174	
C16	fxd, mica 30pF 300Vdc	1	RDM15E300J3C	00853	0160-2199	1
CR1,2	Rectifier Si 200V 1A	4	IN5059	28480	1901-0327	4
CR3-6		4				4
62003A thru 62006A	Diode Si 200V 3A		IN4999	28480	1901-0416	
62010A thru 62048A	Diode Si 200V 1A		IN5059	28480	1901-0327	
CR8,9	Rectifier Si 200V 1A		IN5059	28480	1901-0327	
CR11-14	Diode Si 250mW 200V	4	IN485B	28480	1901-0033	4
CR15	Stabistor 400mW 10V	1		28480	1901-0460	1
Q1	SS NPN Si	1	40346	02735	1854-0095	1
Q2	SS PNP Si	1		28480	1853-0099	1
Q3	SS NPN Si	1	MM2258	04713	1854-0271	1
R1	fxd, comp 1.5k 5% 1/2W	1	EB-1525	01121	0686-1525	1
R2,3	fxd, met film 6.2k 1% 1/8W	2	Type CEA T-O	07716	0698-5087	1
R4	fxd, met film 750 1% 1/8W	1	Type CEA T-O	07716	0757-0420	1
R5	fxd, ww 5.9k 1% 2/3W	1		28480	0811-1978	1
R6		1				1
62003A	fxd, ww 3.6k 5% 3W		242E3625	56289	0811-1810	
62004A	fxd, ww 4.7k 5% 3W			28480	0811-1812	
62005A	fxd ww 6.8k 5% 3W		242E6825	56289	0811-0960	
62006A	fxd, ww 10k 5% 3W		242E1035	56289	0811-1816	
62010A thru 62048A	Not Used					
R8		1				1
62003A	fxd, ww 2100 1% 1W			28480	0811-3187	
62004A	fxd, ww 2950 1% 1W			28480	0811-3192	
62005A	fxd, ww 3800 1% 1W			28480	0811-3195	
62006A	fxd, ww 4660 1% 1W			28480	0811-3193	
62010A	fxd, ww 10,750 1% 3W			28480	0811-3194	
62012A	fxd, ww 12,900 1% 3W			28480	0811-3186	

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REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
62015A	fxd, ww 16,100 1% 3W			28480	0811-3196	
62018A	fxd, ww 19,350 1% 3W			28480	0811-3190	
62024A	fxd, ww 25,800 1% 4W			28480	0811-3188	
62028A	fxd, ww 30,050 1% 4W			28480	0811-3191	
62048A	fxd, ww 51,550 1% 5W			28480	0811-3197	
R10		1				1
62003A thru 62006A	fxd, comp 1k 5% 1/2W		EB-1025	01121	0686-1025	
62010A thru 62015A	fxd, comp 3.9k 5% 1/2W		EB-3925	01121	0686-3925	
62018A	fxd, comp 4.3k 5% 1/2W		EB-4325	01121	0686-4325	
62024A	fxd, comp 5.6k 5% 1/2W		EB-5625	01121	0686-5625	
62028A	fxd, comp 7.5k 5% 1/2W		EB-7525	01121	0686-7525	
62048A	fxd, comp 22 5% 1/2W		EB-2205	01121	0686-2205	
R11	fxd, ww 1k 5% 3W	1	242E1025	56289	0813-0001	1
R12	fxd, comp 7.5k 5% 1/2W	1	EB-7525	01121	0686-7525	1
R13	fxd, comp 560 5% 1/2	2	EB-5615	01121	0686-5615	1
R15	(Current Sampling)	1				1
62003A thru 62005A	fxd, ww 0.125 10% 3W		Type CW2B-1	91637	0811-1828	
62006A thru 62015A	fxd, ww 0.15 5% 3W			28480	0812-0045	
62018A	fxd, ww 0.25 10% 3W		Type CW2B-1	91637	0811-1829	
62024A, 62028A	fxd, ww 0.33 5% 2W		Type BWH	07716	0812-0066	
62048A	fxd, ww 0.51 5% 2W		Type BWH	07716	0811-0929	
R18	(Current Limit Adjust)	1				1
62003A thru 62006A	var. ww 5 20% 1.5W		Type 110-F4	11236	2100-1821	
62010 thru 62048A	var. ww 10 20% 1.5W		Type 110-F4	11236	2100-1822	
R19		1				1
62003A thru 62006A	fxd, met. oxide 30 5% 2W			28480	0764-0041	
62010A thru 62018A	fxd, met. oxide 270 5% 2W		Type C-425	16299	0698-3629	
62024A, 62028A	fxd, met. oxide 560 5% 2W		Type C-425	16299	0764-0015	
62048A	fxd, met. oxide 1.1k 5% 3W		Type 242E	56289	0811-2878	
R20		1				1
62003A thru 62005A						
62018A thru 62048A	fxd, met. film 139 1% 1/8W		Type CEA T-0	07716	0698-4099	
62006A thru 62012A	fxd, met. film 150 1% 1/8W		Type CEA T-0	07716	0757-0284	
62015A	fxd, met. film 107 1% 1/8W			28480	0698-4405	
R21	fxd, met. film 68.1k 1% 1/8W	1	Type CEA T-0	07716	0757-0461	1
R22	fxd, comp 100 5% 1/2W	3	EB-1015	01121	0686-1015	1
R23	fxd, comp 560 5% 1/2W		EB-5615	01121	0686-5615	
R25	fxd, comp 1.3k 5% 1/2W	1	EB-1325	01121	0686-1325	1
R26	fxd, comp 270 5% 1/2W	1	EB-2715	01121	0686-2715	1
R27		1				1
62003A thru 62028A	fxd, comp 12 5% 1/2W		EB-1205	01121	0686-1205	
62048A	Not Used					
R28		1				1
62003A thru 62028A	fxd, comp 1k 5% 1/2W	1	EB-1025	01121	0686-1025	
62048A	Not Used					
R29		1				1
62003A	fxd, met. oxide 30 5% 2W		Type C-425	16299	0764-0041	
62004A, 62005A	fxd, met. oxide 56 5% 2W		Type C-425	16299	0764-0013	
62006A	fxd, met. oxide 100 5% 2W		Type C-425	16299	0698-3260	

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REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
62010A	fxd, met. oxide 200 5% 2W			28480	0698-3627	
62012A	fxd, met. oxide 270 5% 2W		Type C-425	16299	0698-3629	
62015A	fxd, met. oxide 390 5% 2W		Type C-425	16299	0698-3633	
62018A	fxd, met. oxide 510 5% 2W		Type C-425	16299	0698-0030	
62024A	fxd, met. oxide 680 5% 2W		Type C-425	16299	0698-3635	
62028A	fxd, met. oxide 820 5% 2W		Type C-425	16299	0098-3637	
62048A	fxd, met. oxide 2k 5% 3W			28480	0811-1806	
R30	fxd, comp 75 5% 1/2W	1	EB-7505	01121	0686-7505	1
R31		1				1
62003A thru 62010A	fxd, comp 1.5k 5% 1W		6B-1525	01121	0689-1525	
62012A thru 62018A	fxd, comp 3k 5% 1W		6B-3025	01121	0689-3025	
62024A, 62028A	fxd, comp 5.1k 5% 1W		6B-5125	01121	0689-5125	
62048A	fxd, comp 5.6k 3% 3W		RS2B-95	91637	0812-0091	
R32, 33	fxd, comp 100 5% 1/2W		EB-1015	01121	0686-1015	
U1-3	Operational Amplifier	3	LM301A	07014	1820-0223	1
VR1	Diode, zener 7.5V 400mW	1		28480	1902-0064	1
VR2	Diode, zener 6.2V 250mW	1		28480	1902-1221	1
	Chassis Electrical					
F1		1				5
62003A thru 62006A	Fuse, 0.5A 250V		312.500	75915	2110-0012	
62010A thru 62048A	Fuse, 0.75A 250V			28480	2110-0063	
Q4	Power NPN Si	1		28480	1854-0563	1
R7	(Voltage Adjust)	1				1
62003A thru 62006A	var. ww 2700 5% 2W			28480	2100-3255	
62010A thru 62048A	var. ww 1800 5% 2W			28480	2100-3254	
T1		1				1
62003A thru 62005A	Power Transformer			28480	5080-7193	
62006A thru 62015A	Power Transformer			28480	5080-7194	
62018A thru 62028A	Power Transformer			28480	5080-7195	
62048A	Power Transformer			28480	62048-80091	
TB1	Terminal Block (Rear), 7-Term.	1		28480	0360-1766	
TC1	Thermal Switch, open 220 ±6°F, close 195 ±8°F	1		28480	3103-0018	1
	Mechanical					
	Wrap Around Cover	1		28480		
	62003A				62003-60001	
	62004A				62004-60001	
	62005A				62005-60001	
	62006A				62006-60001	
	62010A				62010-60001	
	62012A				62012-60001	
	62015A				62015-60001	
	62018A				62018-60001	
	62024A				62024-60001	
	62028A				62028-60001	

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REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
	62048A				62048-60001	
	Side Panel	1		28480	5020-8087	
	Snap Bushing, Side Panel (Current Limit Adj.)	1		28480	0400-0064	
	Terminal Block Jumper (TB1)	2		28480	0360-1784	
	Terminal Block Cover (TB1)	1		28480	4040-0948	
	Heat Sink (Q4)	1		28480	5000-9349	
	Insulator, Mica (Q4)	1	757-T0-3	08530	0340-0181	
	Insulator, Transistor Pin (Q4)	2		28480	0340-0167	
	Insulator, Shoulder Washer (Q4)	2		28480	2190-0490	
	Fuseholder, F1	1	342014	75915	1400-0084	
	Insulator, Fuseholder	1	901-129	75915	1400-0090	
	Bracket, Rear Chassis	1		28480	5000-9351	
	Bracket, Volt. Adj.	1		28480	5000-9348	
	Tie Wrap (C9 and C11)	3		28480	1400-0265	
	Plug (Crowbar Adjust hole)	1		28480		
	Packing Carton	1		28480	9211-1197	
	Floater Pad, Packing Carton	1		28480	9220-1411	
	Floater Pad, Packing Carton	1		28480	9220-1414	
	Floater Pad, Packing Carton	1		28480	9220-1415	
	Option 101 (220V ac)					
	Option 102 (240V ac)					
F1		1				5
62003A thru 62006A	Fuse, 0.3A 250V			28480	2110-0067	
62010A thru 62048	Fuse, 0.375A 250V			28480	2110-0065	
T1	Power Transformer (wired for 220V ac for option 101 or 240V ac for option 102					
62003A thru 62005A				28480	5080-7199	
62006A thru 62015A				28480	5080-7200	
62018A thru 62028A				28480	5081-4919	
62048A				28480	62048-80095	
	Option 103 (120V ac 240V ac)					
62003A thru 62006A	Fuse, 0.3A 250V (replaces F1 if T1 wired for 240V ac)	1		28480	2110-0067	5
62010A thru 62048A	Fuse, 0.375A 250V (replaces F1 if T1 wired for 240V ac)	1		28480	2110-0065	5
T1	Power Transformer (shipped wired for 120V ac)	1				

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REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
	C-SERIES (62003C thru 62048C)					
	Main Power Supply Board					
C1	fxd, elect. 300μF 40V dc	1	34D307G040GJ2	56289	0180-1805	1
C2	fxd, mica 390pF 300V dc	1		28480	0140-0200	1
C3	fxd, mylar. 0.47μF 25V dc	2		28480	0160-0174	1
C12		1				1
62003C thru 620028C	fxd, tantalum 4.7μF 35V dc		150D475X9035B2	56289	0180-0100	
620048C	fxd, tantalum 5μF 65V dc			28480	0180-1836	
C13	fxd, mylar. .01μF 200V dc	1	192P10392	56289	0160-0161	1
C14	fxd, mica 10pF 300V dc	1	RDM15C10053C	00853	0160-2197	1
C15	fxd, mylar. 0.47μF 25V dc			28480	0160-0174	
C16	fxd, mica 30pF 300V dc	1	ROM15E30053C	00853	0160-2199	1
C18	fxd, mica 100pF 500V dc	1	RCM15E101J	00853	0140-0041	1
C19		1				1
62003C thru 62010C	fxd, mylar. .01μF 200V dc		192P10392	56289	0160-0161	
62012C thru 62018C	fxd, mylar. .0047μF 200V dc		192P47292	56289	0160-0157	
62024C thru 62048C	fxd, mylar. .001μF 200V dc			56289	0160-0157	
CR1,2	Rectifier S1 200V 1A	2	1N5059	28480	1901-0327	2
CR3-6		4				4
62003C thru 62018C	Not Used					
62024C thru 62048C	Rectifier S1 200V 1A		1N5059	28480	1901-0327	
CR8,9	Diode S1 200V 3A	2	1N4999	28480	1901-0416	2
CR11-14	Diode S1 250mW 200V	4	1N485B	28480	1901-0033	4
CR15	Stabistor 400mW 10V	1		28480	1901-0460	1
Q1	SS NPN S1	1	40346	02735	1854-0095	1
Q2		1				1
62003C thru 62018C	SS PNP S1			28480	1853-0099	
62024C thru 62028C	SS PNP S1			28480	1853-0041	
62048C	SS PNP S1			28480	1853-0037	
Q3		1				1
62003C thru 62018C	SS NPN S1			28480	1854-0244	
62024C thru 62048C	SS NPN S1		MM2258	04713	1854-0271	
R1	fxd, comp 1.5k 5% 1/2W	1	EB-1525	01121	0686-1525	1
R2,3	fxd, met. film 6.2k 1% 1/8W	2	Type CEA T-0	07716	0698-5087	1
R4	fxd, met. film 750 1% 1/8W	1	Type CEA T-0	07716	0757-0420	1
R5	fxd, ww 5.9k 1% 2/3W	1		28480	0811-1978	1
R6		1				1
62003C	fxd, ww 3.6k 5% 3W		242E 3625	56289	0811-1810	
62004C	fxd, ww 4.7k 5% 3W			28480	0811-1812	
62005C	fxd, ww 6.8k 5% 3W		242E 6825	56289	0811-0960	
62006C	fxd, ww 10k 5% 3W		242E 1035	56289	0811-1816	
62010C thru 62048C	Not Used					
R8		1				1
62003C	fxd, ww 2100 1% 1W			28480	0811-3187	
62004C	fxd, ww 2950 1% 1W			28480	0811-3192	
62005C	fxd, ww 3800 1% 1W			28480	0811-3195	
62006C	fxd, ww 4660 1% 1W			28480	0811-3193	
62010C	fxd, ww 10,750 1% 3W			28480	0811-3194	

