

**HEWLETT-PACKARD**

# 711A

POWER SUPPLY

SERIALS PREFIXED: 002-

OPERATING AND SERVICING MANUAL



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MODEL 711A  
POWER SUPPLY

SERIALS PREFIXED: 002 -



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## SPECIFICATIONS

### OUTPUT VOLTAGES

DC Regulated High Voltage: 0 to 500 volts (without switching), 100 ma maximum load.  
AC Unregulated: 6.3 volts, 6 amps maximum load; 12.6 volts CT, 3 amps maximum load

### REGULATION

For line voltage 115/230 volts  $\pm 10\%$ , less than 0.5% change or 1.0 volt change, whichever is greater; from no load to full load, change of less than 0.5% or 1.0 volt (whichever is greater).

### RIPPLE

Less than 1.0 mv

### METERING

Current Meter: 0 to 100 ma; 0 to 10 with push-button  
Voltage Meter: 0 to +500 volts; 0 to +50 volts with push-button

### TERMINALS

Either positive or negative dc regulated high voltage terminal may be grounded

### OVERLOAD PROTECTION

AC line fused. Overload relay prevents dc output from greatly exceeding current rating of output milliammeter thus protecting instrument from overload conditions including short circuit output.

### POWER

115/230 volts  $\pm 10\%$ , 50/1000 cps. Approximately 145 watts depending on load and line voltage.

### SIZE

Cabinet Mount: 7-3/8 in. wide, 11-1/2 in. high, 14-1/4 in. deep.  
Rack Mount: 19 in. wide, 7 in. high, 12-7/8 in. deep behind panel.

### WEIGHT

Cabinet Mount: Net: 20 lbs., shipping: 26 lbs.  
Rack Mount: Net: 24 lbs., shipping: 35 lbs.

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# SECTION I

## GENERAL DESCRIPTION

### CAUTION

- - Dangerous voltages are present at the terminals and within this instrument - -

#### 1-1 GENERAL DESCRIPTION

The Model 711A Power Supply is a general-purpose low-power d-c and a-c voltage supply particularly suited to powering experimental setups.

By means of the facilities provided by the Model 711A the following voltages are made available at the output terminals on the control panel:

##### Unregulated ac:

- 6.3 volts, 3 amperes maximum load current (two supplies) or
- 6.3 volts, 6 amperes maximum load current (one supply) or
- 12.6 volts, 3 amperes maximum load current (one supply, tapped at 6.3V).

##### Regulated dc:

0 to 500 volts, continuously variable; maximum output load current, 100 ma.

**NOTE:** Insulation within the Model 711A permits operating the d-c output voltage as much as 500 volts from chassis ground so that two Model 711A power supplies may be operated in series to obtain 1000 volts d-c output while each instrument chassis remains at ground potential.

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The d-c output of the Model 711A has high stability; for line voltage variations within rated limits, the

level of the regulated output will vary less than 0.5% or 1 volt (whichever is greater), and from no load to full load the level of the output will vary less than 0.5% or 1 volt (whichever is greater). Ripple will be less than 0.001 volt.

While the internal impedance of the Model 711A will vary both with the d-c load current and the frequency of any reflections from the equipment being powered, the internal impedance of the Model 711A will be less than 10 ohms with any load current and at any frequency up to a few megacycles.

The dc output is continuously monitored by two meters, a voltmeter and a milliammeter. A low and high range are provided for each meter so that low values of voltage and current may be read accurately.

The power supply is protected from input or output overload by (1) a fuse in the line-voltage input circuit and (2) a relay, in the main positive bus, which operates at overload current to interrupt conduction through the regulator.

#### 1-2 INSPECTION

This instrument was thoroughly tested and inspected before being shipped, and is ready for use when received.

After the instrument is unpacked, it should be inspected carefully for damage received in transit. If any shipping damage is found, follow the procedure outlined in the "Claim for Damage in Shipment" sheet in this instruction manual.

### 1-3 POWER CABLE

The three-conductor power cable supplied with this instrument is terminated in a polarized three-prong male connector recommended by the National Electrical Manufacturers' Association. The third contact is an offset round pin added to a standard two-blade connector which grounds the instrument chassis when used with an appropriate receptacle. To use this connector with a standard two contact receptacle, an adapter should be used to connect the NEMA connector to the two-contact system. When the adapter is used, the third contact is terminated in a short lead from the adapter which can then be connected to the outlet mounting box in order to ground the instrument chassis.

### 1-4 230-VOLT OPERATION

This instrument is normally shipped from the factory with the dual 115 volt primary windings of the transformer connected in parallel for operation from a nominal 115 volt source. If operation from a nominal 230 volt source is desired, the windings may easily be reconnected in series.

Refer to the schematic drawing for details.

The power fuse must be changed from a 1.6 ampere slow-blow fuse to a 0.8 ampere slow-blow fuse.

# SECTION II

## OPERATING INSTRUCTIONS

### 2-1 CONTROLS AND TERMINALS

All controls and terminals except the fuseholder are mounted on the front panel. The fuseholder is mounted on the rear plate of the instrument.

#### Voltmeter -

This single-scale, two-range (0 to 500 volts; 0 to 50 volts) voltmeter indicates the voltage level at the output of the main regulator. With the DC VOLTAGE switch at ON, the level of voltage at the DC VOLTAGE output terminals is indicated by the voltmeter. Normally the meter indicates on the 0- to 500-volt range; with the 50 VOLTS FULL SCALE push-button switch depressed, the meter indicates on the 0- to 50-volt range.

#### Milliammeter -

This single-scale, two-range (0 to 100 milliamperes; 0 to 10 ma) milliammeter indicates the value of the d-c load current. Up to 100 ma can flow in the load circuit without overloading the milliammeter. Normally the meter indicates on the 0- to 100-ma range; with the 10 MA FULL SCALE push-button depressed, the meter indicates on the 0- to 10-ma range.

#### 50 VOLTS FULL SCALE -

When operated (depressed), this SPDT push-button switch opens the high-range series multiplier resistor and inserts the low-range multiplier.

#### 10 MA FULL SCALE -

This push-button switch, which is connected for DPST operation, controls the proportion of current diverted by the respective shunts across (1) the milliammeter and (2) the protective relay in series with the milliammeter. When the 10 MA FULL SCALE switch is operated, the protective relay operates at between 11 and 17 ma to interrupt conduction through the regulator and thereby to interrupt the flow of current through the milliammeter.

With the switch at normal, the protective relay operates at between 110 and 170 ma.

#### D-C VOLTS ADJ.

Adjustment of the regulated d-c voltage to the desired level is by means of the FINE and COARSE control mounted under the D. C. VOLTS ADJ. designation. The level of voltage obtained at any given setting of the controls is indicated by the voltmeter, and the resulting flow of current in the load circuit is indicated by the milliammeter.

#### COARSE -

Operation of the COARSE control (1) adjusts the setting of a 1-megohm variable resistor, R11, and (2) operates two microswitches, S1A and S1B.

a. Variable resistor R11 is part of the voltage divider in the circuit which controls the level of the regulated d-c output voltage.

b. The microswitches make connection to various taps on the power transformer secondary winding which furnishes voltage for the main d-c supply circuit. At the low-voltage position (ccw) of the COARSE control, the main d-c supply circuit is fed by the low-voltage section of the winding. As the control is turned cw, the microswitches are actuated to complete connection to the higher voltage taps.

#### FINE -

Operation of the FINE control varies the setting of variable resistor R12. This resistor also is part of the voltage divider in the circuit which controls the level of the regulated d-c output voltage.

#### Indicator Lights -

There are two indicator lights on the control panel:

**AC VOLTAGE** - This red indicator light glows to indicate that power is applied to the instrument circuits.

**DC VOLTAGE** - The operating circuit of this indicator light is controlled by the DC VOLTAGE switch, and the light glows red when the switch is at ON to indicate that voltage is applied to the DC VOLTAGE output terminals.

**AC VOLTAGE Switch** -

This SPST toggle switch is in the primary circuit of the power transformer. With the AC VOLTAGE switch at ON, line voltage is closed to power transformer T1.

**DC VOLTAGE Switch** -

There is no voltage on the DC VOLTAGE output terminals until the DC VOLTAGE switch is at the ON position. When operated, this DPST toggle switch: (1) connects the positive d-c bus to the DC VOLTAGE output terminals and (2) closes the circuit to the DC VOLTAGE indicator light.

**Output Terminals** -

Both the AC VOLTAGE and DC VOLTAGE output terminals are of the binding-post type, will accommodate either a banana plug or wire, and are so arranged that any banana plug with 3/4-inch spacing may be used.

**AC VOLTAGE** -

There are two pairs of output terminals associated with the a-c voltage supply. Depending on how the terminal connections are made (see paragraph 2-3 below), the Model 711A may be arranged to supply the following a-c voltages:

- 6.3 volts at 3 amperes (two circuits), or
- 6.3 volts at 6 amperes (one circuit), or
- 12.6 volts at 3 amperes (one circuit, tapped at 6.3 V).

**DC VOLTAGE** -

There is one pair of output terminals for the regulated d-c voltage supply: + and -. The binding-post nuts for the + and - terminals are insulated. Neither the + nor the - terminal is connected to the chassis within the instrument so that the d-c supply may be operated either above or below ground by appropriate external connection to ground.

On the same mounting plate with the + and - terminals is a terminal (G) which is connected to the instrument chassis. The G terminal is connected to earth ground when the power-cable connector is plugged into a grounded female connector.

**FUSE** -

The fuseholder, which is mounted on the rear plate of the instrument, contains the time-delay cartridge fuse which protects the input circuit. Before starting to install a new fuse, check that the power cable is disconnected from the line. Replacement fuses must be of the slow-blow type: 1.6-ampere fuse for 115-volt operation or a 0.8-ampere fuse for 230-volt operation.

**2-2 OPERATING PROCEDURE**

Be sure the Model 711A is so placed that nothing can obstruct the ventilating louvers in the sides of the cabinet. Safe operating temperatures with the cabinet depend upon free air flow through the louvers.

- a. Before operating the instrument for the first time, see paragraph 4-7, Meter Zero Adjustment.
- b. Check that both the AC VOLTAGE and DC VOLTAGE switches are in the off position. After the Model 711A has been plugged into a power source of specified voltage and frequency, turn the AC VOLTAGE switch to ON, and allow a two-minute warmup period.

**NOTE:** If the Model 711A is to be operated from a 230-volt source, check (1) that power transformer T1 is strapped for 230-volt operation (strapping options are shown on the schematic diagram), and (2) that fuse F1 is a 0.8-ampere Slo-Blo fuse. See paragraph 4-8.

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With the DC VOLTAGE switch still in the off position, connect the load. For connection arrangements for the various options, see paragraph 2-3, below.

- c. Check that the COARSE control is in its maximum counterclockwise (low-voltage) position. Turn the DC VOLTAGE switch to ON.
- d. To obtain the desired level of d-c voltage, adjust the COARSE and FINE controls. The voltmeter indicates the level of the d-c voltage being supplied to the + and - output terminals. If the level of the d-c supply is below 50 volts, the voltmeter may be operated on the 50-volt range by depressing the 50 VOLTS FULL SCALE push-button during the voltage adjustment procedure.



**2-3 OUTPUT OPTIONS**

A-C Options - (Figure 2-1)

The a-c supply may be arranged for any one of three options:

Two 6.3-volt, 3-ampere supplies (Figure 2-1A)

One 6.3-volt, 6-ampere supply, by connecting the two 6.3-volt supplies in parallel (Figure 2-1B)

One 12.6-volt, 3-ampere supply, by connecting the two 6.3-volt supplies in series (Figure 2-1C)

D-C Options -

Among the operating options for which the d-c voltage supply terminations may be arranged are the following:

0 to 500 volts, positive or negative with respect to chassis ground.

0 to 500 volts, neither side grounded. (It is recommended that the instrument chassis be grounded whenever both d-c terminals are operated at a potential above or below ground.)

Up to 1000 volts, by connecting two Model 711A's in series.

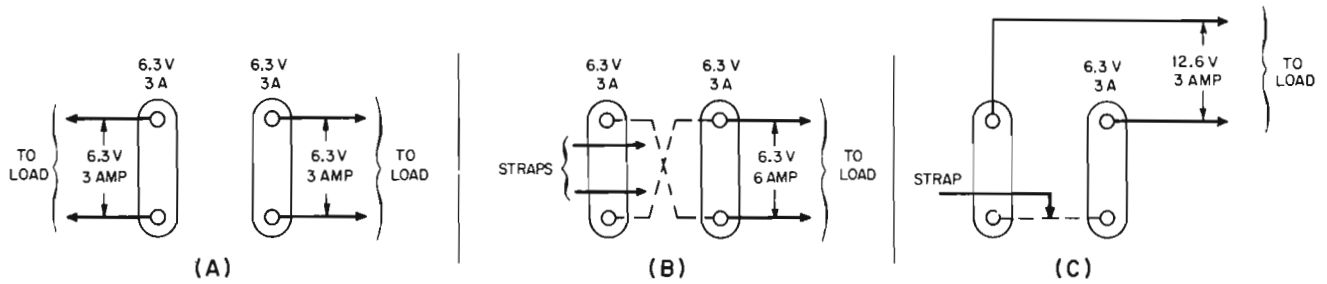


Figure 2-1. Model 711A Connection Arrangements for A-C Supply Options

# SECTION III CIRCUIT DESCRIPTION

## 3-1 GENERAL DESCRIPTION

The Model 711A Power Supply furnishes a regulated variable d-c voltage (HV supply) and an unregulated a-c voltage. Regulation of the HV supply is obtained by means of a main regulator, which regulates the voltage supplied to the DC VOLTAGE output terminals, and a secondary regulator which regulates the voltage which supplies the reference voltage and most of the operating potentials for the regulator circuits. Arrangement of the main components of the d-c supply circuit is indicated in block diagram form in Figure 3-1, and detailed circuitry of the Model 711A is shown in the schematic diagram.

