HEWLETT-PACKARD COMPANY / OPERATING AND SERVICE MANUAL

722A/AR

DC POWER SUPPLY

hp 722A/AR

OPERATING AND SERVICE MANUAL

MODEL 722A/AR

SERIALS PREFIXED: 105-

DC POWER SUPPLY

01155-1 Printed: NOV 1961

TABLE OF CONTENTS

Section		Page
I	GENERAL INFORMATION	1-1
1-1.	Introduction	1-1
1-4.	Description	1-1
1-8.	Differences in Equipment	1-1
1-10.	Equipment Supplied	1-1
1-12.	Other Modes of Operation	1-1
II	PREPARATION FOR USE	2-1
2-1.	Unpacking and Mechanical Inspection	2-1
2-4.	Site Selection and Installation	2-1
2-6.	Line Power	2-1
2-8.	Operation from 230-Volt Supply	2-1
2-11.	Preparation for Storage and Shipment	2-1
2-14.	Storage	2-1
2-16.	Incoming Inspection &Perform. Test	2-1
III	OPERATING INSTRUCTIONS	3-1
3-1.	Operation	3-1
3-3.	Current Limiting	3-1
3-6.	Remote Sensing	3-1
IV	PRINCIPLES OF OPERATION	4-1
4-1.	Overall Block Diagram	4-1
4-3.	Rectifying and Filtering Circuits	4-1
4-6.	Series Regulator	4-2
4-8.	Output Circuit	4-2
4-10.	Voltage Regulating Circuit	4-2
4-14.	Current-Power Limiter	4-2
4-18.	Protection Circuits	4-3
V	MAINTENANCE	5-1
5-1.	Introduction	5-1
5-3.	Maintenance Procedures	5-1
5-4.	Dustcover Removal	5-1
5-6.	Zero-Setting the Meter	5-1
5-8.	Printed Circuit Board Removal	5-1
5-10.	Test Equipment Required	5-1
5-12.	Performance Check	5-1
5-14.	Troubleshooting	5-1
5-15.	Introduction	5-1
5-17.	Trouble Analysis	5-1
5-20.	Detailed Test Procedure	5-5
5-23.	Reference Voltage Adjustment	5-6
5-25.	Monitoring	5-6
5-27.	Voltage Range	5-6
5-29.	Current Limit	5-6
5-32.	Performance Test	5-6
5-34.	Voltage Range	5-6
5-36.	Current Limiting	5-7
5-38.	Operation Characteristics	5-7
5-39.	Ripple Characteristics	5-7
5-40.	Load Regulation	5-7
5-41.	Line Regulation	5-8
VI	REPLACEABLE PARTS	6-1
6-1.	Introduction	6-1
6-5.	Ordering Information	6-1

LIST OF ILLUSTRATIONS

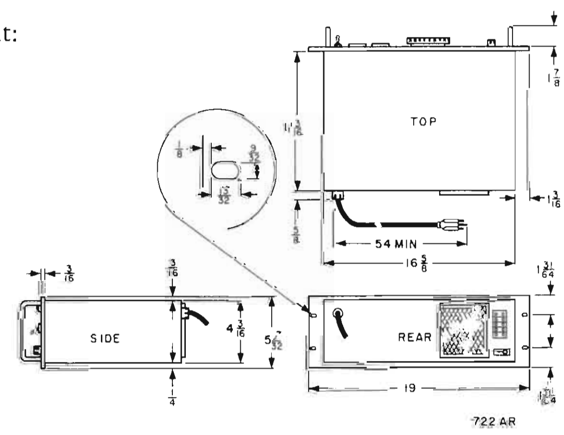
Number	Title	Page
1-1.	Model 722AR DC Power Supply	1-1
3-1.	Operating Controls	3-0
3-2.	Remote Sensing	3-1
3-3.	Charging Batteries	3-1
3-4.	Parallel Operation	3-1
4-1.	Simplified Schematic	4-0
4-2.	Block Diagram	4-1
4-3.	Current Power Limiter	4-3
5-1.	Model 722A Bottom View	5-2
5-2.	Model 722A Top View	5-3
5-3.	Servicing Etched Circuit Boards	5-4
5-4.	Reference Power Supply (Schematic)	5-9
5-5.	Power Supply (Schematic)	5-10

LIST OF TABLES

Number	Title	Page
1-1.	Specifications	1-0
5-1.	Recommended Test Equipment	5-0
5-2.	Troubleshooting Guide	5-5
5-3.	Replacement Guide	5-5
6-1.	Reference Designation Index	6-2
6-2.	Replaceable Parts	6-6

Table 1-1. Specifications

RATED OUTPUT:	0 to 60 volts dc; 0 to 2 amperes dc
LINE REGULATION:	Less than 2.5 mv change for ±10% line voltage change; output set between 0 to 60 volts
LOAD REGULATION:	Less than 5 mv change at output terminals for 0 to 2 amperes change; output set between 0 and 60 volts
TRANSIENT RECOVERY TIME:	Less than 200 μsec for recovery within 5 mv for a change from 0 to full load or full load to 0 at any rated output or line voltage
NOISE AND RIPPLE:	Less than 250 μv rms
TEMPERATURE STABILITY:	Better than 0.02%/^{O}C or 5 mv/^{O}C, whichever is larger
TEMPERATURE RANGE:	0 to 55^{O} for operation within specifications
OUTPUT IMPEDANCE:	DC: Less than 2.5 milliohms AC: Less than 5 milliohms in series with 10 μh
OUTPUT METERS:	Voltage: 0 to 60 volts, one range Current: 0 to 2.5 amp, one range
PROTECTION:	Output current limiter continuously adjustable from 100 ma to 2.2 a
COOLING:	Forced air
DIMENSIONS:	Rack Mount:



WEIGHT:	Rack Mount: Net 34 lb
POWER:	115 or 230 volts ±10%, 50 to 60 cps, 40 to 250 watts depending on line and load conditions

SECTION I
GENERAL INFORMATION

1-1. INTRODUCTION.

1-2. This is an operating and service manual for the Model 722A DC Power Supply. This manual is applicable only to instruments with the prefix shown on the front cover except as modified by change sheets.

1-3. Hewlett-Packard instruments use a two-section eight-digit serial number, that is, 000-00000. The first three digits are an identification number; the last five digits are the instrument serial number. If the identification number on the instrument does not agree with the identification number shown on the manual title page, there are differences between the manual and instrument. These differences are described in manual change sheets having the proper identification number.

1-4. DESCRIPTION.

1-5. The ⓗⓟ Model 722A DC Power Supply is a completely transistorized, regulated power supply. It will supply up to 60 volts at 2 amperes with continuous adjustment of voltage and current limiting. The current limit can be set at any current between 100 ma and 2 amperes to protect circuit elements, such as transistors, under test.

1-6. Two meters measure both current and voltage drawn by the load continuously so that you may monitor power supply drain conveniently. The output impedance is low for both dc and ac so that a minimum of decoupling is required in cascaded circuits. Terminals for remote sensing are provided on the rear of the chassis so that the ohmic resistance of the supply leads is minimized.

1-7. The usefulness of the Model 722A is not limited to transistor applications, but is useful wherever high stability is required. For instance, Model 722A is an excellent source for regulating the filament voltage of vacuum tubes.

1-8. DIFFERENCES IN EQUIPMENT.

1-9. This manual has been written and illustrated for the Model 722AR (rack-mounted instrument) since this is the only style of instrument available at the time of writing. A cabinet-mount model may become available in the future. This manual will also apply to the electrical details of the cabinet-mounted model even though the physical configuration may be different.

1-10. EQUIPMENT SUPPLIED.

1-11. The equipment supplied consists of only the Model 722A DC Power Supply as this supply is complete in itself.

1-12. OTHER MODES OF OPERATION.

1-13. Two Model 722A's may be connected in series for greater voltage. Do not connect more than two 722A's in series. Refer to section III for instructions before attempting to operate these supplies in parallel.

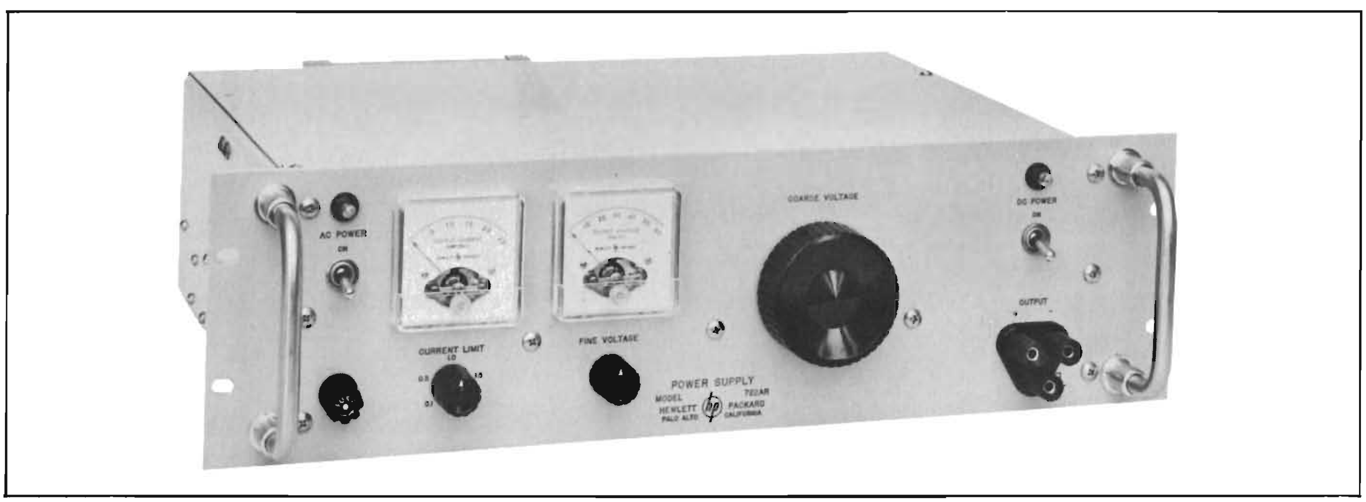


Figure 1-1. Model 722AR DC Power Supply

SECTION II
PREPARATION FOR USE

2-1. UNPACKING & MECHANICAL INSPECTION.

2-2. Inspect instrument for signs of damage incurred in shipment. This instrument should be tested as soon as it is received. If it fails to operate properly, or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent, and this report should be forwarded to us. We will then advise you of the disposition to be made of the equipment and arrange for repair or replacement. Include model number and serial number when referring to this instrument for any reason.

2-3. Hewlett-Packard Company warrants each instrument manufactured by them to be free from defects in material and workmanship. Our liability under this warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose and to replace any defective parts thereof. Any damage to the instrument upon receipt is due to the carrier. File a claim with the carrier as instructed in the preceding paragraph.

2-4. SITE SELECTION AND INSTALLATION.

2-5. The Model 722A should be mounted securely in a rack. In environments of severe vibration the rear of the chassis should also be fastened securely. There should be sufficient space to the rear and along the sides of the instrument to permit free flow of cool air for cooling. This instrument will fit any standard 19-inch rack which has a space 5-1/4 inches high. If the rack is not accessible from the rear, plug the power cable in before sliding instrument into rack. Also make any connections to the rear terminal strip. If the rack is accessible from the rear, these connections may be made at any time. Secure the instrument to the rack with screws and cup-washers. Connect the power cable and connections, if any, to the rear terminals. Connect the power cable to the power source.

2-6. LINE POWER.

2-7. The three-conductor power cable supplied with the instrument is terminated in a polarized, three-prong male connector recommended by the National Electrical Manufacturers' Association (NEMA).

WARNING

The third conductor grounds the instrument chassis for the PROTECTION OF OPERATING PERSONNEL. When using a three-prong to two-prong adapter ground third lead (green wire) externally.

2-8. OPERATION FROM 230-VOLT SUPPLY.

2-9. This instrument may be used with either a 115-volt or 230-volt supply with a frequency from 50 to 60 cps, single-phase. This instrument is shipped from the factory ready for operation from a 115-volt source unless otherwise indicated. Operation from a 230-volt supply is possible by changing jumper connections or by flipping a switch if the instrument is equipped with the 115-volt to 230-volt switch option. To change the jumpers refer to the schematic for details (see also figure 5-5).

WARNING

Remove the power cable from the wall receptacle before removing the dust cover. Dangerous potentials are exposed inside the instrument.

Replace the fuse with the one called out for 230-volt operation in the table of replaceable parts (section VI).

2-10. If your instrument has the 115-volt to 230-volt switch option the input voltage may be changed without removing the instrument from the rack. First turn the instrument off or remove the power cable. Then with a pointed tool, such as the point of a pencil, flip the 115-volt to 230-volt switch on the rear apron of the instrument to 230 volts. Replace the fuse with the one called out for 230-volt operation in the table of replaceable parts (section VI).

2-11. PREPARATION FOR STORAGE AND SHIPMENT.

2-12. The best method of packing the instrument is in the original shipping carton with the original fillers packed in the same manner as when received from the factory. Therefore, when unpacking note carefully the method of packing and save the original packing material for possible future re-use.

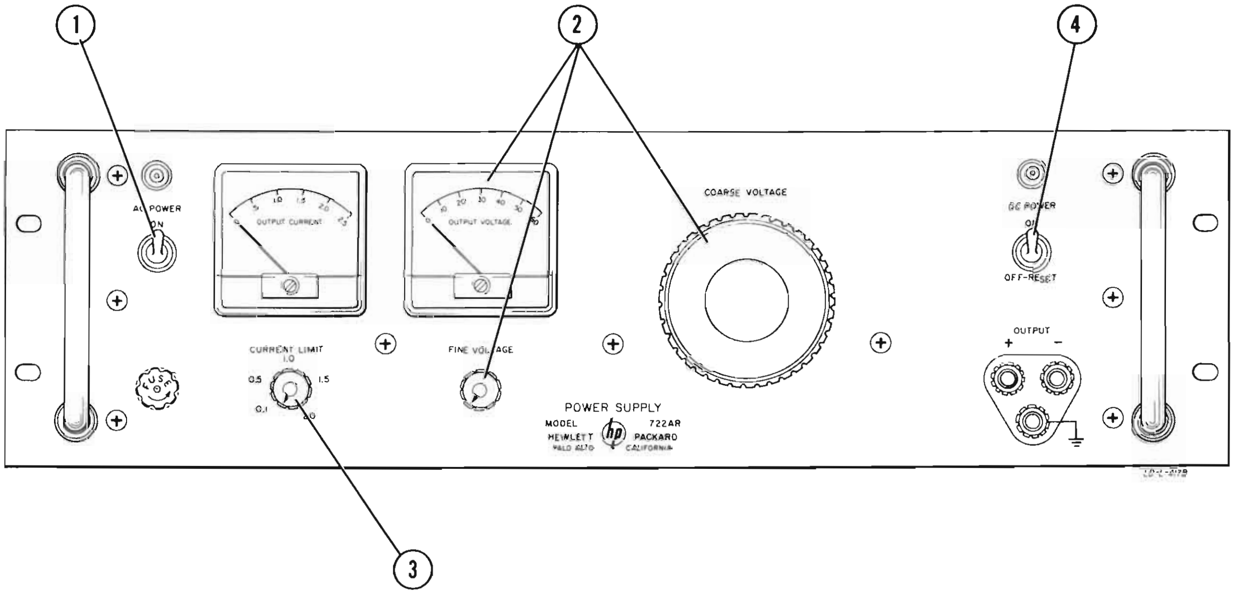
2-13. If the original packing material is not available and it is desired to package the instrument for storage or shipment, first wrap the instrument in heavy kraft paper to avoid scratching the paint. Then pack in a cardboard carton with a bursting strength of at least 150 lb per square inch. Pad the instrument on all sides with at least 2 inches of rubberized hair or at least 4 inches of tightly packed excelsior.