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REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
62012C	fxd, ww 12,900 1% 3W			28480	0811-3186	
62015C	fxd, ww 16,100 1% 3W			28480	0811-3196	
62018C	fxd, ww 19,350 1% 3W			28480	0811-3190	
62024C	fxd, ww 25,800 1% 4W			28480	0811-3188	
62028C	fxd, ww 30,050 1% 4W			28480	0811-3191	
62048C	fxd, ww 51,550 1% 5W			28480	0811-3197	
R10		1				1
62003, 62004C	fxd, comp 430 5% 1/2W		EB-4315	01121	0686-4315	
62005C	fxd, comp 1k 5% 1/2W		EB-1025	01121	0686-1025	
62006C thru 62012C	fxd, comp 2k 5% 1/2W		EB-2025	01121	0686-2025	
62015C	fxd, comp 2.4k 5% 1/2W		EB-2425	01121	0686-2425	
62018C	fxd, comp 4.3k 5% 1/2W		EB-4325	01121	0686-4325	
62024C	fxd, comp 4.7k 5% 1/2W		EB-4725	01121	0686-4725	
62028C	fxd, comp 7.5k 5% 1/2W		EB-7525	01121	0686-7525	
62048C	fxd, comp 8.2k 5% 1/2W		EB-8225	01121	0686-8225	
R11	fxd, ww 1k 5% 3W	1	242E1025	56289	0813-0001	1
R12	fxd, comp 7.5k 5% 1/2W	1	EB-7525	01121	0686-7525	1
R13	fxd, comp 560 5% 1/2W	2	EB-5615	01121	0686-5615	1
R15	(Current Sampling)	1				1
62003C thru 62015C	fxd, ww .07 5% 5W			28480	0811-3174	
62018C	fxd, ww 0.1 5% 3W			28480	0811-1827	
62024C, 62028C	fxd, ww 0.125 5% 3W		Type CW2B-1	91637	0811-1828	
62048C	fxd, ww 0.25 10% 3W		Type CW2B-1	91637	0811-1829	
R17		1				1
62003C thru 62006C	fxd, ww 3.3 5% 2W		Type BWH	07716	0811-1672	
62010C, 62012C	fxd, ww 3 5% 3W		Type 242E3R05	56289	0811-1224	
62015C	fxd, ww 2.7 5% 2W		Type BWH	07716	0811-1671	
62018C, 62028C	fxd, ww 4.3 5% 2W		Type BWH	07716	0811-1760	
62024C	fxd, ww 4.7 5% 2W		Type BWH	07716	0811-1674	
62048C	fxd, ww 1.5 5% 3W			28480	0811-1557	1
R18	var. ww 100 20%	1	Type 110-F4	11236	2100-0281	1
R19		1				1
62003C	fxd, met. oxide 22 5% 2W		Type C-425	16299	0698-3609	
62004C	fxd, met. oxide 30 5% 2W			28480	0764-0041	
62005C	fxd, met. oxide 43 5% 2W		Type C-425	16299	0698-3614	
62006C	fxd, met. oxide 56 5% 2W		Type C-425	16299	0764-0013	
62010C	fxd, met. oxide 100 5% 2W		Type C-425	16299	0698-3620	
62012C	fxd, ww 135 5% 3W		Type 242E	56289	0698-3609	
62015C	fxd, met. oxide 180 5% 2W		Type C-425	16299	0698-3626	
62018C	fxd, met. oxide 270 5% 2W		Type C-425	16299	0698-3629	
62024C	fxd, ww 390 5% 3W		Type BWH	07716	0811-1799	
62028C	fxd, ww 490 5% 3W		242E 4915	56289	0811-1801	
62048C	fxd, ww 1.4k 5% 3W		242E 1425	56289	0811-1804	
R20		1				1
62003C thru 62006C, 62015C, 62048C	fxd, met. film 139 1% 1/8W		Type CEA T-0	07716	0698-4099	
62010C, 62012C	fxd, met. film 110 1% 1/8W		Type CEA T-0	07716	0757-0402	
62018C	fxd, met. film 115 1% 1/8W		Type CEA T-0	07716	0698-4406	
62024C	fxd, met. film 150 1% 1/8W		Type CEA T-0	07716	0757-0284	

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REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
62028C	fxd, met. film 121 1% 1/8W		Type CEA T-0	07716	0757--4-3	
R21		1				1
62003C	fxd, met. film 61.9k 1% 1/8W		Type CEA T-0	07716	0757-0460	
62004C, 62005C, 62010C, 62018C, 62028C	fxd, met. film 64k 1% 1/8W		Type CEA T-0	07716	0698-6274	
62006C, 62012C, 62015C, 62024C, 62048C	fxd, met. film 68.1k 1% 1/8W		Type CEA T-0	07716	0757-0461	
R22	fxd, comp 100 5% 1/2W	3	EB-1015	01121	0686-1015	1
R23	fxd, comp 560 5% 1/2W		EB-5615	01121	0686-5615	
R25	fxd, comp 1.3k 5% 1/2W	1	EB-1325	01121	0686-1325	1
R26	fxd, comp 270 5% 1/2W	1	EB-2715	01121	0686-2715	1
R27		1				1
62003C, 62004C 62024C thru 62048C	fxd, comp 10 5% 1/2W		EB-1005	01121	0686-1005	
62005C thru 62018C	fxd, comp 8.2 5% 1/2W		EB-82G5	01121	0698-5479	
R28	fxd, comp 1k 5% 1/2W	1	EB-1025	01121	0686-1025	1
R29		1				1
62003C	fxd, met. oxide 22 5% 2W		Type C-425	16299	0698-3909	
62004C, 62005C	fxd, met. oxide 30 5% 2W			28480	0764-0041	
62006C	fxd, met. oxide 43 5% 2W		Type C-425	16299	0698-3614	
62010C	fxd, ww 75 5% 5W		243E9505	56289	0812-0097	
62012C	fxd, ww 120 5% 5W			28480	0811-2138	
62015C	fxd, ww 150 5% 5W		243E1515	56289	0811-1217	
62018C	fxd, ww 200 5% 5W		243E2015	56289	0811-1204	
62024C	fxd, met. oxide 430 5% 2W		Type C-425	16299	0764-0024	
62028C	fxd, ww 600 5% 5W		243E6015	56289	0811-1860	
62048C	fxd, ww 1.4k 5% 3W		242E1425	56289	0811-1804	
R30	fxd, comp 75 5% 1/2W	1	EB-7505	01121	0686-7505	1
R31		1				1
62003C thru 62006C	fxd, ww 470 5% 3W		242E4715	56289	0811-1555	
62010C	fxd, ww 490 5% 3W		242E4915	56289	0811-1801	
62012C, 62015C	fxd, ww 820 5% 3W		242E8215	56289	0811-0010	
62018C	fxd, ww 970 5% 3W		242E9715	56289	0811-1802	
62024C	fxd, ww 1.5k 5% 3W		242E1525	56289	0811-1805	
62028C	fxd, ww 2k 5% 3W		242E2025	56289	0811-1806	
62048C	fxd, ww 4.7k 5% 3W			28480	0811-1812	
R32, 33	fxd, comp 100 5% 1/2W		EB-1015	01121	0686-1015	
U1-3	Operational Amplifier	3	LM301A	07014	1820-0223	1
VR1	Diode, zener 7.5V 400mW	1	1N5236B	28480	1902-0064	1
VR2	Diode, zener 6.2V 250mW	1	1N825	28480	1902-1221	1
	Chassis Electrical					
C4	fxd, mylar 0.47μF 25V dc	1		28480	0160-0970	1
C9		1				1
62003C thru 62006C	fxd, elect 8600μF 20V dc			28480	0180-2522	
62010C thru 62015C	fxd, elect 6600μF 30V dc			28480	0180-2523	
62018C thru 62024C	fxd, elect 5800μF 50V dc			28480	0180-2518	

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REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
62048C	fxd, elect 3000μF 100V dc			28480	0180-2517	
C11		1				1
62003C thru 62010C	fxd, elect 3000μF 40V dc			28480	0180-1899	
62012C thru 62018C	fxd, elect 1600μF 85V dc			28480	0180-1986	
62024C thru 62048C	fxd, elect 1000μF 100V dc			28480	0180-1881	
F1		1				5
62003C thru 62006C	Fuse, 1.5A 250V		312015	75915	2110-0043	
62010C thru 62048C	Fuse, 2A 250V		312002	75915	2110-0002	
Q4	Power NPN S1	1		28480	1854-0563	1
R7	Voltage Adjust	1				1
62003C thru 62006C	var, ww 2700 5% 2W			28480	2100-3255	
62010C thru 62048C	var, ww 1800 5% 2W			28480	2100-3254	
T1		1				1
62003C thru 62006C	Power Transformer			28480	5080-7196	
62010C thru 62015C	Power Transformer			28480	5080-7197	
62018C thru 62028C	Power Transformer			28480	5080-7198	
62048C	Power Transformer			28480	62048-80092	
TB1	Terminal Block (Rear) 7-Terminal	1		28480	0360-1766	
TC1	Thermal Switch open 193 ±5°F close 168 ±8°F	1		28480	3103-0017	1
U4		1				1
62003C thru 62024C	Diode Assembly, Integrated Circuit		1N4436/T/F	28480	1906-0041	
62028C, 62048C	Not Used					
	Mechanical					
	Cover, Front-Top	1				
	62003C			28480	62003-60002	
	62004C			28480	62004-60002	
	62005C			28480	62005-60002	
	62006C			28480	62006-60002	
	62010C			28480	62010-60002	
	62012C			28480	62012-60002	
	62015C			28480	62015-60002	
	62018C			28480	62018-60002	
	62024C			28480	62024-60002	
	62028C			28480	62028-60002	
	62048C			28480	62048-60002	
	Cover, Bottom-Rear	1				
	62003C thru 62006C			28480	5060-9639	
	62010C thru 62048C			28480	5060-9640	
	Side Panel, Right	1		28480	5020-8092	
	Side Panel, Left	1		28480	5020-8093	
	Snap Bushing, Left Side Panel	1		28480	0400-0064	
	Jumper, Terminal Block	2		28480	0360-1784	
	Cover, Terminal Block	1		28480	4040-0948	

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REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
	Heat Sink (Q4)	1		28480	5020-8404	
	Insulator, Mica (Q4)	1	757-T0-3	08530	0340-0181	
	Shoulder Washer, Insulator (Q4)	1		28480		
	Fuseholder, F1	1	342014	75915	1400-0084	
	Insulator, Fuseholder	1	901-129	75915	1400-0090	
	Heat Sink, Transistor (Q3)	1	NF-207	05820	1205-0033	
	Bracket, Rear Chassis	1		28480	5000-9351	
	Bracket, Voltage Adjust	1		28480	5000-9348	
	Bracket, Capacitor 1 3/8"	2		28480	5000-9352	
	Bracket, Capacitor 2"	2		28480	5000-9355	
	Spacer 8/32 x 3/4 (T1)	4		28480	0380-0720	
	Plug (Crowbar Adjust Hole)	1		28480		
	Packing Carton	1			9211-1198	
	Floater Pad, Packing Carton	1			9220-1412	
	Floater Pad, Packing Carton	1			9220-1414	
	Floater Pad, Packing Carton	1			9220-1415	
	Option 101 (220V ac)					
	Option 102 (240V ac)					
F1		1				5
62003C thru 62006C	Fuse, 0.75A 250V			28480	2110-0063	
62010C thru 62048C	Fuse, 1A 250V			28480	2110-0001	
T1	Power Transformer (wired for 220V ac for option 101 or 240V ac for option 102)	1				1
62003C thru 62006C				28480	5081-4920	
62010C thru 62015C				28480	5081-4921	
62018C thru 62028C				28480	5081-4922	
62048C				28480	62048-80096	
	Option 103 (120V ac 240V ac)					
62003C thru 62006C	Fuse, 0.75A 250V (Replaces F1 if it is wired for 240V ac)	1		28480	2100-0063	5
62010C thru 62048C	Fuse, 1A 250V (Replaces F1 if it is wired for 240V ac)	1		28480	2110-0001	5
T1	Power Transformer (shipped wired for 120V ac)	1		28480		1
	E-SERIES (62003E thru 62048E)					
	Main Power Supply Board					
C1	fxd, elect 300µF 40V dc	1	34D307G040GJ2	56289	0180-1805	1
C2	fxd, mica 390pF 300V dc	1		28480	0140-0200	1
C3	fxd, mylar 0.47µF 25V dc	2		28480	0160-0174	1
C12		1				1
62003E, 62004E, 62010E	fxd, tantalum 3.3µF 50V dc			28480	0180-2141	
62005E, 62006E,	fxd, tantalum 1µF 35V dc		150D105X9035A2	56289	0180-0291	

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REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
62012E thru 62028E						
62048E	fxd, tantalum 0.47μF 80V dc		192D4749R8	56289	0160-0154	
C13	fxd, mylar .01μF 200V dc	1	192P10392	56289	0160-0161	1
C14	fxd, mica 10pF 300V dc	1	RDM15C100J3C	00853	0160-2197	1
C15	fxd, mylar 0.47μF 25V dc			28480	0160-0174	1
C16	fxd, mica 30pF 300V dc	1	RDM15E300J3C	00853	0160-2199	1
C18	fxd, mica 100pF 500V dc	1	RCM15E1015	00853	0140-0041	1
C19		1				1
62003E thru 62006E	fxd, mylar .01μF 200V dc		192P10392	56289	0180-2141	
62010E thru 62028E	fxd, mylar .0047μF 200V dc		192D47292	56289	0160-0157	
62048E	fxd, mylar .0022μF 200V dc		192P22292	56289	0160-0154	
CR1,2	Rectifier S1 200V 1A	2	1N5059	28480	1901-0327	2
CR11-14	Diode S1 250mV 200V	4	1N485B	28480	1901-0033	4
CR15	Stabistor 400mW 10V	1		28480	1901-0460	1
Q1	SS NPN S1	1	40346	02735	1854-0095	1
Q2		1				1
62003E thru 62028E	SS PNP S1			28480	1853-0041	
62048E	SS PNP S1			28480	1853-0037	
R1	fxd, comp 1.5k 5% 1/2W	1	EB-1525	01121	0686-1525	1
R2,3	fxd, met. film 6.2k 1% 1/8W	2	Type CEA T-0	07716	0698-5087	1
R4	fxd, met. film 750 1% 1/8W	1	Type CEA T-0	07716	0757-0420	1
R5	fxd, ww 5.9k 1% 2/3W	1		28480	0811-1978	1
R6		1				1
62003E	fxd, ww 3.6k 5% 3W		242E3625	56289	0811-1810	
62004E	fxd, ww 4.7k 5% 3W			28480	0811-1812	
62005E	fxd, ww 6.8k 5% 3W		242E6825	56289	0811-0960	
62006E	fxd, ww 10k 5% 3W		242E1035	56289	0811-1816	
62010E thru 62048E	Not Used					
R8		1				1
62003E	fxd, ww 2100 1% 1W			28480	0811-3187	
62004E	fxd, ww 2950 1% 1W			28480	0811-3192	
62005E	fxd, ww 3800 1% 1W			28480	0811-3195	
62006E	fxd, ww 4660 1% 1W			28480	0811-3193	
62010E	fxd, ww 10,750 1% 3W			28480	0811-3194	
62012E	fxd, ww 12,900 1% 3W			28480	0811-3186	
62015E	fxd, ww 16,100 1% 3W			28480	0811-3196	
62018E	fxd, ww 19,350 1% 3W			28480	0811-3190	
62024E	fxd, ww 25,800 1% 4W			28480	0811-3188	
62028E	fxd, ww 30,050 1% 4W			28480	0811-3191	
62048E	fxd, ww 51,550 1% 5W			28480	0811-3197	
R10		1				1
62003E	fxd, comp 430 5% 1/2W		EB-4315	01121	0686-4315	1
62004E thru 62010E	fxd, comp 470 5% 1/2W		EB-4715	01121	0686-4715	
62012E thru 62028E	fxd, comp 1k 5% 1/2W		EB-1025	01121	0686-1025	
62048E	fxd, comp 2k 5% 1/2W		EB-2025	01121	0686-2025	
R11	fxd, ww 1k 5% 3W	1	242E1025	56289	0813-0001	1
R12	fxd, comp 7.5k 5% 1/2W	1	EB-7525	01121	0686-7525	1
R13	fxd, comp 560 5% 1/2W	2	EB-5615	01121	0686-5615	1
R15	Current Sampling Resistor	1				1
62003E thru 62010E	fxd, ww .033 5% 10W			28480	0811-3175	