On the schematic, voltages shown for the main positive bus, the HV voltage supply, and the main series regulator are with reference to the main negative bus; those shown for the main control tube, cathode follower, secondary regulator (V3A and V3B), and secondary regulator voltage supply are with refer-

ence to the reference voltage bus (which is approximately 200 volts negative with respect to the main negative bus).

Power from an external source is applied to the Model 711A through power transformer T1. Voltage for the HV supply is taken from a T1 secondary winding which is tapped for various output voltages and, by means of connections through microswitches operated by the COARSE control, provides an input which is variable (paragraph 3-4b). Voltage from the tapped secondary feeds selenium rectifiers SR2, SR3, and capacitors C2, C3 connected as a voltage doubler.

From the doubler, the positive bus is brought through the winding of overload relay K1 (para. 3-5), the series regulator, V1 and V2 (para. 3-3), the DC VOLTAGE switch, and the milliammeter, to the DC VOLTAGE + output terminal. The voltmeter is connected across the main positive and negative busses. With the output circuit so arranged, there is continuous

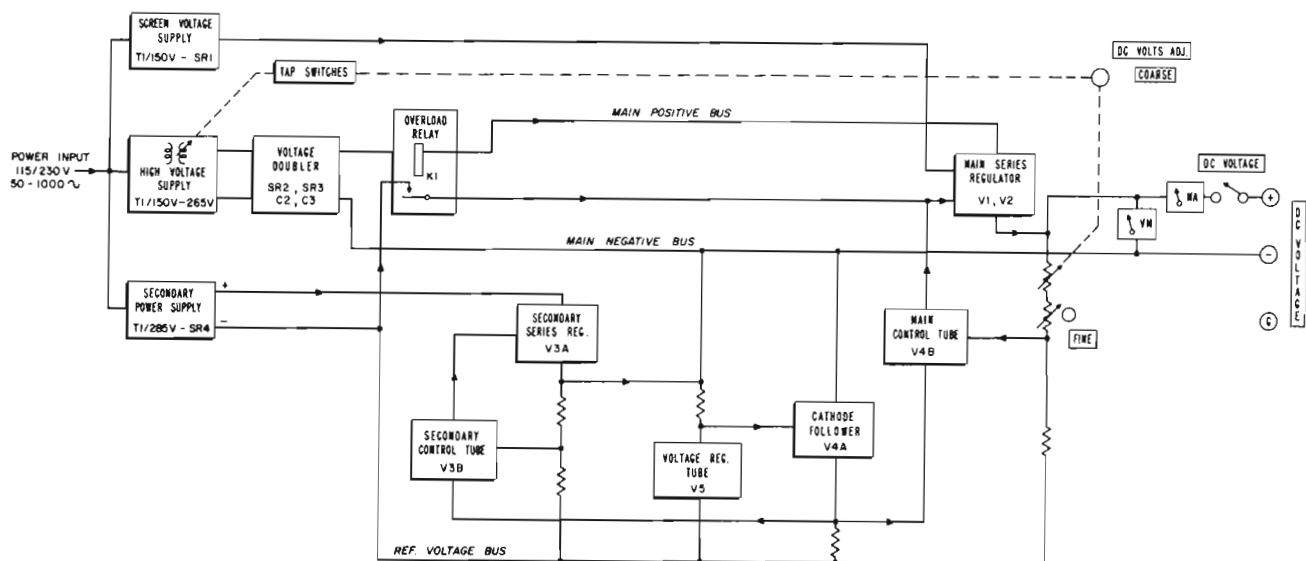


Figure 3-1. Model 711A Power Supply Block Diagram

indication of the level of the voltage between the DC VOLTAGE + and - output terminals and of current flow through the load. The Model 711A circuit is discussed in greater detail in the following paragraphs.

**3-2 INPUT**

Line voltage is applied to the primary of power transformer T1 through fuse F1 and AC VOLTAGE switch S5. To accommodate operation from either a 115-volt or a 230-volt source, the primary of transformer T1 is arranged in two sections. For operation from a 115-volt source the two sections are strapped in parallel, and for operation from a 230-volt source, the sections are strapped in series. The schematic diagram shows the primary windings strapped for 115-volt operation, the standard factory strapping.

Indicator light I1 is connected across one of the filament windings of transformer T1 to give indication as soon as the transformer is energized.

**3-3 REGULATION**

Regulation of the Model 711A d-c output voltage is obtained by using two electronic regulators which are designated main and secondary in the following

discussion. The cathodes of the control tubes are maintained at a constant level by a voltage-reference tube/cathode follower combination, a circuit designed to accommodate the current through the cathodes of both control tubes. The regulator circuits are shown in Figure 3-2, a partial schematic.

a. **Main Regulator** - The control tube of the main regulator compares a sample of the output voltage with a reference voltage, and any difference between the two results in a compensating adjustment in the amount of resistance inserted in series with the main positive bus.

Pentode V4B is the control tube and the series regulator is pentodes V1 and V2 connected in parallel. A portion of the output voltage, sampled with respect to the reference voltage bus, is applied to the grid of control tube V4B, the cathode of which is held at a constant potential. The plate of V4B is tied to the grids of the series regulator tubes. With the circuit so arranged, any rise or drop in the level of the output voltage will cause a change in the potential on the grid of the control tube, and also will result in a change (in the reverse direction) in the potential on the grids of the series regulator tubes. By means of this circuitry, the series regulator becomes a variable resistance which is electronically actuated to increase or decrease as required to maintain the output voltage at a constant level.

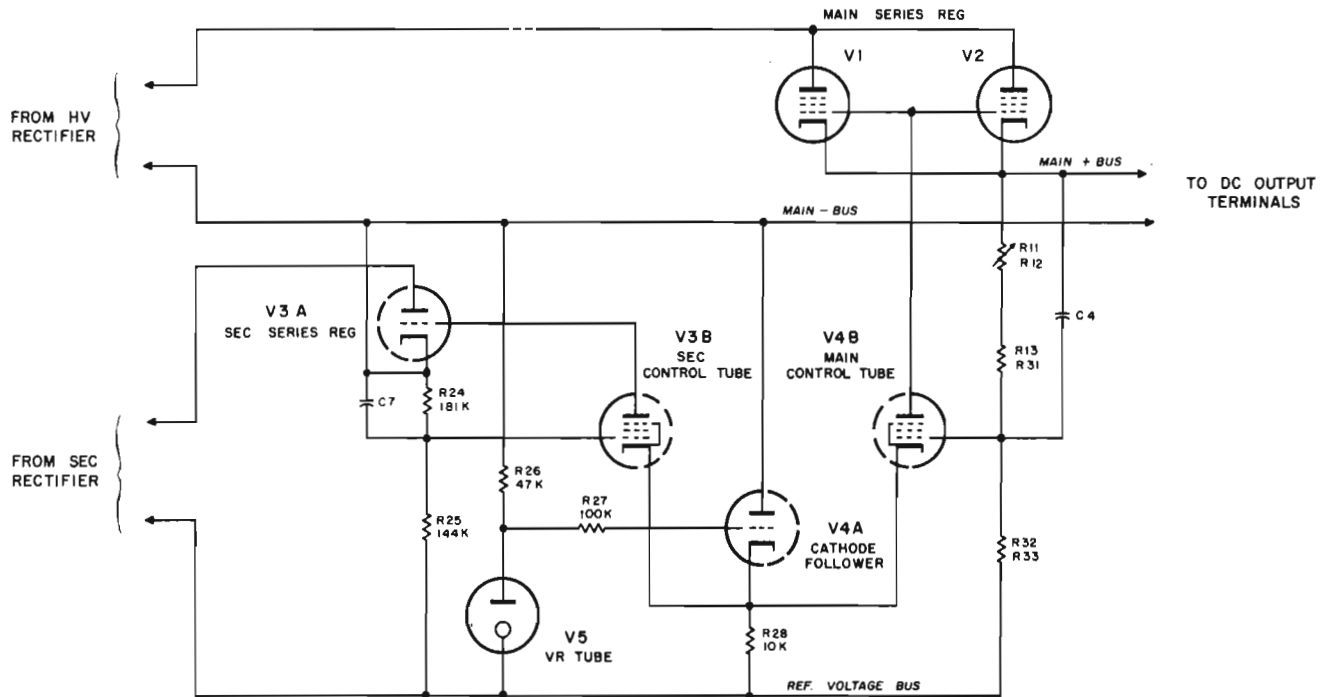


Figure 3-2. Model 711A Main and Secondary Regulator Circuits Partial Schematic

For example, if there is a drop in the level of the d-c output voltage, the potential on the grid of control tube V4B becomes more negative by comparison with the reference voltage on the V4B cathode, and conduction in V4B will be cut down. As a result, the potential on the plate of V4B and on the grids of series regulator tubes V1 and V2 will rise. As conduction through V1 and V2 increases, their plate resistances drop, with a resulting decrease in the voltage drop across the series regulator and rise in the level of the d-c output voltage.

The voltage divider through which the output voltage is sampled is discussed in paragraph 3-4, below.

Any ripple in the output voltage is coupled by capacitor C4 to the grid of control tube V4B.

The pentode connection for beam power amplifiers V1 and V2 gives a series regulator which furnishes high gain at moderate power cost. The separate screen voltage supply for V1 and V2 is fed by rectifier SR1 connected across the 150-volt secondary winding of transformer T1.

b. Secondary Regulator - To regulate the low end of the 0- to 500-volt range, potentials applied to the electrodes of the main control tube must be negative with respect to the main negative bus. The secondary regulator, fed by the 285-volt secondary winding of transformer T1 and full-wave selenium rectifier SR4, is arranged to provide this supply of regulated negative voltage. In conjunction with the voltage-reference tube/cathode follower combination (see paragraph c, below), the secondary regulator also provides the reference voltage for the Model 711A circuits.

The circuit of the secondary regulator is similar to and functions in the same manner as the main regulator. Triode V3A is the series regulator and is in series with the positive side of the secondary power supply. Pentode V3B is the control tube; its cathode is held at a constant potential, a portion of the output voltage is applied to its grid, and its plate is tied to the grid of series regulator V3A. The output voltage is sampled with respect to the reference-voltage bus by a voltage divider which consists of precision resistors R24 and R25. The values selected for R24 and R25 are such that the level of the reference-voltage bus is established at approximately 200 volts below that of the main negative bus. Any ripple in the output is coupled to the grid of V3B by capacitor C7.

c. Reference-Voltage Supply for Control Tube Cathodes - The amount of current through the cathodes of control tubes V3B and V4B is greater than the current capacity of voltage-reference tube V5. Therefore a voltage-reference tube/cathode

follower combination is used to maintain the potential on the cathodes of the control tubes at a constant level.

Arrangement of the reference-voltage supply for the control tube cathodes is indicated in Figure 3-2. The cathode circuits of the control tubes and the cathode follower are connected to the reference-voltage bus through a common resistor, 10,000-ohm R28, and therefore a change in the amount of current through the cathode of one tube also will effect a change in the potential on the cathode of the other control tube and the cathode follower. However, by connecting the grid of cathode follower V4A to voltage-reference tube V5, the V4A grid is maintained at a constant potential, and thus a change in the V4A cathode potential causes such change in V4A conduction that the IR drop across R28 is maintained at a constant value.

For example, if the potential on the grid of main control tube V4B goes negative, conduction in V4B will be cut down, the drop across R28 will be less, and cathode potential will drop. Since the grid of V4A is held at a constant potential and the potential on its cathode is now more negative, there is less difference in potential between grid and cathode, and V4A conduction will increase. The increase in current through the V4A cathode will compensate for the decrease in current through the V4B cathode, the drop across R28 will be returned to proper value, and potential on the cathode of each control tube will be maintained at a constant level regardless of changes in the amount of current flowing through the tube.

### 3-4 SETTING OF OUTPUT VOLTAGE LEVEL

a. General - The level of the d-c output voltage may be varied from 0 to 500 volts by adjusting the level of the potential applied to the grid of main control tube V4B. This adjustment is obtained by operation of the COARSE and FINE controls.

If the HV supply input were the same for all outputs from 0 to 500 volts, the excessive power dissipated in the series regulator tubes would shorten their life. Therefore the design of the Model 711A includes a variable input for the HV supply.

The required variation in HV input is obtained by operation of the COARSE control.

The arrangement of (1) the variable input and (2) the voltage divider through which potential is applied to the grid of main control tube V4B are discussed in the following paragraphs.