2-14. STORAGE.

2-15. No special precautions are necessary in storage except the usual protection against mechanical damage, salt air, etc.

2-16. INCOMING INSPECTION AND PERFORMANCE TEST.

2-17. This instrument should be checked as soon as it is received to determine that its electrical characteristics have not been damaged in shipment. Refer to paragraphs 5-32 through 5-41.



1. Turn AC POWER switch ON.
2. Adjust COARSE and FINE VOLTAGE controls until the voltage on the OUTPUT VOLTAGE meter is of the desired value.
3. Adjust CURRENT LIMIT control until the pointer indicates a current value somewhat greater than the expected value.
4. Turn DC POWER switch ON.

   If the OUTPUT VOLTAGE drops when DC POWER is turned on, the current limit is probably being exceeded.

Figure 3-1. Operating Controls

SECTION III
OPERATING INSTRUCTIONS

3-1. OPERATION.

3-2. Refer to figure 3-1 for a complete illustrated description of all operating controls. No preliminary adjustments are necessary before turning on this instrument. Connect the wires from the load to the output terminals either in the front or back of the instrument. If these leads are long or run past a source of interference, twist them if they are open-wire leads or run a shielded cable. Figure 3-1 explains step by step how to operate this instrument.

3-3. CURRENT LIMITING.

3-4. The maximum current delivered by this supply may be set to any value between 0.1 and 2 amperes. This will limit the current to the set value and protect the equipment under test in addition to protecting the transistors in the Model 722A from dissipating too much power.

3-5. Occasionally when the current-limit control is set to maximum current and maximum current is drawn, the instrument will not adjust down later to a smaller current limit. In this case switch the power switch to OFF-RESET position momentarily and then back ON. The instrument will now be reset and will limit at lower levels of current limit.

3-6. REMOTE SENSING.

3-7. When the Remote-Local switch on the rear of the instrument is in the Local position the voltage for regulation control (sensing voltage) is taken off the output of the supply at the front panel. This is not always the best point to obtain this voltage because there is a drop in the supply leads between the load and the supply.

3-8. To minimize this effect a separate set of terminals for the sensing voltage is provided on the rear of the instrument. These terminals permit a separate pair of leads to connect at the load to supply the sensing voltage. These leads carry no load current but are actually inside the regulating loop of the amplifier.

3-9. To use remote sensing run a separate set of leads from the load to the supply. These leads do not need to be as heavy as the supply leads but they must be protected from hum pick-up. Run either twisted pair open-wire leads or shielded leads if hum pick-up is severe. Connect the leads to the terminals marked REM+ and REM- on the terminal strip on the rear of the instrument. At the load connect these leads to the load (see figure 3-2).

CAUTION

Be sure to observe polarity when making these connections. Wrong connections may damage the supply.

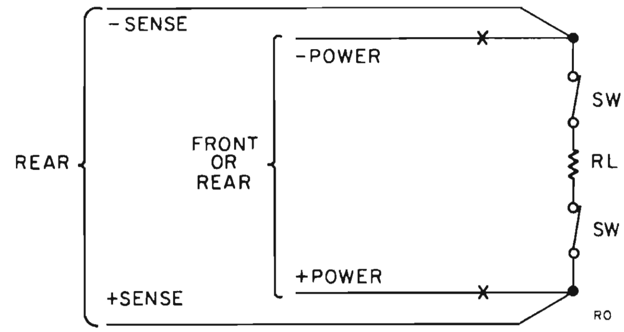


Figure 3-2. Remote Sensing

3-10. If the load must be removed with the supply on be careful where you break the leads going to the load. Referring to figure 3-2 you may break the circuit at the point(s) marked SW. Do NOT break the circuit at the point(s) marked X as the supply will be damaged.

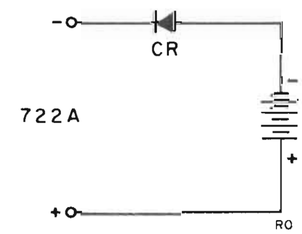


Figure 3-3. Charging Batteries

3-11. If this supply is to be connected to an active load (one which supplies voltage) further precautions must be taken. The load must not be allowed to run current through the supply in the reverse direction. WHEN CONNECTING THIS SUPPLY TO AN ACTIVE LOAD ALWAYS MAKE SURE THAT THE VOLTAGE OF THE MODEL 722A SUPPLY IS GREATER THAN THE VOLTAGE ON THE TERMINALS WHERE THE SUPPLY IS TO BE CONNECTED. The recommended way of protecting the supply is to use diodes. Figures 3-3 and 3-4 illustrate the proper way to connect these diodes when connecting this supply to a battery or when connecting two supplies in parallel. These diodes must be able to carry 2 amperes current and have a peak inverse voltage greater than 50 volts. A suitable diode may be ordered from Hewlett-Packard as stock number 1901-0019.

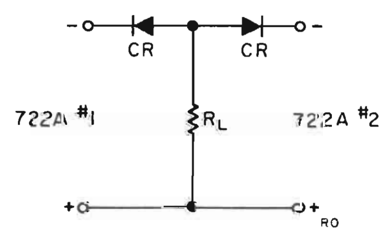


Figure 3-4. Parallel Operation

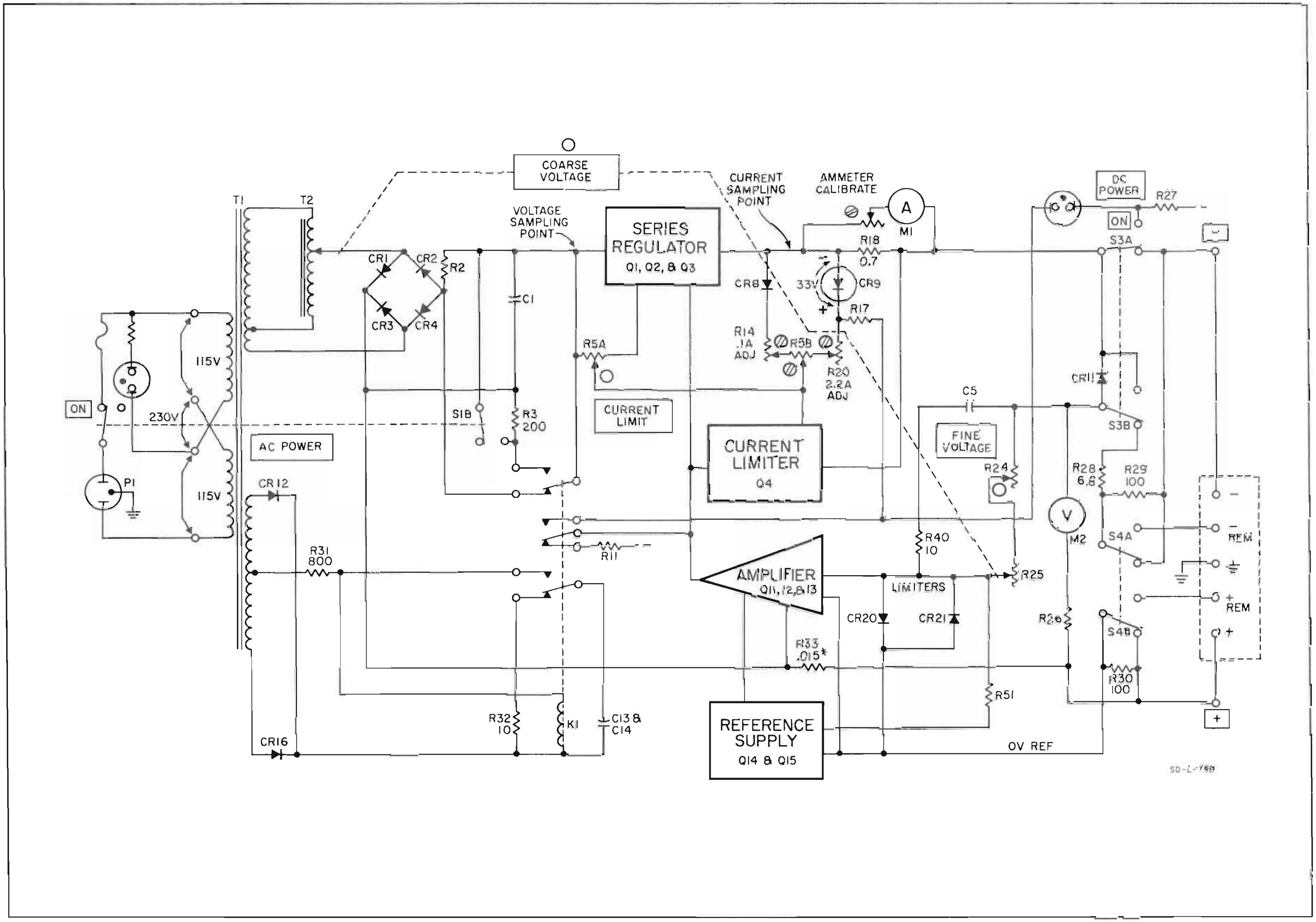


Figure 4-1. Simplified Schematic

SECTION IV
PRINCIPLES OF OPERATION

4-1. OVERALL BLOCK DIAGRAM.

4-2. Referring to figure 4-2, block diagram, note that the power-line voltage passes through a power transformer, a variable transformer, and then to a bridge rectifier circuit. The COARSE VOLTAGE control varies the voltage from the variable voltage transformer delivered to the bridge rectifier. The rectified ac from the rectifier is filtered and supplied to the series regulator. The current goes through the series regulator to the load. A voltmeter across the output and an ammeter in series with the output monitors the direct voltage and current fed to the load. Current and voltage sampling circuits feed the current limiter. The current limiter enables the operator to set the maximum current the Model 722A will deliver to the load to any value between 0.1 amp and 2.0 amps. The current limiter also serves to limit the maximum power dissipated in the series regulator to a safe value. The amplified dc voltage change at the output is applied as a voltage to the series regulators which tends to counteract the change in output voltage. The reference power supply furnishes constant voltages which are used throughout the instrument for reference and supply purposes. Terminals are provided for remote sensing so the sensing voltage can be connected to the output externally.

Note

> In discussions that follow, the positive side of the output voltage is considered circuit ground.

4-3. RECTIFYING AND FILTERING CIRCUITS.

4-4. Referring to figure 4-1 note that alternating current is fed through a conventional power transformer T1 into a variable autotransformer T2. The purpose of T2 is to keep the voltage across the series regulators Q1 and Q2 more or less constant regardless of the output voltage. Transformer T2 is ganged with the output voltage control (COARSE VOLTAGE) R25. If the output voltage were reduced to a low value without reducing the input voltage to the voltage regulator, excessive power would have to be dissipated in the transistors of the series regulator at maximum output current. By the use of a variable autotransformer this dissipation is kept to acceptable values.

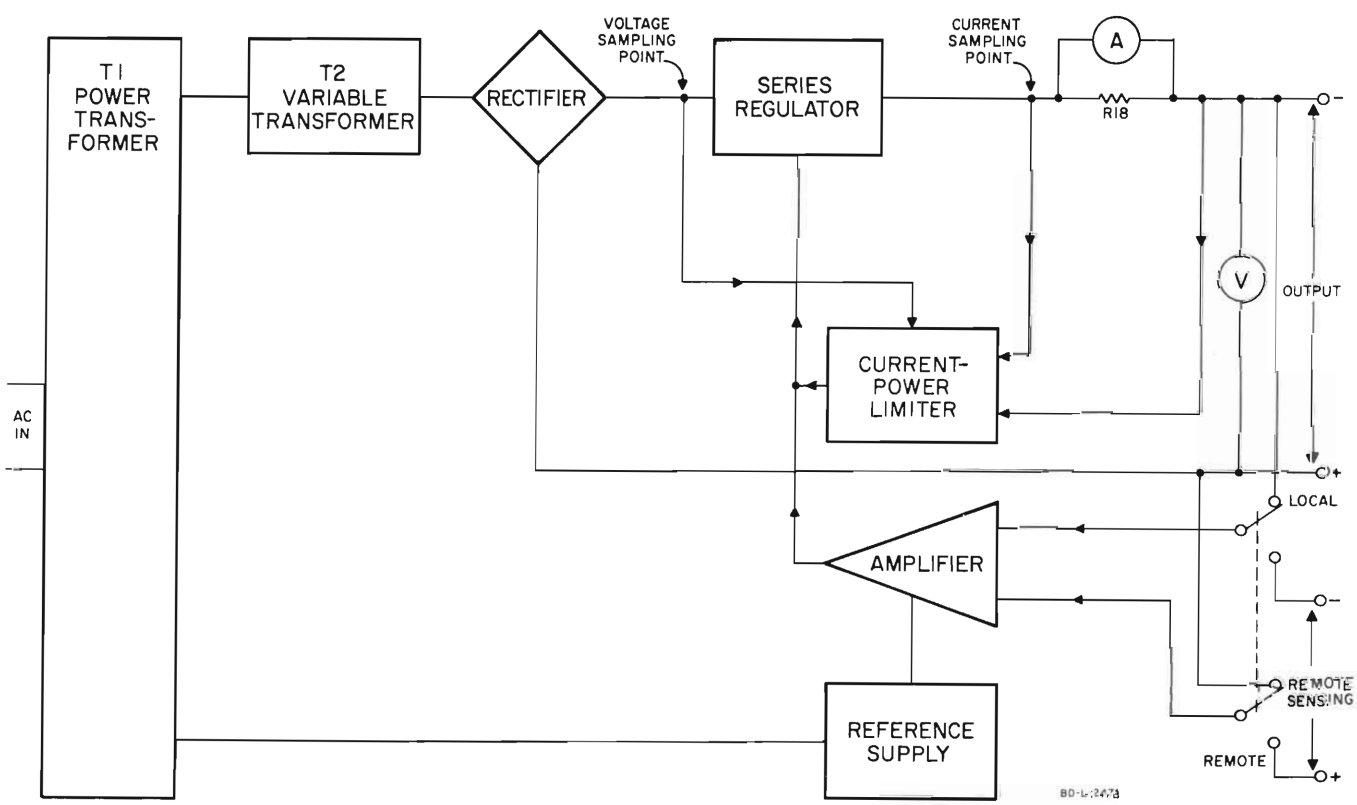


Figure 4-2. Block Diagram

4-5. Alternating current from the autotransformer is rectified in a bridge rectifier CR1-4. The output of the bridge is a full-wave rectified ac voltage. This voltage is filtered by the large capacitor C1. Thus the voltage supplied to the series regulator is almost pure direct current.

