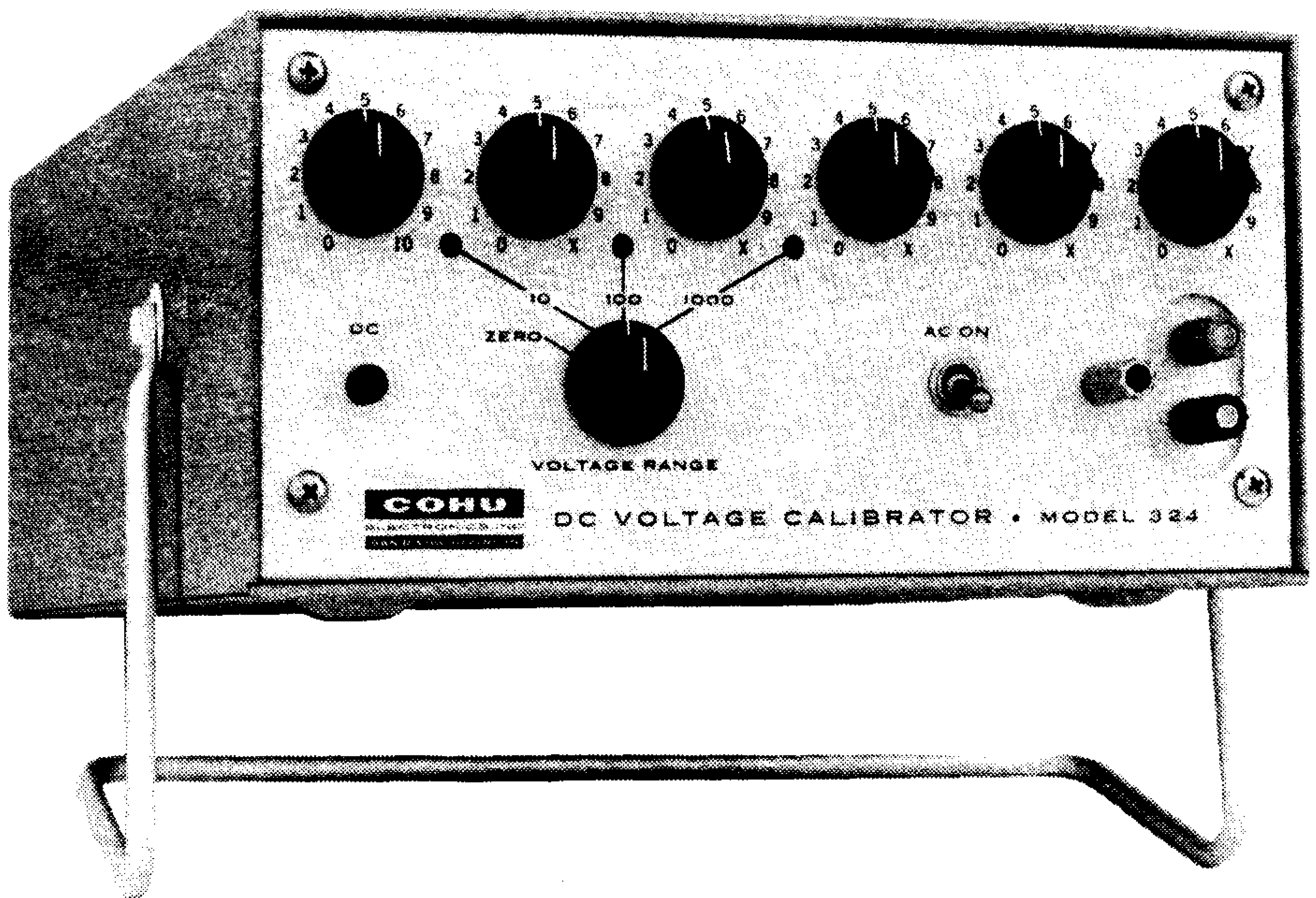
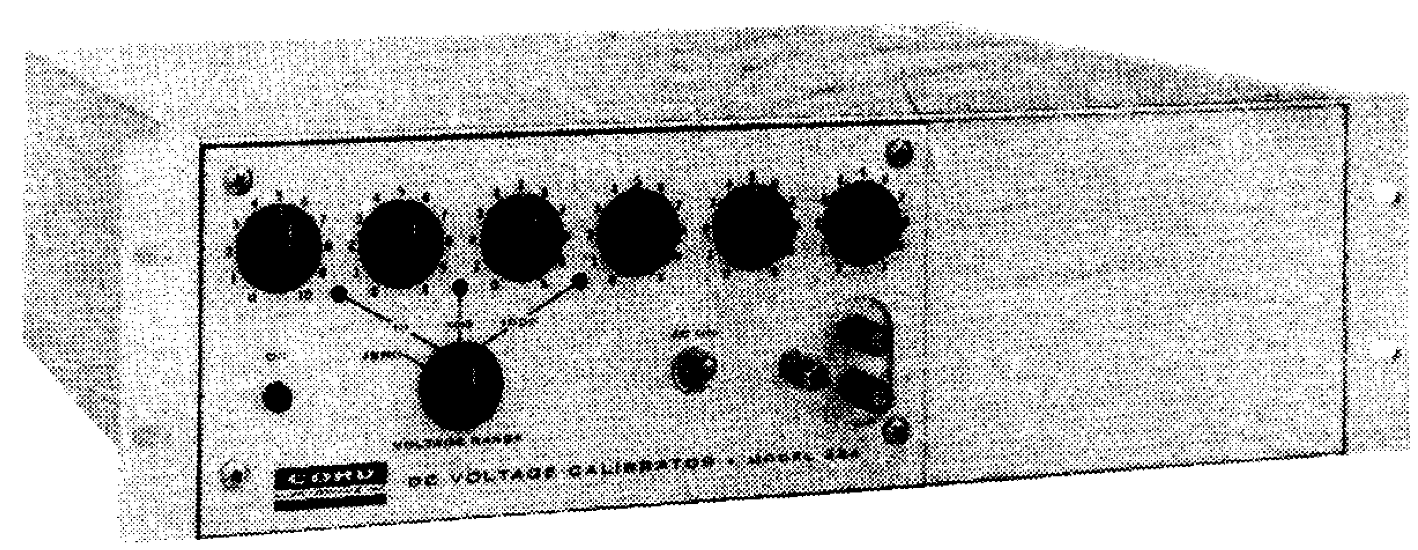
Technical Manual
Code No. 15X-61