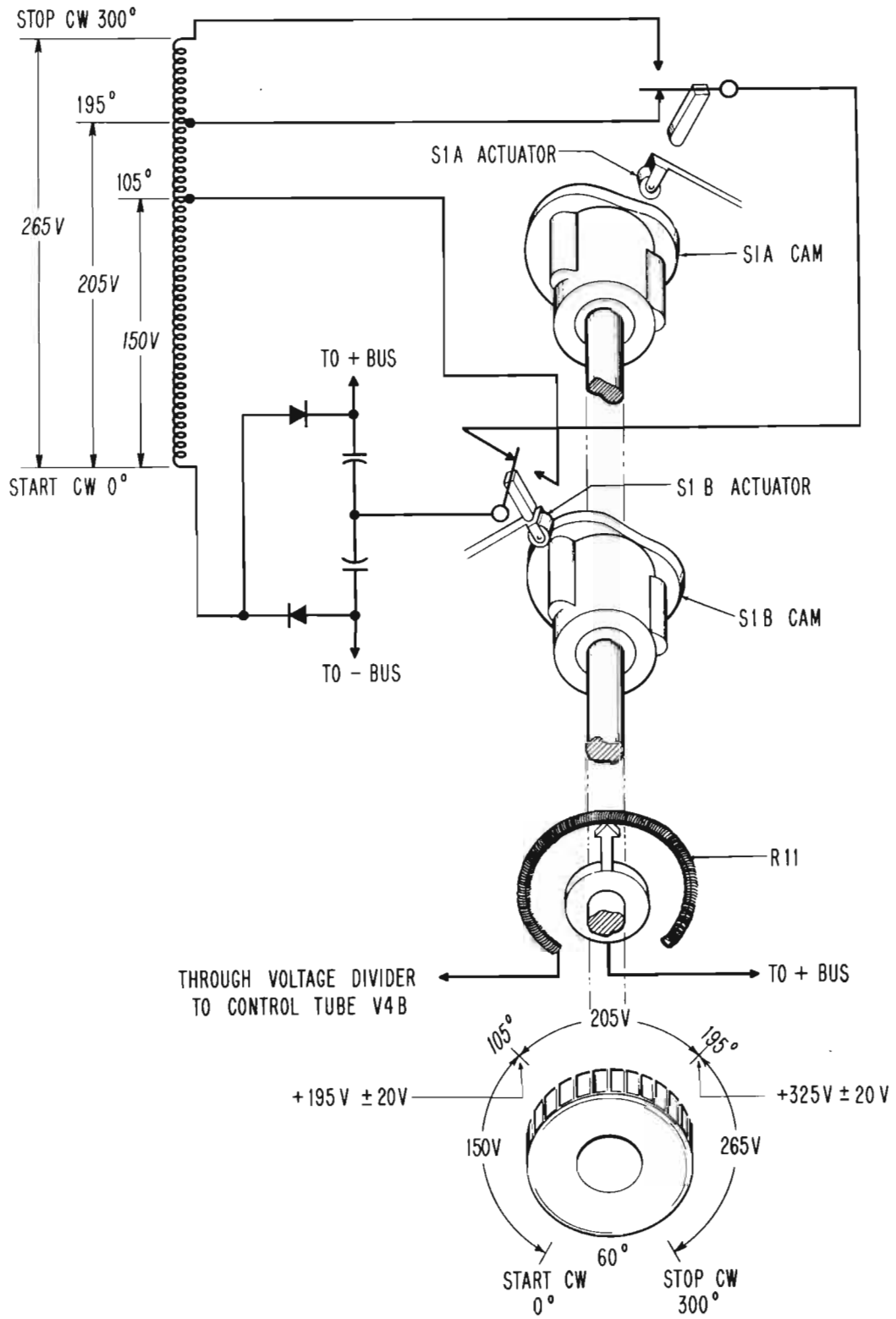


Figure 3-3. Model 711A Arrangement of Tap Switch Actuators and Cams on COARSE Control Shaft FINE Control (not shown) at Electrical Center

b. Tap Switching Arrangement, HV Supply -

The T1 secondary winding which feeds the high-voltage supply is tapped for 150, 205, and 265 volts, and the taps are brought out to contacts on two snap-action, cam-actuated, SPDT microswitches, S1A and S1B. So that S1B will operate before S1A, and will be held operated during the time S1A is operated, the periphery of the high side of the S1B cam is made longer than the periphery of the high side of the S1A cam. Both cams are mounted on an extension of the shaft of the COARSE control. Arrangement of the COARSE control shaft, the cams and switch actuators, the switch contacts, and connections to the tapped winding of T1 are indicated in Figure 3-3.

Through approximately 105° of COARSE control travel, the low side of each cam is toward its respective switch actuator, therefore neither switch is operated, and the voltage-doubler connection is to the 150-volt tap on the transformer secondary winding. In this condition of the circuit (shown on the schematic) with both switches at normal, the level of the voltage doubler output will be approximately 400 volts.

For the next approximately 90° of control travel, the high side of the S1B cam is engaging the S1B actuator, and operated S1B completes connection to the 205-volt tap. In this condition (indicated in Figure 3-3), with S1B operated and S1A at normal, the level at the voltage doubler output will be approximately 560 volts. With the FINE control set at electrical center, at the point of change-over from the 150-volt to the 205-volt connection, the panel voltmeter indication will be approximately 195 volts.

Through the remaining travel of the COARSE control, the high side of the S1A cam is engaging the S1A actuator and, with both switches operated, connection is completed to the 265-volt tap. In this condition of the supply circuit, the level at the output of the voltage doubler will be approximately 715 volts. With the FINE control set at electrical center, at the point of change-over from the 205 volt to the 265 volt tap, the panel voltmeter indication will be approximately 325 volts.

c. Main Control Tube - The potential on the grid of main control tube V4B is applied through a voltage divider which is connected between the main positive bus and the reference-voltage bus. The divider includes four variable resistors, two of which (R31 and R33) are adjusted at the factory and for

the purposes of this discussion, therefore, may be considered fixed. Adjustments for the other two variables (R11 and R12) are brought out to the front panel as the COARSE and FINE controls. The magnitude of the potential on the control tube grid, therefore, varies not only with the level of the voltage on the main positive bus but also with the amount of resistance in the variable arm of the voltage divider, as fixed by the setting of the COARSE control and, to a lesser extent, of the FINE control.

As explained in paragraph 3-3, the level of the d-c output voltage is increased or decreased as the potential on the grid of V4B becomes more negative or more positive with respect to the reference voltage on the V4B cathode.

Unless it is necessary to replace control tube V3B or V4B, and after tube replacement it is not possible to get rated output, it is improbable that the setting of R31 and R33 will require readjustment. Procedure for adjusting R31 and R33 after tube replacement is given in paragraph 4-3c, below.

### 3-5 OVERLOAD RELAY

To protect the milliammeter, the Model 711A circuit is so arranged that if current flow in the main positive bus reaches a value that can damage the meter, a high negative voltage will be applied to the grids of the series regulator tubes. Arrangement of the circuit which protects the milliammeter is shown in Figure 3-4, a partial schematic.

Overload relay K1 is equipped with a set of make-break contacts: the make contact is connected to the reference-voltage bus, and the movable member is tied to the grids of the series regulator tubes; the break contact is unconnected, the positive bus is brought through the winding of relay K1. The operating circuit of K1 is so designed that until the current in its winding reaches such value that the meter can be damaged, relay K1 remains unoperated. At meter-overload value (approximately 180 ma), however, relay K1 operates and, through its make contacts, applies approximately -200 volts to the grids of V1 and V2. Cut off of the series regulator tubes opens (1) the circuit to the meter and (2) the operating circuit of K1. With the restoration of K1, the high negative potential on the grids of V1 and V2 is removed, and normal conduction through the series regulator is resumed. As long as overload current is flowing, however, relay K1 will continue to oper-

ate intermittently, interrupting conduction through the series regulator until the overload condition is corrected.

Operation of the 10 MA FULL SCALE switch opens the approximately 82 ohms(150 ohms and 180 ohms,

in parallel) arm of the shunt across the winding of relay K1. This effectively increases the resistance of the shunt, a greater proportion of current therefore will flow through the winding of relay K1, and K1 operates when current flow in the main positive bus is between approximately 12 and 18 ma.

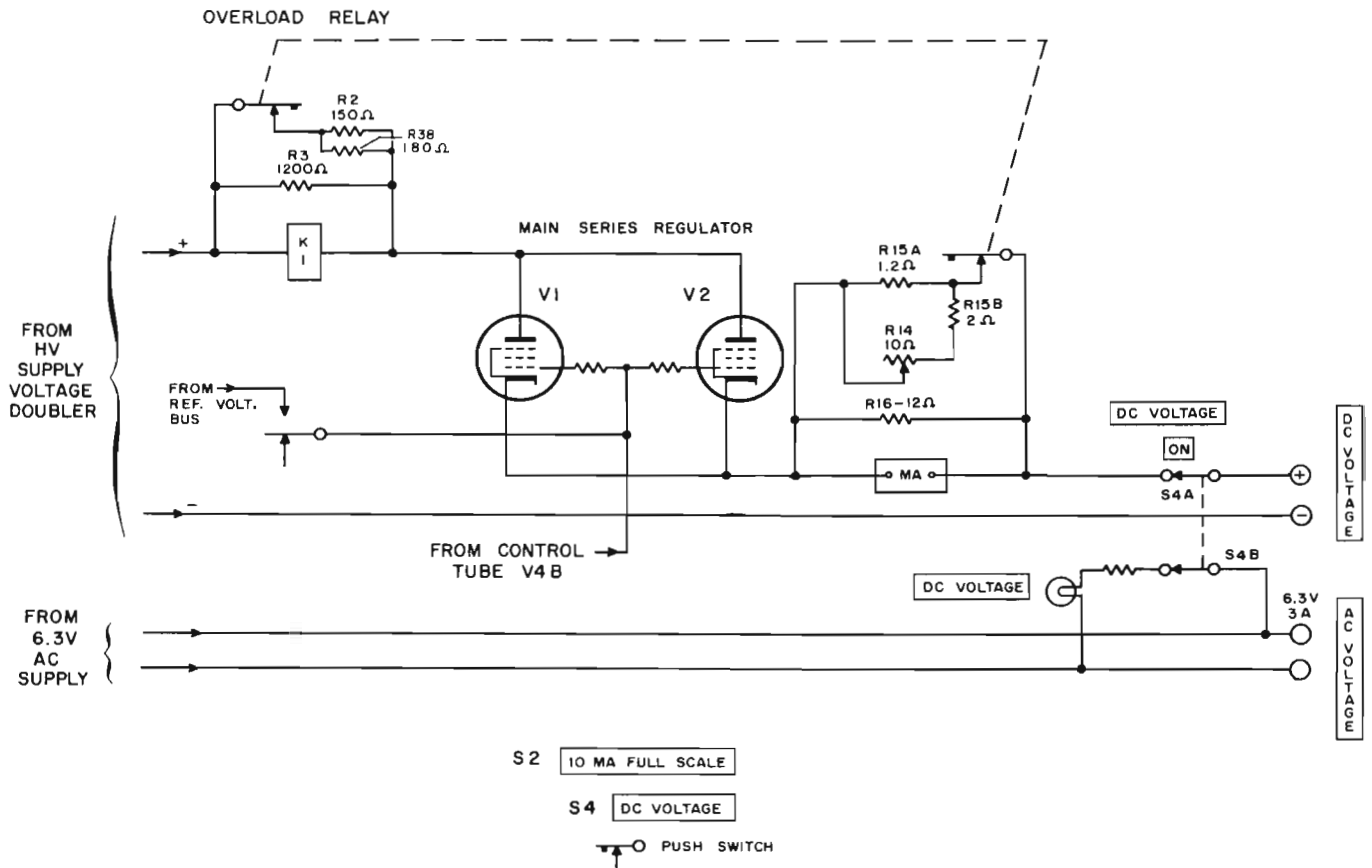


Figure 3-4. Model 711A Arrangement of positive Bus showing Overload Relay, Milliammeter, and Associated Switches - Switch S4 shown Operated Partial Schematic

# SECTION IV MAINTENANCE

## 4-1 GENERAL

The Model 711A Power Supply is designed conservatively for long component life, and it is probable that tube replacement will correct a majority of the difficulties which may develop. Tube replacement instructions are given in paragraph 4-3.

The maintenance data provided in this section assumes that maintenance personnel are familiar with the operating procedures and circuit theory given in Sections II and III, respectively.

As a guide in tracing the cause of substandard operation, a troubleshooting chart is provided in paragraph 4-9. The chart indicates causes and remedies for certain specific troubles. Where the cause of the trouble is of a more obscure nature than the possibilities covered by the chart, the instrument should be tested to localize the failure to the section in trouble. General data on localization procedures is given in paragraph 4-10.

After locating the source and eliminating the cause of trouble, the instrument should be tested and adjusted. Rated performance specifications are given at the front of this instruction book.

## 4-2 COVER REMOVAL

On both cabinet and rack models, the cover is fastened to the chassis at the rear with two screws. To remove the cover, remove the screws, and slide the cover to the rear and off the instrument.

**NOTE:** When replacing the cover, pull the power cable through the opening in the rear of the cover. Be sure the cable is free of the cover along the entire length of the cable so that it cannot get caught between chassis and cover as the cover is slid onto the instrument.

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## 4-3 TUBE REPLACEMENT

- a. General - Any tube in the Model 711A may be replaced by a tube which has corresponding standard RETMA characteristics. In general, neither checks or adjustments are required when tubes are replaced except in the case of the main and secondary control tubes, V3B and V4B.
- b. Replacement of V3 and V4 - After replacement of either of these tubes, check the low end and the high end of the d-c output-voltage range and, if required, adjust R31 and/or R33 to bring the output within rated limits.
- c. Low-End and High-End Adjustments - The adjustments for R31 and R33 are brought out to the upper side of the deck, and are identified in Figure 4-2.

### Check low end of range:

- 1) Turn FINE and COARSE control maximum ccw.
- 2) Note voltmeter indication; if not zero volts, adjust variable resistor R31 to obtain zero volts.

### Check high end of range:

- 1) Turn FINE and COARSE control maximum cw.
- 2) Note voltmeter indication; if not 500 volts, adjust variable resistor R33 to obtain 500 volts.

### Check low end of range again:

- 1) If zero volts not obtained, adjust R31 to obtain zero volts, and then check high end of range and adjust R33 to obtain 500 volts.
- 2) The settings of R31 and R33 are interdependent. Continue to adjust for zero and 500 volts until they are obtained simultaneously.



#### 4-4 REPLACEMENT OF ELECTROLYTIC CAPACITORS

The electrolytic capacitors in this instrument are high quality units which have a useful life of from five to ten years. Do not replace these capacitors unless they are proved defective by accurate tests.

#### 4-5 REPLACEMENT OF VARIABLE RESISTORS

##### 1. VARIABLE RESISTOR R11 -

Connections to variable resistor R11 are indicated in Figure 4-5 and location on the chassis in Figure 4-3.

To remove the old R11 and install the new, the instrument should be so placed that the bottom is uppermost. For convenience of maintenance personnel, all instructions in the following are with respect to the instrument in this upsidedown position. Front and rear are with respect to the control panel. Cams are identified in Figure 4-3.

a. Removal - The cams which actuate the micro-switches are mounted on an extension of the shaft of variable resistor R11, one (S1B) immediately in front of the switch mounting plate, the other immediately behind the mounting plate. The shaft of R11 and the extension are connected by means of a flexible mechanical coupler. To remove R11, it will be necessary to reposition the S1B cam and to disconnect the coupler from the R11 shaft. The procedure follows.