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REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
62012E thru 62018E	fxd, ww .05 5% 10W		Type CW10-1	91637	0811-1887	
62024E, 62028E	fxd, ww .07 5% 5W			28480	0811-3174	
62048E	fxd, ww .125 10% 5W		Type CW5-2	91637	0811-1846	
R17		1				1
62003E, 62006E, 62010E	fxd, ww 6.8 5% 2W	1	Type BWH	07716	0811-1676	
62004E, 62018E	fxd, ww 2.7 5% 2W		Type BWH	07716	0811-1671	
62005E, 62012E, 62015E	fxd, ww 3.9 5% 2W		Type BWH	07716	0811-1673	
62024E	fxd, ww 3 5% 3W		242E3R05	56289	0811-1224	
62028E	fxd, ww 7.5 5% 2W		Type BWH	07716	0811-2553	
62048E	fxd, ww 5.6 5% 2W			28480	0811-1675	
R18	var, ww 100 20%	1	Type 110-F4	11236	2100-0281	1
R19		1				1
62003E	fxd, ww 10 5% 3W		242E1005	56289	0811-1718	
62004E, 62005E	fxd, ww 22 5% 2W		Type C-425	16299	0698-3609	
62006E	fxd, ww 25 5% 5W			28480	0811-1853	
62010E, 62012E	fxd, ww 50 5% 5W		242E5005	56289	0811-1854	
62015E	fxd, ww 75 5% 5W		243E7505	56289	0812-0097	
62018E	fxd, ww 135 5% 5W		243E	56289	0812-0098	
62024E	fxd, ww 200 5% 5W		243E2015	56289	0811-1224	
62028E	fxd, ww 300 5% 5W		243E3015	56289	0811-1215	
62048E	fxd, ww 750 5% 5W		243E7515	56289	0811-1861	
R20		1				1
62003E	fxd, met. film 150 1% 1/8W		Type CEA T-0	07716	0757-0284	
62004E, 62005E, 62024E	fxd, met. film 139 1% 1/8W		Type CEA T-0	07716	0698-4099	
62006E	fxd, met. film 130 1% 1/8W		Type CEA T-0	07716	0757-0404	
62010E, 62028E	fxd, met. film 115 1% 1/8W		Type CEA T-0	07716	0698-4406	
62012E	fxd, met. film 107 1% 1/8W		Type CEA T-0	07716	0698-4405	
62015E	fxd, met. film 182 1% 1/8W		Type CEA T-0	07716	0757-0406	
62018E	fxd, met. film 162 1% 1/8W		Type CEA T-0	07716	0757-0405	
62048E	fxd, met. film 110 1% 1/8W		Type CEA T-0	07716	0757-0402	
R21	fxd, met. film 68.1k 1% 1/8W	1	Type CEA T-0	07716	0757-0461	1
R22	fxd, comp 100 5% 1/2W	3	EB-1015	01121	0686-1015	1
R23	fxd, comp 560 5% 1/2W		EB-5615	01121	0686-5615	
R25	fxd, comp 1.3k 5% 1/2W	1	EB-1325	01121	0686-1325	1
R26	fxd, comp 270 5% 1/2W	1	EB-2715	01121	0686-2715	1
R27		1				1
62003E, 62004E, 62006E, thru 62012E	fxd, comp 6.8 5% 1/2W			28480	0686-5525	
62005E	fxd, comp 5.1 5% 1/2W			28480	0686-0515	
62015E thru 62028E	fzd, comp 10 5% 1/2W		EB-1005	01121	0686-1005	
62048E	fxd, comp 12 5% 1/2W		EB-1205	01121	0686-1205	
R28	fxd, comp 75 5% 1/2W	1	EB-7505	01121	0686-7525	1
R29		1				1
62003E	fxd, ww 5.1 5% 2W	1	Type BWH	07716	0811-1761	1
62004E	fxd, ww 10 5% 3W		242E1005	56289	0811-1718	
62005E	fxd, ww 15 5% 3W			28480	0811-1557	

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REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
62006E	fxd, ww 20 5% 5W		28480	28480	0813-0040	
62010E	fxd, ww 40 5% 5W			28480	0812-0083	
62012E	fxd, ww 50 5% 5W		243E5005	56289	0811-1854	
62015E	fxd, ww 75 5% 5W		243E7505	56289	0812-0097	
62018E	fxd, ww 135 5% 5W		243E1315	56289	0812-0098	
62024E	fxd, ww 200 5% 5W		243E2015	56289	0811-1204	
62028E	fxd, ww 300 5% 5W		243E3015	56289	0811-1215	
62048E	fxd, ww 680 5% 5W		243E6815	56289	0811-2099	
R30	fxd, comp 33 5% 1/2W	1	EB-3305	01121	0686-3305	1
R31		1				1
62003E thru 62006E	fxd, ww 200 5% 5W		243E2015	56289	0811-1204	
62010E, 62012E	fxd, ww 400 5% 5W		243E4015	56289	0811-1857	
62015E, 62018E	fxd, ww 600 5% 5W		243E6015	56289	0811-1860	
62024E, 62028E	fxd, ww 1k 5% 5W		243E1025	56289	0811-0099	
62048E	fxd, ww 3k 5% 5W		243E3025	56289	0812-0050	
R32, 33	fxd, comp 100 5% 1/2W		EB-1015	01121	0686-1015	
R34, 36		2				1
62003E thru 62005E	fxd, ww 0.18 5% 10W			28480		
62006E thru 62012E	fxd, ww 0.33 5% 5W			28480	0811-3176	
62015E thru 62024E	fxd, ww 0.5 5% 5W		Type CW5-2	91637	0811-1848	
62028E	fxd, ww 0.6 5% 10W		Type CW10-1	91637	0811-1890	
62048E	fxd, ww 1 5% 5W		243E1R05	56289	0811-1340	
U1-3	Operational Amplifier	3	LM301A	07014	1820-0223	1
VR1	Diode, zener 7.5V 400mW	1	1N5236B	28480	1902-0064	1
VR2	Diode, zener 6.2V 250mW	1	1N825	28480	1902-1221	1
	Chassis Electrical					
C4	fxd, mylar 0.47μF 80V dc	1	192PA749R8	56289	0160-0970	1
C5		1				1
62003E thru 62028E	fxd, mylar 0.47μF 80V dc		192PA749R8	56289	0160-0970	
62048E	Not Used					
C9		1				1
62003E thru 62006E	fxd, elect 20,000μF 20V dc			28480	0180-2524	1
62010E thru 62015E	fxd, elect 15,000μF 20V dc			28480	0180-2525	
62018E thru 62028E	fxd, elect 10,000μF 50V dc			28480	0180-2526	
62048E	fxd, elect 5,900μF 85V dc			28480	0180-2527	
C11		1				1
62003E thru 62012E	fxd, elect 8600μF 25V dc			28480	0180-1882	
62015E thru 62048E	fxd, elect 3000μF 40V dc			28480	0180-1899	
F1		1				5
62003E thru 62006E	Fuse 3A 250V		312003	75915	2110-0003	
62012E thru 62048E	Fuse 4A 250V		312004	75915	2110-0055	
Q3,4,5	Power NPN S1	3		28480	1854-0563	3
R7	Voltage Adjust	1				1
62003E thru 62006E	var, ww 2700 5% 2W			28480	2100-3255	
62010E thru 62048E	var, ww 1800 5% 2W			28480	2100-3254	
T1		1				1
62003E	Power Transformer			28480	62003-80093	
62004E	Power Transformer			28480	62004-80093	

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REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
62005E	Power Transformer			28480	62005-80093	
62006E	Power Transformer			28480	62006-80093	
62010E	Power Transformer			28486	62010-80093	
62012E	Power Transformer			28480	62012-80093	
62015E	Power Transformer			28480	62015-80093	
62018E	Power Transformer			28480	62018-80093	
62024E	Power Transformer			28480	62024-80093	
62028E	Power Transformer			28480	62028-80093	
62048E	Power Transformer			28480	62048-80093	
TB1	Terminal Block (Rear) 7-Terminal	1		28480	3103-0017	1
TC1	Thermal Switch open 248°F ±6°F close 223°F ±8°F	1		28480	3103-0019	1
U4		1				1
62003E thru 620028E	Diode Assembly Integrated Circuit			28480	1906-0039	
62048E	Diode Assembly Integrated Circuit			28480	1906-0041	
U5	Full Wave Doubler 100prv 15A	1		28480	1906-0040	1
	Mechanical					
	Cover, Top-Rear	1				
	62003E			28480	62003-60003	
	62004E			28480	62004-60003	
	62005E			28480	62005-60003	
	62006E			28480	62006-60003	
	62010E			28480	62010-60003	
	62012E			28480	62012-60003	
	62015E			28480	62015-60003	
	62018E			28480	62018-60003	
	62024E			28480	62024-60003	
	62028E			28480	62028-60003	
	62048E			28480	62048-60003	
	Cover, Bottom-Rear	1				
	62003E thru 62006E			28480	5060-9641	
	62010E thru 62048E			28480	5060-9642	
	Bracket, 2" (C11)	2				
	62003E thru 62028E			28480	5000-9355	
	62048E Not Used					
	Bracket 1 3/8" (C11)					
	62003E thru 62028E Not Used					
	62048E	1		28480	5000-9353	
	Heat Sink Transistor (Q2)	1				
	62006E thru 62018E Not Used					
	62024E thru 62048			28480	1250-0030	
	Side Panel, Right	1		28480	5020-8092	
	Side Panel, Left	1		28480	5020-8094	
	Snap Bushing, Left Side Panel	1		28480	0400-0064	

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REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
	Terminal Block, Jumper	2		28480	0360-1784	
	Terminal Block, Cover	1		28480	4040-0948	
	Heat Sink (Q3-Q5)	1		28480	5020-8404	
	Insulator, Mica (Q3-Q5)	3	757-T0-3	08530	0340-0181	
	Shoulder washer, Insulator (Q3-Q5)	3		28480		
	Thermal Compound (Heat Sink)			28480	6040-0625	
	Fuseholder, F1	1	342014	75915	1400-0084	
	Insulator, Fuseholder	1	901-129	75915	1400-0090	
	Bracket, Rear Chassis	1		28480	5000-9351	
	Bracket, Voltage Adjust	1		28480	500-9348	
	Bracket, 2" (C9)	2		28480	5000-9355	
	Spacer, 8/32" x 3/4" (T1)	4		28480	0380-0720	
	Plug (Crowbar Adjust Hole)	1		28480		
	Packing Carton	1			9211-1198	
	Floater Pad, Packing Carton	1			9220-1412	
	Floater Pad, Packing Carton	1			9220-1414	
	Floater Pad, Packing Carton	1			9220-1415	
	Option 101 (220V ac)					
	Option 102 (240V ac)					
F1		1				5
62003E thru 62006E	Fuse, 1.5A 250V			28480	2100-0043	
62010E thru 62048E	Fuse, 20A 250V			28480	2100-0262	
T1	Power Transformer (wired for 220V ac for option 101 or 240V ac for option 102)	1				1
62003E				28480	62003-80097	
62004E				28480	62004-80097	
62005E				28480	62005-80097	
62006E				28480	62006-80097	
62010E				28480	62010-80097	
62012E				28480	62012-80097	
62015E				28480	62015-80097	
62018E				28480	62018-80097	
62024E				28480	62024-80097	
62028E				28480	62028-80097	
62048E				28480	62048-80097	
	Option 103 (120V ac 240V ac)					
62003E thru 62006E	Fuse 1.5A 250V (replaces F1 of T1 wired for 240Vac)	1		28480	2100-0043	
62010E	Fuse, 2.0A 250V (replaces F1 of T1 wired for 240Vac)			28480	2100-0262	
T1	Power Transformer (wired for 120V ac)	1		28480		

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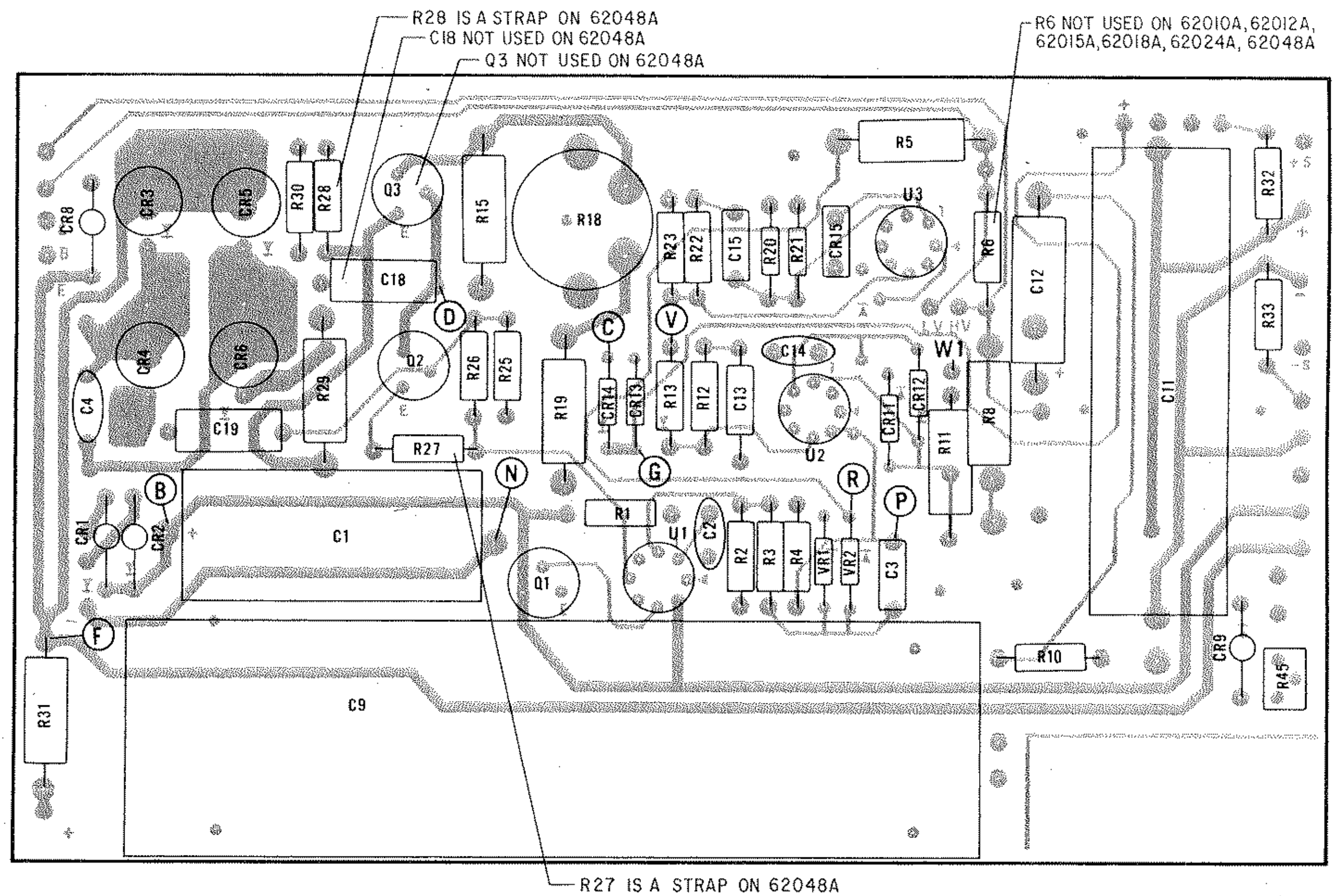

NOTES:

1. C4 LOCATED ON XFMR.
2. Q4, R7, U5 LOCATED ON CHASSIS.

A-Series Supplies, Component Location

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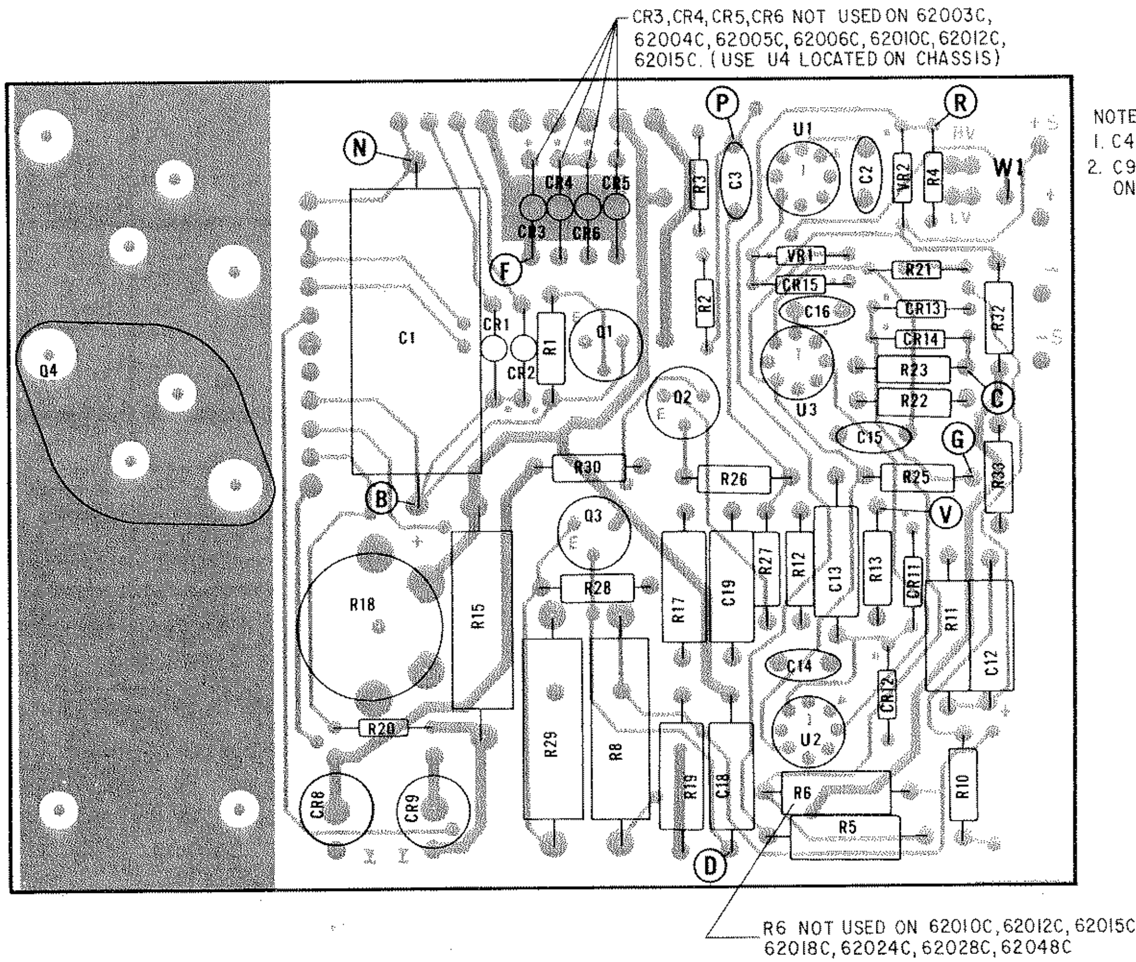

NOTES:
1. C4 LOCATED ON XFMR.
2. C9, C11, R7 LOCATED ON CHASSIS.

C-Series Supplies, Component Location

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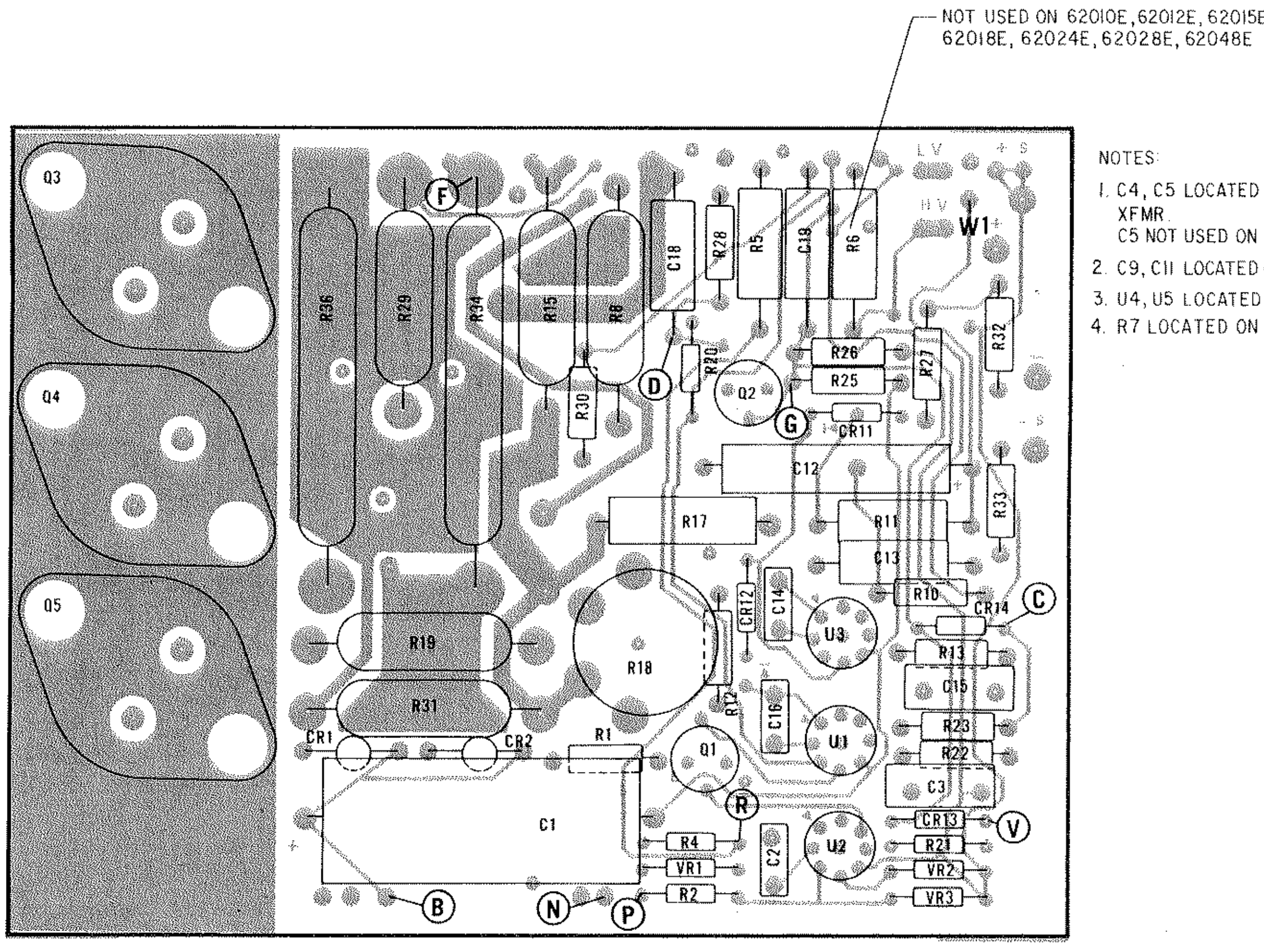

NOTES:

1. C4, C5 LOCATED ON XFMR.
   C5 NOT USED ON 62048E
2. C9, C11 LOCATED ON CHASSIS.
3. U4, U5 LOCATED ON CHASSIS.
4. R7 LOCATED ON CHASSIS.

E-Series Supplies, Component Location

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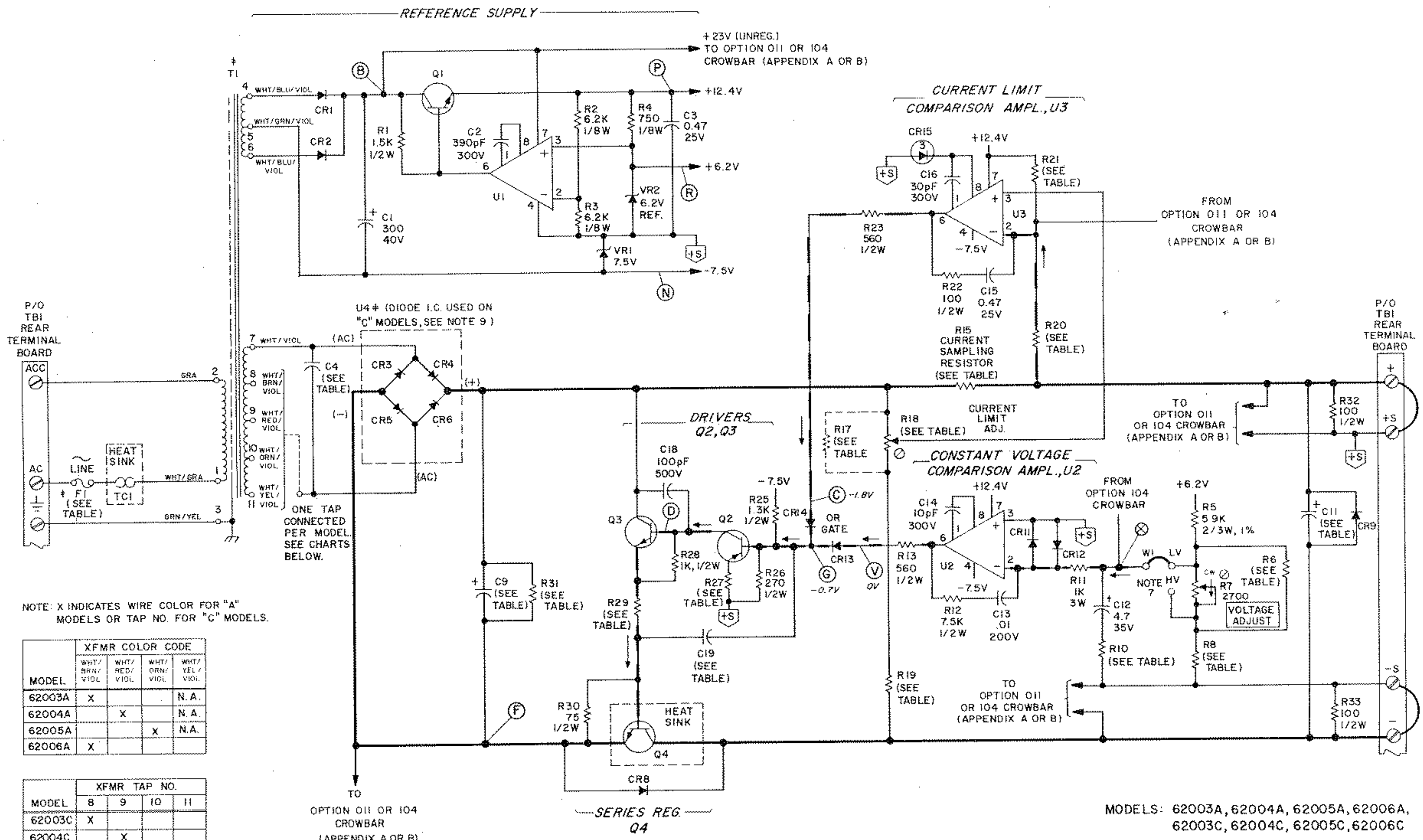

NOTE: X INDICATES WIRE COLOR FOR "A" MODELS OR TAP NO. FOR "C" MODELS.

MODEL	XFMR COLOR CODE WHT/BRN/VIOL	WHT/RED/VIOL	WHT/ORN/VIOL	WHT/YEL/VIOL
62003A	X			N.A.
62004A		X		N.A.
62005A			X	N.A.
62006A	X			

MODEL	XFMR TAP NO. 8	9	10	11
62003C	X			
62004C		X		
62005C			X	
62006C				X

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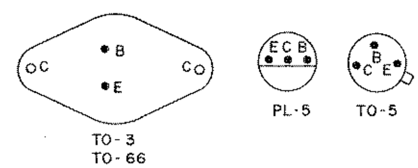
MODEL	OUTPUT VOLTAGE (VDC)	OUTPUT CURRENT (ADC @ 50° C)	TEST POINT (F) VOLTAGE	SCHEMATIC COMPONENTS																		
				CR3-CR6	C4	C9	C11	C19	U4	R6	R8	R10	R15	R17	R18	R19	R20	R21	R27	R29	R31	F1
62003A	3 ±0.5V	2	−12V							3.6K 3W	2100 1W									30 2W		
62004A	4 ±0.5V	2	−13V	USED	.05 400V	6000 25V	1400 30V	.0047 200V	NOT USED	4.7K 3W	2950 1W	1K 1/2W	0.125 3W	NOT USED	5	30 2W	139 1/8W	68.1K 1/8W	12 1/2W	56 2W	1.5K 1W	0.5A 250V
62005A	5 ± 0.5V	2	−15V							6.8K 3W	3800 1W											
62006A	6 ± 0.6V	1.75	−16V							10K 3W	4660 1W		0.15 3W				150 1/8W			100 2W		
62003C	3 ± 0.5V	4.25	−12V							3.6K 3W	2100 1W	430 1/2W				22 2W		61.9K 1/8W	10 1/2W	22 2W		
62004C	4 ±0.5V	4	−13V	NOT USED	# 0.47 80V	# 8600 20V	# 3000 40V	0.01 200V	USED	4.7K 3W	2950 1W		.07 5W	3.3 2W	100	30 2W	139 1/8W	64K 1/8W		30 2W	470 3W	1.5A 250V
62005C	5± 0.5V	4	−15V							6.8K 3W	3800 1W	1K 1/2W				43 2W			8.2 1/2W			
62006C	6± 0.5V	3.75	−16V							10K 3W	4660 1W	2K 1/2W				56 2W		68.1K 1/8W		43 2W		

NOTES:

1. ALL COMPONENTS ARE LOCATED ON P.C. BOARD UNLESS OTHERWISE INDICATED.
2. # DENOTES CHASSIS MOUNTED COMPONENTS.
3. ——-——-—— DENOTES CONSTANT VOLTAGE FEEDBACK PATH.
4. ———— DENOTES CURRENT FEEDBACK PATH.
5. ALL RESISTORS ARE IN OHMS.
   ALL 1/2W RESISTORS, ±5%, UNLESS OTHERWISE INDICATED.
   ALL 1/8W RESISTORS, ±1%, UNLESS OTHERWISE INDICATED.
6. ALL CAPACITORS IN MICROFARADS, UNLESS OTHERWISE INDICATED.
7. JUMPER W1 IS CONNECTED TO LV PAD FOR ALL LOW VOLTAGE (BELOW 10V) SUPPLIES AND TO HV FOR ALL HIGHER VOLTAGE (10V AND ABOVE) SUPPLIES. SEPARATE SCHEMATICS ARE SHOWN FOR EACH TYPE.
8. TEST POINT VOLTAGES MEASURED UNDER THE FOLLOWING CONDITIONS.
   A. HP MODEL 427A OR EQUIVALENT
   B. 115VAC INPUT.
   C. ALL VOLTAGES REFERENCED TO +S.
   D. READINGS ARE TYPICAL ±10%
   E. ALL READINGS TAKEN IN CONSTANT VOLTAGE OPERATION.
9. RECTIFIER CONSISTS OF DISCRETE DIODES (CR3-CR6) IN MODELS 62003A THRU 62006A. RECTIFIER IS I.C. PACKAGE (U4) IN MODELS 62003C THRU 62006C. SEE NOTE 11 FOR PIN LOCATIONS OF U4.
10. PIN LOCATIONS FOR TRANSISTORS ARE SHOWN BELOW:



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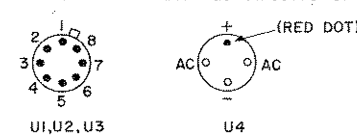
11. PIN LOCATIONS FOR INTEGRATED CIRCUITS U1 - U4 ARE SHOWN BELOW:



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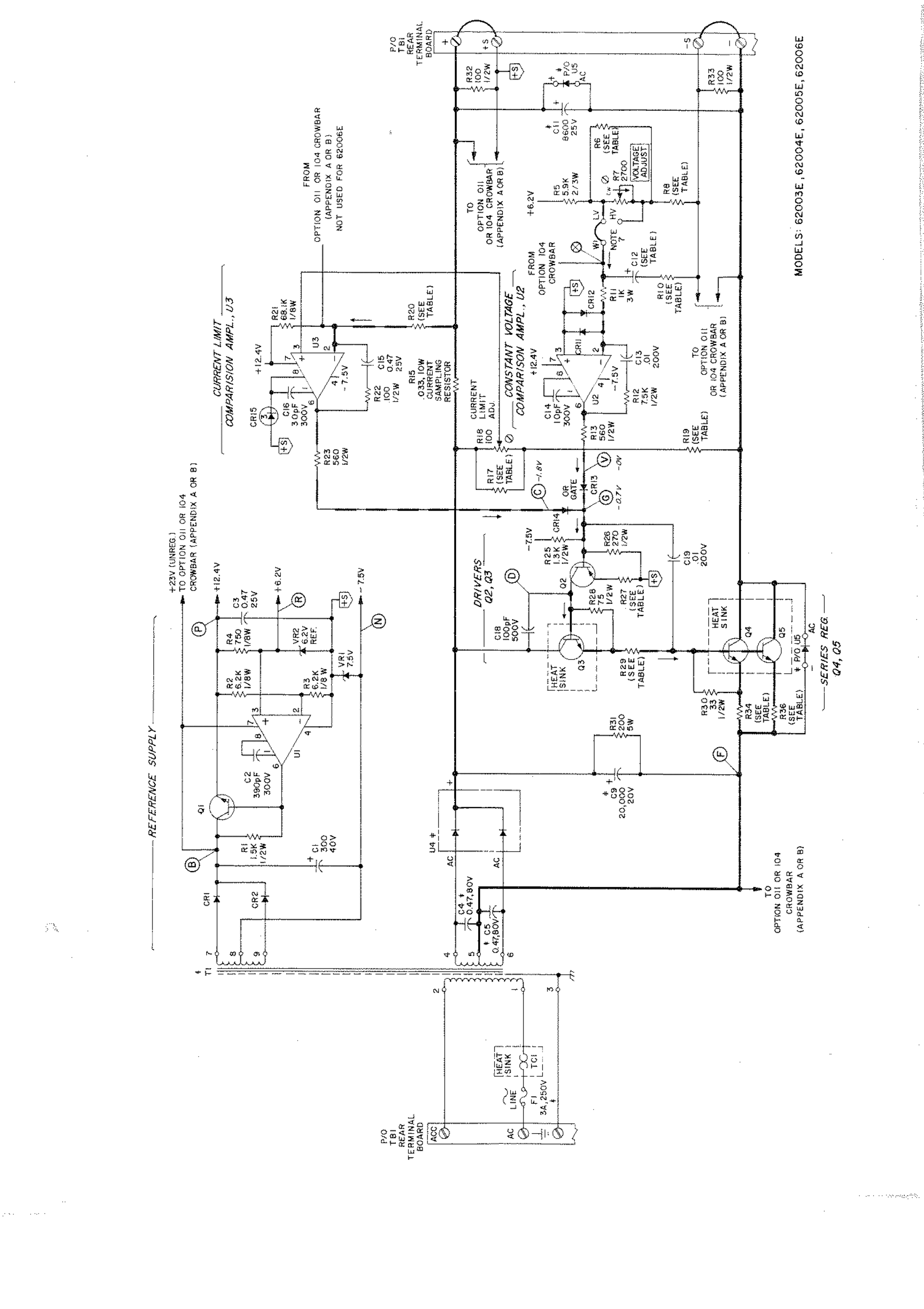

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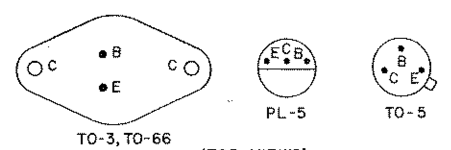
<table>
<tr><th rowspan="2">MODEL</th><th rowspan="2">OUTPUT VOLTAGE (VDC)</th><th rowspan="2">OUTPUT (ADC @ 50°C)</th><th rowspan="2">TEST POINT (F) VOLTAGE</th><th colspan="11">SCHEMATIC COMPONENTS</th></tr>
<tr><th>C12</th><th>R6</th><th>R8</th><th>R10</th><th>R17</th><th>R19</th><th>R20</th><th>R27</th><th>R29</th><th>R34 R35</th></tr>
<tr><td>62003E</td><td>3 ± 0.5</td><td>8.5</td><td>-12V</td><td rowspan="2">3.3 50V</td><td>3.6K 3W</td><td>2100 1W</td><td>430 1/2W</td><td>6.8 2W</td><td>10 2W</td><td>150 1/8W</td><td rowspan="2">6.8 1/2W</td><td>5.1 2W</td><td rowspan="3">0.18 10W</td></tr>
<tr><td>62004E</td><td>4 ± 0.5</td><td>8.0</td><td>-13V</td><td>4.7K 3W</td><td>2950 1W</td><td rowspan="3">470 1/2W</td><td>2.7 2W</td><td rowspan="2">22 3W</td><td rowspan="2">139 1/8W</td><td>10 3W</td></tr>
<tr><td>62005E</td><td>5 ± 0.5</td><td>8.0</td><td>-15V</td><td rowspan="2">1 35V</td><td>6.8K 3W</td><td>3800 1W</td><td>39 2W</td><td>5.1 1/2W</td><td>15 3W</td></tr>
<tr><td>62006E</td><td>6 ± 0.5</td><td>7.5</td><td>-16V</td><td>10K 3W</td><td>4660 1W</td><td>6.8 2W</td><td>25 5W</td><td>130 1/8W</td><td>6.8 1/2W</td><td>20 5W</td><td>0.33 10W</td></tr>
</table>

NOTES:

1. ALL COMPONENTS ARE LOCATED ON P.C. BOARD UNLESS OTHERWISE INDICATED.
2. ≠ DENOTES CHASSIS MOUNTED COMPONENTS
3. ——— DENOTES CONSTANT VOLTAGE FEEDBACK PATH.
4. ——— DENOTES CURRENT FEEDBACK PATH.
5. ALL RESISTORS IN OHMS.
   ALL 1/2W RESISTORS ±5%, UNLESS OTHERWISE INDICATED.
   ALL 1/8W RESISTORS ±1%, UNLESS OTHERWISE INDICATED.
6. ALL CAPACITORS IN MICROFARADS, UNLESS OTHERWISE INDICATED.
7. JUMPER W1 IS CONNECTED TO LV PAD FOR ALL LOW VOLTAGE (BELOW 10V) SUPPLIES AND TO HV FOR ALL HIGHER VOLTAGE (10V AND ABOVE) SUPPLIES. SEPARATE SCHEMATICS ARE SHOWN FOR EACH TYPE.
8. TEST POINT VOLTAGES MEASURED UNDER THE FOLLOWING CONDITIONS:
   A. HP MODEL 427A OR EQUIVALENT.
   B. 115VAC INPUT.
   C. ALL VOLTAGES REFERENCED TO +S.
   D. READINGS ARE TYPICAL ±10%.
   E. ALL READINGS TAKEN IN CONSTANT VOLTAGE OPERATION.
9. PIN LOCATIONS FOR TRANSISTORS ARE SHOWN BELOW:



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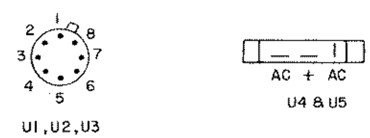
10. PIN LOCATIONS FOR INTEGRATED CIRCUITS U1 THRU U5 ARE SHOWN BELOW:



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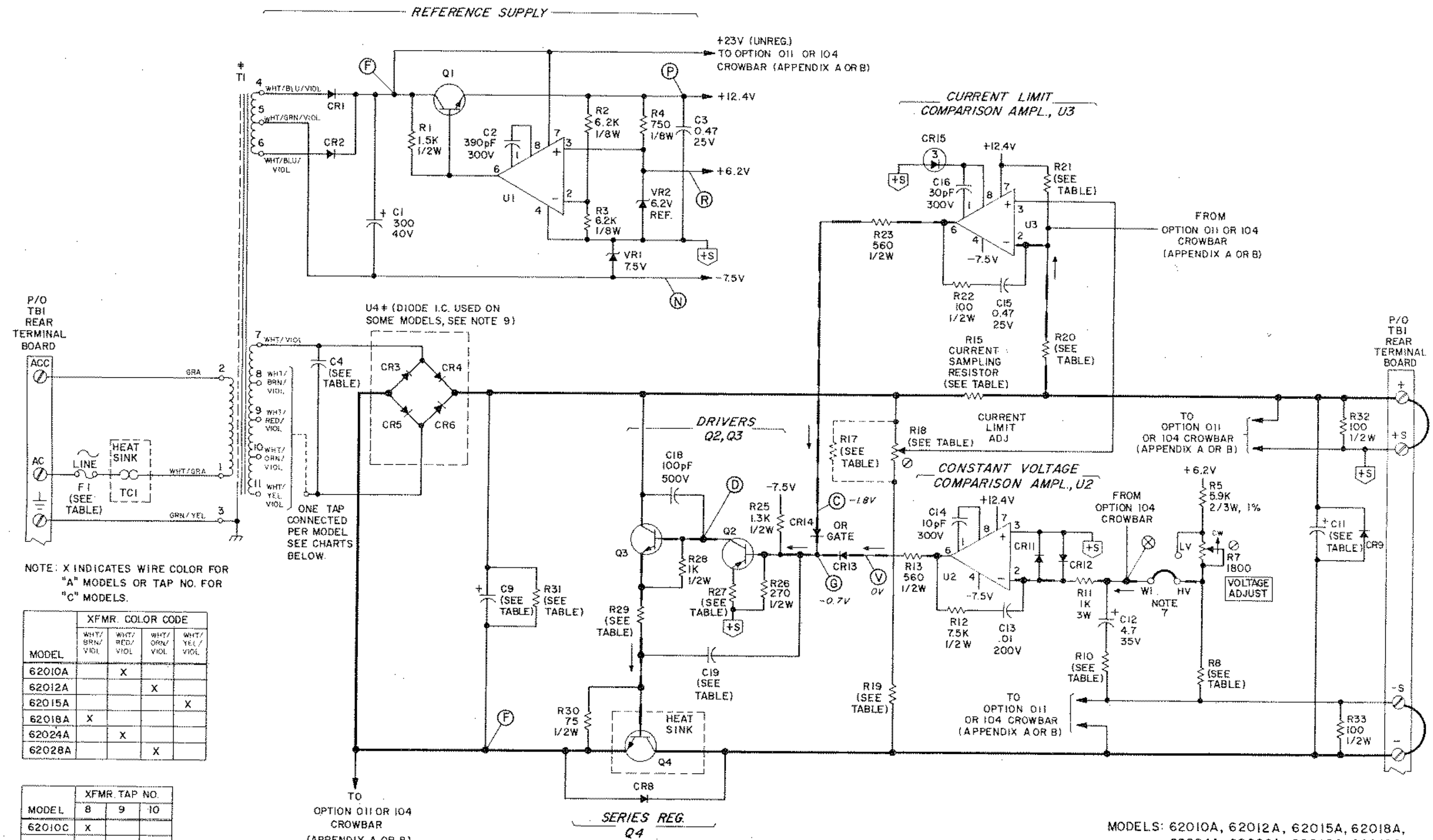

NOTE: X INDICATES WIRE COLOR FOR "A" MODELS OR TAP NO. FOR "C" MODELS.

MODEL	XFMR. COLOR CODE			
	WHT/BRN/VIOL	WHT/RED/VIOL	WHT/ORN/VIOL	WHT/YEL/VIOL
62010A		X		
62012A			X	
62015A				X
62018A	X			
62024A		X		
62028A			X	

MODEL	XFMR. TAP NO.		
	8	9	10
62010C	X		
62012C		X	
62015C			X
62018C	X		
62024C		X	
62028C			X
62048C	X		

MODELS: 62010A, 62012A, 62015A, 62018A, 62024A, 62028A, 62010C, 62012C, 62015C, 62018C, 62024C, 62028C, 62048C

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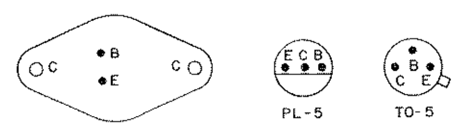
MODEL	OUTPUT VOLTAGE (VDC)	OUTPUT CURRENT (ADC @ 50°C)	TEST POINT (F) VOLTAGE	SCHEMATIC COMPONENTS CR3-CR6	C4	C9	C11	C12	C19	U4	R8	R10	R15	R17	R18	R19	R20	R21	R27	R29	R31	F1
62010A	10±0.50	1.50	-21V			6000 25V			.0033 200V		10750 3W						150 1/8W			200 2W	1.5K 1W	
62012A	10±0.50	1.50	-24V								12900 3W	3.9K 1/2W	0.15 3W			270 2W				270 2W		
62015A	15±0.75	1.25	-28V	USED	.05 400V	3000 50V	1400 30V			NOT USED	16100 3W			NOT ASSIGN	10		107 1/8W	68.1K 1/8W	12 1/2W	390 2W	3K 1W	0.75A 250V
62018A	18±0.90	1.00	-32V						.0047 200V		19350 3W	4.3K 1/2W	0.25 3W							510 2W		
62024A	24±1.20	0.75	-40V								25800 4W	5.6K 1/2W	0.33 2W			560 2W	139 1/8W			680 2W	5.1K 1W	
62028A	28±1.40	0.70	-45V				490 65V	4.7 35V			30050 4W	7.5K 1/2W								820 2W		
62010C	10±0.50	3.25	-21V				‡ 3000 40V		.01 200V		10750 3W	2K 1/2W		3 3W		100 2W	110 1/8W	64K 1/8W		75 5W	490 3W	
62012C	12±0.60	3.00	-24V	NOT USED		‡ 6600 30V				USED	12900 3W		.07 5W			135 3W		68.1K 1/8W	8.2 1/2W	120 5W	820 3W	
62015C	15±0.75	2.50	-28V				‡ 1600 85V		.0047 200V		16100 3W	2.4K 1/2W		2.7 2W		180 2W	139 1/8W			150 5W		
62018C	18±0.90	2.25	-32V		0.47 80V						19350 3W	4.3K 1/2W	0.1 3W	4.3 2W	100	270 2W	115 1/8W	64K 1/8W		200 5W	970 3W	2A 250V
62024C	24±1.20	1.75	-40V	USED		‡ 5800 50V				NOT USED	25800 4W	4.7K 1/2W	0.125 3W	4.7 2W		390 3W	150 1/8W	68.1K 1/8W		430 2W	1.5K 3W	
62028C	28±1.40	1.50	-45V				‡ 1000 100V		.001 200V		30050 4W	7.5K 1/2W		4.3 2W		490 3W	121 1/8W	64K 1/8W	10 1/2W	600 5W	2K 3W	
62048C	48±2.40	1.00	-72V			3000 100V		5 65V			51550 5W	8.2K 1/2W	0.25 3W	15 3W		1.4K 3W	139 1/8W	68.1K 1/8W		1.4K 3W	4.7K 3W	

NOTES:

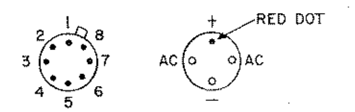
1. ALL COMPONENTS ARE LOCATED ON P.C. BOARD UNLESS OTHERWISE INDICATED.
2. ‡ DENOTES CHASSIS MOUNTED COMPONENTS.
3. ——— DENOTES CONSTANT VOLTAGE FEEDBACK PATH.
4. ——— DENOTES CURRENT FEEDBACK PATH.
5. ALL RESISTORS IN OHMS.
   ALL 1/2W RESISTORS ±5%, UNLESS OTHERWISE INDICATED.
   ALL 1/8W RESISTORS ±1%, UNLESS OTHERWISE INDICATED.
6. ALL CAPACITORS ARE IN MICROFARADS, UNLESS OTHERWISE INDICATED.
7. JUMPER W1 IS CONNECTED TO LV PAD FOR ALL LOW VOLTAGE (BELOW 10V) SUPPLIES AND TO HIGHER VOLTAGE (10V AND ABOVE) SUPPLIES. SEPARATE SCHEMATICS ARE SHOWN FOR EACH TYPE.
8. TEST POINT VOLTAGES MEASURED UNDER THE FOLLOWING CONDITIONS
   A. HP MODEL 427A OR EQUIVALENT.
   B. 115VAC INPUT
   C. ALL VOLTAGES REFERENCED TO +S.
   D. READINGS ARE TYPICAL ±
   E. ALL READINGS TAKEN IN CONSTANT VOLTAGE OPERATION.
9. MODELS 62010C THRU 62018C USE DIODE I.C. PACKAGE, REMAINING MODELS USE DISCRETE DIODES; CR3 THRU CR6.
10. PIN LOCATIONS FOR TRANSISTORS ARE SHOWN BELOW:



TO-3, TO-66 PL-5 TO-5

(TOP VIEWS)

11. PIN LOCATIONS FOR INTEGRATED CIRCUITS U1 THRU U4 ARE SHOWN BELOW:



U1, U2, U3 ALL MODELS

U4 MODELS 62010C, 62012C, 62015C ONLY

(TOP VIEWS)

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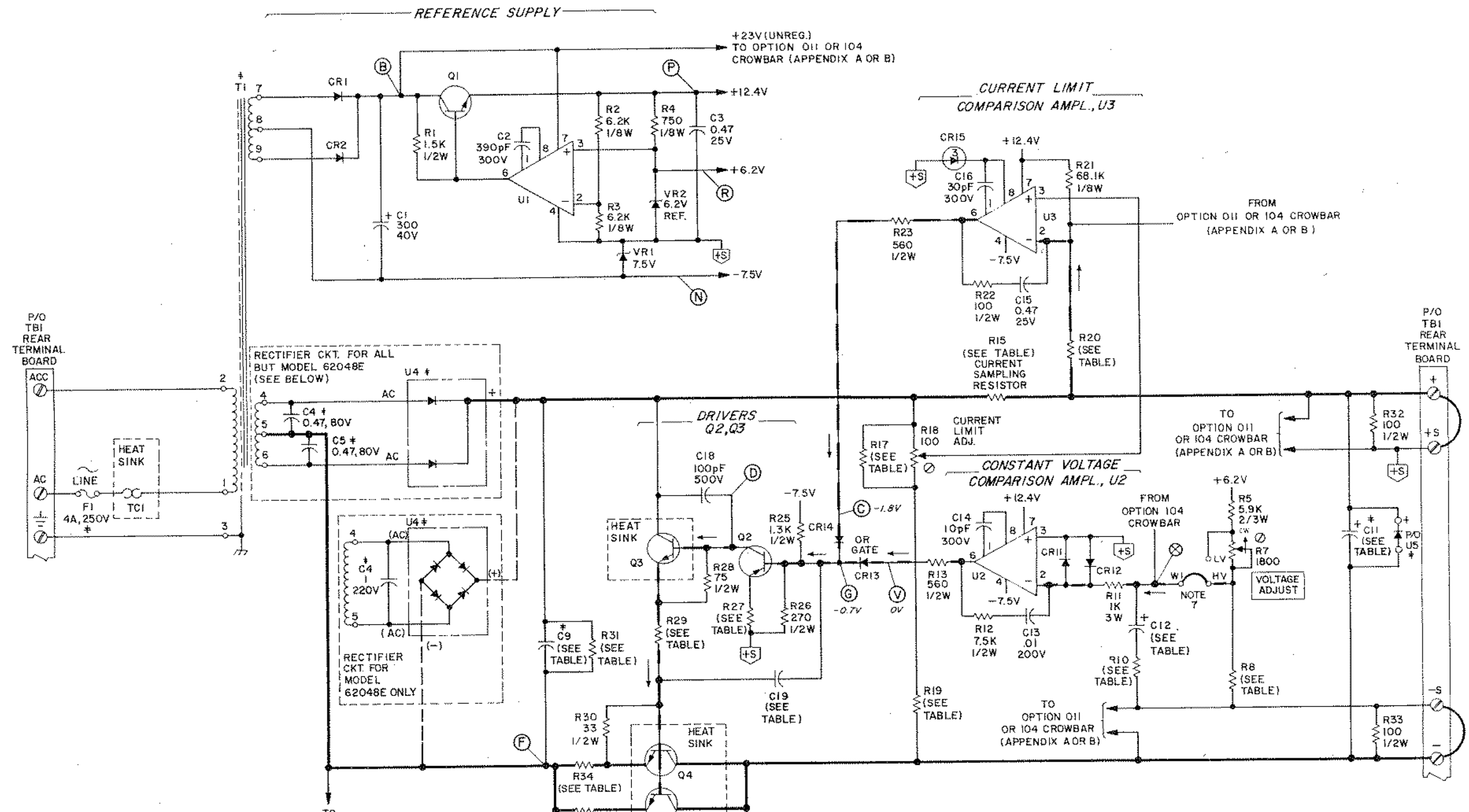

MODELS: 62010E, 62012E, 62015E, 62018E
62024E, 62028E, 62048E

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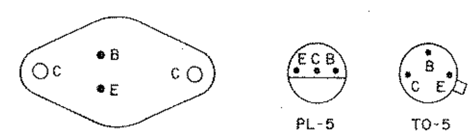
<table>
<tr><th rowspan="2">MODEL</th><th rowspan="2">OUTPUT VOLTAGE (VDC)</th><th rowspan="2">OUTPUT (ADC @ 50°C)</th><th rowspan="2">TEST POINT (F) VOLTAGE</th><th colspan="14">SCHEMATIC COMPONENTS</th></tr>
<tr><th>C9</th><th>C11</th><th>C12</th><th>C19</th><th>R8</th><th>R10</th><th>R15</th><th>R17</th><th>R19</th><th>R20</th><th>R27</th><th>R29</th><th>R31</th><th>R34, R36</th></tr>
<tr><td>62010E</td><td>10±0.5</td><td>6.50</td><td>-12V</td><td rowspan="3">15000 30V</td><td rowspan="2">8600 25V</td><td>3.3 50V</td><td rowspan="6">.0047 200V</td><td>10750 3W</td><td>470 1/2W</td><td>.033 10W</td><td>6.8 2W</td><td rowspan="2">50 5W</td><td>115 1/8W</td><td rowspan="2">6.8 1/2W</td><td>40 5W</td><td rowspan="2">400 5W</td><td rowspan="2">0.33 10W</td></tr>
<tr><td>62012E</td><td>12±0.6</td><td>6.00</td><td>-24V</td><td rowspan="5">1 35V</td><td>12900 3W</td><td rowspan="5">1K 1/2W</td><td rowspan="3">.05 10W</td><td rowspan="2">3.9 2W</td><td>107 1/8W</td><td>50 5W</td></tr>
<tr><td>62015E</td><td>15±0.75</td><td>5.00</td><td>-28V</td><td rowspan="4">3000 40V</td><td>16100 3W</td><td>75 5W</td><td>182 1/8W</td><td rowspan="4">10 1/2W</td><td>75 5W</td><td rowspan="2">600 5W</td><td rowspan="3">0.5 5W</td></tr>
<tr><td>62018E</td><td>18±0.9</td><td>4.50</td><td>-32V</td><td rowspan="3">10000 50V</td><td>19350 3W</td><td>2.7 2W</td><td>135 5W</td><td>162 1/8W</td><td>135 5W</td></tr>
<tr><td>62024E</td><td>24±1.2</td><td>3.75</td><td>-40V</td><td>25800 4W</td><td rowspan="2">.07 5W</td><td>3 3W</td><td>200 5W</td><td>139 1/8W</td><td>200 5W</td><td rowspan="2">1K 5W</td></tr>
<tr><td>62028E</td><td>28±1.4</td><td>3.25</td><td>-45V</td><td>30050 4W</td><td>7.5 2W</td><td>300 5W</td><td>115 1/8W</td><td>300 5W</td><td>0.6 10W</td></tr>
<tr><td>62048E</td><td>48±2.4</td><td>2.00</td><td>-72V</td><td>5900 85V</td><td>3000 85V</td><td>0.47 80V</td><td>.0022 200V</td><td>51550 5W</td><td>2K 1/2W</td><td>0.125 5W</td><td>5.6 2W</td><td>750 5W</td><td>110 1/8W</td><td>12 1/2W</td><td>680 5W</td><td>3K 5W</td><td>1 5W</td></tr>
</table>

NOTES:

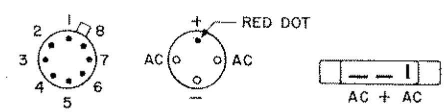
1. ALL COMPONENTS ARE LOCATED ON P.C. BOARD UNLESS OTHERWISE INDICATED.
2. ‡ DENOTES CHASSIS MOUNTED COMPONENTS.
3. ——— DENOTES CONSTANT VOLTAGE FEEDBACK PATH.
4. ——— DENOTES CURRENT FEEDBACK PATH.
5. ALL RESISTORS IN OHMS.
   ALL 1/2W RESISTORS ±5%, UNLESS OTHERWISE INDICATED.
   ALL 1/8W RESISTORS ±1%, UNLESS OTHERWISE INDICATED.
6. ALL CAPACITORS IN MICROFARADS, UNLESS OTHERWISE INDICATED.
7. JUMPER W1 CONNECTED TO LV PAD FOR ALL LOW VOLTAGE (BELOW 10V) SUPPLIES AND TO HV FOR HIGHER VOLTAGE (10V AND ABOVE) SUPPLIES SEPARATE SCHEMATICS ARE SHOWN FOR EACH TYPE.
8. TEST POINT VOLTAGES MEASURED UNDER THE FOLLOWING CONDITIONS:
   A. HP MODEL 427A OR EQUIVALENT.
   B. 115 VAC INPUT.
   C. ALL VOLTAGES REFERENCED TO +S.
   D. READINGS ARE TYPICAL ±10%
   E. ALL READINGS TAKEN IN CONSTANT VOLTAGE OPERATION.
9. PIN LOCATIONS FOR TRANSISTORS ARE SHOWN BELOW:



TO-3, TO-66 PL-5 TO-5

(TOP VIEWS)

10. PIN LOCATIONS FOR INTEGRATED CIRCUITS U1 THRU U5 ARE SHOWN BELOW:



U1, U2, U3 U4 62048E ONLY U4 & U5

(TOP VIEWS)

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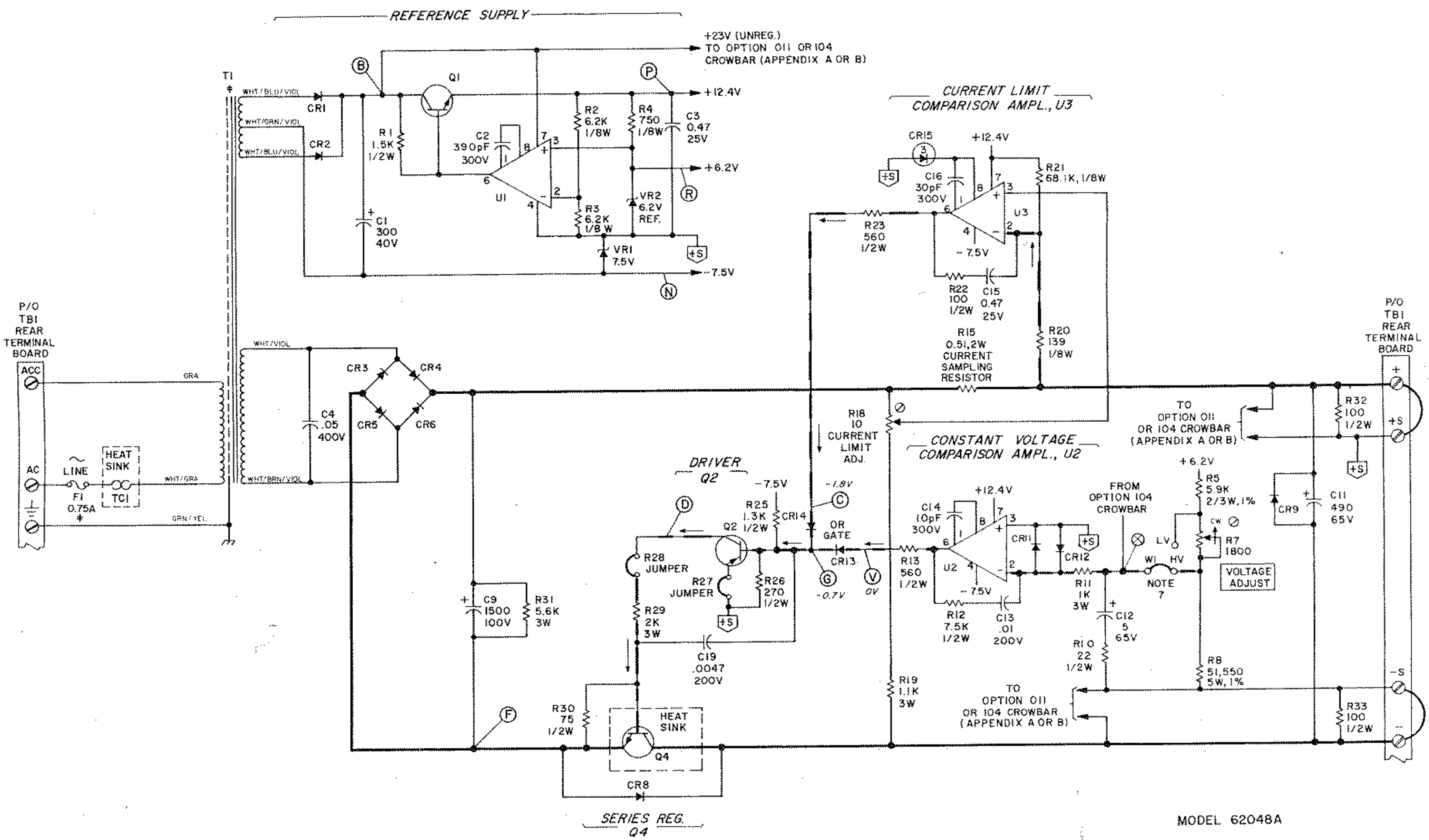

MODEL 62048A

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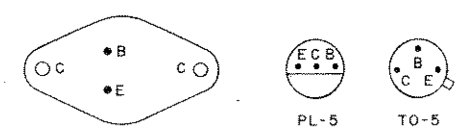
NOTES:

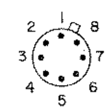
1. ALL COMPONENTS LOCATED ON P.C. BOARD, UNLESS OTHERWISE INDICATED.
2. ≠ DENOTES CHASSIS MOUNTED COMPONENTS.
3. ——— DENOTES CONSTANT VOLTAGE FEEDBACK PATH.
4. ——— DENOTES CURRENT FEEDBACK PATH.
5. ALL RESISTORS IN OHMS.
   ALL 1/2W RESISTORS ±5%, UNLESS OTHERWISE INDICATED.
   ALL 1/8W RESISTORS ±1%, UNLESS OTHERWISE INDICATED.
6. ALL CAPACITORS ARE IN MICROFARADS, UNLESS OTHERWISE INDICATED.
7. JUMPER W1 IS CONNECTED TO LV PAD FOR ALL LOW VOLTAGE (BELOW 10V) SUPPLIES AND TO HV FOR ALL HIGHER VOLTAGE (10V AND ABOVE) SUPPLIES. SEPARATE SCHEMATICS ARE SHOWN FOR EACH.
8. TEST POINT VOLTAGES MEASURED UNDER THE FOLLOWING CONDITIONS:
   A. HP MODEL 427A OR EQUIVALENT.
   B. 115VAC INPUT.
   C. ALL VOLTAGES REFERENCED TO +S.
   D. READINGS ARE TYPICAL ±10%.
   E. ALL READINGS TAKEN IN CONSTANT VOLTAGE OPERATION
9. PIN LOCATIONS FOR TRANSISTORS ARE SHOWN BELOW:



TO-3, TO-66 PL-5 TO-5

(TOP VIEW)

10. PIN LOCATIONS FOR INTEGRATED CIRCUITS U1 THRU U3 ARE SHOWN BELOW:



(TOP VIEW)

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APPENDIX A

OPTION 011, Overvoltage Protection Crowbar

INTRODUCTION

This option is installed and tested at the factory and applies to the following Hewlett-Packard modular power supplies:

62003A through 62048A
62003C through 62048C
62003E through 62048E
62003G through 62048G

The Option 011 crowbar circuits for the above supplies are similar in design with many supplies utilizing identical crowbar circuits. Some variations in circuit operation and in component values do; however, exist so that two crowbar schematics are presented as part of this appendix. Also, all significant differences in circuit operation among the crowbar circuits are completely described.