OPERATING AND MAINTENANCE INSTRUCTIONS FOR

DC VOLTAGE CALIBRATOR

MODEL 324

Box 623 / San Diego, California 92112 / Phone (714) 277-6700

COHU ELECTRONICS, INC
SAN DIEGO DIVISION

Technical Manual
Code No. 15X-61

OPERATING AND MAINTENANCE INSTRUCTIONS FOR MODEL 324 DC VOLTAGE CALIBRATOR

SERIAL NUMBERS 1-0001 THROUGH 1-0110

COHU ELECTRONICS, INC.
Box 623, San Diego, California 92112

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Section I
GENERAL DESCRIPTION

1–1. INTRODUCTION

The DC Voltage Calibrator is a portable, low-impedance source of highly accurate and stable dc voltage. The instrument supplies voltages from 0.00000 to ±1111.110 volts, which are selected by a range multiplier dial and six decade dials. The range dial has nominal full-scale 10-, 100-, and 1000-volt ranges, and indicates the decimal-point placement, in the readout of the decade dials, according to the range selected. The range dial also has a zero-volt-output position. The decade dials control detented, bi-directional, make-before-break, rotary switches. Output voltages higher than 1000 volts are obtained by the use of the overrange positions marked X (marked 10 on the extreme left-hand dial) on the decade dials.

The output current capability of the instrument is 25 milliamperes nominal at all output voltage settings. The instrument is protected by an overcurrent circuit which reduces the output voltage to zero and flashes the front panel indicator if the output current exceeds the nominal 25 milliamperes. The protective circuit cycles on and off so long as the overcurrent condition exists and then resets automatically when the condition is removed.

The output of the instrument is isolated from the ac-power line and the outer case so that the output can be applied to isolated or grounded loads. The metal terminal on the front panel may be used to ground either side of the output.

1–2. PHYSICAL DETAILS

The instrument is contained in a cabinet, or in an enclosure that can be mounted in a standard, 19-inch rack or cabinet. All operating controls, indicators, and binding posts are mounted on the front panel. The primary-power fuse and entry are located at the rear. Ventilation is provided by a fan that is located in the rear of the instrument.

1–3. COMPONENTS

The instrument includes electron-tube and solid-state circuits, the majority of which are provided by two open, etched-circuit boards. Most of the components are mounted on the main board, which is secured in a horizontal position to the bottom of the chassis by screws. Other components are on a vertically-mounted board which plugs into the main board. The remaining components are mounted immediately behind the front panel.