1) Unsolder the three leads connected to two R11 terminals.

2) Disconnect the coupler from the R11 shaft. With No. 6 allen wrench, loosen the two setscrews which fasten the front collar on the coupler to the shaft of resistor R11.

3) Reposition the S1B cam. With No. 8 allen wrench, loosen the two setscrews which fasten the cam to the shaft. Slide the cam toward the control panel.

4) Slide the shaft extension toward the rear of the instrument.

5) Remove COARSE control knob:

A. With No. 8 allen wrench, loosen the two setscrews, and remove the knob.

B. With 1/2" socket wrench, remove hex nut and flat washer on front of control panel, and two lockwashers on rear.

6) Remove R11 from chassis.

b. Installation - 1) Install assembly in reverse-of-removal order. NOTE: Do not fasten S1B cam to shaft at this time.

2) Solder leads to R11 terminals. Connections are shown in Figure 4-5.

c. Adjustments - 1) Coarse positioning of cams:

A. With No. 8 allen wrench, loosen setscrews on S1A (blue) cam immediately to rear of switch mounting plate.

B. Turn COARSE control max ccw. Position each cam with low side of cam toward switch actuator so that neither switch is operated.

C. Turn COARSE control max cw. See that high side of each cam is engaging respective switch actuator so that both switches are operated.

D. Tighten setscrews sufficiently to hold cams in position on shaft.

2) Set FINE control at electrical center, COARSE control max ccw.

3) Turn on instrument, and allow two-minute warm-up.

4) Fine positioning of S1B (black) cam:

A. Turn COARSE control until panel voltmeter indicates 195V.

B. Loosen setscrews and so position S1B (black) cam that (1) as COARSE control is turned cw, switch S1B operates as voltmeter indication is between 195V and approximately 200V; (2) as COARSE control is turned ccw, switch S1B releases as voltmeter indication is between 190V and approximately 195V.

C. Lock setscrews.

5) Fine positioning of S1A (blue) cam:

A. Turn COARSE control until panel voltmeter indicates 325V.

B. Loosen setscrews and so position S1A cam that (1) as COARSE control is turned cw, switch S1A operates as voltmeter indication is between 325 and approximately 330V; (2) as COARSE control is turned ccw, switch S1A releases as voltmeter indication is between 320 and approximately 325V.

C. Lock setscrews. Recheck high and low voltage limits (see paragraph 4-3c).

## 2. VARIABLE RESISTOR R14 -

Variable resistor R14, which is part of the shunt network across milliammeter M2, is mounted on resistor board RB2. Connections to R14 are indicated in Figure 4-4, and the location of RB2 on the chassis is shown in Figure 4-2.

To adjust R14 after replacement, the use of a standard milliammeter is required. The following adjustment procedure is recommended.

- a. Connect a standard milliammeter and a load, in series, across the DC VOLTAGE + and - output terminals.
- b. Adjust the COARSE control to obtain a reading of 80 ma on the reference milliammeter.
- c. If the Model 711A milliammeter does not indicate 80 ma, adjust R14 to bring the 711A milliammeter pointer right on 80.

## 4-6 REPLACEMENT OF RECTIFIERS

- a. Connections to the rectifiers are shown in Figure 4-5 and their locations on the chassis in Figure 4-3.
- b. After replacement of any rectifier, voltage at the output of the associated filter should be measured. If the output is not within the limits specified in subparagraph c, the replacement rectifier does not meet specifications and should be replaced.
- c. Measurements should be made with a 20,000 ohms-per-volt or better voltmeter, a line input of exactly 115 (or 230) volts, and no load connected to the output terminals.

SR1: connect voltmeter to capacitor C1 terminals 1 and 2; meter indication should be 200V  $\pm 10\%$ .

SR2-

- SR3: connect voltmeter to terminal 1 of capacitor C3 and to terminal 2 of capacitor C2.
- 1) With COARSE control at max ccw, meter indication should be 400V  $\pm 10\%$ .
  - 2) With COARSE control at max cw, meter indication should be 715V  $\pm 10\%$ .

SR4: connect voltmeter to capacitor C6 terminals 1 and 2; meter indication should be 350V  $\pm 10\%$ .

## 4-7 METER ZERO ADJUSTMENT

When the voltmeter is received from the factory, the position of the voltmeter and milliammeter pointers should be checked, and if the respective pointer does not indicate exactly on zero, the pointer should be reset to zero. The adjustment should be made before the voltmeter is connected to a power source.

The adjust screw is in the meter frame at a mid-point immediately below the meter face. The adjustment is made properly only when pointer adjust travel is in the opposite direction to the turn of the adjust screw. Though the adjust screw may be turned in either direction, a practical procedure is to turn the screw in a clockwise direction until the pointer starts to swing back toward zero. Then, still turning the screw clockwise, bring the pointer (now traveling counterclockwise) back to zero.

**NOTE:** For accurate positioning of the pointer, the resetting must be done with power disconnected from the instrument circuits. If during the life of the voltmeter it is necessary to reposition the pointer, wait at least fifteen minutes after disconnecting the power before resetting the pointer on zero.

## 4-8 POWER TRANSFORMER PRIMARY CONNECTIONS

Connections from the primary winding of power transformer T1 are brought out to a terminal strip (identified in Figure 4-3) mounted on under side of the deck, at the rear of the instrument.

The two sections of the power transformer primary are strapped at the factory for 115-volt operation. If the instrument is to be operated from a 230-volt power source:

- a. Change the strapping to connect the two sections of the primary in series, as indicated for 230-volt operation on the schematic diagram.
- b. Replace 1.6-ampere fuse F1 with a 0.8-ampere cartridge fuse of the same slo-blo type (see F1 description in the Table of Replaceable Parts, Section V).

**4-9 TROUBLE SHOOTING CHART**

The following chart lists various symptoms of trouble and for each indicates the part or parts of the circuit which should be checked. In the main, for purposes of simplification, only tubes are referenced, but it should be remembered that components associated with referenced tubes also are failure possibilities. With each section of the chart, checking should be performed in the order given since it is assumed throughout a procedure that the parts checked pre-

viously are functioning correctly.

When testing the Model 711A, it is recommended that line voltage be applied to the instrument through a variable transformer, and that the transformer be adjusted to deliver a voltage at the low end of the rated 103- to 127-volt range. An instrument in good condition operates satisfactorily from any line voltage within rated range, but where there is marginal operation (from weak tubes, etc.) weaknesses become easier to trace at low line voltages.

Table 4-1. Trouble Shooting Chart

SYMPTOM AND POSSIBLE CAUSE	TEST PROCEDURE
<p>1. Instrument NOT operating; AC voltage indicator light NOT lighted.</p> <p>a. Fuse open due to defective fuse or overload in power supply.</p>	<p>a. Replace fuse. If this fuse blows:</p> <ol style="list-style-type: none"> <li>(1) Remove all tubes and K1; again replace fuse.</li> <li>(2) If this fuse does not blow:                     <ol style="list-style-type: none"> <li>A. Check voltage across C1, C2-3 (with COARSE control max ccw), C6 (from terminal 3 to 1).                             <ol style="list-style-type: none"> <li>1. If output voltages are somewhat higher than those shown on the schematic, proceed to step B.</li> <li>2. If output from any rectifier less than normal, check rectifier and associated electrolytic capacitor.</li> </ol> </li> <li>B. Replace V3, V4, V5.                             <ol style="list-style-type: none"> <li>1. If fuse does not blow, proceed to step C.</li> <li>2. If fuse does blow:                                     <ol style="list-style-type: none"> <li>a. Check tubes by substituting tubes known to be good.</li> <li>b. If trouble is not in tubes, check resistors, capacitors, and wiring in secondary regulator and V4B circuits; tolerances given in Table of Replaceable Parts.</li> </ol> </li> </ol> </li> <li>C. Check that no load is connected to d-c output terminals. Reinstall V1 and V2, but not K1.                             <ol style="list-style-type: none"> <li>1. If fuse does not blow, replace K1.</li> <li>2. If fuse does blow, check V1 and V2 by removing one 6L6 and leaving other in circuit.</li> <li>3. If fuse blows when K1 is installed, K1 may be defective and arcing to ground.</li> </ol> </li> </ol> </li> <li>(3) If 2nd fuse does blow, localize as follows:                     <ol style="list-style-type: none"> <li>A. Disconnect rectifiers from their respective T1 secondary windings: one grey T1 lead from SR1, red T1 lead from SR3, one green T1 lead from SR4. Replace fuse.                             <ol style="list-style-type: none"> <li>1. If fuse does not blow, proceed to step B.</li> <li>2. If fuse does blow, short is in the primary or a filament winding. Disconnect green lead from pin 2, V2, and replace fuse. If fuse does not blow, trouble is in V1-V2 filament supply. If fuse blows, trouble probably is in V3-V4 filament supply, though it can be in a-c supply, indicator light circuits, or primary.</li> </ol> </li> </ol> </li> </ol>

Table 4-1. Trouble Shooting Chart (Cont'd.)

SYMPTOM AND POSSIBLE CAUSE	TEST PROCEDURE
<p>1. Instrument NOT operating; AC voltage indicator light NOT lighted.</p> <p>a. Fuse open due to defective fuse or overload in power supply. (CONT'D.)</p> <p>b. Poor connection to line voltage.</p>	<p>B. Reconnect green T1 lead to SR4.</p> <ol style="list-style-type: none"> <li>1. If fuse does not blow, proceed to step C.</li> <li>2. If fuse blows: <ol style="list-style-type: none"> <li>a. Check SR4 and associated wiring; if OK.</li> <li>b. Disconnect green T1 lead from SR4, replace fuse, and measure a-c voltage across SR4-supply winding: <ol style="list-style-type: none"> <li>1) Input voltage: exactly 115 (or 230)V, 50-1000<math>\nu</math>.</li> <li>2) Voltmeter: high impedance, average-responding VTVM - such as an <math>\phi</math> Model 400D.</li> <li>3) Rated rms voltage: <math>285 \pm 3\%</math> (VTVM connection may be made to disconnected lead and SR4 lug which terminates other green T1 lead).</li> </ol> </li> </ol> </li> </ol> <p>C. Reconnect green T1 lead to SR1.</p> <ol style="list-style-type: none"> <li>1. If fuse does not blow, proceed to step D.</li> <li>2. If fuse does blow: <ol style="list-style-type: none"> <li>a. Check SR1 and associated wiring; if OK.</li> <li>b. Disconnect grey T1 lead from SR1, replace fuse, and measure a-c voltage across SR1-supply winding: <ol style="list-style-type: none"> <li>1) See B2b (1), (2), above.</li> <li>2) Rated rms voltage: <math>150 \pm 3\%</math>.</li> </ol> </li> </ol> </li> </ol> <p>D. Check SR2, SR3, and associated wiring. If rectifiers and wiring are OK, measure a-c voltage across HV-supply winding:</p> <ol style="list-style-type: none"> <li>1. See B2b (1), (2) above.</li> <li>2. Turn COARSE control max cw.</li> <li>3. VTVM may be connected to red T1 lead, unsoldered from SR3, and S1A lug which terminates blue T1 lead.</li> <li>4. Rated rms voltage: <math>265 \pm 3\%</math>.</li> </ol> <p>b. Check power cable, and connections of both ends of cable.</p>
<p>2. Instrument NOT operating; AC voltage indicator light lighted.</p> <p>a. Secondary power supply and regulator not operating properly.</p> <p>b. Defective tube in main regulator.</p>	<p>a. Check voltage at output of secondary regulator:</p> <ol style="list-style-type: none"> <li>(1) D-c output voltage should be <math>200V \pm 10\%</math>. If d-c output not <math>200V \pm 10\%</math>, check V3, V4, and V5, SR4, and then other components of secondary regulator. <ol style="list-style-type: none"> <li>A. Connect voltmeter to pin 8 or V3 and pin 4 of V5.</li> <li>B. Use 20,000 ohms-per-volt voltmeter or better.</li> </ol> </li> <li>(2) A-c voltage should not be more than 0.002V. If ripple exceeds 0.003V, check V3. <ol style="list-style-type: none"> <li>A. Connect as in (1) A.</li> <li>B. Use high impedance, average-responding VTVM such as <math>\phi</math> Model 400D.</li> </ol> </li> </ol> <p>b. Check V4, V1, V2.</p> <ol style="list-style-type: none"> <li>(1) Check V4 by substituting 6U8 known to be good, and by checking potentials on tube pins; should be within <math>\pm 10\%</math> of values shown in Figure 4-8.</li> </ol>

Table 4-1. Trouble Shooting Chart (Cont'd.).

SYMPTOM AND POSSIBLE CAUSE	TEST PROCEDURE
<p>b. Defective tube in main regulator. (CONT'D.)</p> <p>c. Potential applied to tube pins not of proper values.</p> <p>d. Relay K1 held operated.</p>	<p>(2) Check V1, V2 as follows:</p> <p>A. Check that no load is connected to d-c output terminals.</p> <p>B. Remove one 6L6 and leave other in circuit. If trouble clears with one 6L6 out of circuit, replace that 6L6.</p> <p>c. Check d-c voltage on pins of all tube sockets: should be within <math>\pm 10\%</math> of those shown in Figure 4-8.</p> <p>d. Check that no load is connected to d-c output terminals. Remove K1. If voltmeter indicates the removal of K1 has corrected the trouble:</p> <p>(1) Check contacts on switch S2 (Figure 4-2)</p> <p>(2) Check for open resistor R2.</p> <p>(3) Check K1 by substituting relay known to be good.</p>
<p>3. Instrument operating, but output voltage is not at proper level.</p> <p>a. Control tube V4B not operating properly.</p> <p>b. Defective component in voltage divider.</p>	<p>a. Check V4 by substituting 6U8 known to be good, and by checking potentials on tube pins; should be within <math>\pm 10\%</math> of values shown in Figure 4-8.</p> <p>b. Turn COARSE and FINE controls from max ccw to max cw, and note voltmeter indication:</p> <p>(1) At max ccw, vm should read less than zero.</p> <p>(2) At max cw, vm should read more than 500. Refer to paragraph 4-3c for adjustment.</p>
<p>4. Level of output cannot be adjusted lower than 175-225 volts.</p> <p>a. Short in V1 and/or V2.</p>	<p>a. Check that no load is connected to d-c output terminals, remove one 6L6, and leave other in circuit. If zero output can be obtained with one 6L6 out of circuit, replace that 6L6.</p>
<p>5. When relay K1 is operated (current at overload), resistor R2 burns out.</p>	<p>5. R2 burns out because of intermittent arc or permanent short between K1 pin 7 (+400 to +700V) and pin 6 (-200V) when relay K1 is operated.</p>

#### 4-10 TROUBLE LOCALIZATION

When the cause of instrument failure or substandard operation is of a more obscure nature than the possibilities covered by the trouble-shooting chart, the failure should be localized to a section of the circuit, and then isolated within the section. Basic sections of the circuit are defined in Figure 4-1. It is

recommended that testing to localize trouble start with the secondary regulator.