In general, the crowbar circuits consist of components mounted on a separate printed wiring board. For the A-suffix models however, the trip level adjustment (R45) is mounted on the power supply main printed wiring board. For the G-suffix models, this resistor is mounted on the power supply main chassis.

CIRCUIT DESCRIPTION

The overvoltage protection crowbar circuit protects delicate loads from high voltage conditions that might result from a power supply failure such as a shorted series regulator. The crowbar circuit monitors the output of the power supply such that if the output exceeds an adjustable threshold, a virtual short circuit is placed across the output of the supply. The short circuit causes the output current to attempt to rise at which time the current limit comparison amplifier responds to reduce output voltage towards zero. Due to differences in voltage/current ratings among the modular power supplies, some employ a triac as the shorting element while others utilize an SCR. In addition, because of possible circuit delays in the low-voltage/high-current supplies as well as due to the high current dissipation requirements of some of the intermediate-voltage supplies, an alternate holding current path for the shorting element in these supplies is provided to prevent the supply from turning completely off during crowbar operation.

Figures A-1 and A-2 illustrate the two basic crowbar circuits provided for the 011 Option. As shown in the illustrations, the crowbar circuits are similar in design. Resistor R45, (CROWBAR ADJUST) adjusts the bias of Q1 with respect to –S and zener diode VR1 provides a stable reference voltage which is compared with the –S potential. During normal operation, Q_1 is conducting and the next stage (Q2 or Q3) is cut-off. If the output voltage exceeds the voltage at which R45 is set, Q1 turns off which turns on the next stage to trigger the triac (CR5) or SCR (CR6) depending on the particular model. The triac or SCR thus places a short circuit across the output. The choice between using either the triac or SCR is merely a function of the current rating of the supplies with the higher current supplies employing the SCR circuit. Notice that all crowbar circuits employing the SCR require a pulse transformer (T1) which produces a positive trigger pulse to fire the SCR. The triac does not require a positive trigger pulse so the pulse transformer is not employed.

Notice that the higher current rated models (using either the triac or SCR) have a holding current path (through R9) returned to the negative side of C9 in the main power supply. This holding path keeps the SCR or triac conducting if the series regulator is turned off by the current limit circuit. For supplies with the highest current ratings (Figure A-2), transistor Q4 is included to immediately initiate turn-off when the crowbar fires. Turning down the supply in this manner, limits current dissipation in the crowbar circuit.

Temperature switch TS1 (Figure A-2 only) is provided to shut off the supply in the event of certain types of power supply failures where the current limit circuit cannot turn down the output and the line fuse does not blow. For example, if the series regulator became shorted, a turn-down signal from transistor Q4 would have no effect and the continuous current flow through the CR6 crowbar path could cause component damage. In this case, the current flow through the TS1 "heater" leads causes the device to open the positive lead in the main supply. Notice that once a temperature switch has been activated, it must be replaced as outlined on the next page. For those supplies with lower current ratings (Figure A-1), a temperature switch is not required because the line fuse will blow in the event of a series regulator short or any other failure where the supply cannot be turned-down automatically.

OPERATION

The crowbar can be set to trip anywhere in the range from +0.5Vdc above the minimum rated output voltage of the supply to +2V above the maximum rated output voltage. For example, the 62003A crowbar trip point can be set anywhere between 3.0Vdc to 5.5Vdc.

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NOTE

To prevent transients from falsely tripping the crowbar, the trip voltage should be set higher than the power supply output by at least 0.75Vdc.

To set the crowbar trip voltage, perform the following procedures.

NOTE

Do not connect a load to the supply when setting the crowbar trip voltage.

1. Turn the CROWBAR ADJUST (screwdriver control) fully clockwise (trip voltage set at maximum).

2. Measure the power supply output voltage and set the output voltage (with the VOLTAGE ADJUST screwdriver control) for the desired crowbar trip voltage. If the desired trip voltage is beyond the maximum output voltage that can be attained by adjusting VOLTAGE ADJUST, perform the next step. If the supply can be set to the desired crowbar trip voltage, go on to step 4.

3. If the output of the supply cannot be set to the desired crowbar trip voltage:
   a. Turn VOLTAGE ADJUST to minimum setting.
   b. Turn off the supply and temporarily shunt a 12k, 5%, ½W resistor across resistor R5 on the main power supply board.
   c. Turn on the supply and set power supply output to desired crowbar trip voltage.

CAUTION

Do not set output voltage more than 2V above the maximum output voltage rating of the supply.

4. Slowly turn the CROWBAR ADJUST counterclockwise until the crowbar trips (output falls towards 0 volt).

5. The crowbar remains activated and the output shorted until the supply is turned off. To reset the crowbar, turn the supply off. Before turning the supply back on, remove the shunt resistor installed in step 3 (if necessary) and turn VOLTAGE ADJUST to minimum. Turn the supply back on and set the power supply output voltage at least 0.75V below the crowbar trip voltage setting.

Resetting Crowbar

If the crowbar trips during normal operation (supply output goes to near zero), remove the input power to the supply and then disconnect any load from the power supply. Re-apply input power and determine if the crowbar again trips. If it does, there is a problem in the power supply. Check the line fuse and the temperature switch, TS1 (if provided) for open. If either of these devices are open, refer to the operating and service manual for troubleshooting procedures that can be used to isolate the cause of the overvoltage condition. If the supply does not crowbar when the load is removed, check the load circuit or the trip point setting.

Temperature Switch

A temperature switch, TS1, is included on some supplies (Figure A-2, Note 6) to shut down the unit in case of internal failures where the current through the SCR crowbar path could result in excessive dissipation. The power leads of the device will open if the current flow through the heater leads causes the temperature to reach 115 ± 1.5°C. It takes between 4 to 40 seconds (depending mainly on the rating of the supply in question) after the SCR fires for the device to reach the activation temperature. Once a temperature switch has opened, it must be replaced as described in the next paragraph.

The temperature switch is polarity sensitive and its power leads must be connected as shown on Figure A-2, Note 6. The side with the ceramic insulator must be connected to the positive side of the rectifier (marked with a plated polarity dot on the P.C. board). The other power lead must be connected to current sampling resistor, R15. The heater leads are not polarity dependent and can be connected in any manner. When soldering in any of the temperature switch leads, apply heat to the leads for as short a period as possible as it requires only 115°C for the switch to open. The power leads are particularly susceptible to heat and the caution note below must be observed.

CAUTION

When soldering in the power leads of a temperature switch, connect an alligator clip to each lead to help dissipate heat. The switch will open at approximately 115°C, so solder the leads as quickly as possible.

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Table A-1. Replaceable Parts Option 011 Crowbar (Models 62003A thru 62048A; 62006C thru 62048C; 62018E thru 62048E; 62018G thru 62048G)

REF. DESIG.	DESCRIPTION	TQ	MFR.PART NO.	MFR. CODE	HP PART NO.	RS
	Main Power Supply Board					
R45		1				1
62003A thru 62048A only	Var. ww 1K, 5%, 1W (Crowbar Adjust)		Type CT-106-4	07716	2100-1758	
	Option 011 Crowbar P.C. Board					
C1	fxd, mylar .001μF 200Vdc	1	192P10392	56289	0160-0153	1
C2	fxd, elect. 1μF 50Vdc	1	30D105G050BA2	56289	0180-0108	1
CR1	Diode Si 250mW 200V	1		28480	1901-0033	1
CR3						
62003A, 62004A	Diode Si 200V 3A	1		28480	1901-0416	1
62005A thru 62048A, 62006C thru 62048C, 62018E thru 62048E, 62018G thru 62048G	Not Used (Jumper Installed)					
CR5	Triac	1			1884-0220	1
Q1	SS NPN Si	1		28480	1854-0071	1
Q2	SS NPN Si	1		28480	1854-0087	1
R1	fxd, ww 1.3K, 5%, 3W	1	242E1325	56289	0811-1803	1
R2		1				1
62003A	fxd, met. film 909, 1%, 1/8W		Type CEA T-0	07716	0757-0422	
62004A, 05A	fxd, met. film 1K, 1%, 1/8W		Type CEA T-0	07716	0757-0280	
62006A, 6C	fxd, met. film 1.1K, 1%, 1/8W			28480	0757-0424	
62010A, 10C	fxd, met. film 1.62K, 1%, 1/8W		Type CEA T-0	07716	0757-0428	
62012A, 12C	fxd, met. film 1.78K, 1%, 1/8W		Type CEA T-0	07716	0757-0278	
62015A, 15C	fxd, met. film 1.82K, 1%, 1/8W		Type CEA T-0	07716	0757-0429	
62018A,18C,18E,18G	fxd, met. film 1.96K, 1%, 1/8W		Type CEA T-0	07716	0698-0083	
62024A,24C,24E,24G	fxd, met. film 2.15K, 1%, 1/8W		Type CEA T-0	07716	0698-0084	
62028A,28C,28E,28G	fxd, met. film 2.21K, 1%, 1/8W		Type CEA T-0	07716	0757-0430	
62048A,48C,48E,48G	fxd, met. film 2.37K, 1%, 1/8W		Type CEA T-0	07716	0698-3150	
R4		1				1
62003A	fxd, met. film 1.21K, 1%, 1/8W		Type CEA T-0	07716	0757-0274	
62004A	fxd, met. film 1.62K, 1%, 1/8W		Type CEA T-0	07716	0757-0428	
62005A	fxd, met. film 1.96K, 1%, 1/8W			28480	0698-0083	
62006A, 6C	fxd, met. film 2.37K, 1%, 1/8W		Type CEA T-0	07716	0698-3150	
62010A, 10C	fxd, met. film 4.87K, 1%, 1/8W		Type CEA T-0	07716	0698-4444	
62012A, 12C	fxd, met. film 6.19K, 1%, 1/8W		Type CEA T-0	07716	0757-0290	
62015A, 15C	fxd, met. film 7.5K, 1%, 1/8W		Type CEA T-0	07716	0757-0440	
62018A,18C,18E,18G	fxd, met. film 9.31K, 1%, 1/8W		Type CEA T-0	07716	0698-0064	
62024A,24C,24E,24G	fxd, met. film 13.3K, 1%, 1/8W		Type CEA T-0	07716	0757-0289	
62028A,28C,28E,28G	fxd, met. film 16.2K, 1%, 1/8W		Type CEA T-0	07716	0757-0447	
62048A,48C,48E,48G	fxd, met. film 28.7K, 1%, 1/8W		Type CEA T-0	07716	0698-3449	
R5	fxd, met. film 2K, 1%, 1/8W		Type CEA T-0	07716	0757-0283	1
R6, 7	fxd, comp 10K, 5%, ½W	2	EB-1035	01121	0686-1035	1
R8	fxd, comp 51, 5%, ½W	1	EB-5105	01121	0686-5105	1

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Table A-1. Replaceable Parts (Continued)

REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
R9						
62003A	fxd, ww 100, 5%, 3W	1	Type 242E1015	56289	0813-0050	1
62004A	fxd, ww 135, 5%, 3W	1	Type 242E	56289	0812-0112	1
62005A thru 62048A, 62006C thru 62048C, 62018E thru 62048E, 62018G thru 62048G	Not Used					
R13		1				1
62003A thru 62006A	fxd, ww 0.125, 10%, 3W		Type CW2B-1	91637	0811-1828	
62010A thru 62018A	fxd, ww 0.25, 10%, 3W		Type CW2B-1	91637	0811-1829	
62024A, 62028A	fxd, ww 0.5, 10%, 3W		Type CW2B-1	91637	0811-1830	
62048A	fxd, ww 1.0, 5%, 3W		Type 242E1R05	56289	0811-1732	
62006C	Not Used (Jumper Installed)					
62010C	fxd, ww 0.25, 10%, 3W		Type CW2B-1	91637	0811-1829	
62012C thru 62018C, 62024E,62024G	fxd, ww 0.25, 10%, 5W		Type CW5-2	91637	0811-1847	
62024C,62028C, 62028E,62028G	fxd, ww 0.5, 5W		Type CW5-2	91637	0811-1848	
62048C,62048E	fxd, ww 1, 10%, 5W		Type 243E1R05	56289	0811-1340	
62018E	fxd, ww 0.125, 10%, 5W		K46509	21740	0811-1846	
62018G	fxd, ww 0.07, 5%, 5W		RS-5-78	68601	0811-3174	
62048G	fxd, ww 0.5, 10%, 5W		CW5-2	91637	0811-1848	
R17		1				1
62003A thru 62048A, 62006C thru 62048C, 62018E thru 62048E	Not Used					
62018G thru 62048G	fxd, ww 2.4K, 5%, 3W				0811-1807	
R45		1				1
(See Main Supply for A-Series)						
62006C thru 62048C, 62010E thru 62048E	Var. ww 1K, 5%, 1W		Type CT-106-4	07716	2100-1758	
62010G thru 62048G	Var. ww 1800, 5%, 1W			28480	2100-3254	
VR1	Diode, zener, 5.62V, 400mW	1		28480	1902-3104	

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Table A-2. Replaceable Parts Option 011 Crowbar (Models 62003C thru 62005C; 62003E thru 62015E; 62003G thru 62015G)

REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	HP PART NO.	RS
	Option 011 Crowbar P.C. Board					
C1	fxd, mylar .001μF 200Vdc	1	192P10392	56289	0160-0153	1
C2	fxd, elect. 1μF 50Vdc	1	30D105G050BA2	56289	0180-0108	1
C3	fxd, mylar .022μF 200V	1	292P22392-PTS	56289	0160-0162	1
CR1, CR2	Diode Si 250mW 200V	3		28480	1901-0033	3
CR3						
62003C, 62004C 62003E thru 62005E, 62003G thru 62006G	Diode Si 12A, 100V	1	1N1200A	02735	1901-0002	1
62005C, 62006E, 62010G thru 62015G	Not Used (Jumper Installed)					
CR4	Diode Si 250mW 200V			28480	1901-0033	
CR6	SCR	1	2N3669	02735	1884-0019	1
Q1	SS NPN Si	1		28480	1854-0071	1
Q3	SS NPN Si	1		28480	1854-0087	1
Q4						
62003C, 62004C, 62003E thru 62005E, 62003G thru 62006G	SS NPN Si	1		24480	1854-0071	1
62005C, 62006E, 62010G thru 62015G	Not Used					
R1	fxd, ww 1.3K, 5%, 3W	1	242E1325	56289	0811-1803	1
R2		1				1
62003C, 62003E, 62003G	fxd, met. film 909, 1%, 1/8W		Type CEA T-0	07716	0757-0422	
62004C, 5C, 62004E, 5E, 62004G, 5G	fxd, met. film 1K, 1%, 1/8W		Type CEA T-0	07716	0757-0280	
62006E, 6G	fxd, met. film 1.1K, 1%, 1/8W		Type CEA T-0	07716	0757-0424	
62010E, 10G	fxd, met. film 1.62K, 1%, 1/8W		Type CEA T-0	07716	0757-0428	
62012E, 12G	fxd, met. film 1.78K, 1%, 1/8W		Type CEA T-0	07716	0757-0278	
62015E, 15G	fxd, met. film 1.82K, 1%, 1/8W		Type CEA T-0	07716	0757-0429	
R4		1				1
62003C, 3E, 3G	fxd, met. film 1.21K, 1%, 1/8W		Type CEA T-0	07716	0757-0274	
62004C, 4E, 4G	fxd, met. film 1.62K, 1%, 1/8W		Type CEA T-0	07716	0757-0428	
62005C, 5E, 5G	fxd, met. film 1.96K, 1%, 1/8W		Type CEA T-0	07716	0698-0083	
62006E, 6G	fxd, met. film 2.37K, 1%, 1/8W		Type CEA T-0	07716	0698-3150	
62010E, 10G	fxd, met. film 4.87K, 1%, 1/8W		Type CEA T-0	07716	0698-4444	
62012E, 12G	fxd, met. film 6.19K, 1%, 1/8W		Type CEA T-0	07716	0757-0290	
62015E, 15G	fxd, met. film 7.5K, 1%, 1/8W		Type CEA T-0	07716	0757-0440	
R5	fxd, met. film 2K, 1%, 1/8W		Type CEA T-0	07716	0757-0283	1
R6, 7	fxd, comp 10K, 5%, ½W	2	EB-1035	01121	0686-1035	1
R8	fxd, comp 51, 5%, ½W	1	EB-5105	01121	0686-5105	1