4-6. SERIES REGULATOR.

4-7. The series regulator consists of two transistors in series, one of which is driven by the series regulator driver Q3. The other transistor is driven by Q11, the third stage in the amplifier. The action of these circuits is explained in paragraphs under these titles.

4-8. OUTPUT CIRCUIT.

4-9. Resistor R18 is connected between the output of the series regulator and the negative output terminal. An ammeter connected across R18 is calibrated to read the current to the load. Voltmeter M2 is connected across the output and reads the output voltage. The output is available on the front panel terminals and on the rear terminal strip for remote application.

4-10. VOLTAGE REGULATING CIRCUIT.

4-11. The voltage regulating circuit consists of the FINE VOLTAGE adjustment R24 (refer to figure 4-1), the COARSE VOLTAGE adjustment R25, the amplifier circuit (Q13, Q12 and Q11 and associated circuitry) and the series regulator Q2. The diode limiters, CR20 and CR21, limit the input to the amplifier in both the positive and negative directions. Consider what happens when the output voltage drops. This drop may be a slow shift in output voltage or an ac signal on the output. AC signals are fed to the amplifier through C5 and R40. This low-impedance path increases the loop gain for ac signals. When the voltage on the base of Q13 (see figure 4-3) becomes more positive (less negative as when the output of the supply drops) Q13 draws more base current since the emitter-base bias is increased (Q13 is a npn-type transistor). This signal is amplified and reversed in phase. When coupled to Q12, this reversed signal again causes more current to flow since the forward bias is again increased (Q12 is a pnp-type transistor).

4-12. Diodes CR18 and CR19 are zener diodes which provide direct coupling between the stages in the amplifier and maintain proper collector voltages on the transistor elements. These diodes are kept in the zener breakdown condition by the currents flowing in resistors R35, R36, R38, and R39. The signal is amplified and inverted in Q12. Capacitor C15, inductance L1 and resistor R31 in the emitter circuit of Q12 help stabilize the loop. The emitter of Q12 is connected through these components to a point which is separated from the positive output terminal by resistor R33. Load current through this resistor injects current feedback into the loop which improves the load regulation. The inverted signal from Q12 tends to reduce the base current in Q11 (a pnp-type transistor). The signal is amplified and inverted in Q11 and fed to the base of Q2. This signal tends to increase the current through Q2 (another pnp-type transistor). Increasing the current through Q2 increases the voltage out of the supply. Since the original action was a decrease in voltage this action will tend to restore the original conditions, regulating the supply.

4-13. The dc output voltage is set by varying the COARSE and FINE VOLTAGE controls R24 and R25. In explaining this circuit, resistor R51 can be thought of as a constant-current source. Most of this current normally flows out through R24 and R25 to the series regulator with only an insignificant amount going to the base of Q13. Thus as the resistance of R24 and R25 is increased the voltage on the negative output lead will go further negative since the constant current through these resistors will develop a greater voltage drop.

4-14. CURRENT-POWER LIMITER.

4-15. Transistor Q4 plus associated circuitry forms a protective circuit which limits the current and power dissipation in the series regulators and load. Referring to figure 4-3, no current flows through Q4 under normal conditions since the base is biased positive with respect to the emitter. The maximum current available for the base of Q2 is fixed by the resistors R10 and R11 and the reference supply. Normally, the current not used by the base of Q2 to supply a certain load current passes through the collector of Q11.

4-16. When the instrument is in the current-limiting condition, it is essentially a constant-current supply rather than a voltage supply. The voltage derived across R18 is coupled to the base of Q4 through CR8 and R14. As the load current increases, this voltage increases to a level where Q4 begins to conduct. Any attempt to increase the load current further merely turns Q4 on harder, depriving Q2 of the necessary base current to sustain this larger load current. This action tends to keep the load current constant. Since the output voltage is below the desired output voltage in the current-limiting condition, the amplifier turns off Q11. With Q11 turned off the only paths for the current through R10 and R11 are into the base of Q2 and the collector of Q4.

4-17. Referring to figure 4-3, as the load resistance is further decreased the output voltage decreases since the current is held constant. This tends to increase the voltage across the series regulator. When this voltage reaches a certain value, the zener diode CR6 will start to conduct. This current appears to Q4 to be due to increasing load current and Q4 tends to conduct more current away from the base of Q2 thus decreasing the load current and limiting the maximum dissipation in the series elements. Diode CR8 acts as a 0.7 volt battery since it is forward biased at all times by the current through R12. Resistor R14 adjusts the lower limit of the current limit range while R20 adjusts the upper limit. The CURRENT LIMIT potentiometer R5 adjusts the current limit to any value between the upper and lower current limits.

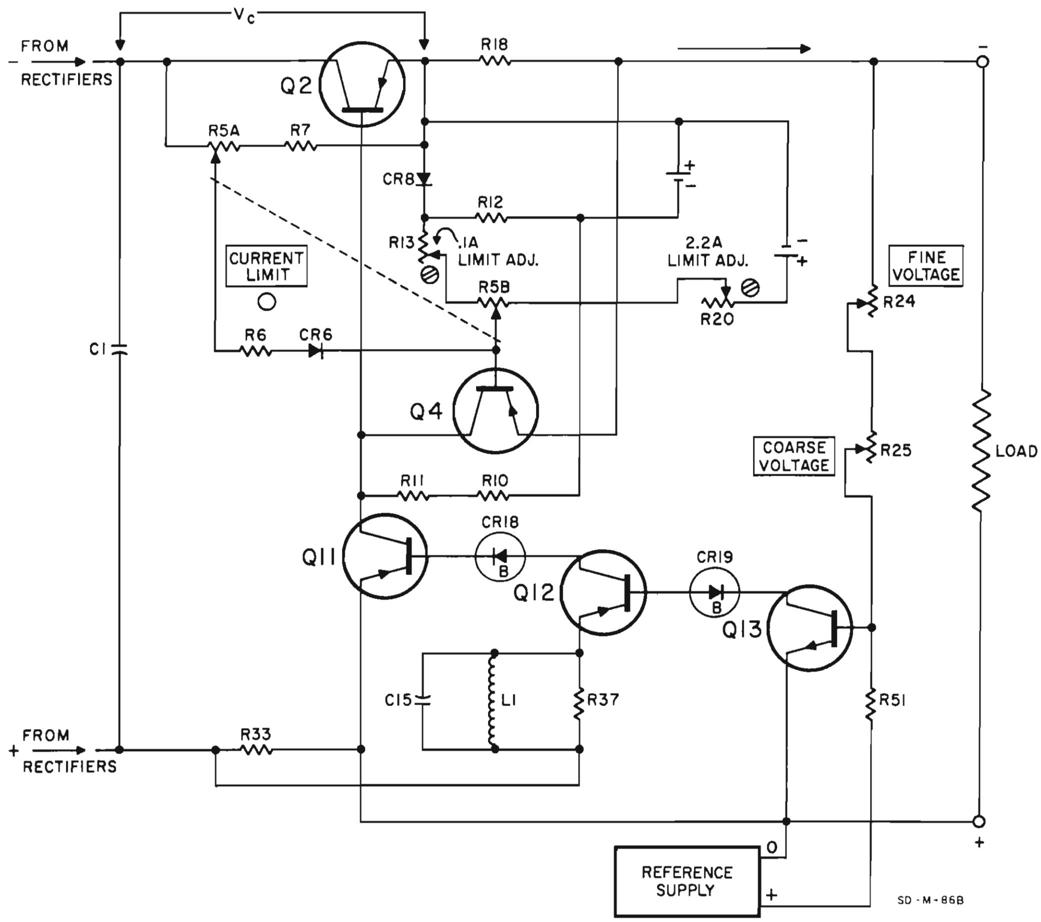


Figure 4-3. Current Power Limiter

4-18. PROTECTION CIRCUITS.

4-19. Referring to the schematic in the back of the manual, note that relay K1 is shown in the normal energized position. When the instrument is turned off, or if the power fails, the relay will return to the opposite position immediately. The center contacts of the relay K1 on the schematic then apply a fixed positive bias to the base of Q2 tending to turn it off. If this were not done the output voltage would have a transient impressed upon it due to the fact that the amplifier loses control of the series elements faster than the large input capacitor C1 can be discharged through R3. Note that the relay switches R3 across C1 when a power failure occurs to help discharge C1.

4-20. When the instrument is first turned on the relay K1 is in the opposite position to that shown in the schematic at the end of this manual. The voltage applied to the coil of K1 must first charge capacitors C13 and C14 through R31 before the relay coil becomes energized. When these capacitors charge up, the relay coil will become energized and the relay contacts will switch, providing a time-delay in turn-on. The top set of contacts switch R2 out of the circuit. This resistance is used during the initial time-delay period to limit the in-rush of current through the bridge rectifiers CR1-4. The middle set of contacts switch the base of Q2 from a fixed positive voltage to its normal operating condition. This positive voltage keeps Q2 turned off during the initial turn-on delay, giving the amplifier time so its voltages can reach their operating levels and gain control of the feedback loop. This action will prevent output voltage transients which could exceed the desired output voltage. The bottom set of contacts discharge the capacitors C13 and C14 through R32, preparing the circuit for the next turn-on cycle.

Table 5-1. Recommended Test Equipment

Instrument Type	Required Characteristics	Use	Instrument Recommended
DC Voltmeter	Accuracy of ±1%	Measure voltages	Analog, hp Model 412A/AR Digital, hp Model 405A/B/C
AC Voltmeter	Accuracy of ±3% Floating input Battery operated	Measure ripple	hp Model 403A
Oscilloscope	5 mv-cm sensitivity	Measure ripple peaks	hp Model 130B, 150A with Model 151B hp Model 160B/170A with Model 162D
Variable Transformer	Monitor meter 1 volt resolution and ±1% accuracy	Change ac input voltage	Superior type UC1M
Low-Heat Soldering Iron	23-1/2 watt element	Solder printed circuit boards (connect iron to 75 volt line)	Ungar Model 776 Soldering Iron Handle Ungar Model 535 Heater Element Ungar Model PL333 Soldering Iron Tip
Stable Voltage Source	Noise and ripple less than 250 microvolt at 60 volts	Reference voltage to test regulation	Another hp Model 722A; 45 volt and 7 volt battery connected in series
Load	25 ohms at 150 watts	Load for measuring ripple, regulation, etc.	Any resistor or combination of resistors of suitable value (may use wirewound resistors, supply not affected by inductive load)
Precision Resistor	1 ohm ±1%, 5 watt resistor	Measure current with voltmeter	hp stock number 0811-0040

SECTION V
MAINTENANCE

5-1. INTRODUCTION.

5-2. This section contains maintenance and service information for the Model 722A DC Power Supply. A performance check is included at the end of this section to be used to verify instrument operation. This check can be made with the instrument in its cabinet and is a good test as part of preventive maintenance and incoming quality control inspection.

5-3. MAINTENANCE PROCEDURES.

5-4. DUSTCOVER REMOVAL.

5-5. Remove the eight screws (four on top and four below) holding the dustcover on the instrument. Pull the dustcover from the instrument.

5-6. ZERO-SETTING THE METER.

5-7. The meter pointer must rest on the zero calibration mark on the meter scale when the instrument is at normal operating temperature, resting in its normal operating position, and the instrument is turned off. To zero-set the meter proceed as follows:

a. Turn on instrument and allow it to come up to normal operating temperature (about 20 minutes).

b. Turn the instrument off. Wait two minutes for power-supply capacitors to discharge completely.

c. Rotate adjustment screw on front of meter clockwise until the meter pointer is to the left of zero and further clockwise rotation will move the pointer upscale towards zero.

d. Turn the adjustment screw clockwise until the pointer is exactly over the zero mark on the scale. If the screw is turned too far, repeat steps c and d.

e. Turn meter adjustment screw counterclockwise about 15 degrees to break contact between adjustment screw and pointer mounting yoke, but not far enough to move the pointer back downscale. If screw is turned too far, as shown by the needle moving, repeat the procedure. The meter is now zero-set for best accuracy and mechanical stability.

5-8. PRINTED CIRCUIT BOARD REMOVAL.

CAUTION

Be sure to turn off the instrument and allow time for the capacitors to discharge before changing the printed circuit boards. Do not attempt to operate this instrument with any of the printed circuit board missing.

5-9. The printed circuit boards are held in by being plugged into sockets. Since these sockets have many contacts the board is held in quite firmly without being fastened in any other way. To remove these boards some additional help may be needed. Place a screwdriver (right-angle screwdriver with boards A & B) under the end of the board nearest the chassis and pry up.

5-10. TEST EQUIPMENT REQUIRED.

5-11. Test equipment required to test this instrument is listed in table 5-1. The necessary specifications required to test this instrument are listed so that other equipment with equivalent specifications may be used.

5-12. PERFORMANCE CHECK.

5-13. Before attempting to troubleshoot this instrument make sure the fault is with the instrument and not with the associated circuit under test. The performance check will enable you to determine this without having to remove the instrument from the cabinet. BE SURE TO PERFORM THIS TEST BEFORE DISTURBING ANY OF THE INTERNAL ADJUSTMENTS OF THE INSTRUMENT. This test may also be used as an incoming inspection test to make sure the instrument has not been damaged in shipment, for periodic maintenance, or to check operation of the instrument after repairs. The performance test will be found in paragraph 5-32.

5-14. TROUBLESHOOTING.

5-15. INTRODUCTION.

5-16. Components within Hewlett-Packard instruments are conservatively operated to provide maximum instrument reliability. In spite of this, parts within an instrument may fail. Usually, the instrument must be immediately repaired with a minimum of "down time". A systematic approach, such as is given later in this section, can greatly simplify and thereby speed up the repair.

CAUTION

Be careful not to short voltages across the transistors. Small bias changes may ruin a transistor due to excessive dissipation. BE SURE TO TURN THE INSTRUMENT OFF BEFORE DOING ANY SOLDERING. A small leakage current from the soldering iron applied at the input being amplified may exceed ratings on the output transistors.

5-17. TROUBLE ANALYSIS.