1–4. CONSTRUCTION

Details of the materials used in the construction of the instrument are as follows:

Etched-circuit boards – epoxy glass

Chassis – aluminum

Front panel – aluminum

Rear panel – CRS (cold rolled steel)

Cabinet model enclosure – aluminum

Rackmount model enclosure – CRS

1–5. FINISH

The structural parts of the instrument are finished as follows:

Chassis – clear alodine

Front panel – clear alodine, front and sides painted semi-gloss light gray enamel COHU No. 3310042-218 (color No. 26492 per FED-STD-595), silk screened in black

Rear panel – cadmium plated

Cabinet model enclosure – yellow alodine, outside painted medium gray medium wrinkle enamel COHU No. 3310042-418 (color No. 26251 per FED-STD-595)

Rackmount model enclosure – cadmium plated, blank front panel painted semi-gloss light gray enamel COHU No. 3310042-218 (color No. 26492 per FED-STD-595)

1–6. DIMENSIONS AND WEIGHT

The dimensions and weight of the instrument are as follows:

Cabinet model

Net weight – 20 pounds

Shipping weight – 30 pounds

Dimensions – See Figure 1-1

Rackmount model

Net weight – 27 pounds

Shipping weight – 40 pounds

Dimensions – See Figure 1-2

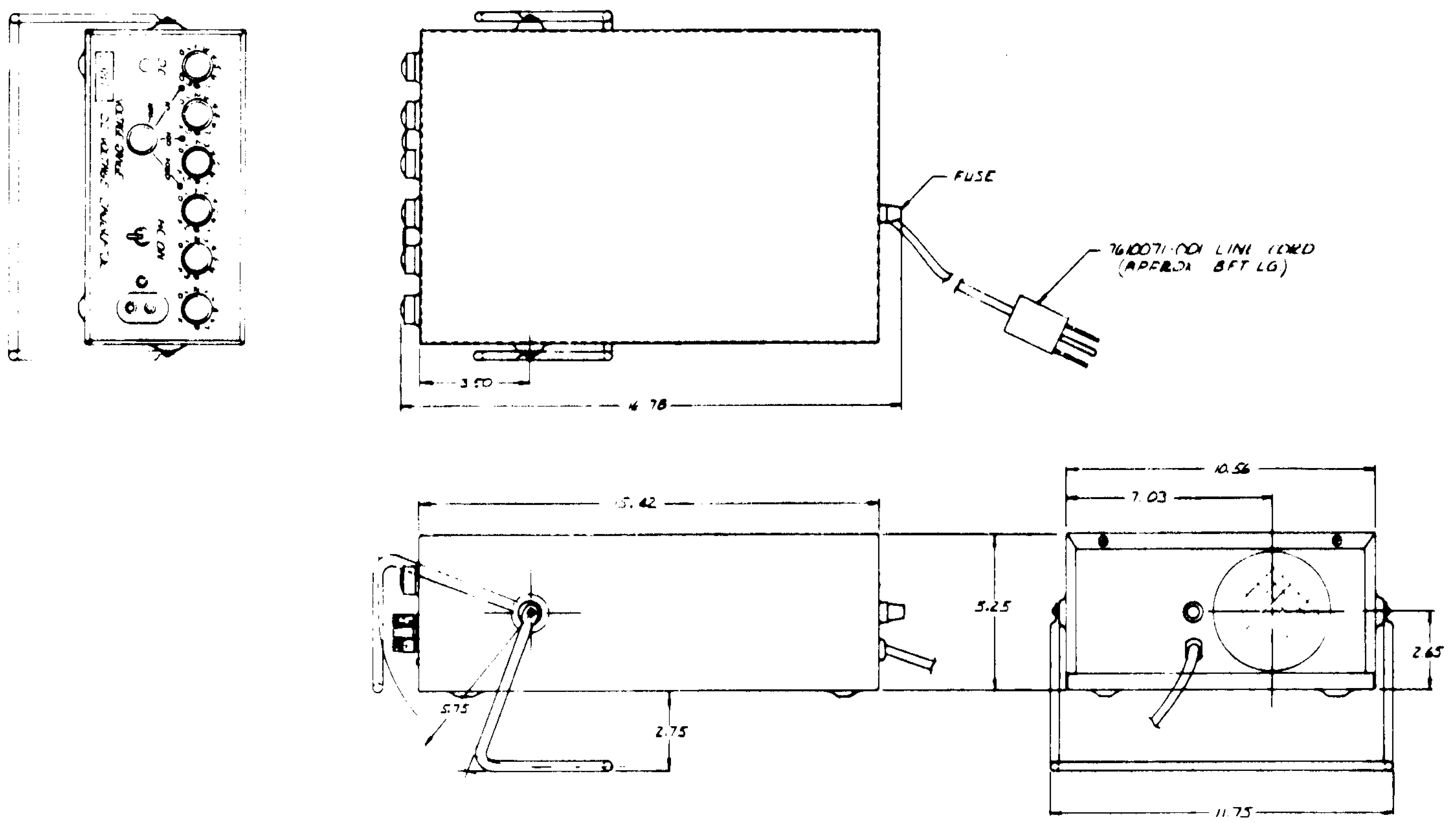


Figure 1-1. Cabinet Model Dimensions and Outline

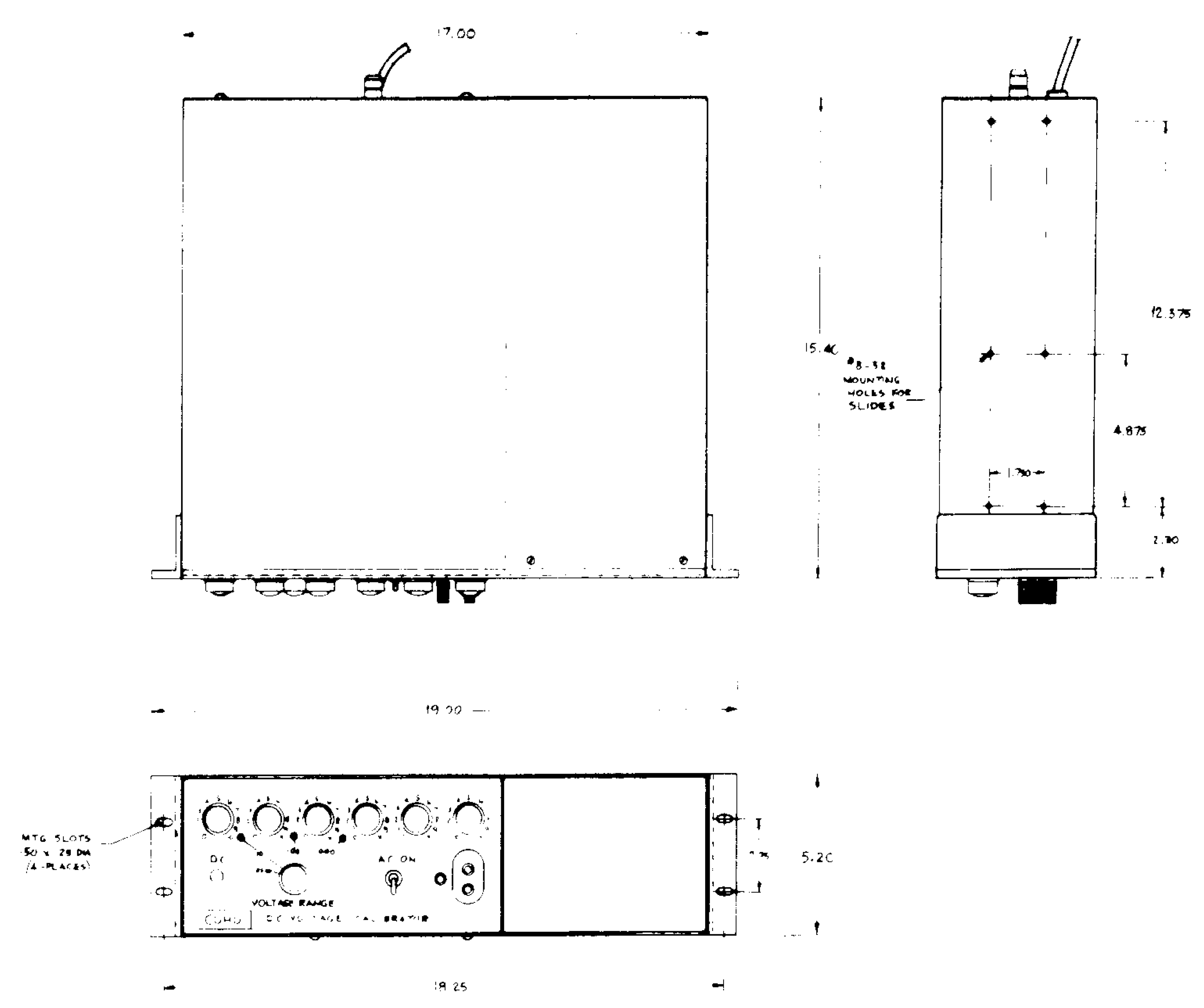


Figure 1-2. Rackmount Model Dimensions and Outline

Table 1-1. Electrical Specifications

OUTPUT VOLTAGE:	0.00000 to ±1000.000 volts in 3 decade ranges (±1111.110 volts at maximum overrange)
OUTPUT CURRENT:	0 to 25 milliamperes nominal at any voltage setting
ACCURACY: (Refer to para. 1-8)	10-V range, 0.01% of setting plus 50 μV 100-V range, 0.01% of setting plus 100 μV 1000-V range, 0.01% of setting plus 250 μV
STABILITY: (Refer to para. 1-9)	24 hours, within 30 ppm of mean value plus 25 μV 30 days, within 50 ppm of mean value plus 50 μV
NOISE AND HUM:	<100 μV rms above 0.1 Hz
SOURCE RESISTANCE:	<0.001 ohm plus 0.0002 ohm/volt at dc
LOAD REGULATION:	<0.0005% of setting plus 25 μV no load to full load
LINE VOLTAGE REGULATION:	<0.0007% of setting plus 20 μV for 10% change from nominal ac-line voltage
TEMPERATURE COEFFICIENT:	<(20 ppm plus 2 μV)/°C from +20°C to +40°C
POWER REQUIREMENTS:	105-125 or 210-250 volts, 50-60 Hz, 120 watts maximum