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REF. DESIG.	DESCRIPTION	TQ	MFR.PART NO.	MFR. CODE	HP PART NO.	RS
R9						
62003C, 3E, 3G	fxd, ww 50, 5%, 5W	1	Type 243E5005	56289	0811-1854	1
62004C, 4E, 4G	fxd, ww 75, 5%, 5W	1	Type 243E7505	56289	0812-0097	1
62005C	Not Used					
62005E, 5G	fxd, ww 100, 3%, 5W	1	Type 243E1015	56289	0812-0018	1
62006E	Not Used					
62006G	fxd, ww 135, 3%, 5W	1				
62010E thru 62015E, 62010G thru 62015G	Not Used					
R10		1				1
62003C, 3E,4G,5E	fxd, comp 510, 5%, ½W		EB-5115	01121	0686-5115	
62003G	fxd, comp 270, 5%, ½W		EB-2715	01121	0686-2715	
62004C, 4E	fxd, comp 750, 5%, ½W		EB-7515	01121	0686-7515	
62005C, 6E	Not Used					
62005G	fxd, comp 630, 5%, ½W		EB-6815	01121	0686-6815	
62006G	fxd, comp 1K, 5%, ½W		EB-1025	01121	0686-1025	
62010E thru 62015E, 62010G thru 62015G	Not Used					
R12	fxd, comp 10, 5%, ½W	1	EB-1005	01121	0686-1005	1
R17						
62003C thru 62005C, 62003E thru 62006E	Not Used					
62003G thru 62015G	fxd, ww 2.4K, 5%, 3W	1			0811-1807	1
R18		1				1
62003C thru 62005C, 62003E thru 62006E, 62003G thru 62006G	Not Used (Jumper Installed)					
62010E thru 62015E, 62010G thru 62015G	fxd, ww 0.18, 5%, 10W				0811-3222	
R19		1				1
62003C thru 62005C	Not Used					
62003E thru 62006E	fxd, ww 0.33, 5%, 10W		RS-10-46	68601	0811-3177	
62010E thru 62015E	fxd, ww 0.25, 5%, 10W		RS-10-46	68601	0811-3716	
62003G, 62010G thru 62015G	fxd, ww 0.18, 5%, 10W		RS-10-46	68601	0811-3222	
62004G thru 62006G	fxd, ww 0.07, 5%, 5W		RS-5-78	68601	0811-3174	
R45		1				1
62003C thru 62005C, 62003E thru 62015E	Var. ww 1K, 5%, 1W		Type CT-106-4	07716	2100-1758	
62003G thru 62015G	Var. ww 1800, 5%, 1W			28480	2100-3254	
T1	Pulse Transformer	1		28480	9100-2160	1
VR1	Diode, zener 5.62V 400mW	1		28480	1902-3104	1
TS1	Temperature Switch	1	923917	27012	2110-0471	3

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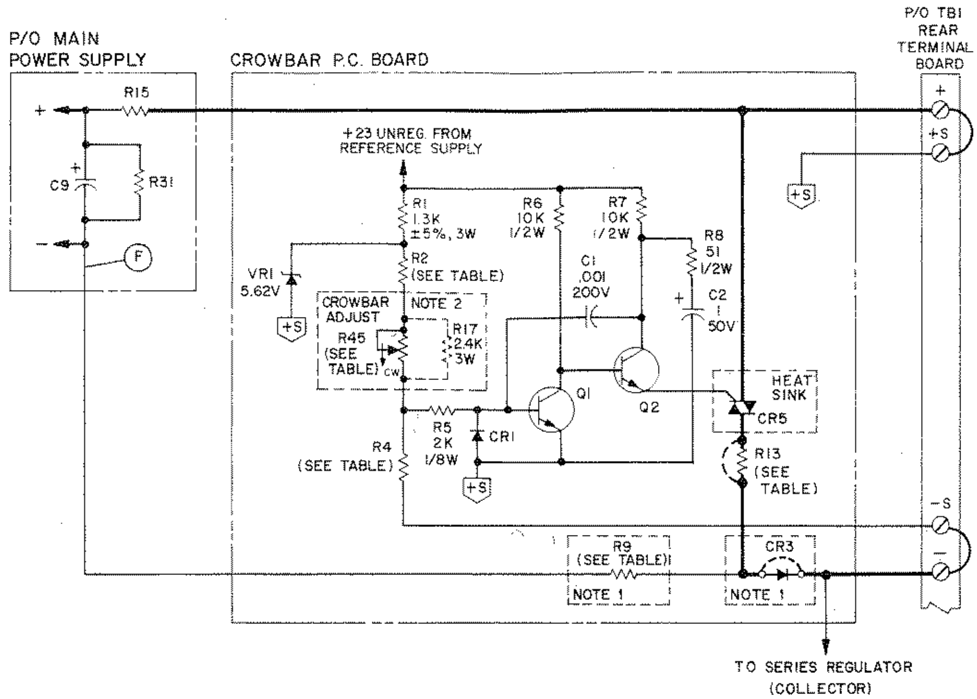

COMPONENT	VALUE(S) FOR MODEL(S) (IN OHMS)										
	62003A	62004A	62005A	62006A 62006C	62010A 62010C	62012A 62012C	62015A 62015C	62018A 62018C 62018E 62018G	62024A 62024C 62024E 62024G	62028A 62028C 62028E 62028G	62048A 62048C 62048E 62048G
R2	909 1/8W	1K 1/8W	1K 1/8W	1.1K 1/8W	1.62K 1/8W	1.78K 1/8W	1.82K 1/8W	1.96K 1/8W	2.15K 1/8W	2.21K 1/8W	2.37K 1/8W
R4	1.21K 1/8W	1.62K 1/8W	1.96K 1/8W	2.37K 1/8W	4.87K 1/8W	6.19K 1/8W	7.5K 1/8W	9.31K 1/8W	13.3K 1/8W	16.2K 1/8W	28.7K 1/8W
R9	100 3W	135 3W	—	—	—	—	—	—	—	—	—
R13	0.125 3W	0.125 3W	0.125 3W	6A-0.125 3W 6C-JUMPER	0.25 3W	12A-0.25 3W 12C-0.25 5W	15A-0.25 3W 15C-0.25 5W	18A-0.25,3W 18C-0.25,5W 18E-0.125,5W 18G-0.07,5W	24A-0.5,3W 24C-0.5,5W 24E, 24G - 0.25 5W	28A-0.5,3W 28C, 28E, 28G - 0.5 5W	48A-1,3W 48C, 48E - 1,5W 48G-0.5,5W
R45	1K	1K	1K	1K	1K	1K	1K	18A, 18C, 18E - 1K 18G - 1.8K	18A, 24C, 24E - 1K 24G - 1.8K	28A, 28C, 28E - 1K 28G - 1.8K	48A, 48C, 48E - 1K 48G - 1.8K

NOTES:

1. CR3 AND R9 PROVIDED FOR 62003A AND 62004A ONLY. CR3 DELETED (JUMPER INSTALLED) AND R9 DELETED FOR ALL OTHER MODELS (NO CONNECTION FROM CROWBAR BOARD TO NEGATIVE SIDE OF C9).
2. R17 PROVIDED FOR 62018G THROUGH 62048G SUPPLIES ONLY. ALSO, FOR THESE SUPPLIES, R45 MOUNTED ON CHASSIS. FOR ENTIRE "A" SUFFIX SERIES, R45 MOUNTED ON MAIN POWER SUPPLY PRINTED WIRING BOARD. FOR OTHER ("C" AND "E" SUFFIX) SUPPLIES, R45 MOUNTED ON CROWBAR PRINTED WIRING BOARD.
3. ALL RESISTORS IN OHMS, 1/2W RESISTORS ±5%, ALL 1/8W RESISTORS ±1%, UNLESS OTHERWISE INDICATED.
4. ALL CAPACITORS IN MICROFARADS, UNLESS OTHERWISE INDICATED.

Figure A-1. Option 011 Crowbar Schematic, Models 62003A thru 62048A, 62006C thru 62048C, 62018E thru 62048E, and 62018G thru 62048G.

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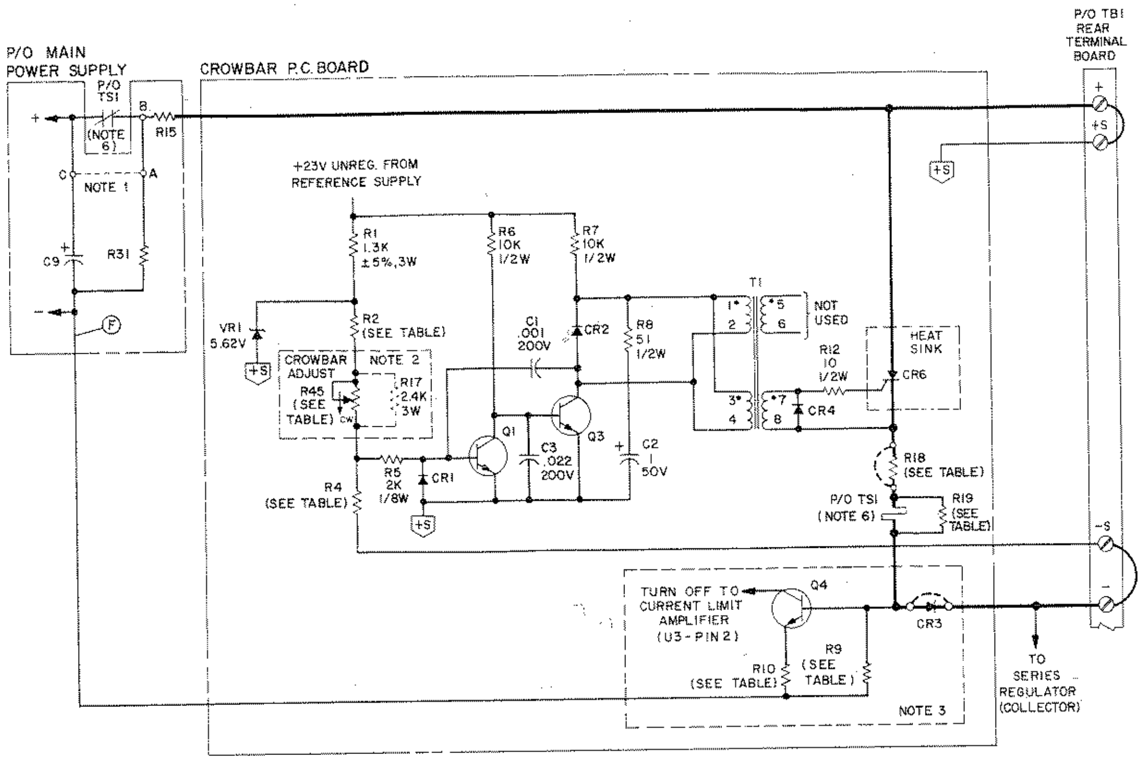

COMPONENT	62003C 62003E 62003G	62004C 62004E 62004G	62005C 62005E 62005G	62006E 62006G	62010E 62010G	62012E 62012G	62015E 62015G
	VALUE (S) PER MODEL(S) IN OHMS						
R2	909 1/8W	1K 1/8W	1K 1/8W	1.1K 1/8W	1.62K 1/8W	1.78K 1/8W	1.82K 1/8W
R4	1.21K 1/8W	1.62K 1/8W	1.96K 1/8W	2.37K 1/8W	4.87K 1/8W	6.19K 1/8W	7.5K 1/8W
R9	50 5W	75 5W	5C-NOT USED 5E, 5G - 100, 5W	6E-NOT USED 6G-135, 5W	—	—	—
R10	3C, 3E - 510, 1/2W 3G-270, 1/2W	4C, 4E - 750, 1/2W 4G-510, 1/2W	5C-NOT USED 5E-750, 1/2W 5G-680, 1/2W	6E-NOT USED 6G-1K, 1/2W	—	—	—
R18	JUMPER	JUMPER	JUMPER	JUMPER	0.18 10W	0.18 10W	0.18 10W
R19	3C-NOT USED 3E-0.33, 10W 3G-0.18, 10W	4C-NOT USED 4E-0.33, 10W 4G-0.07, 5W	5C-0.18, 10W 5E-0.33, 10W 5G-0.07, 5W	6E-0.33, 10W 6G-0.07, 5W	10E-0.25, 10W 10G-0.18, 10W	12E-0.25, 10W 12G-0.18, 10W	15E-0.25, 10W 15G-0.18, 10W
R45	3C, 3E - 1K 3G-1.8K	4C, 4E - 1K 4G-1.8K	5C, 5E - 1K 5G-1.8K	6E-1K 6G-1.8K	10E-1K 10G-1.8K	12E-1K 12G-1.8K	15E-1K

NOTES:

1. POINT A WIRED TO B FOR 62003C THRU 62005C AND 62003E THRU 62015E SUPPLIES. FOR 62003G THRU 62015G SUPPLIES, POINT A IS CONNECTED TO POINT C.
2. R17 PROVIDED FOR 62003G THRU 62015G SUPPLIES ONLY. ALSO FOR THESE SUPPLIES, R45 MOUNTED ON CHASSIS. FOR OTHER ("C" AND "E" SUFFIX) SUPPLIES, R45 MOUNTED ON CROWBAR PRINTED WIRING BOARD.
3. CR3, Q4, R9 AND R10 PROVIDED FOR THE 62003C, 62004C, 62003E THRU 62005E AND 62003G THRU 62006G MODELS ONLY. FOR ALL OTHER MODELS (62005C, 62006E AND 62010G THRU 62015G), A JUMPER IS INSTALLED IN PLACE OF CR3 AND THE OTHER COMPONENTS REMOVED (NO CONNECTION FROM CROWBAR TO NEGATIVE SIDE OF C9).
4. ALL RESISTORS IN OHMS, 1/2W RESISTORS ±5%, ALL 1/8W RESISTORS ±1%, UNLESS OTHERWISE INDICATED.
5. ALL CAPACITORS IN MICROFARADS, UNLESS OTHERWISE INDICATED.
6. TEMPERATURE SWITCH TS1 IS SHOWN BELOW. THE POWER LEADS MUST BE CONNECTED AS SHOWN. READ DESCRIPTION AND REPLACEMENT PROCEDURES ON PAGE A-2.

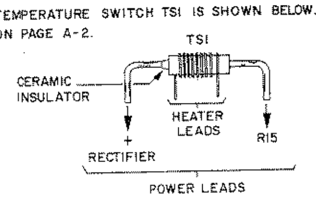

Figure A-2. Option 011 Crowbar Schematic, Models 62003C thru 62005C, 62003E thru 62015E, and 62003G thru 62015G.

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