5-18. Some systematic troubleshooting can be done with this instrument. For instance, if there is no voltage throughout the instrument check the fuse and

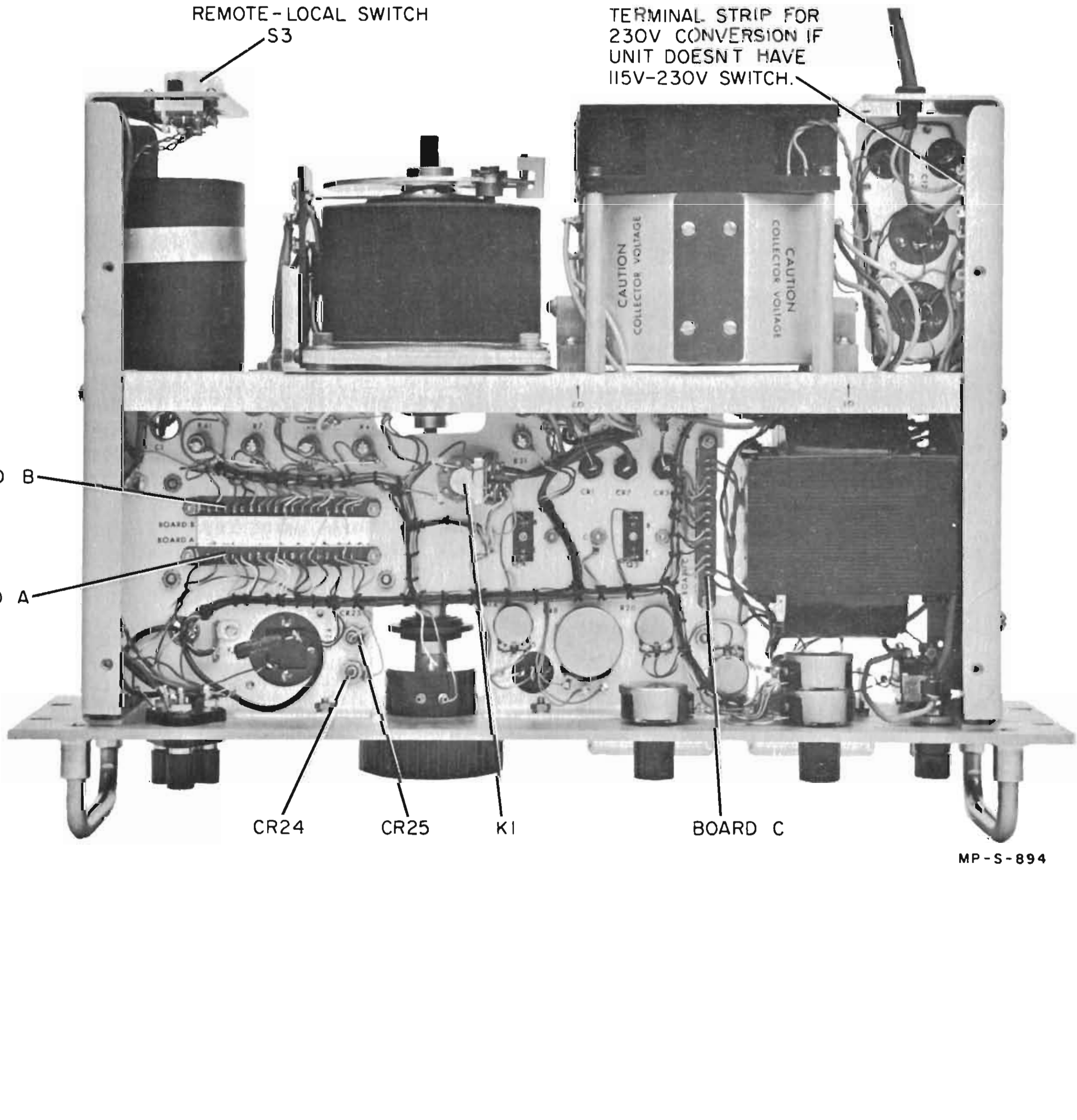


Figure 5-1. Model 722A Bottom View

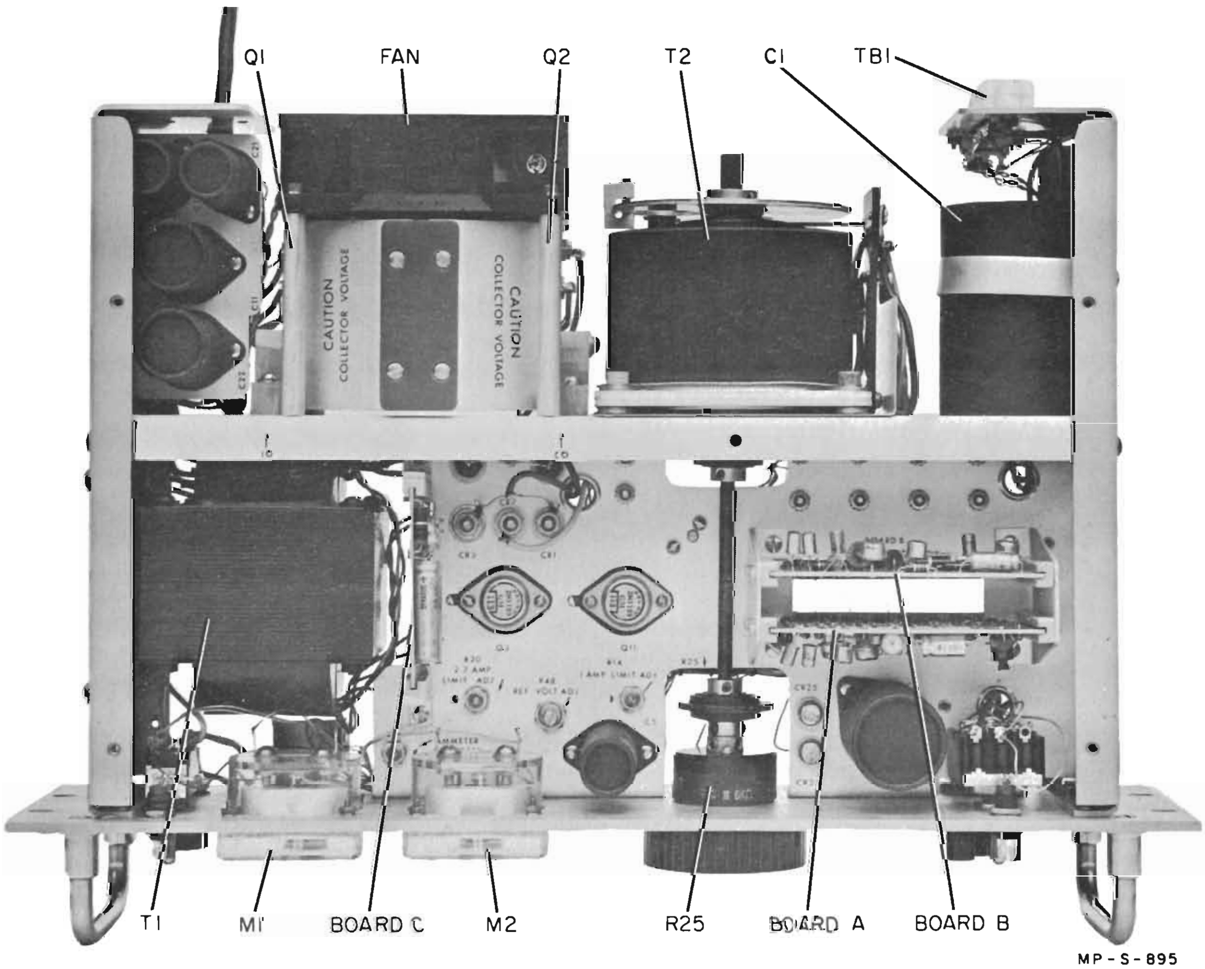


Figure 5-2. Model 722A Top View

SERVICING ETCHED CIRCUIT BOARDS

Excessive heat or pressure can lift the copper strip from the board. Avoid damage by using a low power soldering iron (50 watts maximum) and following these instructions. Copper that lifts off the board should be cemented in place with a quick drying acetate base cement having good electrical insulating properties.

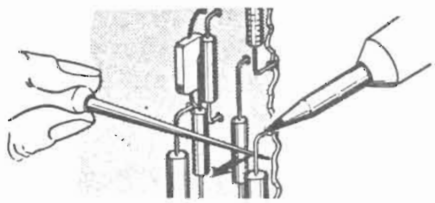
A break in the copper should be repaired by soldering a short length of tinned copper wire across the break.

Use only high quality rosin core solder when repairing etched circuit boards. NEVER USE PASTE FLUX. After soldering, clean off any excess flux and coat the repaired area with a high quality electrical varnish or lacquer.

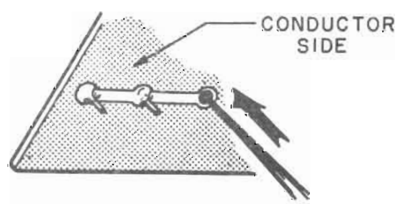
When replacing components with multiple mounting pins such as tube sockets, electrolytic capacitors, and potentiometers, it will be necessary to lift each pin slightly, working around the components several times until it is free.

WARNING: If the specific instructions outlined in the steps below regarding etched circuit boards without eyelets are not followed, extensive damage to the etched circuit board will result.

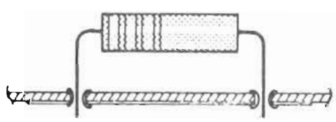
1. Apply heat sparingly to lead of component to be replaced. If lead of component passes through an eyelet in the circuit board, apply heat on component side of board. If lead of component does not pass through an eyelet, apply heat to conductor side of board.



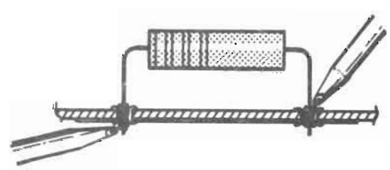
2. Reheat solder in vacant eyelet and quickly insert a small awl to clean inside of hole. If hole does not have an eyelet, insert awl or a #57 drill from conductor side of board.



3. Bend clean tinned leads on new part and carefully insert through eyelets or holes in board.

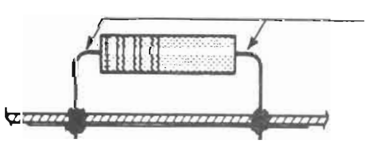


4. Hold part against board (avoid overheating) and solder leads. Apply heat to component leads on correct side of board as explained in step 1.

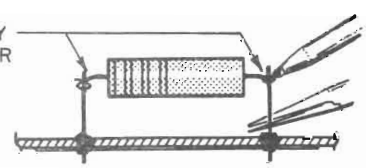


In the event that either the circuit board has been damaged or the conventional method is impractical, use method shown below. This is especially applicable for circuit boards without eyelets.

1. Clip lead as shown below.



2. Bend protruding leads upward. Bend lead of new component around protruding lead. Apply solder using a pair of long nose pliers as a heat sink.



This procedure is used in the field only as an alternate means of repair. It is not used within the factory.

Figure 5-3. Servicing Etched Circuit Boards primary circuit. Transistors Q1-3 should share the output voltage (a voltage drop should appear across each of these transistors). If there is no voltage drop across one of these transistors, it is most likely shorted. If some component on an etched circuit board is suspected and you have another instrument that is functioning properly, substitute the board containing that component from the good instrument.

5-19. The circuit consisting of the series regulators and amplifiers presents a difficult problem for systematic trouble analysis. This is a feedback circuit in which a faulty component anywhere will affect the entire loop. In this case symptomatic trouble analysis may be easier. Refer to the symptom column in table 5-2, Troubleshooting Guide and test the corresponding transistor or diode. If you have to replace any transistors or diodes refer also to table 5-3, Replacement Guide for additional tests which may be necessary.

Table 5-2. Troubleshooting Guide

Symptom	Check
Blown line fuse	CR1, CR2, CR3, CR4, CR12, CR13, CR14, CR15, CR16, CR22, CR23, shorted winding on T1, or brush and winding on T2.
Poor load regulation	CR5, CR11, CR17, Q2, Q4, Q11, Q12, Q13, R33 and S3
Poor current limiting	CR6, CR8, CR17, Q4, R9

See table 5-3, Replacement Guide, for additional tests which may be necessary if you replace the above components. See figure 5-3, Servicing Etched Circuit Boards.

Note

Q1 and Q2 are located on the fan heat-sink. To remove these transistors proceed as follows:

1) Loosen fan by removing four allen-head screws holding fan to spacers. Slide fan to one side.

2) Unsolder wires going to transistor. Note that the heavy wire goes to the emitter and the finer wire goes to the base (collector is connected to case).

3) With a wrench remove the screw holding the transistor. Remove transistor.

Installation of a new transistor is the reverse of the above procedure. Be sure to note which is the emitter and which is the base pin before mounting the transistor.

Table 5-3. Replacement Guide

CAUTION

All transistors and diodes on the chassis have an anodized aluminum washer and silicon grease between the transistor and the chassis. The transistors on the fan heat-sink have grease only. When replacing transistors or diodes be sure to replace the insulating washer (if any) and the silicon grease so that these components will have good heat conduction to the chassis. Use a good grade of heat-conducting grease, such as Dow Corning silicon grease #3 or Compound 5.

If you change:	Check these items:
CR1, 2, 3, or 4	Line fuse, brush and winding on T2
CR5	Regulation
CR6	Current limiting
CR7	Voltage CR7 (should be about 0.8 volts)
CR8	Current limiting, recalibrate current limits
CR9	Current limiting
CR10	Output C6
CR11	Load regulation and transients with dc switching
CR12-16	Ripple, voltage output, maximum current, relay operation
CR17	Current limiting, transient response to loading
CR18, 19	Collector voltage on Q12 and Q13
Q1, 2, or 3	Check for voltage drop across transistors; regulation at 103 volts in, 60 volt to 2 amp out
Q4	Current limiting, R14, R20
Q11	CR17, Q4, output voltage; regulation at 127 volts in, low output voltage
Q12, 13	Voltage control and regulation

5-20. DETAILED TEST PROCEDURE.

5-21. The following test procedure should be performed only after the performance test (paragraph 5-32) has shown that this instrument is faulty. DO NOT PERFORM THIS PROCEDURE AS AN INCOMING INSPECTION OR PROOF OF PERFORMANCE CHECK. The specifications for your instrument are given in the front of this manual (table 1-1). The following test procedure contains extra checks to help you analyze the troubles in this instrument. These extra checks and the data they contain cannot be considered as specifications.

5-22. Do not perform all the tests in this procedure. Do only those tests associated with the particular sections of the instrument shown to be faulty by the performance test. Indiscriminate adjustment of the internal controls to "refine" the settings may actually cause trouble.

5-23. REFERENCE VOLTAGE ADJUSTMENT.

5-24. To set the reference voltage proceed as follows:

a. Connect a voltmeter, such as the hp Model 405A/B/C across C24 (reference supply filter capacitor on board A).

b. Adjust R48 (Reference Voltage Adjust potentiometer) until the meter reads 13.2 ±0.2 volts.

c. Remove meter.

5-25. MONITORING.

5-26. For all following tests (subparagraphs 5-27 and 5-29) the output voltage should be monitored. The positive output terminal of the Model 722A is considered circuit ground. To monitor the output connect a voltmeter, such as the hp Model 405A/B/C as follows:

a. Turn AC and DC switches to OFF. Remote-Local switch on Local.

b. Turn COARSE VOLTAGE potentiometer R25 fully counterclockwise.

c. Attach voltmeter to the output terminals (front or rear) of the Model 722A with the black terminal of the voltmeter connected to the red (positive) terminal of the Model 722A. (In this test procedure the positive side of the Model 722A output is considered circuit ground.)

5-27. VOLTAGE RANGE.

5-28. To check the voltage range of the Model 722A proceed as follows:

a. Turn the AC and DC POWER switches to ON.

b. Turn the COARSE and FINE VOLTAGE controls on the front panel fully clockwise. The voltmeter across the output should indicate 60.1 to 60.3 volts. If not, adjust R48.

c. Turn the COARSE and FINE VOLTAGE controls on the front panel fully counterclockwise. The voltmeter across the output should indicate 0.05 to 0.02 volt (positive terminal on the Model 722A is considered ground).