After isolating trouble to a section of the circuit which includes more than one tube, the next step is to determine the tube circuit involved. A replacement tube should be tried before attempting

any other tests. If trouble persists, voltage and resistance measurements should be made. Typical d-c voltages and resistances to ground from tube socket pins are given in Figure 4-8. Variations from these values do not necessarily indicate trouble, as the values will vary somewhat between instruments, with variations in line voltages, and with

component tolerances. Generally a variation of  $\pm 10\%$  is to be expected and even higher variations may be within the normal range. As a guide to the order of variation that may be considered normal, consult the Table of Replaceable Parts at the back of the instruction book; the Table includes tolerances for most resistors and capacitors.

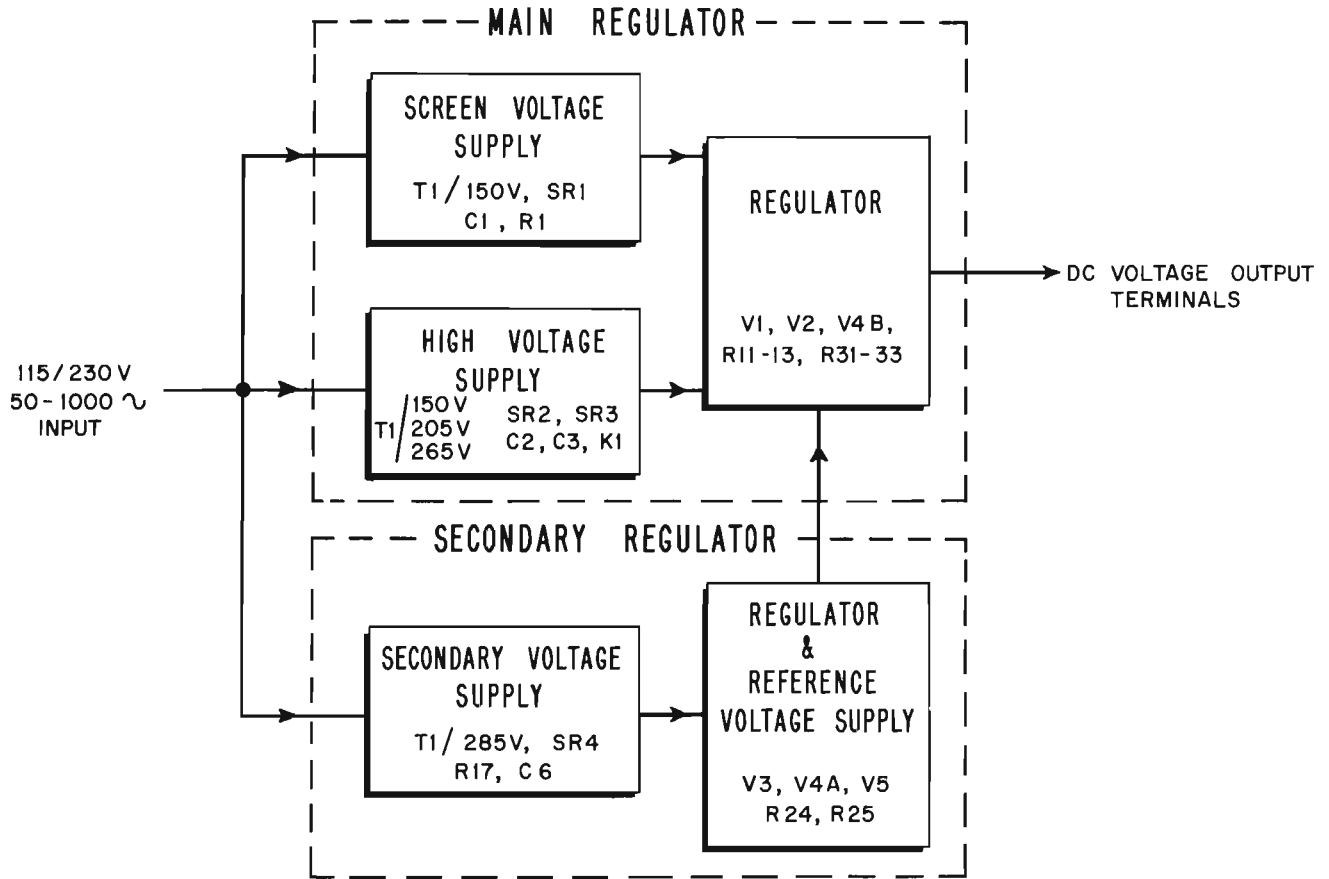


Figure 4-1. Model 711A Sectionalization Diagram

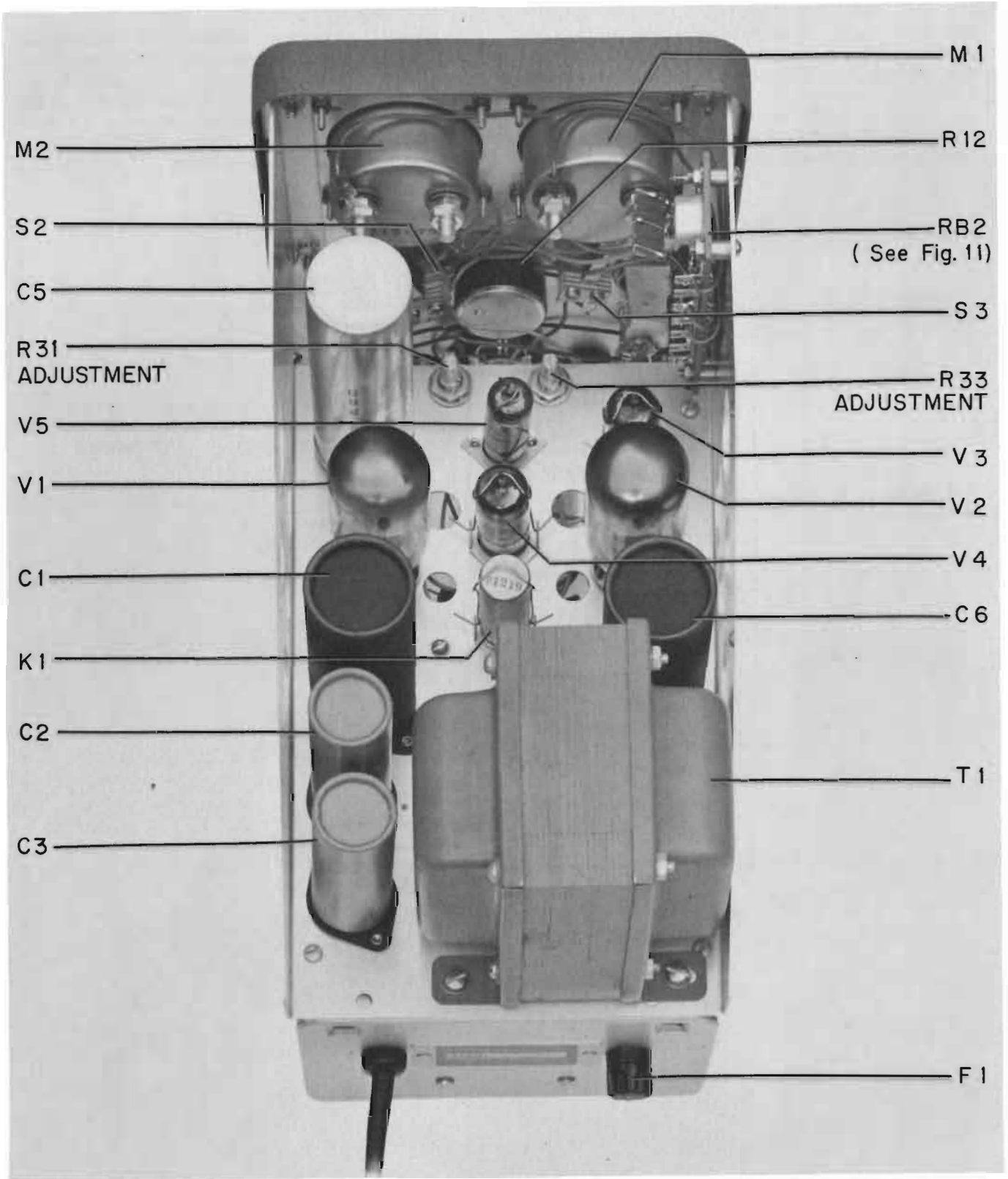


Figure 4-2. Model 711A Top View Cover Removed

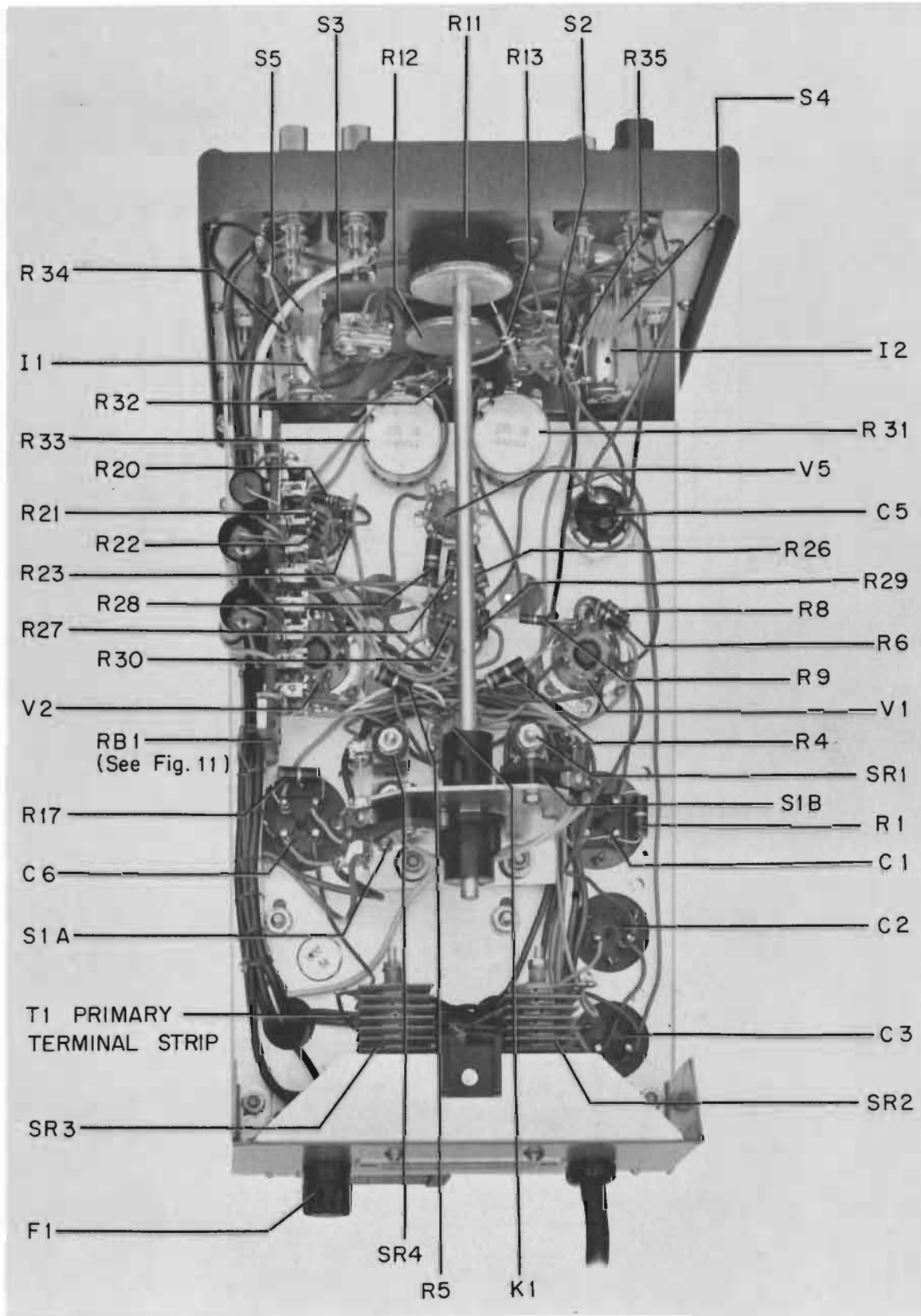
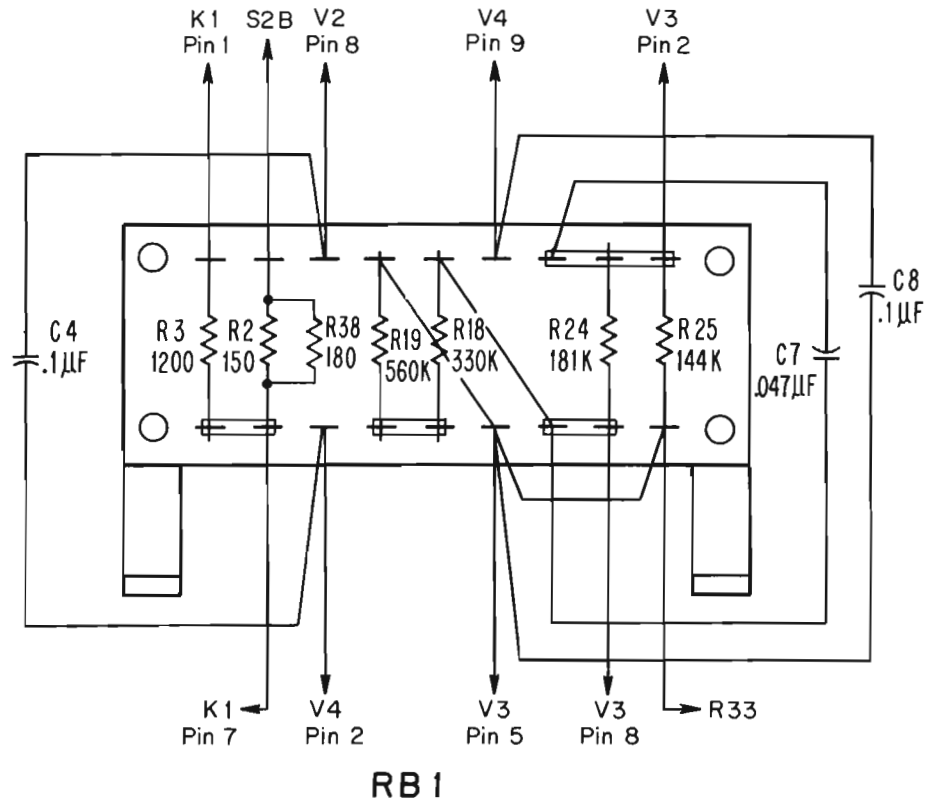
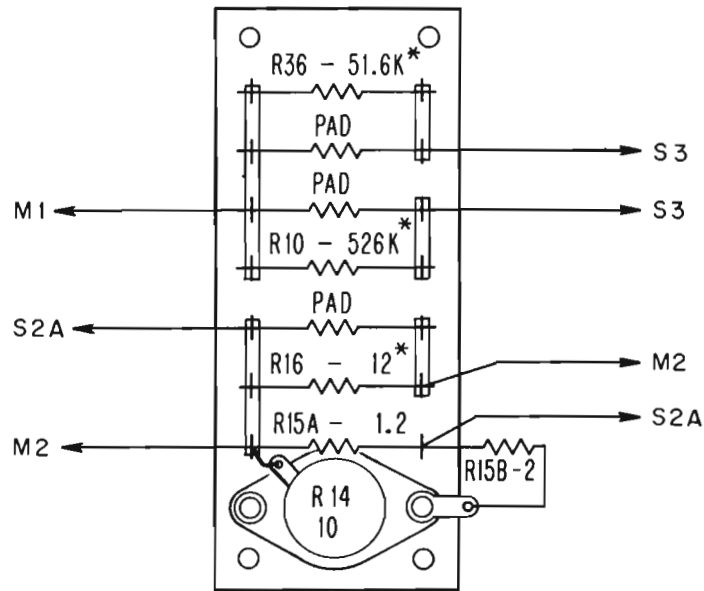