STORAGE TEMPERATURE:	-15°C to +85°C with relative humidity to 100%
OPERATING TEMPERATURE:	+20°C to +40°C with relative humidity less than 90%

COHU reserves the right to change specifications without notice.

1–7. ELECTRICAL SPECIFICATIONS

The electrical specifications of the instrument are listed in Table 1-1.

1–8. ACCURACY

For a period of 30 days after calibration the output voltage, referred to the volt maintained by the National Bureau of Standards, is equal to the set value within the tolerances specified (refer to Table 1-1) 99.7 percent of the time for any combination of the following conditions: line voltage, ±10 volts rms from nominal; line frequency, ±1 Hz from nominal; ambient temperature, ±1° C from nominal; external load, 0 to 25 milliamperes; relative humidity, 80 percent maximum. The accuracy specification includes the effects of the stability specification and all the specifications within the ranges of the variables in the list of specifications in Table 1-1.

1–9. STABILITY

The stability specification applies for a constant external load and the following standard reference conditions: ambient temperature, 23 ±1°C; relative humidity, ≤55 percent; atmospheric pressure, 575 to 800 millimeters of mercury; line voltage, nominal ±1 volt rms; and line frequency, nominal ±0.5 Hz. For any 24-hour period, the output voltage is within 30 ppm of its mean value plus 25 microvolts 99.7 percent of the time. For any 30-day period, the output voltage is within 50 ppm of its mean value plus 50 microvolts 99.7 percent of the time.

1–10. ACCURACY AND STABILITY MEASUREMENTS

The accuracy and stability measurements are made using a low-pass filter or measuring system having a cut-off frequency of 0.1 Hz or less and a slope of 20 dB per decade or more to over 60 dB down.

Section II
OPERATION

2–1. INITIAL CHECK

The performance of the instrument should be checked upon receipt to detect possible concealed damage caused during shipment (refer to form P-293-5-62-5M enclosed with instrument). Check the instrument in accordance with the information and instructions in this section. A procedure for functionally checking the instrument is given in paragraph 2-9.

2–2. INSTALLATION