5-29. CURRENT LIMIT.

5-30. A simple way to measure current with a voltmeter is to use a load made up of a 25 ohm, 150 watt resistor in series with a precision 1%, 1 ohm, 5 watt resistor, hp stock number 0811-0040. Connect a voltmeter in shunt with this precision resistor. In the following procedure the term shunt voltmeter will be used to distinguish this voltmeter from other voltmeters.

5-31. To adjust the current limiting proceed as follows:

a. Turn the DC POWER switch to OFF.

b. Connect the load mentioned above the OUTPUT terminals.

c. Connect the shunt voltmeter across the 1 ohm precision resistor.

d. Turn the DC POWER switch to ON.

e. Turn the CURRENT LIMIT potentiometer on the front panel fully clockwise and the COARSE VOLTAGE control fully counterclockwise.

f. Turn the COARSE VOLTAGE control slowly clockwise until the current appears to limit (voltmeter on panel stops rising). The voltage on the shunt voltmeter should be 2.3 volts. If not, adjust R20.

g. Adjust the COARSE and FINE VOLTAGE control until the shunt voltmeter reads exactly 2.00 volts (indicating 2 amps current).

h. The OUTPUT CURRENT meter should read exactly 2.00 amps. If not, adjust Ammeter Calibrate potentiometer (R16) until the OUTPUT CURRENT meter does read exactly 2.00 amps.

i. Turn COARSE VOLTAGE control until the output voltage is about 10 volts and turn CURRENT LIMIT control fully counterclockwise.

j. The voltage on the shunt voltmeter should be 0.08 volts (0.08 amp) or less. If not, pad R13.

5-32. PERFORMANCE TEST.

5-33. Before attempting to troubleshoot this instrument make sure the fault is with the instrument and not in the associated circuit under test. This procedure will enable you to determine this without having to remove the instrument from the cabinet. BE SURE TO PERFORM THIS TEST BEFORE DISTURBING ANY OF THE INTERNAL ADJUSTMENTS OF THE INSTRUMENT. This test may also be used as in incoming inspection test to make sure the instrument has not been damaged in shipment, for periodic maintenance, or to check operation of the instrument after repairs.

5-34. VOLTAGE RANGE.

5-35. To check the voltage range proceed as follows:

a. Connect voltmeter across output of power supply.

b. Turn COARSE and FINE VOLTAGE controls fully clockwise. Voltage out should be greater than 60.0 volts.

c. Turn COARSE and FINE VOLTAGE controls fully counterclockwise. Output voltage should go through zero to 0.05 to 0.2 volts positive (positive terminal on Model 722A is considered ground).

5-36. CURRENT LIMITING.

5-37. To check current limiting proceed as follows:

a. Connect 25 ohm, 150 watt load in series with a precision 1%, 1 ohm, 5 watt resistor, to the output of the Model 722A.

b. Connect a voltmeter in shunt with the precision 1 ohm resistor. This voltmeter will be called the shunt voltmeter.

c. Turn CURRENT LIMIT control fully clockwise.

d. Turn COARSE VOLTAGE control clockwise until current appears to limit (voltmeter on front panel stops rising). Shunt voltmeter should read 2.3 volts.

e. Adjust the COARSE and FINE VOLTAGE controls until shunt voltmeter reads 2.00 volts. The OUTPUT CURRENT meter should read 2 amperes.

f. Turn COARSE VOLTAGE control for 10 volts out and CURRENT LIMIT control fully counterclockwise. The output voltage should be 0.08 volt or less.

5-38. OPERATION CHARACTERISTICS.

a. With the DC POWER switch turned off, attach a well-shielded coaxial cable between the OUTPUT terminals of the Model 722A and an oscilloscope, such as the ⓗⓟ Models 130B/150A with 151B plug-in, 160B or 170A with 162D plug-in. It is absolutely essential that this lead be as well-shielded and as short as possible. Not only must this lead be well shielded but it also must be connected to the OUTPUT terminals as close to the instrument as possible. Unscrew the plastic ferrules on the OUTPUT connectors and connect bare wire or clip-leads tightly.

b. Connect a voltmeter and load as instructed in paragraph 5-36, Current Limiting. This voltmeter will be called the shunt voltmeter.

c. Turn DC POWER to ON and adjust CURRENT controls for 2 amperes current (2 volts on shunt voltmeter).

d. Set oscilloscope for 5 mv/cm sensitivity and a sweep speed of 5 ms/cm.

e. Plug the Model 722A into a variable transformer and reduce the input voltage until the output ripple reaches at least 5 mv peak-to-peak. This voltage should be less than 102 volts ac.

5-39. RIPPLE CHARACTERISTICS.

Note

The instrument under test must not be lying on magnetic material for this test.

a. Connect a voltmeter and load as instructed in paragraph 5-36, Current Limiting. This voltmeter will be called the shunt voltmeter.

b. Connect an oscilloscope as instructed in paragraph 5-38, Operation Characteristics.

c. Connect a floating, battery-operated voltmeter, such as the ⓗⓟ Model 403A, to the OUTPUT terminals of the Model 722A with a short shielded lead.

d. Turn up the COARSE VOLTAGE control until the shunt voltmeter reads 2 volts (2 amps current).

e. Read the ripple voltage on the Model 403A. This voltage should be less than 150 microvolts rms. The peak-to-peak voltage measured on the oscilloscope should be less than 1.0 millivolt. If not, make sure the REMOTE-LOCAL switch on the rear of the instrument is on LOCAL.

5-40. LOAD REGULATION.

a. With the Model 722A connected as in paragraph 5-39, Ripple Characteristics, turn the DC POWER switch off and disconnect the load.

Note

In this test we wish to measure voltages within 3 millivolts. The resolution of the Model 405 Voltmeter is not sufficient to measure this small a voltage at the full output voltage. For this reason we will buck-out almost all of the output voltage with a stable voltage source, such as another Model 722A, and then measure only the difference voltage with high resolution.

b. Connect the load as indicated in paragraphs 5-38, Operation Characteristics. Unscrew the plastic insulated ferrules on the two OUTPUT binding posts of the Model 722A. Attach one end of an alligator clip-lead to the main body of the negative terminal binding post in the vicinity of the cross hole. Attach the other end of this clip-lead to the negative terminal of the reference voltage supply. Attach one of the alligator clips of an ⓗⓟ AC-16S (shielded dual banana plug to alligator clips) to the main body of the positive terminal binding post in the vicinity of the cross hole. Attach the other alligator clip of the AC-16S to the positive terminal binding post of the reference voltage supply.

c. Attach the dual banana plug of the AC-16S to the Model 405 Voltmeter.

d. Turn the CURRENT LIMIT control on the front panel fully clockwise.

e. Adjust the output current of the Model 722A under test to 2 amperes on the meter on the front panel. Adjust the voltage on the reference Model 722A such that the reading on the Model 405 Voltmeter is less than one volt (difference between the 722's).

f. WARNING! Be careful! Disconnect one end of the load but leave load in such a position that the load may be connected with the aid of an insulated tool.

g. Reconnect load with an insulted tool while watching change in voltage on Model 405 Voltmeter. The change in voltage should be less than 3 millivolts. If not, turn both supplies off and tighten connections. If the change in voltage is still too great check the LOCAL-REMOTE switch to be sure it is in the LOCAL position.

5-41. LINE REGULATION.

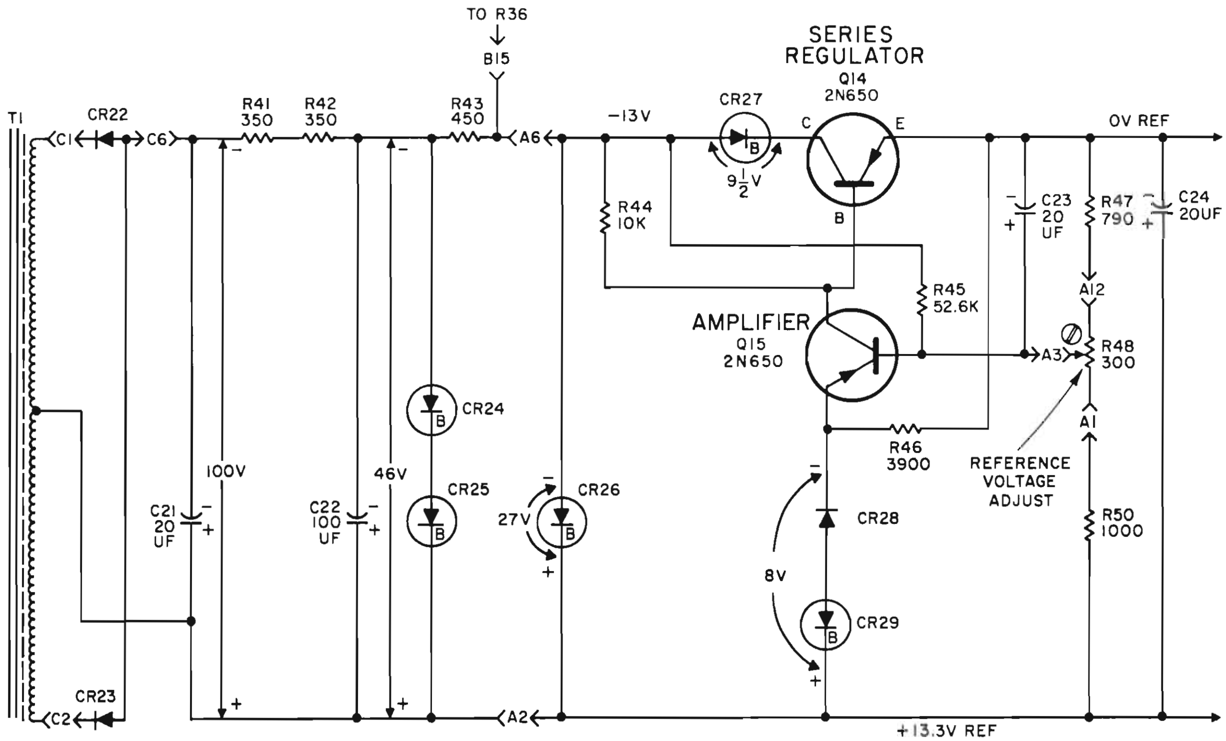
a. With the two Model 722's connected as in paragraph 5-40, Load Regulation, connect the 722 under test to a variable power supply.

b. Change the line voltage from 115 volts to 103.5 volts and note the change in the output voltage. The change should be 2 millivolts or less.

c. Increase the line voltage to 126.5 volts and note the output voltage change. This change should be 2.5 millivolts or less.

SCHEMATIC DIAGRAM NOTES

1. Heavy solid line shows main signal path; heavy dashed line shows control, secondary signal, or feedback path.
2. Heavy box indicates front-panel engraving; light box indicates chassis marking.
3. Arrows on potentiometers indicate clockwise rotation as viewed from the round shaft end, counterclockwise from the rectangular shaft end.
4. Resistance values in ohms, inductance in microhenries, and capacitance in picofarads unless otherwise specified.
5. Rotary switch schematics are electrical representations; for exact switching details refer to the switch assembly drawings.
6. Relays shown in condition prevailing during normal instrument operation.
7. Connections between the etched circuit board and the chassis wiring are indicated by the usual arrowhead-arrowtail combination. The arrowhead indicates the connections on the board which plugs into the socket on the chassis (indicated by the arrowtail). The board and connection is indicated by the letter-number combination, e.g. A2 indicates a connection on board A at pin 2.



722A - REF PS - T105 B

Figure 5-4. Reference Power Supply

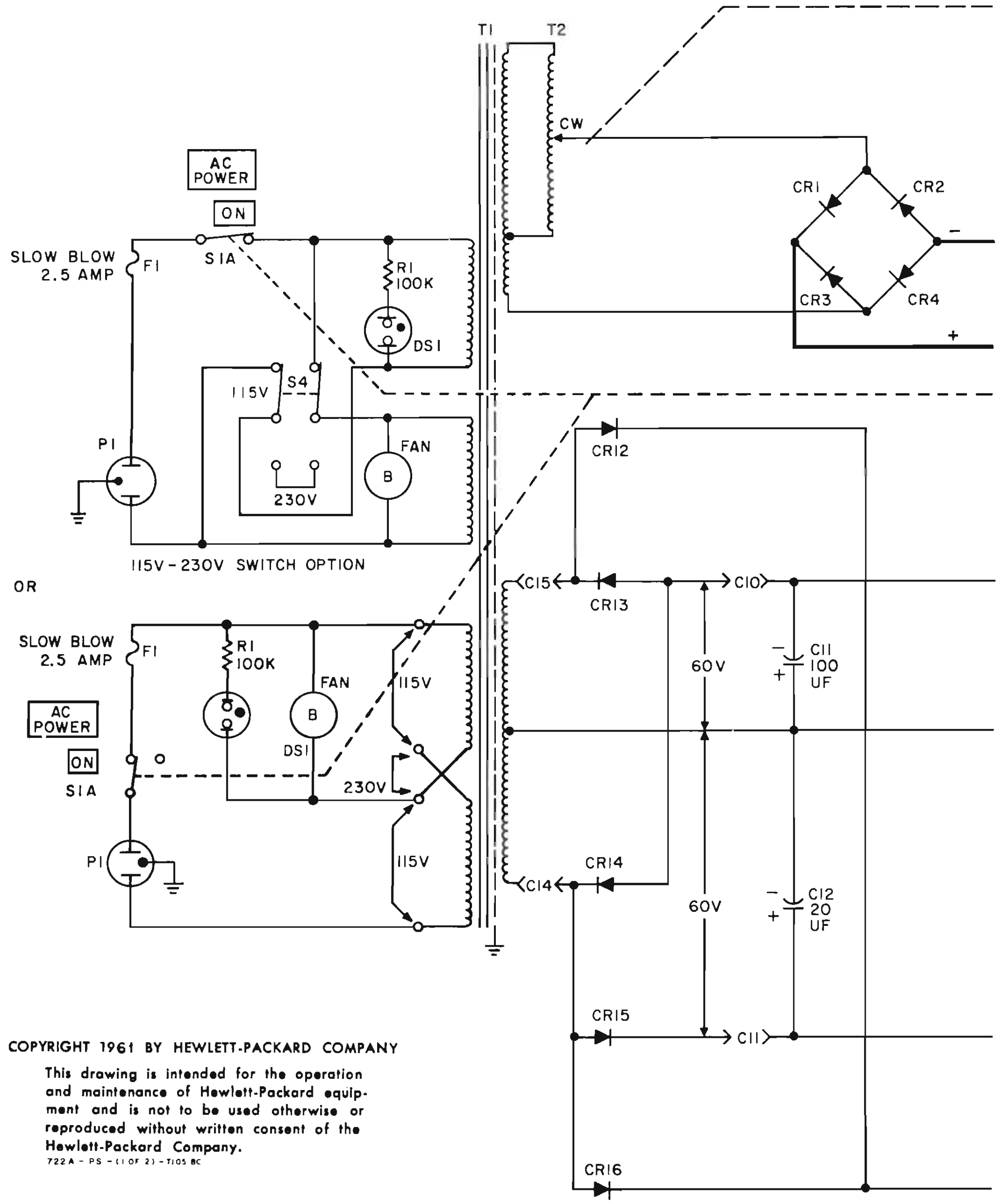


Figure 5-5. Power Supply (sheet 1 of 2)