Figure 4-3. Model 711A Bottom View Cover Removed





RB1



RB2

Figure 4-4. Model 711A Resistor Board Detail

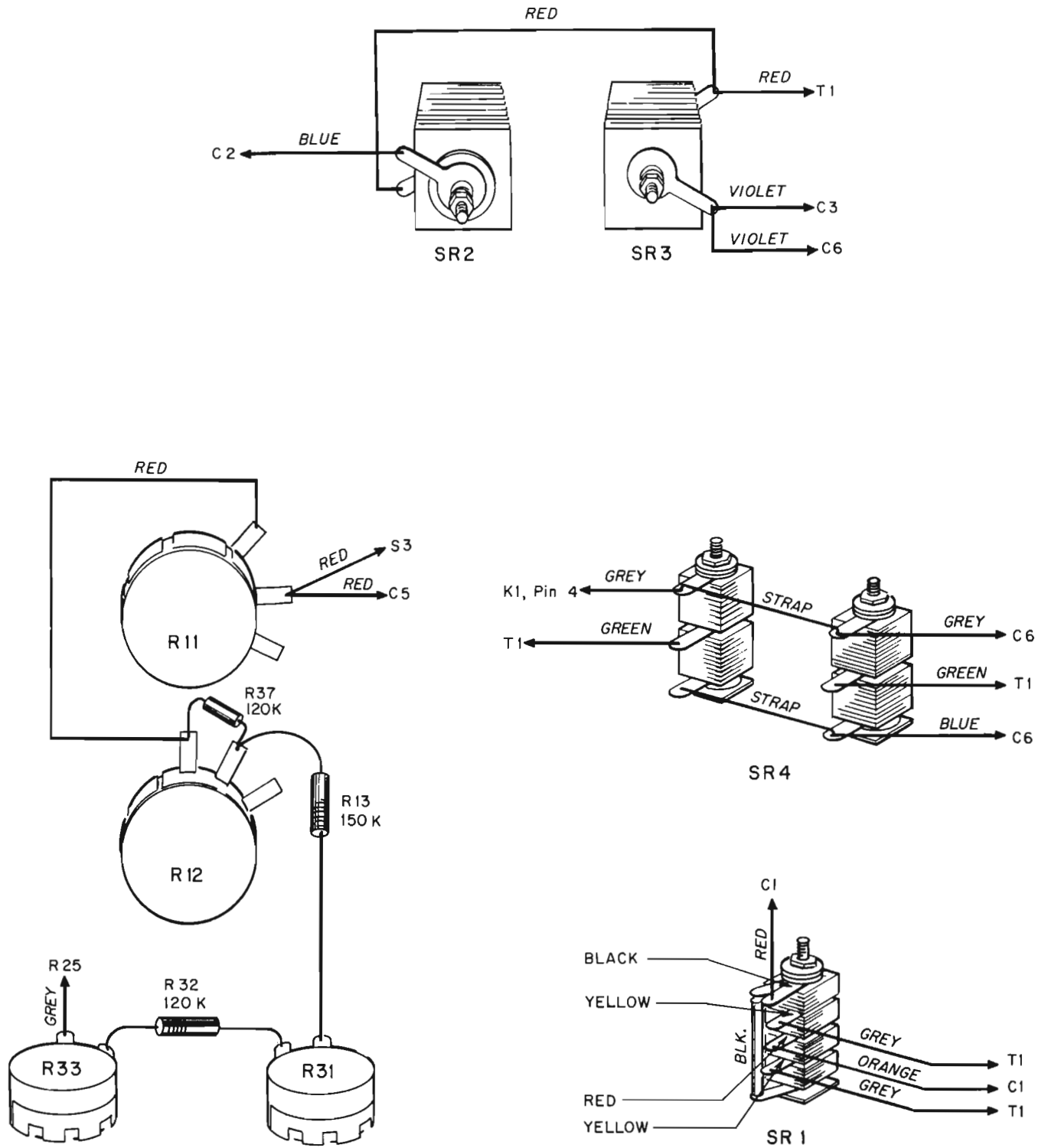


Figure 4-5. Model 711A Variable Resistor and Rectifier Detail

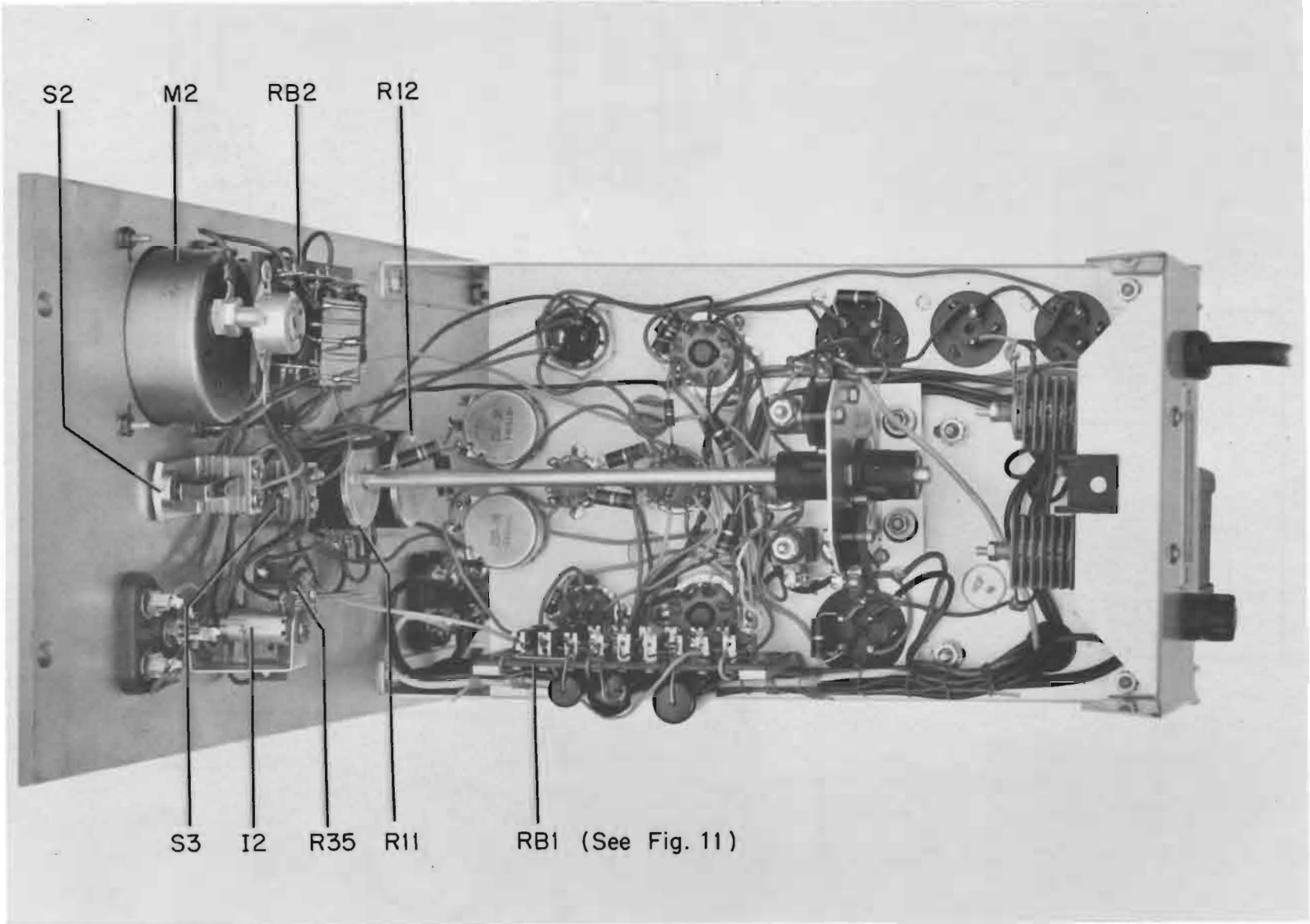


Figure 4-6. Model 711AR View of Right Side Cover Removed

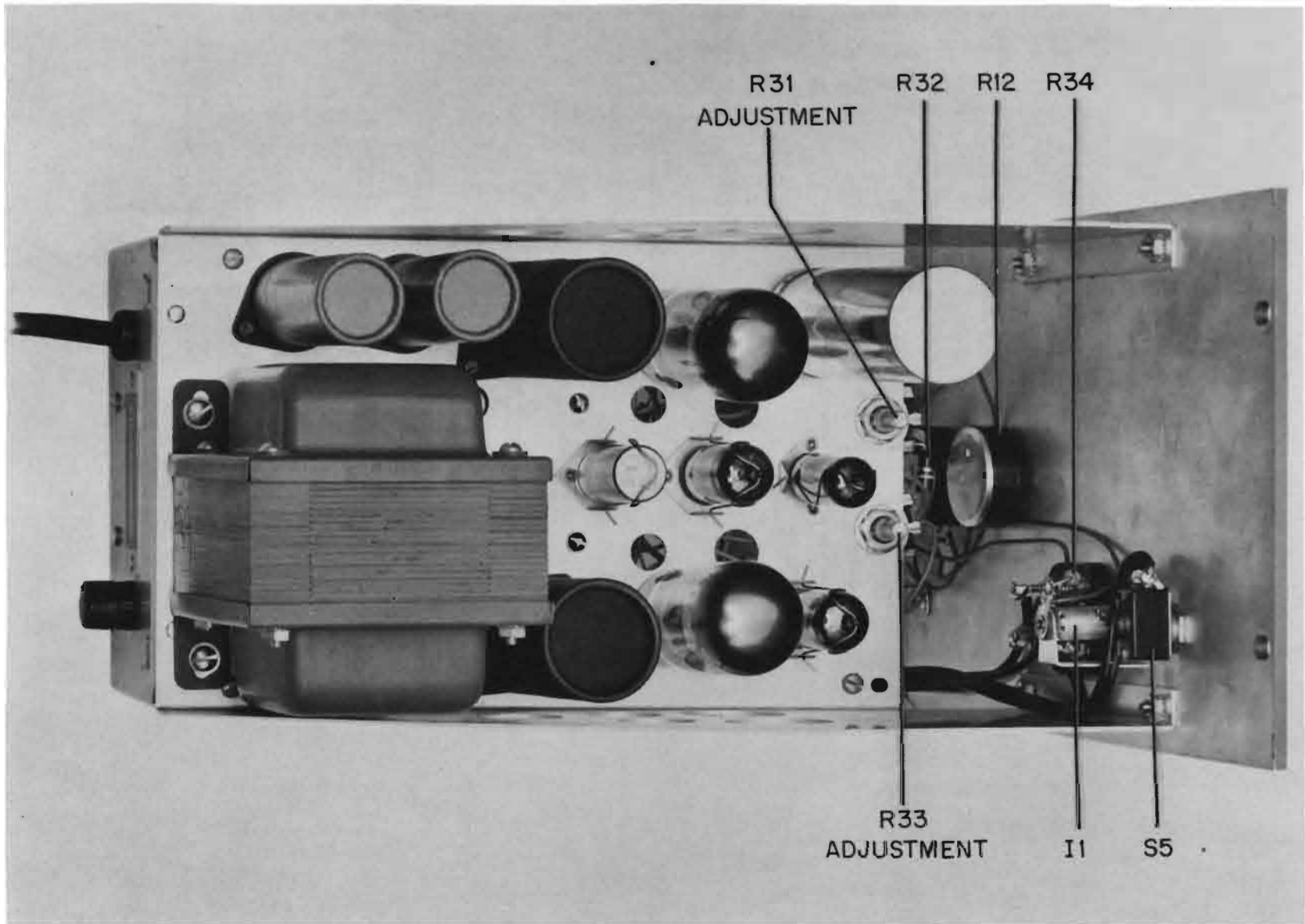


Figure 4-7. Model 711AR View of Left Side Cover Removed

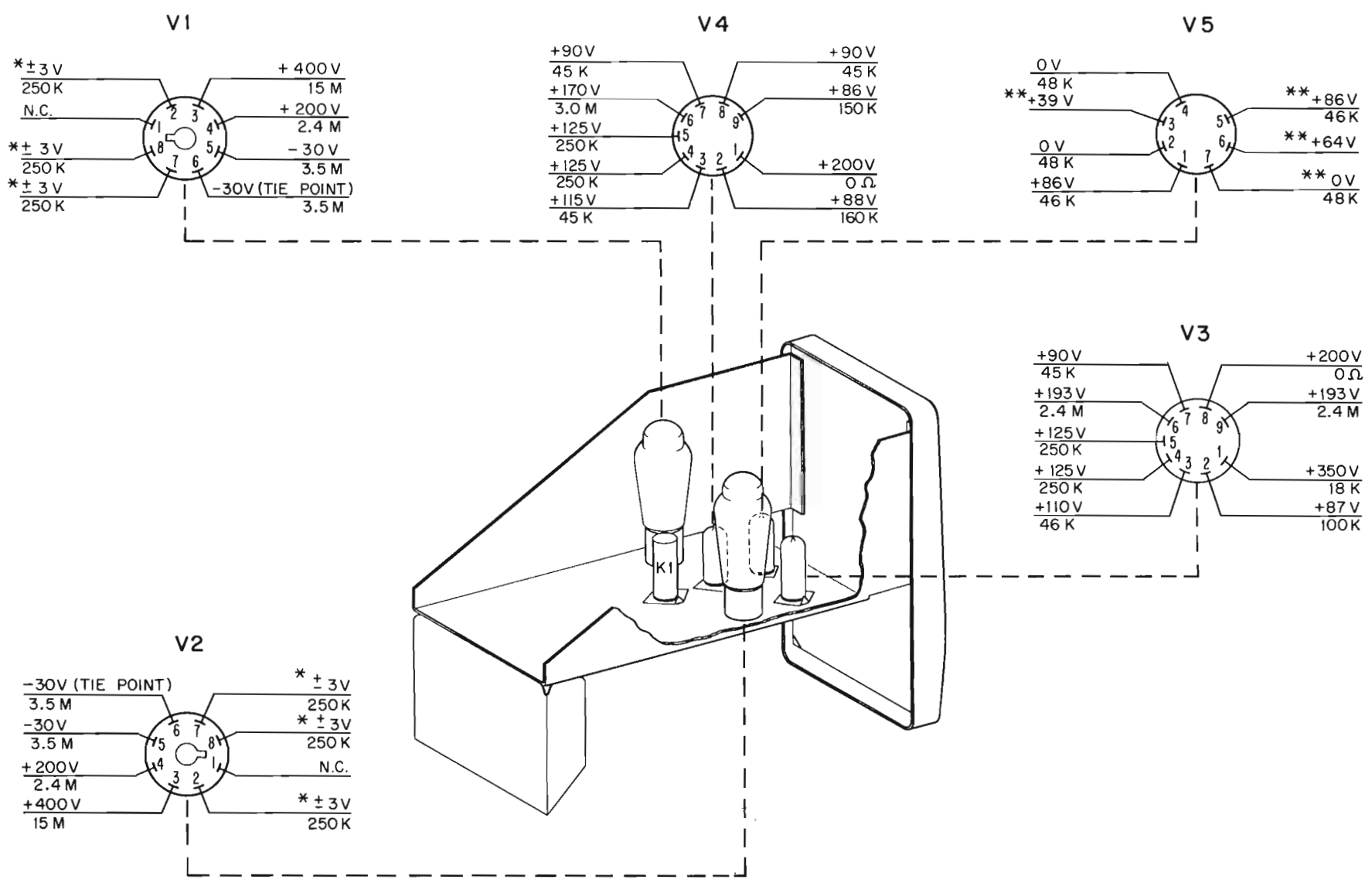
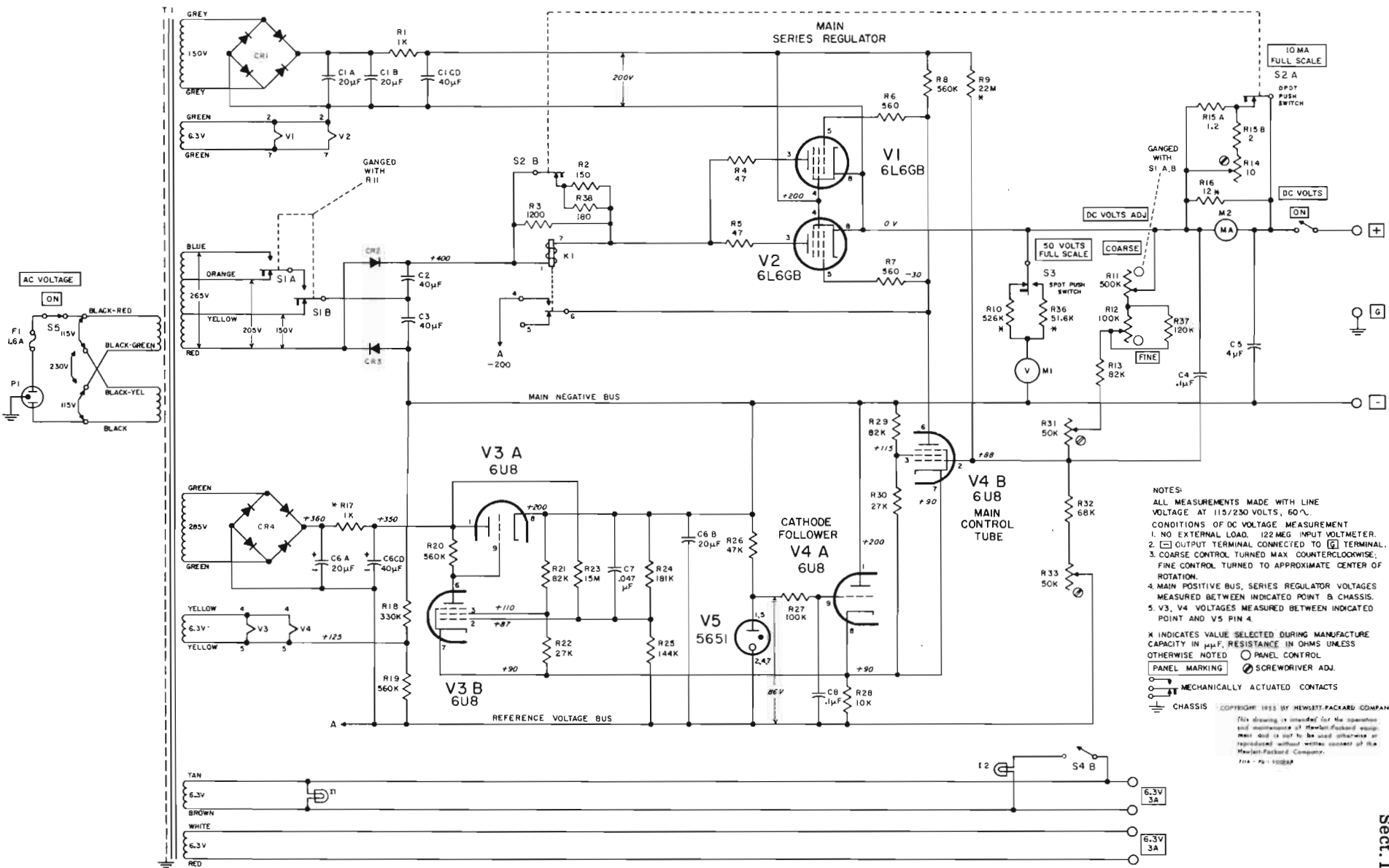


Figure 4-8. Model 711A Tube Diagram Typical Socket Voltages and Resistances



NOTES:  
 ALL MEASUREMENTS MADE WITH LINE VOLTAGE AT 115/230 VOLTS, 60 $\phi$ .  
 CONDITIONS OF DC VOLTAGE MEASUREMENT  
 1. NO EXTERNAL LOAD. 122 MEG INPUT VOLTAGE.  
 2. [C] OUTPUT TERMINAL CONNECTED TO [G] TERMINAL.  
 3. COARSE CONTROL TURNED MAX. COUNTERCLOCKWISE, FINE CONTROL TURNED TO APPROXIMATE CENTER OF ROTATION.  
 4. MAIN POSITIVE BUS, SERIES REGULATOR VOLTAGES MEASURED BETWEEN INDICATED POINT & CHASSIS.  
 5. V3, V4 VOLTAGES MEASURED BETWEEN INDICATED POINT AND V5 PIN 4.  
 X INDICATES VALUE SELECTED DURING MANUFACTURE CAPACITY IN  $\mu$ F, RESISTANCE IN OHMS UNLESS OTHERWISE NOTED  
 ○ PANEL CONTROL    ⊕ SCREWDRIVER ADJ.  
 ○ MECHANICALLY ACTUATED CONTACTS  
 ⊕ CHASSIS

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 711A - P4 - 100288P


Figure 4-9. Model 711A Schematic Diagram

## SECTION V TABLE OF REPLACEABLE PARTS

### NOTE

Standard components have been used in this instrument, whenever possible. Special components may be obtained from your local Hewlett-Packard representative or from the factory.

When ordering parts always include:

1.  Stock Number.
2. Complete description of part including circuit reference.
3. Model number and serial number of instrument.
4. If part is not listed, give complete description, function and location of part.

Corrections to the Table of Replaceable Parts are listed on an Instruction Manual Change sheet at the front of this manual.

### RECOMMENDED SPARE PARTS LIST

Column RS in the Table lists the recommended spare parts quantities to maintain one instrument for one year of isolated service. Order complete spare parts kits from the Factory Parts Sales Department. ALWAYS MENTION THE MODEL AND SERIAL NUMBERS OF INSTRUMENTS INVOLVED.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	STOCK NO.	TQ	RS		
C1A-D	Capacitor: fixed, electrolytic, 4 section, 20 $\mu$ f/sect., 450 vdcw HP*	18-42HP	2	1		
C2, 3	Capacitor: fixed, electrolytic, 40 $\mu$ f, 450 vdcw HP*	18-40HP	2	1		