The instrument may be used as a bench unit or it may be mounted in a standard, 19-inch rack or cabinet, dependent on whether the instrument has a bench-type or rackmount enclosure. For proper ventilation, the vent at the rear of the instrument should not be obstructed.

2–3. PRIMARY-POWER CONNECTION

Connect the instrument to a three-contact outlet so that the enclosure is grounded through the ground lead of the ac-power cable. If the instrument is to be operated from a two-contact outlet, use a three-contact adapter with a pigtail and connect the pigtail to ground. The instrument is connected for 115-volt operation unless 230-volt operation is specified on order (see the schematic diagram, Figure 4-4 or 4-5, for the alternative connections).

2–4. OUTPUT CONNECTIONS

The instrument has three front panel terminals which accept spade lugs and banana plugs. Two of the terminals, one red and one black, furnish an isolated output, and the other is a metal terminal for grounding. If a grounded output is required, positive or negative voltage is obtained by grounding the appropriate output terminal. Positive voltage is provided when the black terminal is grounded, and negative voltage is provided when the red terminal is grounded.

2–5. OPERATION

The instrument's operating controls and their functions, the uses of the overrange positions, and a recommended operating procedure are given in the following paragraphs.

2–6. OPERATING CONTROLS

Toggle Switch

The ac power energizes the instrument when this switch is positioned to AC ON. Approximately 15 seconds after the toggle switch is positioned to AC ON, the voltage indicated by the decade and range dials is available at the output terminals.

DC Indicator

After the toggle switch is positioned to AC ON, the DC indicator lights for approximately 5 seconds, extinguishes for approximately 10 seconds, and then relights and remains steady.

If an overcurrent condition occurs, because of an external overload or fault within the instrument, the DC indicator flashes off and on while the condition persists.

VOLTAGE RANGE Dial

This dial is used for selecting nominal full-scale 10-volt, 100-volt, and 1000-volt ranges, and zero-volt output. Also, the dial indicates the decimal-point placement in the readout of the decade dials.