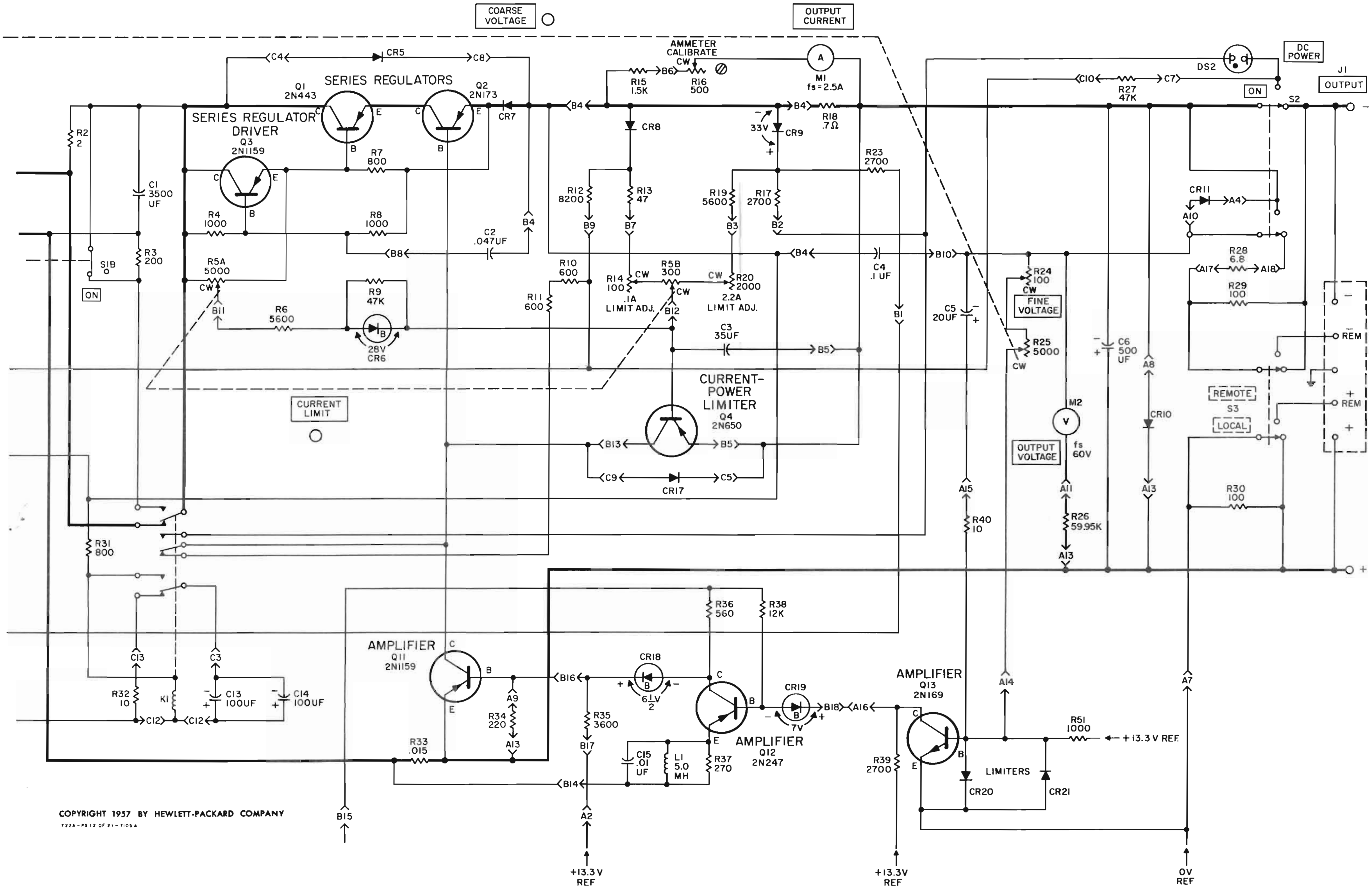


Figure 5-5. Power Supply (sheet 2 of 2)

SECTION VI
REPLACEABLE PARTS

6-1. INTRODUCTION.

6-2. This section contains information for ordering replacement parts for the Model 722A DC Power Supply.

6-3. Table 6-1 lists parts in alpha-numerical order of their reference designators and indicates the description and ⓗⓟ stock number of each part, together with any applicable notes. Table 6-2 lists parts in alpha-numerical order of their ⓗⓟ stock numbers and provides the following information on each part:

a. Description of the part (see list of abbreviations below).

b. Manufacturer of the part in a five-digit code; see list of manufacturers in appendix.

c. Typical manufacturer's stock number.

d. Total quantity used in the instrument (TQ column).

e. Recommended spare part quantity for complete maintenance during one year of isolated service (RS column).

6-4. Miscellaneous parts not indexed in table 6-1 are listed at the end of table 6-2.

6-5. ORDERING INFORMATION.

6-6. To order a replacement part, address order or inquiry either to your authorized Hewlett-Packard sales representative or to

CUSTOMER SERVICE
Hewlett-Packard Company
395 Page Mill Road
Palo Alto, California,

or, in Western Europe, to

Hewlett-Packard S.A.
Rue du Vieux Billard No. 1
Geneva, Switzerland.

6-7. Specify the following information for each part:

a. Model and complete serial number of instrument.

b. Hewlett-Packard stock number.

c. Circuit reference designator.

d. Description.

6-8. To order a part not listed in tables 6-1, 6-2, give a complete description of the part and include its function and location.

REFERENCE DESIGNATORS

A = assembly
B = motor
C = capacitor
CR = diode
DL = delay line
DS = device signaling (lamp)
F = fuse
FL = filter
J = jack
K = relay
L = inductor
M = meter
P = plug
Q = transistor
R = resistor
RT = thermistor
S = switch
T = transformer
V = vacuum tube, neon bulb, photocell, etc.
W = cable
X = socket
XF = fuseholder
XV = tube socket
XDS = lampholder

ABBREVIATIONS

bp = bandpass
bwo = backward wave oscillator
c = carbon
cer = ceramic
cmo = cabinet mount only
coef = coefficient
com = common
comp = composition
conn = connection
crt = cathode-ray tube
dep = deposited
det = detector
EIA = Tubes and transistors selected for best performance will be supplied if ordered by ⓗⓟ stock numbers; tubes or transistors meeting Electronic Industries' Association standards will normally result in instrument operating within specifications
elect = electrolytic
encap = encapsulated
f = farads
fxd = fixed
Ge = germanium
grd = ground (ed)
h = henries
Hg = mercury
impg = impregnated
incd = incandescent
ins = insulation (ed)
K = kilohms
lin = linear taper
log = logarithmic taper
m = milli = 10^{-3}
M = megohms
ma = milliamperes
minat = miniature
mfg = metal film on glass
mfr = manufacturer
mtg = mounting
my = mylar
NC = normally closed
Ne = neon
NO = normally open
NPO = negative positive zero-zero temperature coefficient
nsr = not separately replaceable
obd = order by description
p = peak
pc = printed circuit board
pf = picofarads = 10^{-12} farads
pp = peak-to-peak
piv = peak inverse voltage
pos = position(s)
poly = polystyrene
pot = potentiometer
rect = rectifier
rot = rotary
rms = root-mean-square
rmo = rack mount only
s-b = slow-blow
Se = selenium
sect = section(s)
Si = silicon
sl = slide
td = time delay
TiO_2 = titanium dioxide
tog = toggle
tol = tolerance
trim = trimmer
twt = traveling wave tube
var = variable
w/ = with
W = watts
ww = wirewound
w/o = without
* = optimum value selected at factory, average value shown (part may be omitted)

Table 6-1. Reference Designation Index

Circuit Reference	ⓗⓟ Stock No.	Description	Note
C1	0180-0096	fxd, elect, 3500 uf, 100 vdcw	
C2	0170-0040	fxd, my, 0.047 uf ±10%, 200 vdcw	
C3	0180-0064	fxd, elect, 35 uf + 100% -10%, 6 vdcw	
C4	0170-0055	fxd, my, 0.1 uf ±20%, 100 vdcw	
C5	0180-0093	fxd, elect, 20 uf, 150 vdcw	
C6	0180-0047	fxd, elect, 500 uf, 75 vdcw	
C7 thru C10		Not Assigned	
C11	0180-0095	fxd, elect, 100 uf, 100 vdcw	
C12		Same as C5	
C13, 14	0180-0094	fxd, elect, 100 uf, 25 vdcw	
C15	0170-0017	fxd, my, 0.01 uf ±5%, 400 vdcw	
C16 thru C20		Not Assigned	
C21		Same as C5	
C22		Same as C11	
C23, 24	0180-0045	fxd, elect, 20 uf, 25 vdcw	
CR1 thru CR4	1901-0019	Diode, si: 1N1344	
CR5	1901-0007	Diode, si: 500 ma, 400 PIV	
CR6	G-29G-53	Diode, si	
CR7		Same as CR1	
CR8	G-29A-74	Diode, si	
CR9	G-31G-33L	Diode, si	
CR10, 11	1901-0008	Diode, si: 500 ma 100 PIV	
CR12 thru CR16		Same as CR5	
CR17		Same as CR10	
CR18	G-31A-7L	Diode, si	
CR19		Same as CR8	
CR20, 21	1901-0020	Diode, si: 1N2069	
CR22, 23		Same as CR5	
CR24, 25	G-31H-22H	Diode, si	
CR26	G-29G-54	Diode, si	
CR27	G-31G-10L	Diode, si	
CR28	G-29A-10	Diode, si	
CR29	G-29A-26	Diode, si	
DS1, 2	1450-0025	Lamp, neon: indicator, clear lens	
F1	2110-0015	Fuse, cartridge: 2.5 amp, slow blow (for 115 V operation)	
	2110-0021	Fuse, cartridge: 1.25 amp, slow blow (for 230 V operation)	
J1	0360-0079	Board, terminal: 5 terminal	
K1	0490-0032	Relay, inductor: 2500 ohms ±10%	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	ⓗ Stock No.	Description	Note
L1	9140-0037	Inductor, fixed: 5.0 mh	
M1	1120-0104	Meter: 0-2.5 amps	
M2	1120-0103	Meter: 0-60 volts	
P1	8120-0050	Cord, power	
Q1	1850-0058	Transistor: 2N443	
Q2	1850-0059	Transistor: 2N173	
Q3	1850-0057	Transistor: 2N1159	
Q4	1850-0048	Transistor: 2N650	
Q5 thru Q10		Not Assigned	
Q11		Same as Q3	
Q12	1850-0037	Transistor: 2N274	
Q13	1851-0001	Transistor: 2N169	
Q14, 15		Same as Q4	
R1	0687-1041	fxd, comp, 100K ohms ±10%, 1/2 W	
R2	0813-0021	fxd, ww, 2 ohms ±10%, 5 W	
R3	0813-0022	fxd, ww, 200 ohms ±10%, 5 W	
R4	0813-0027	fxd, ww, 1K ohms ±10%, 5 W	
R5A, B	2100-0263	var, ww, dual ganged; front sect-5K ohms ±10%, 2 W; rear sect, lin, 300 ohms ±10%, 2 W	
R6	0693-5621	fxd, comp, 5600 ohms ±10%, 2 W	
R7	0813-0026	fxd, ww, 800 ohms ±10%, 5 W	
R8		Same as R4	
R9	0687-4731	fxd, comp, 47K ohms ±10%, 1/2 W	
R10, 11	0813-0025	fxd, ww, 600 ohms ±10%, 5 W	
R12	0690-8221	fxd, comp, 8200 ohms ±10%, 1 W	
R13	0687-4701	fxd, comp, 47 ohms ±10%, 1/2 W	
R14	2100-0118	var, comp, 100 ohms ±20%, 0.2 W	
R15	0727-0110	fxd, dep c, 1500 ohms ±1%, 1/2 W	
R16	2100-0078	var, ww, lin, 500 ohms ±30%, 3/10 W	
R17	0687-2721	fxd, comp, 2700 ohms ±10%, 1/2 W	
R18	0812-0013	fxd, ww, 0.7 ohm ±3%, 5 W	
R19	0687-5621	fxd, comp, 5600 ohms ±10%, 1/2 W	
R20	2100-0261	var, comp, 2000 ohms ±20%, 0.3 W	
R21, 22		Not Assigned	
R23	0690-2721	fxd, comp, 2700 ohms ±10%, 1 W	
R24	2100-0003	var, ww, 100 ohms ±10%, 2 W	
R25	2100-0262	var, ww, 5K ohms ±5%, 4.5 W	
R26	0727-0327	fxd, dep c, 59,950 ohms ±1%, 1/2 W	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	ⓗ Stock No.	Description	Note
R27		Same as R9	
R28	0699-0002	fxd, comp, 6.8 ohms ±10%, 1/2 W	
R29, 30	0687-1011	fxd, comp, 100 ohms ±10%, 1/2 W	
R31		Same as R7	
R32	0690-1001	fxd, comp, 10 ohms ±10%, 1 W	
R33		Consists of approximately 11 inches of stranded #22 wire; adjusted at factory	
R34	0687-2211	fxd, comp, 220 ohms ±10%, 1/2 W	
R35	0686-3625	fxd, comp, 3600 ohms ±5%, 1/2 W	
R36	0687-5611	fxd, comp, 560 ohms ±10%, 1/2 W	
R37	0687-2711	fxd, comp, 270 ohms ±10%, 1/2 W	
R38	0687-1231	fxd, comp, 12000 ohms ±10%, 1/2 W	
R39		Same as R17	
R40	0687-1001	fxd, comp, 10 ohms ±10%, 1/2 W	
R41, 42	0813-0023	fxd, ww, 350 ohms ±10%, 5 W	
R43	0813-0024	fxd, ww, 450 ohms ±10%, 5 W	
R44	0687-1031	fxd, comp, 10K ohms ±10%, 1/2 W	
R45	0727-0196	fxd, dep c, 52,600 ohms ±1%, 1/2 W	
R46	0687-3921	fxd, comp, 3900 ohms ±10%, 1/2 W	
R47	0727-0091	fxd, dep c, 790 ohms ±1/2%, 1/2 W	
R48	2100-0038	var, ww, 300 ohms	
R49		Not Assigned	
R50, 51	0757-0021	fxd, mfg, 1K ohms ±1%, 1/2 W	
S1	3101-0031	Switch, toggle: 3PDT	
	3101-0033	Switch, slide: DPDT	
S2	3101-0017	Switch, toggle: DPDT	
S3	3101-0011	Switch, slide: DPDT	
S4		Same as S1 (3101-0033)	
T1	9100-0132	Transformer, power	
T2	9100-0133	Transformer, variable: 115 V input 0-115 V output 0-135 V output	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	ⓗⓟ Stock No.	Description	Note
		MISCELLANEOUS	
	AC-10C	Binding post, black: output terminal	
	AC-54C	Insulator, binding post, 3 hole black, output	
	G-10G	Binding post, red: output terminal	
	G-32R	Coupler-bellows: 1/4" to 3/8" shaft	
	G-74BB	Knob, black: 2 3/4", COARSE VOLTAGE	
	G-74D	Knob, black: 3/4" w/pointer, CURRENT LIMIT, FINE VOLTAGE	
	G-110D	Guide, printed circuit	
	712A-12C	Clamp-stop (coarse voltage)	
	722A-65A	Assembly, circuit board "A"	
	722A-65B	Assembly, circuit board "B"	
	722A-65C	Assembly, circuit board "C"	
	722A-85A	Holder, air filter	
	1200-0043	Insulator, transistor mounting	
	1200-0044	Socket, transistor mounting	
	1251-0140	Connector, printed circuit: 15 pin	
	1251-0141	Connector, printed circuit: 18 pin	
	3150-0017	Filter, air	
	3160-0026	Fan: 100 CFU, 115 VAC $\pm$10%, 50/60 cycles, 14 W	