C4	Capacitor: fixed, paper, .1 $\mu$ f $\pm$ 5%, 600 vdcw CC*	16-54	1	1		
C5	Capacitor: fixed, paper, 4 $\mu$ f $\pm$ 10%, 600 vdcw Z*	17-10	1	1		
C6A-D	Same as C1A-D					
C7	Capacitor: fixed, paper, .047 $\mu$ f $\pm$ 10%, 600 vdcw CC*	16-15	1	1		
C8	Capacitor: fixed, paper, .1 $\mu$ f $\pm$ 10%, 600 vdcw CC*	16-1	1	1		
CR1	Rectifier, metallic: 180V rms 40 ma dc max CN*	212-95	1	1		
CR2, 3	Rectifier, metallic: 585V rms max 120 ma dc max N*	212-107	2	2		
CR4	Rectifier, metallic: 162V rms max 20 ma dc max CN*	212-114	1	1		
F1	Fuse: 1.6A, 125V, slow-blow E*	211-15	1	10		
I1, 2	Lamp, incandescent: 6-8V 2 pin base, GE #12 O*	211-78	2	2		
K1	Relay: SPDT CT*	49-21	1	1		
M1	Meter: voltmeter, 0-500 V HP*	112-73	1	1		
P1	Cable, power HP*	812-56	1	1		

\* See "List of Manufacturers Code Letters For Replaceable Parts Table".

TQ - Total quantity used in the instrument.

RS - Recommended spares for one year isolated service for one instrument.



TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	Ⓢ STOCK NO.	TQ	RS		
R1	Resistor: fixed, composition, 1000 ohms $\pm 10\%$ , 1 W B*	24-1000	1	1		
R2	Resistor: fixed, composition, 150 ohms $\pm 10\%$ , 1 W B*	24-150	1	1		
R3	Resistor: fixed, composition, 1200 ohms $\pm 10\%$ , 1 W B*	24-1200	1	1		
R4, 5	Resistor: fixed, composition, 47 ohms $\pm 10\%$ , 1 W B*	24-47	2	1		
R6, 7	Resistor: fixed, composition, 560 ohms $\pm 10\%$ , 1/2 W B*	23-560	2	1		
R8	Resistor: fixed, composition, 560,000 ohms $\pm 10\%$ , 1 W B*	24-560K	1	1		
R9	Resistor: fixed, composition, 22 megohms $\pm 10\%$ , 1/2 W Optimum value selected at factory. Average value shown. B*	23-22M	1	1		
R10	Resistor: fixed, deposited carbon, 526,000 ohms $\pm 1\%$ , 1 W HP*	31-526K	1	1		
R11	Resistor: variable, composition, 500,000 ohms $\pm 20\%$ , 2 W B*	210-140	1	1		
R12	Resistor: variable, composition, 100,000 ohms $\pm 10\%$ , 2 W B*	210-64	1	1		
R13	Resistor: fixed, composition, 82,000 ohms $\pm 10\%$ , 1 W B*	24-82K	1	1		
R14	Resistor: variable, wirewound, linear taper 10 ohms $\pm 30\%$ , 1 W AT*	210-43	1	1		
R15A, B	Resistor: fixed, wirewound, 2 section, 1.2 ohms, 2 ohms HP*	711A-26A	1	1		
R16	Resistor: fixed, composition, 12 ohms $\pm 10\%$ , 1/2 W B*	23-12	1	1		
R17	Resistor: fixed, composition, 1000 ohms $\pm 10\%$ , 1 W Optimum value selected at factory. Average value shown. B*	24-1000	1	1		
R18	Resistor: fixed, composition, 330,000 ohms $\pm 10\%$ , 1/2 W B*	23-330K	1	1		

\* See "List of Manufacturers Code Letters For Replaceable Parts Table".