When the dial is set to the ZERO position it overrides any voltage indicated by the decade dials, reducing the output voltage to zero. The ZERO position may be used as a safety precaution when connecting or disconnecting a load or when the instrument is on standby.

Decade Dials

These six dials are used in conjunction with the VOLTAGE RANGE dial to set the level of output voltage.

2–7. OVERRANGE DIALING

Each of the decade dials has eleven positions. The dial at the extreme left has positions 0

Table 2-1. Examples of Dial Settings Using Overrange Positions

FEATURE	DIAL SETTING	OUTPUT VOLTAGE
Convenient to use the X position to change output voltage	199.900	199.9
	199.X00	200
Linearity self-check (100-volt range)	49.999X	50
	49.99X0	50
	49.9X00	50
	49.X000	50
	4X.0000	50
	50.0000	50
Necessary use of the X positions (only one setting possible)	10XX.XXX	1111.110

through 9, and an overrange position marked 10. The other dials each have positions 0 through 9, and an overrange position marked X. The X position of a dial indicates a voltage ten times greater than that of position 1 of the same dial, and equal to the voltage indicated by position 1 of the next higher-decade dial (the dial to the left). By using the overrange positions, the same output voltage can be obtained with several different decade dial settings on each range; this permits the output voltage to be compared (using external indicating equipment) and provides a means for "self-checking" the linearity of the decade resistors. Also, it is sometimes more convenient to use the overrange positions to change the level of output voltage. Use of the overrange positions is mandatory to obtain the maximum output voltage on each range. To illustrate these features of the instrument some examples are given in Table 2-1.

2–8. OPERATING PROCEDURE

a. Set the VOLTAGE RANGE dial to ZERO.

b. Set each decade dial to 0.

c. Position the toggle switch to AC ON and allow approximately 15 minutes for the instrument to stabilize.

d. Connect the output terminals to the load.

e. Set the VOLTAGE RANGE dial to the appropriate range.

f. Set the decade dials for the required output voltage.

WARNING

Do not connect or disconnect the load unless the VOLTAGE RANGE dial is set to ZERO; the output voltage may be set at a high level.

2–9. FUNCTIONAL CHECK

A functional check of the instrument may be made using a multimeter and a 100-ohm resistor. The procedure is as follows:

a. Before energizing the instrument, check for shorts between the output terminals and between each output terminal and the ground terminal.

b. Set the VOLTAGE RANGE dial to ZERO and set each decade dial to 0.

c. Position the toggle switch to AC ON. The DC indicator should light for approximately 5 seconds, extinguish for approximately

10 seconds, and then light and remain steady. The fan should operate.

d. Connect the multimeter to the output terminals.

e. Set the VOLTAGE RANGE dial to 10.

f. Turn the dial at the extreme left through its eleven positions (1-volt steps) and compare each setting with the voltage indicated by the meter. Return the dial to 0.

g. Set the VOLTAGE RANGE dial to 100 and repeat the instructions in step f using the second dial from the left.

h. Set the VOLTAGE RANGE dial to 1000 and repeat the instructions in step f using the third dial from the left.

i. With the VOLTAGE RANGE dial still set at 1000, repeat step f using the fourth dial from the left (0.1-volt steps), then the fifth dial (10-millivolt steps), and finally the dial at the extreme right (1-millivolt steps).

j. Set the VOLTAGE RANGE dial to ZERO.

k. Replace the multimeter with the 100-ohm resistor.

l. Set the decade dials to 2.7 volts on the 10-volt range.

m. Set the VOLTAGE RANGE dial to 10. The DC indicator should flash off and on continuously.

n. Set the decade dials to 2.5 volts. The DC indicator should stop flashing and remain steady.

o. Set the VOLTAGE RANGE dial to ZERO.

p. Repeat steps l through o using the 100-volt range and then the 1000-volt range.

q. Disconnect the resistor from the output terminals.

If the proper results are not obtained when performing steps l through p the protective circuit may require adjustment, in which case, refer to paragraph 4-18.

Section III
CIRCUIT DESCRIPTION

3-1. GENERAL CIRCUIT DESCRIPTION

A simplified block diagram indicating the functional sections of the instrument is shown in Figure 3-1. The major functional section is the amplifier system. The amplifier system consists of a 60-Hz, suppressed carrier modulator, a carrier amplifier demodulator, an ac-coupled wideband amplifier, and a direct-coupled amplifier. The carrier amplifier is paralleled by the wideband amplifier, the combined outputs of which are applied to the dc amplifier. The dc amplifier drives the output tube, which controls the output voltage. Interstage coupling networks and internal feedback shape the response characteristics of the amplifier system to provide stability.