See introduction to this section

Table 6-2. Replaceable Parts (Cont'd)

ⓗ Stock No.	Description	Mfr.	Mfr. Part No.	TQ	RS		
G-29A-10	Diode, si	28480	G-29A-10	1	1		
G-29A-26	Diode, si	28480	G-29A-26	1	1		
G-29A-74	Diode, si	28480	G-29A-74	2	2		
G-29G-53	Diode, si	28480	G-29G-53	1	1		
G-29G-54	Diode, si	28480	G-29G-54	1	1		
G-31A-7L	Diode, si	28480	G-31A-7L	1	1		
G-31G-10L	Diode, si	28480	G-31G-10L	1	1		
G-31G-33L	Diode, si	28480	G-31G-33L	1	1		
G-31H-22H	Diode, si	28480	G-31H-22H	2	2		
0170-0017	fxd, my, 0.01 uf ±5%, 400 vdcw	84411	620S	1	1		
0170-0040	fxd, my, 0.047 uf ±10%, 200 vdcw	56289	148P47392	1	1		
0170-0055	fxd, my, 0.1 uf ±20%, 100 vdcw	56289	148P10491	1	1		
0180-0045	fxd, elect, 20 uf, 25 vdcw	56289	type 30D	2	1		
0180-0047	fxd, elect, 500 uf, 75 vdcw	56289	D32443	1	1		
0180-0064	fxd, elect, 35 uf -10% +100%, 6 vdcw	56289	30D132A1	1	1		
0180-0093	fxd, elect, 20 uf, 150 vdcw	56289	D32610	3	1		
0180-0094	fxd, elect, 100 uf, 25 vdcw	56289	30D188A1	2	1		
0180-0095	fxd, elect, 100 uf, 100 vdcw	56289	D32611	2	1		
0180-0096	fxd, elect, 3500 uf, 100 vdcw	56289	type 32D	1	1		
0360-0079	Board, terminal: 5 terminal	71286	Order by description	1	0		
0490-0032	Relay, inductor: 2500 ohms ±10%	71482	R#A-110526	1	1		
0686-3625	fxd, comp, 3600 ohms ±5%, 1/2 W	01121	EB 3625	1	1		
0687-1001	fxd, comp, 10 ohms ±10%, 1/2 W	01121	EB 1001	1	1		
0687-1011	fxd, comp, 100 ohms ±10%, 1/2 W	01121	EB 1011	2	1		
0687-1031	fxd, comp, 10,000 ohms ±10%, 1/2 W	01121	EB 1031	1	1		
0687-1041	fxd, comp, 100K ohms ±10%, 1/2 W	01121	EB 1041	1	1		
0687-1231	fxd, comp, 12K ohms ±10%, 1/2 W	01121	EB 1231	1	1		
0687-2211	fxd, comp, 220 ohms ±10%, 1/2 W	01121	EB 2211	1	1		
0687-2711	fxd, comp, 270 ohms ±10%, 1/2 W	01121	EB 2711	1	1		
0687-2721	fxd, comp, 2700 ohms ±10%, 1/2 W	01121	EB 2721	2	1		
0687-3921	fxd, comp, 3900 ohms ±10%, 1/2 W	01121	EB 3921	1	1		
0687-4701	fxd, comp, 47 ohms ±10%, 1/2 W	01121	EB 4701	1	1		
0687-4731	fxd, comp, 47K ohms ±10%, 1/2 W	01121	EB 4731	2	1		
0687-5611	fxd, comp, 560 ohms ±10%, 1/2 W	01121	EB 5611	1	1		
0687-5621	fxd, comp, 5600 ohms ±10%, 1/2 W	01121	EB 5621	1	1		
0690-1001	fxd, comp, 10 ohms ±10%, 1 W	01121	GB 1001	1	1		
0690-2721	fxd, comp, 2700 ohms ±10%, 1 W	01121	GB 2721	1	1		

See introduction to this section

Table 6-2. Replaceable Parts (Cont'd)

ⓗ Stock No.	Description	Mfr.	Mfr. Part No.	TQ	RS		
0690-8221	fxd, comp, 8200 ohms ±10%, 1 W	01121	GB 8221	1	1		
0693-5621	fxd, comp, 5600 ohms ±10%, 2 W	01121	HB 5621	1	1		
0699-0002	fxd, comp, 6.8 ohms ±10%, 1/2 W	01121	EB 68G1	1	1		
0727-0091	fxd, dep c, 790 ohms ±1/2%, 1/2 W	19701	DC-1/2C special, order by description	1	1		
0727-0110	fxd, dep c, 1500 ohms ±1%, 1/2 W	19701	DC1/2CR5, order by description	1	1		
0727-0196	fxd, dep c, 52,600 ohms ±1%, 1/2 W	19701	DC-1/2CR5, order by description	1	1		
0727-0327	fxd, dep c, 59,950 ohms ±1%, 1/2 W	19701	DC-1/2R5, order by description	1	1		
0757-0021	fxd, mfg, 1K ohms ±1%, 1/2 W	19701	MF1/2T-2, order by description	2	1		
0812-0013	fxd, ww, 0.7 ohm ±3%, 5 W	91637	RS5	1	1		
0813-0021	fxd, ww, 2 ohms ±10%, 5 W	35434	CN5, order by description	1	1		
0813-0022	fxd, ww, 200 ohms ±10%, 5 W	35434	CN5, order by description	1	1		
0813-0023	fxd, ww, 350 ohms ±10%, 5 W	35434	CN5, order by description	2	1		
0813-0024	fxd, ww, 450 ohms ±10%, 5 W	35434	CN5, order by description	1	1		
0813-0025	fxd, ww, 600 ohms ±10%, 5 W	35434	CN5, order by description	2	1		
0813-0026	fxd, ww, 800 ohms ±10%, 5 W	35434	CN5, order by description	2	1		
0813-0027	fxd, ww, 1K ohms ±10%, 5 W	35434	CN5, order by description	2	1		
1120-0103	Meter: 0-60 volts	06555	type 2PL order by description	1	1		
1120-0104	Meter: 0-2.5 amps	06555	type 2PL, order by description	1	1		
1450-0025	Lamp, neon: indicator,clear lens	03797	E-lite 1AG1-1369	2	2		
1850-0037	Transistor: 2N274	02735	2N274	1	1		
1850-0048	Transistor: 2N650	04713	2N650	3	3		
1850-0057	Transistor: 2N1159	16758	2N1159	2	2		
1850-0058	Transistor: 2N443	16758	2N443	1	1		
1850-0059	Transistor: 2N173	16758	2N173	1	1		
1851-0001	Transistor: 2N169	03508	2N169	1	1		
1901-0007	Diode, silicon: 500 ma, 400 PIV	81483	Order by description	8	8		
1901-0008	Diode, silicon: 500 mn, 100 PIV	81483	SD91A	3	3		
1901-0019	Diode, silicon: 1N1344	05277	1N1344	5	5		

See introduction to this section

Table 6-2. Replaceable Parts (Cont'd)

Stock No.	Description	Mfr.	Mfr. Part No.	TQ	RS		
1901-0020	Diode, silicon: 1N2069	01295	1N2069	2	2		
2100-0003	var, ww, 100 ohms ±10%, 2 W	11237	type 252, order by description	1	1		
2100-0038	var, ww, 300 ohms	11237	type 252, order by description	1	1		
2100-0078	var, ww, lin, 500 ohms ±30%, 3/10 W	11237	model 70, order by description	1	1		
2100-0118	var, comp, 100 ohms ±20%, 0.2 W	11237	type 70, order by description	1	1		
2100-0261	var, comp, 2000 ohms ±20%, 0.3 W	11237	type 70, order by description	1	1		
2100-0262	var, ww, 5K ohms ±5%, 4.5 W	24655	973-M	1	1		
2100-0263	var, ww, dual ganged; front sect-5K ohms ±10%, 2 W; rear sect, lin, 300 ohms ±10%, 2 W	11237	2-252	1	1		
2110-0015	Fuse, cartridge: 2.5 amp, slow blow (for 115 V operation)	71400	MDL2-1/2	1	10		
2110-0021	Fuse, cartridge: 1.25 amp, slow blow (for 230 V operation)	71400	MDL1-25				
3101-0011	Switch, slide: DPDT	42190	4603	1	1		
3101-0017	Switch, toggle: DPDT	04009	AH&H 82611	1	1		
3101-0031	Switch, toggle: 3PDT	88140	CH-7615K2	1	1		
3101-0033	Switch, slide: DPDT	42190	4633	2	1		
8120-0050	Cord, power	70903	CS-9941/PH-151/7.5ft.	1	1		
9100-0132	Transformer, power	98734	9433	1	1		
9100-0133	Transformer, variable: 115 V input 0-115 V output 0-135 V output	24655	W5	1	1		
9140-0037	Inductor, fixed: 5.0 mh	99848	35000-15-502	1	1		

See introduction to this section

Table 6-2. Replaceable Parts

Stock No.	Description	Mfr.	Mfr. Part No.	TQ	RS		
	MISCELLANEOUS						
AC-10C	Binding post, black: output terminal	28480	AC-10C	1	1		
AC-54C	Insulator, binding post, 3 hole black, output	28480	AC-54C	2	0		
G-10G	Binding post, red: output terminal	28480	G-10G	2	1		
G-32R	Coupler-bellows: 1/4" to 3/8" shaft	28480	G-32R	2	0		
G-74BB	Knob, black: 2 3/4", COARSE VOLTAGE	28480	G-74BB	1	0		
G-74D	Knob, black: 3/4" w/pointer, CURRENT LIMIT, FINE VOLTAGE	28480	G-74D	2	0		
G-110D	Guide, printed circuit	28480	G-110D	6	0		
712A-12C	Clamp-stop (coarse voltage)	28480	712A-12C	1	0		
722A-65A	Assembly, circuit board "A"	28480	722A-65A	1	0		
722A-65B	Assembly, circuit board "B"	28480	722A-65B	1	0		
722A-65C	Assembly, circuit board "C"	28480	722A-65C	1	0		
722A-85A	Holder, air filter	28480	722A-85A	1	0		
1200-0043	Insulator, transistor mounting	76530	294457	2	0		
1200-0044	Socket, transistor mounting	83298	210-6400	2	1		
1251-0140	Connector, printed circuit: 15 pin	95354	SD-615L	1	1		
1251-0141	Connector, printed circuit: 18 pin	95354	SD-618L	2	1		
3150-0017	Filter, air	82866	Order by description	1	1		
3160-0026	Fan: 100 CFU, 115 VAC $\pm$10%, 50/60 cycles 14 W	82877	Order by description	1	1		

See introduction to this section

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 1 of 2)

The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) and their latest supplements. The date of revision and the date of the supplements used appear at the bottom of each page. Alphabetical codes have been arbitrarily assigned to suppliers not appearing in the H4 handbooks.