TQ - Total quantity used in the instrument.

RS - Recommended spares for one year isolated service for one instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	Ⓟ STOCK NO.	TQ	RS		
R19	Resistor: fixed, composition, 560,000 ohms $\pm 10\%$ , 1/2 W B*	23-560K	1	1		
R20	Resistor: fixed, composition, 560,000 ohms $\pm 10\%$ , 1 W B*	24-560K	1	1		
R21	Resistor: fixed, composition, 82,000 ohms $\pm 10\%$ , 1/2 W B*	23-82K	2	1		
R22	Resistor: fixed, composition, 27,000 ohms $\pm 10\%$ , 1/2 W B*	23-27K	2	1		
R23	Resistor: fixed, composition, 15 megohms $\pm 10\%$ , 1/2 W B*	23-15M	1	1		
R24	Resistor: fixed, deposited carbon, 181,000 ohms $\pm 1\%$ , 1 W HP*	31-181K	1	1		
R25	Resistor: fixed, deposited carbon, 144,000 ohms $\pm 1\%$ , 1 W HP*	31-144K	1	1		
R26	Resistor: fixed, composition, 27,000 ohms $\pm 10\%$ , 1 W B*	24-27K	1	1		
R27	Resistor: fixed, composition, 100,000 ohms $\pm 10\%$ , 1/2 W B*	23-100K	1	1		
R28	Resistor: fixed, composition, 10,000 ohms $\pm 10\%$ , 1 W B*	24-10K	1	1		
R29	Same as R21					
R30	Same as R22					
R31	Resistor: variable, composition, 50,000 ohms $\pm 20\%$ , 1/3 W BO*	210-209	2	1		
R32	Resistor: fixed, composition, 68,000 ohms $\pm 10\%$ , 1 W B*	24-68K	1	1		
R33	Same as R31					
R34, 35	These circuit references not assigned					
R36	Resistor: fixed, deposited carbon, 51,600 ohms $\pm 1\%$ , 1 W HP*	31-51.6K	1	1		
R37	Resistor: fixed, composition, 120,000 ohms $\pm 10\%$ , 1 W B*	24-120K	1	1		

\* See "List of Manufacturers Code Letters For Replaceable Parts Table".

TQ - Total quantity used in the instrument.

RS - Recommended spares for one year isolated service for one instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	Ⓟ STOCK NO.	TQ	RS		
R38	Resistor: fixed, composition, 180 ohms $\pm 10\%$ , 1 W	B* 24-180	1	1		
S1A, B	Switch, micro: SPDT	AQ* 310-136	1	1		
S2	Switch, push: DPDT	KK* 310-158	1	1		
S3	Switch, push: SPDT	KK* 310-53	1	1		
S4	Switch, toggle: DPST	HP* 310-21	1	1		
S5	Switch, toggle	HP* 310-11	1	1		
T1	Transformer, power	HP* 910-135	1	1		
V1, 2	Tube, electron: 6L6GB	ZZ* 212-6L6GB	2	2		
V3, 4	Tube, electron: 6U8	ZZ* 212-6U8	2	2		
V5	Tube, electron: 5651	ZZ* 212-5651	1	1		
<u>MISCELLANEOUS</u>						
	Binding post assembly: black	HP* G-10C	1	1		
	Binding post assembly: red	HP* G-10D	1	1		
	Insulator, binding post: 2 post	HP* G-83A	1	1		
	Insulator, binding post: 3 post	HP* G-83D	1	1		
	Jewel, pilot light	HP* 145-23A	1	1		
	Knob: FINE	HP* G-74C	1	1		
	Knob: COARSE	HP* G-74R	1	1		
	Lampholder	HP* 145-25	2	1		

\* See "List of Manufacturers Code Letters For Replaceable Parts Table".

TQ - Total quantity used in the instrument.

RS - Recommended spares for one year isolated service for one instrument.

## LIST OF CODE LETTERS USED IN TABLE OF REPLACEABLE PARTS TO DESIGNATE THE MANUFACTURERS

CODE LETTER	MANUFACTURER	ADDRESS	CODE LETTER	MANUFACTURER	ADDRESS
A	Aerovox Corp.	New Bedford, Mass.	AK	Hammerlund Mfg. Co., Inc.	New York 1, N. Y.
B	Allen-Bradley Co.	Milwaukee 4, Wis.	AL	Industrial Condenser Corp.	Chicago 18, Ill.
C	Amperite Co.	New York, N. Y.	AM	Insuline Corp. of America	Manchester, N. H.
D	Arrow, Hart & Hegeman	Hartford, Conn.	AN	Jennings Radio Mfg. Corp.	San Jose, Calif.
E	Bussman Manufacturing Co.	St. Louis, Mo.	AO	E. F. Johnson Co.	Waseca, Minn.
F	Carborundum Co.	Niagara Falls, N. Y.	AP	Lenz Electric Mfg. Co.	Chicago 47, Ill.
G	Centralab	Milwaukee 1, Wis.	AQ	Micro-Switch	Freeport, Ill.
H	Cinch-Jones Mfg. Co.	Chicago 24, Ill.	AR	Mechanical Industries Prod. Co.	Akron 8, Ohio
HP	Hewlett-Packard Co.	Palo Alto, Calif.	AS	Model Eng. & Mfg., Inc.	Huntington, Ind.
I	Clarostat Mfg. Co.	Dover, N. H.	AT	The Muter Co.	Chicago 5, Ill.
J	Cornell Dubilier Elec. Co.	South Plainfield, N. J.	AU	Ohmite Mfg. Co.	Skokie, Ill.
K	Hi-Q Division of Aerovox	Olean, N. Y.	AV	Resistance Products Co.	Harrisburg, Pa.
L	Erie Resistor Corp.	Erie 6, Pa.	AW	Radio Condenser Co.	Camden 3, N. J.
M	Fed. Telephone & Radio Corp.	Clifton, N. J.	AX	Shallcross Manufacturing Co.	Collingdale, Pa.
N	General Electric Co.	Schenectady 5, N. Y.	AY	Solar Manufacturing Co.	Los Angeles 58, Calif.
O	General Electric Supply Corp.	San Francisco, Calif.	AZ	Sealectra Corp.	New Rochelle, N. Y.
P	Girard-Hopkins	Oakland, Calif.	BA	Spencer Thermostat	Attleboro, Mass.
Q	Industrial Products Co.	Danbury, Conn.	BC	Stevens Manufacturing Co.	Mansfield, Ohio
R	International Resistance Co.	Philadelphia 8, Pa.	BD	Torrington Manufacturing Co.	Van Nuys, Calif.
S	Lectrohm Inc.	Chicago 20, Ill.	BE	Vector Electronic Co.	Los Angeles 65, Calif.
T	Littlefuse Inc.	Des Plaines, Ill.	BF	Weston Electrical Inst. Corp.	Newark 5, N. J.
U	Maguire Industries Inc.	Greenwich, Conn.	BG	Advance Electric & Relay Co.	Burbank, Calif.
V	Micamold Radio Corp.	Brooklyn 37, N. Y.	BH	E. I. DuPont	San Francisco, Calif.
W	Oak Manufacturing Co.	Chicago 10, Ill.	BI	Electronics Tube Corp.	Philadelphia 18, Pa.
X	P. R. Mallory Co., Inc.	Indianapolis, Ind.	BJ	Aircraft Radio Corp.	Boonton, N. J.
Y	Radio Corp. of America	Harrison, N. J.	BK	Allied Control Co., Inc.	New York 21, N. Y.
Z	Sangamo Electric Co.	Marion, Ill.	BL	Augat Brothers, Inc.	Attleboro, Mass.
AA	Sarkes Tarzian	Bloomington, Ind.	BM	Carter Radio Division	Chicago, Ill.
BB	Signal Indicator Co.	Brooklyn 37, N. Y.	BN	CBS Hytron Radio & Electric	Danvers, Mass.
CC	Sprague Electric Co.	North Adams, Mass.	BO	Chicago Telephone Supply	Elkhart, Ind.
DD	Stackpole Carbon Co.	St. Marys, Pa.	BP	Henry L. Crowley Co., Inc.	West Orange, N. J.
EE	Sylvania Electric Products Co.	Warren, Pa.	BQ	Curtiss-Wright Corp.	Carlstadt, N. J.
FF	Western Electric Co.	New York 5, N. Y.	BR	Allen B. DuMont Labs	Clifton, N. J.
GG	Wilkor Products, Inc.	Cleveland, Ohio	BS	Excel Transformer Co.	Oakland, Calif.
HH	Amphenol	Chicago 50, Ill.	BT	General Radio Co.	Cambridge 39, Mass.
II	Dial Light Co. of America	Brooklyn 37, N. Y.	BU	Hughes Aircraft Co.	Culver City, Calif.
JJ	Leecraft Manufacturing Co.	New York, N. Y.	BV	International Rectifier Corp.	El Segundo, Calif.
KK	Switchcraft, Inc.	Chicago 22, Ill.	BW	James Knights Co.	Sandwich, Ill.
LL	Gremar Manufacturing Co.	Wakefield, Mass.	BX	Mueller Electric Co.	Cleveland, Ohio
MM	Carad Corp.	Redwood City, Calif.	BY	Precision Thermometer & Inst. Co.	Philadelphia 30, Pa.
NN	Electra Manufacturing Co.	Kansas City, Mo.	BZ	Radio Essentials Inc.	Mt. Vernon, N. Y.
OO	Acro Manufacturing Co.	Columbus 16, Ohio	CA	Raytheon Manufacturing Co.	Newton, Mass.
PP	Alliance Manufacturing Co.	Alliance, Ohio	CB	Tung-Sol Lamp Works, Inc.	Newark 4, N. J.
QQ	Arco Electronics, Inc.	New York 13, N. Y.	CD	Varian Associates	Palo Alto, Calif.
RR	Astron Corp.	East Newark, N. J.	CE	Victory Engineering Corp.	Union, N. J.
SS	Axel Brothers Inc.	Long Island City, N. Y.	CF	Weckesser Co.	Chicago 30, Ill.
TT	Belden Manufacturing Co.	Chicago 44, Ill.	CG	Wilco Corporation	Indianapolis, Ind.
UU	Bird Electronics Corp.	Cleveland 14, Ohio	CH	Winchester Electronics, Inc.	Santa Monica, Calif.
VV	Barber Colman Co.	Rockford, Ill.	CI	Malco Tool & Die	Los Angeles 42, Calif.
WW	Bud Radio Inc.	Cleveland 3, Ohio	CJ	Oxford Electric Corp.	Chicago 15, Ill.
XX	Allen D. Cardwell Mfg. Co.	Plainville, Conn.	CK	Camloc-Fastener Corp.	Paramus, N. J.
YY	Cinema Engineering Co.	Burbank, Calif.	CL	George K. Garrett	Philadelphia 34, Pa.
ZZ	Any brand tube meeting RETMA standards.		CM	Union Switch & Signal	Swissvale, Pa.
AB	Corning Glass Works	Corning, N. Y.	CN	Radio Receptor	New York 11, N. Y.
AC	Dale Products, Inc.	Columbus, Neb.	CO	Automatic & Precision Mfg. Co.	Yonkers, N. Y.
AD	The Drake Mfg. Co.	Chicago 22, Ill.	CP	Bassick Co.	Bridgeport 2, Conn.
AE	Elco Corp.	Philadelphia 24, Pa.	CQ	Birnbach Radio Co.	New York 13, N. Y.
AF	Hugh H. Eby Co.	Philadelphia 44, Pa.	CR	Fischer Specialties	Cincinnati 6, Ohio
AG	Thomas A. Edison, Inc.	West Orange, N. J.	CS	Telefunken (c/o MVM, Inc.)	New York, N. Y.
AH	Fansteel Metallurgical Corp.	North Chicago, Ill.	CT	Potter-Brumfield Co.	Princeton, Ind.
AI	General Ceramics & Steatite Corp.	Keasbey, N. J.	CU	Cannon Electric Co.	Los Angeles, Calif.
AJ	The Gudeman Co.	Sunnyvale, Calif.	CV	Dynac, Inc.	Palo Alto, Calif.
			CW	Good-All Electric Mfg. Co.	Ogallala, Nebr.

## CLAIM FOR DAMAGE IN SHIPMENT

The 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.

## WARRANTY

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. Klystron tubes as well as other electron tubes, fuses and batteries are specifically excluded from any liability. This warranty is effective for one year after delivery to the original purchaser when the instrument is returned, transportation charges prepaid by the original purchaser, and when upon our examination it is disclosed to our satisfaction to be defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost. In this case, an estimate will be submitted before the work is started.

If any fault develops, the following steps should be taken:

1. Notify us, giving full details of the difficulty, and include the model number and serial number. On receipt of this information, we will give you service data or shipping instructions.
2. On receipt of shipping instructions, forward the instrument prepaid, to the factory or to the authorized repair station indicated on the instructions. If requested, an estimate of the charges will be made before the work begins provided the instrument is not covered by the warranty.

## SHIPPING

All shipments of Hewlett-Packard instruments should be made via Truck or Railway Express. The instruments should be packed in a strong exterior container and surrounded by two or three inches of excelsior or similar shock-absorbing material.

## DO NOT HESITATE TO CALL ON US

**HEWLETT-PACKARD COMPANY**

*Laboratory Instruments for Speed and Accuracy*

275 PAGE MILL ROAD

PALO ALTO, CALIF. U.S.A.

CABLE



"HEWPACK"