The amplifier characteristics are such that the accuracy of the output voltage is almost independent of all influences except the reference voltage and the ratio of the range resistors to the feedback-decade resistors. The reference voltage is provided by a circuit that has a temperature-compensated, constant-current preregulator, which provides constant current for the range and feedback-decade networks. The feedback-decade network has six decades of precision resistors; the resistors are selected and connected in series when the decade switches are set for the desired output voltage. The range switch selects one of three precision resistors, the selected resistor determining the current in the feedback-decade network. The voltage developed across the feedback-decade network equals the output voltage of the instrument.

The instrument is basically a low drift, wideband, high gain, negative feedback amplifier system. The feedback control is based on the network theorem that the algebraic sum of the currents at a junction equals zero, in this case, at the summing junction. In Figure 3-2, E_{in} is the reference voltage, R1 is the selected range resistor, R2 represents the selected feedback-decade resistors, A is the loop gain of the amplifier

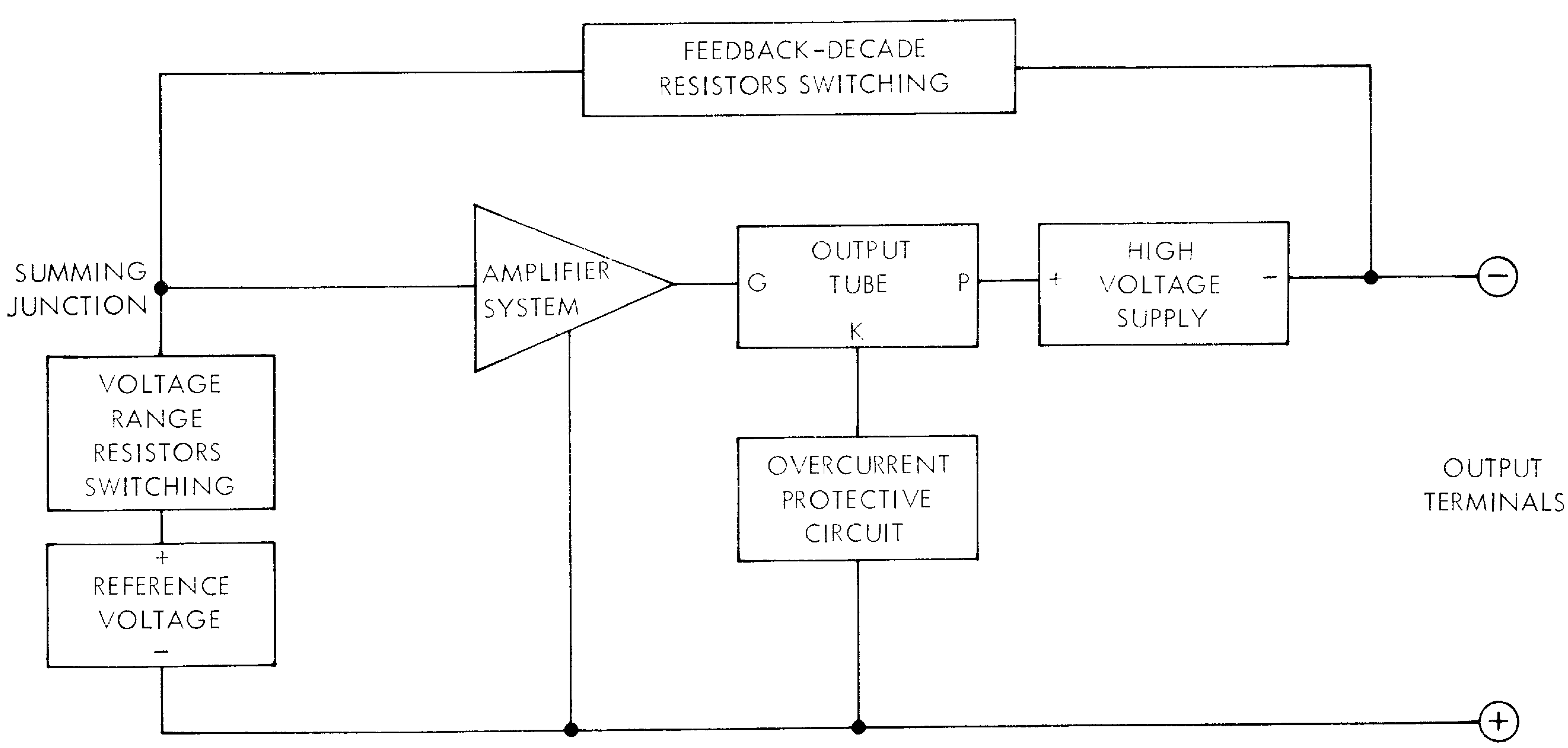


Figure 3-1. Simplified Block Diagram

system, and E_{out} is the output voltage of the instrument. If the input current of the amplifier is negligible, all the current in R1 must flow through R2. The equation for the output voltage is:

$$E_{out} = -\frac{R2}{R1}\left[\frac{A\,\frac{R1}{R1+R2}}{1+A\,\frac{R1}{R1+R2}}\right]E_{in}$$