CODE NO.	MANUFACTURER	ADDRESS
00334	Humidial Co.	Colton, Calif.
00335	Westrex Corp.	New York, N.Y.
00373	Garlock Packing Co., Electronic Products Div.	Camden, N.J.
00656	Aerovox Corp.	New Bedford, Mass.
00779	Amp, Inc.	Harrisburg, Pa.
00781	Aircraft Radio Corp.	Boonton, N.J.
00853	Sangamo Electric Co., Cap. Div.	Marion, Ill.
00866	Goe Engineering Co.	Los Angeles, Calif.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	Pacific Semiconductors, Inc.	Culver City, Calif.
01295	Texas Instruments, Inc. Semiconductor Components Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
01561	Chassi-Trak Corp.	Indianapolis, Ind.
01930	Amerock Corp.	Rockford, Ill.
01961	Pulse Engineering Co.	Santa Clara, Calif.
02114	Ferroxcube Corp. of America	Saugerties, N.Y.
02286	Cole Mfg. Co.	Palo Alto, Calif.
02660	Amphenol Electronics Corp.	Chicago, Ill.
02735	Radio Corp. of America Semiconductor and Materials Div.	Somerville, N.J.
02771	Vocaline Co. of America, Inc.	Old Saybrook, Conn.
02777	Hopkins Engineering Co.	San Fernando, Calif.
03508	G.E. Semiconductor Products Dept.	Syracuse, N.Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp.	El Monte, Calif.
03877	Transitron Electronic Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co.	Morristown, N.J.
03954	Air Marine Motors, Inc.	Los Angeles, Calif.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04062	Elmenco Products Co.	New York, N.Y.
04222	Hi-Q Division of Aerovox	Myrtle Beach, S.C.
04298	Elgin National Watch Co., Electronics Division	Burbank, Calif.
04404	Dymec Division of Hewlett-Packard Co.	Palo Alto, Calif.
04651	Special Tube Operations of Sylvania Electronic Systems	Mountain View, Calif.
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Arizona
04732	Filtron Co., Inc. Western Division	Culver City, Calif.
04773	Automatic Electric Co.	Northlake, Ill.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Calif.
05277	Westinghouse Electric Corp., Semi-Conductor Dept.	Youngwood, Pa.
05593	Illumitronic Engineering Co.	Sunnyvale, Calif.
05624	Barber Colman Co.	Rockford, Ill.
05729	Metropolitan Telecommunications Corp., Metro Cap. Div.	Brooklyn, N.Y.
05783	Stewart Engineering Co.	Soquel, Calif.
06004	The Bassick Co.	Bridgeport, Conn.
06555	Beede Electrical Instrument Co., Inc.	Penacook, N.H.
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.
07115	Corning Glass Works Electronic Components Dept.	Bradford, Pa.
07126	Digitran Co.	Pasadena, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07261	Avnet Corp.	Los Angeles, Calif.
07263	Fairchild Semiconductor Corp.	Mountain View, Calif.
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Rheem Semiconductor Corp.	Mountain View, Calif.
07980	Boonton Radio Corp.	Boonton, N.J.
08145	U.S. Engineering Co.	Los Angeles, Calif.
08358	Burgess Battery Co.	Niagara Falls, Ontario, Canada
08717	Sloan Company	Burbank, Calif.
08718	Cannon Electric Co. Phoenix Div.	Phoenix, Ariz.
08792	CBS Electronics Semiconductor Operations, Div. of C.B.S. Inc.	Lowell, Mass.
09026	Babcock Relays, Inc.	Costa Mesa, Calif.
09134	Texas Capacitor Co.	Houston, Texas
09250	Electro Assemblies, Inc.	Chicago, Ill.
09569	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Canada
10411	Ti-Tal, Inc.	Berkeley, Calif.
10646	Carborundum Co.	Niagara Falls, N.Y.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of California, Inc.	So. Pasadena, Calif.
11312	Microwave Electronics Corp.	Palo Alto, Calif.
11870	Melabs, Inc.	Palo Alto, Calif.
12697	Clarostat Mfg. Co.	Dover, N.H.
14655	Cornell Dubilier Elec. Corp.	So. Plainfield, N.J.
15909	The Daven Co.	Livingston, N.J.
16758	Delco Radio Div. of G. M. Corp.	Kokomo, Ind.
18873	E. I. DuPont and Co., Inc.	Wilmington, Del.
19315	Eclipse Pioneer, Div. of Bendix Aviation Corp.	Teterboro, N.J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N.J.
19701	Electra Manufacturing Co.	Kansas City, Mo.
20183	Electronic Tube Corp.	Philadelphia, Pa.
21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.
21335	The Fafnir Bearing Co.	New Britain, Conn.
21964	Fed. Telephone and Radio Corp.	Clifton, N.J.
24446	General Electric Co.	Schenectady, N.Y.
24455	G.E., Lamp Division	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
26462	Grobet File Co. of America, Inc.	Carlstadt, N.J.
26992	Hamilton Watch Co.	Lancaster, Pa.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
33173	G.E. Receiving Tube Dept.	Owensboro, Ky.
35434	Lectrohm Inc.	Chicago, Ill.
37942	P. R. Mallory & Co., Inc.	Indianapolis, Ind.
39543	Mechanical Industries Prod. Co.	Akron, Ohio
40920	Miniature Precision Bearings, Inc.	Keene, N.H.
42190	Muter Co.	Chicago, Ill.
43990	C. A. Norgren Co.	Englewood, Colo.
44655	Ohmite Mfg. Co.	Skokie, Ill.
47904	Polaroid Corp.	Cambridge, Mass.
48620	Precision Thermometer and Inst. Co.	Philadelphia, Pa.
49956	Raytheon Mfg. Co.	Waltham, Mass.
54294	Shallcross Mfg. Co.	Selma, N.C.
55026	Simpson Electric Co.	Chicago, Ill.
55933	Sonotone Corp.	Elmsford, N.Y.
55938	Sorenson & Co., Inc.	So. Norwalk, Conn.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
59446	Telex, Inc.	St. Paul, Minn.
61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Pittsburgh, Pa.
62119	Universal Electric Co.	Owosso, Mich.
64959	Western Electric Co., Inc.	New York, N.Y.
65092	Weston Inst. Div. of Daystrom, Inc.	Newark, N.J.
66346	Wollensak Optical Co.	Rochester, N.Y.
70276	Allen Mfg. Co.	Hartford, Conn.
70309	Allied Control Co., Inc.	New York, N.Y.
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
70563	Amperite Co., Inc.	New York, N.Y.
70903	Belden Mfg. Co.	Chicago, Ill.
70998	Bird Electronic Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71041	Boston Gear Works Div. of Murray Co. of Texas	Quincy, Mass.
71218	Bud Radio Inc.	Cleveland, Ohio
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Allen D. Cardwell Electronic Prod. Corp.	Plainville, Conn.
71400	Bussmann Fuse Div. of McGraw-Edison Co.	St. Louis, Mo.
71450	CTS Corp.	Elkhart, Ind.
71468	Cannon Electric Co.	Los Angeles, Calif.
71471	Cinema Engineering Co.	Burbank, Calif.
71482	C. P. Clare & Co.	Chicago, Ill.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.
71700	The Cornish Wire Co.	New York, N.Y.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71753	A. O. Smith Corp., Crowley Div.	West Orange, N.J.
71785	Cinch Mfg. Corp.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
72354	John E. Fast & Co.	Chicago, Ill.
72619	Dialight Corp.	Brooklyn, N.Y.
72656	General Ceramics Corp.	Keasbey, N.J.
72758	Girard-Hopkins	Oakland, Calif.
72765	Drake Mfg. Co.	Chicago, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Gudeman Co.	Chicago, Ill.
72982	Erie Resistor Corp.	Erie, Pa.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73138	Helipot Div. of Beckman Instruments, Inc.	Fullerton, Calif.
73293	Hughes Products Div. of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Electronic Co., Div. of North American Phillips Co., Inc.	Hicksville, N.Y.
73506	Bradley Semiconductor Corp.	New Haven, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73682	George K. Garrett Co., Inc.	Philadelphia, Pa.
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	The General Industries Co.	Elyria, Ohio

From: F.S.C. Handbook Supplements
H4-1 Dated April 1961
H4-2 Dated April 1961

00015-17
Revised: 17 October 1961

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 2 of 2)

CODE NO.	MANUFACTURER	ADDRESS
73905	Jennings Radio Mfg. Co.	San Jose, Calif.
74455	J. H. Winns, and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Ill.
74868	Industrial Products Co.	Danbury, Conn.
74970	E. F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75173	Jones, Howard B., Division of Cinch Mfg. Corp.	Chicago, Ill.
75378	James Knights Co.	Sandwich, Ill.
75382	Kulka Electric Mfg. Co., Inc.	Mt. Vernon, N.Y.
75818	Lenz Electric Mfg. Co.	Chicago, Ill.
75915	Littelfuse Inc.	Des Plaines, Ill.
76005	Lord Mfg. Co.	Erie, Pa.
76210	C. W. Marwedel	San Francisco, Calif.
76433	Micamold Electronic Mfg. Corp.	Brooklyn, N.Y.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76530	Monadnock Mills	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio
76854	Oak Manufacturing Co.	Chicago, Ill.
77068	Bendix Corp., Bendix Pacific Div.	No. Hollywood, Calif.
77221	Phaostron Instrument and Electronic Co.	South Pasadena, Calif.
77342	Potter and Brumfield, Inc.	Princeton, Ind.
77630	Radio Condenser Co.	Camden, N.J.
77634	Radio Essentials Inc.	Mt. Vernon, N.Y.
77638	Radio Receptor Co., Inc.	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
78283	Signal Indicator Corp.	New York, N.Y.
78471	Tilley Mfg. Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78790	Transformer Engineers	Pasadena, Calif.
78947	Ucinite Co.	Newtonville, Mass.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Ill.
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80031	Mepco Division of Sessions Clock Co.	Morristown, N.J.
80130	Times Facsimile Corp.	New York, N.Y.
80131	Electronic Industries Association Any brand tube meeting EIA standards	Washington, D.C.
80207	Unimax Switch, Div. of W. L. Maxson Corp.	Wallingford, Conn.
80248	Oxford Electric Corp.	Chicago, Ill.
80411	Acro Manufacturing Co.	Columbus, Ohio
80486	All Star Products Inc.	Defiance, Ohio
80583	Hammerlund Co., Inc.	New York, N.Y.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
81030	International Instruments, Inc.	New Haven, Conn.
81415	Wilkor Products, Inc.	Cleveland, Ohio
81453	Raytheon Mfg. Co., Industrial Tube Division	Quincy, Mass.
81483	International Rectifier Corp.	El Segundo, Calif.
81860	Barry Controls, Inc.	Watertown, Mass.
82042	Carter Parts Co.	Skokie, Ill.
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.
82170	Allen B. DuMont Labs., Inc.	Clifton, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod. Inc., Electronic Tube Div.	Emporium, Pa.
82376	Astron Co.	East Newark, N.J.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Texas Instruments, Inc., Metals and Controls Div., Spencer Products	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Manufacturing Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83148	Electro Cords Co.	Los Angeles, Calif.
83186	Victory Engineering Corp.	Union, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83501	Gavitt Wire and Cable Co., Div. of Amerace Corp.	Brookfield, Mass.
83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N.J.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
84171	Arco Electronics, Inc.	New York, N.Y.
84396	A. J. Glesener Co., Inc.	San Francisco, Calif.
84411	Good All Electric Mfg. Co.	Ogallala, Neb.
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.
85454	Boonton Molding Company	Boonton, N.J.
85474	R. M. Bracamonte & Co.	San Francisco, Calif.
85660	Koiled Kords, Inc.	New Haven, Conn.
85911	Seamless Rubber Co.	Chicago, Ill.
86684	Radio Corp. of America, RCA Electron Tube Div.	Harrison, N.J.
87473	Western Fibrous Glass Products Co.	San Francisco, Calif.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
89473	General Electric Distributing Corp.	Schenectady, N.Y.
89636	Carter Parts Div. of Economy Baler Co.	Chicago, Ill.
89665	United Transformer Co.	Chicago, Ill.
90179	U.S. Rubber Co., Mechanical Goods Div.	Passaic, N.J.
90970	Bearing Engineering Co.	San Francisco, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat Brothers, Inc.	Attleboro, Mass.
91637	Dale Products, Inc.	Columbus, Neb.
91662	Elco Corp.	Philadelphia, Pa.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91827	K F Development Co.	Redwood City, Calif.
91929	Micro-Switch Div. of Minneapolis Honeywell Regulator Co.	Freeport, Ill.
92196	Universal Metal Products, Inc.	Bassett Puente, Calif.
93332	Sylvania Electric Prod. Inc., Semiconductor Div.	Woburn, Mass.
93369	Robbins and Myers, Inc.	New York, N.Y.
93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio
93983	Insuline-Van Norman Ind., Inc. Electronic Division	Manchester, N.H.
94144	Raytheon Mfg. Co., Receiving Tube Div.	Quincy, Mass.
94145	Raytheon Mfg. Co., Semi-conductor Div.	Newton, Mass.
94148	Scientific Radio Products, Inc	Loveland, Colo.
94154	Tung-Sol Electric, Inc.	Newark, N.J.
94197	Curtiss-Wright Corp., Electronics Div.	Carlstadt, N.J.
94310	Tru Ohm Prod. Div. of Model Engineering and Mfg. Co.	Chicago, Ill.
94682	Worcester Pressed Aluminum Corp.	Worcester, Mass.
95236	Allies Products Corp.	Miami, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	New York, N.Y.
95264	Lerco Electronics, Inc.	Burbank, Calif.
95265	National Coil Co.	Sheridan, Wyo.
95275	Vitramon, Inc.	Bridgeport, Conn.
95354	Methode Mfg. Co.	Chicago, Ill.
95987	Weckesser Co.	Chicago, Ill.
96067	Huggins Laboratories	Sunnyvale, Calif.
96095	Hi-Q Division of Aerovox	Olean, N.Y.
96296	Solar Manufacturing Co.	Los Angeles, Calif.
96330	Carlton Screw Co.	Chicago, Ill.
96341	Microwave Associates, Inc.	Burlington, Mass.
96493	J. W. Miller Co.	Los Angeles, Calif.
96501	Excel Transformer Co.	Oakland, Calif.
97539	Automatic and Precision Mfg. Co.	Yonkers, N.Y.
97966	CBS Electronics, Div. of C.B.S., Inc.	Danvers, Mass.
98141	Axel Brothers Inc.	Jamaica, N.Y.
98220	Francis L. Mosley	Pasadena, Calif.
98278	Microdot, Inc.	So. Pasadena, Calif.
98291	Sealectro Corp.	New Rochelle, N.Y.
98405	Carad Corp.	Redwood City, Calif.
98734	Palo Alto Engineering Co., Inc.	Palo Alto, Calif.
98925	Clevite Transistor Prod. Div. of Clevite Corp.	Waltham, Mass.
98978	International Electronic Research Corp.	Burbank, Calif.
99109	Columbia Technical Corp.	New York, N.Y.
99313	Varian Associates	Palo Alto, Calif.
99515	Marshall Industries, Electron Products Division	Pasadena, Calif.
99707	Control Switch Division, Controls Co. of America	El Segundo, Calif.
99800	Delevan Electronics Corp.	East Aurora, N.Y.
99821	North Hills Electric Co.	Great Neck, L.I., N.Y.
99848	Wilco Corporation	Indianapolis, Ind.
99934	Renbrandt, Inc.	Boston, Mass.
99942	Hoffman Semiconductor Div. of Hoffman Electronics Corp.	Evanston, Ill.
99957	Technology Instruments Corp. of Calif.	No. Hollywood, Calif.

THE FOLLOWING H-P VENDORS HAVE NO NUMBER ASSIGNED IN THE LATEST SUPPLEMENT TO THE FEDERAL SUPPLY CODE FOR MANUFACTURERS HANDBOOK.

CODE NO.	MANUFACTURER	ADDRESS
0000C	Connor Spring Mfg. Co.	San Francisco, Calif.
0000F	Malco Tool and Die	Los Angeles, Calif.
0000H	Philco Corp. (Lansdale Division)	Lansdale, Pa.
0000I	Telefunken (c/o American Elite)	New York, N.Y.
0000L	Winchester Electronics, Inc.	Santa Monica, Calif.
0000M	Western Coil Div. of Automatic Ind., Inc.	Redwood City, Calif.
0000N	Nahm-Bros. Spring Co.	San Leandro, Calif.
0000P	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
0000T	Texas Instruments, Inc. Metals and Controls Div.	Versailles, Ky.
0000U	Tower Mfg. Corp.	Providence, R.I.
0000V	Imperial Electronics, Inc.	Buena Park, Calif.
0000W	Webster Electronics Co. Inc.	New York, N.Y.
0000X	Spruce Pine Mica Co.	Spruce Pine, N.C.
0000Y	Midland Mfg. Co. Inc.	Kansas City, Kans.
0000Z	Willow Leather Products Corp.	Newark, N.J.
000AA	British Radio Electronics Ltd.	Washington, D.C.
000BB	Precision Instrument Components Co.	Van Nuys, Calif.
000CC	Computer Diode Corp.	Lodi, N.J.
000DD	General Transistor	Los Angeles, Calif.

00015-17
Revised: 17 October 1961

From: F.S.C. Handbook Supplements
H4-1 Dated April 1961
H4-2 Dated April 1961

MANUAL CHANGES

MODEL 722A/AR

DC POWER SUPPLY

Manual Serial Prefixed: 105-
Manual Printed 11-61

To adapt this manual to instruments with other serial prefixes check for errata below, and make changes shown in tables.

Instrument Serial Prefix	Make Manual Changes	Instrument Serial Prefix	Make Manual Changes
105-	1,2		

CHANGE #1. Figure 4-3

Change reference designator R13 to R14

Figure 5-4, 5-5

Change reference supply voltage to +13.8 ±0.2 volts

Paragraph 5-23 step b,

Change to read: ". . . until the meter reads +13.8 ±0.2 volts"

CHANGE #2 Figure 5-5

Change Amplifier Q12 from 2N247 to 2N274

4/12/62

PRINTED IN U.S.A.