If $A\,\frac{R1}{R1+R2} >> 1$ the term in the bracket is almost unity. Assuming that A is sufficiently large, the output voltage becomes simply $E_{out} = -\frac{R2}{R1}E_{in}$. The amplifier system has the required gain and the input characteristics necessary to make the assumptions involved in the approximate equation valid for output voltage from 0 to -1111.110 volts. The output is isolated from the outer case and the ac-power lines so that output terminal inversion is possible to obtain output voltage from 0 to +1111.110 volts.

3–2. DETAILED CIRCUIT DESCRIPTION

The circuit of the instrument is discussed in more detail in the following paragraphs of this section. The discussion is supported by complete and simplified circuit diagrams.

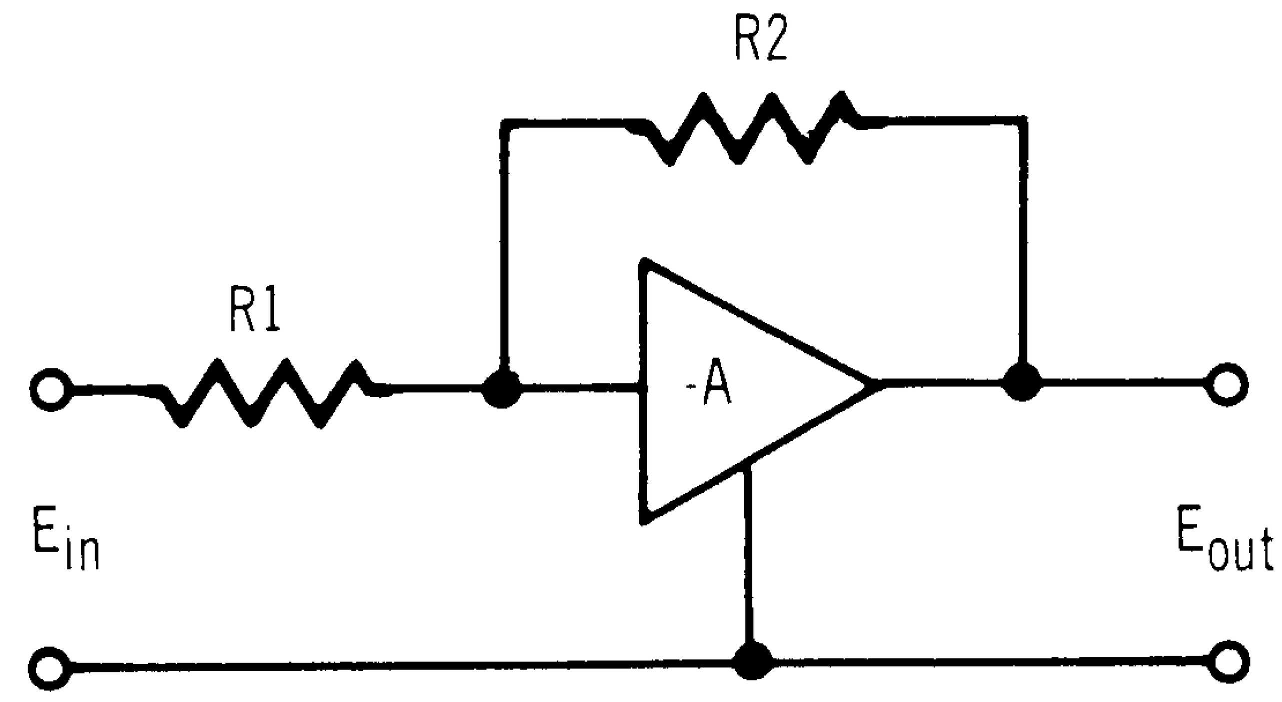


Figure 3-2. Feedback Amplifier

3–3. POWER SUPPLY

Power is supplied via a transformer which has two primary and five secondary windings. (See the schematic diagram, Figure 4-4 or 4-5.) The primary windings are connected for nominal 115-volt or 230-volt operation. The secondary windings drive circuits that provide the following power supply outputs (all voltages are referenced to circuit common except the +1400-volt supply):

+1400 volts for the plate of the output tube, V4.

+350 volts for the carrier amplifier, the direct-coupled amplifier, and the protective circuit.

-300 volts (dropped to -39 volts, bias voltage) for the control grid of the output tube.

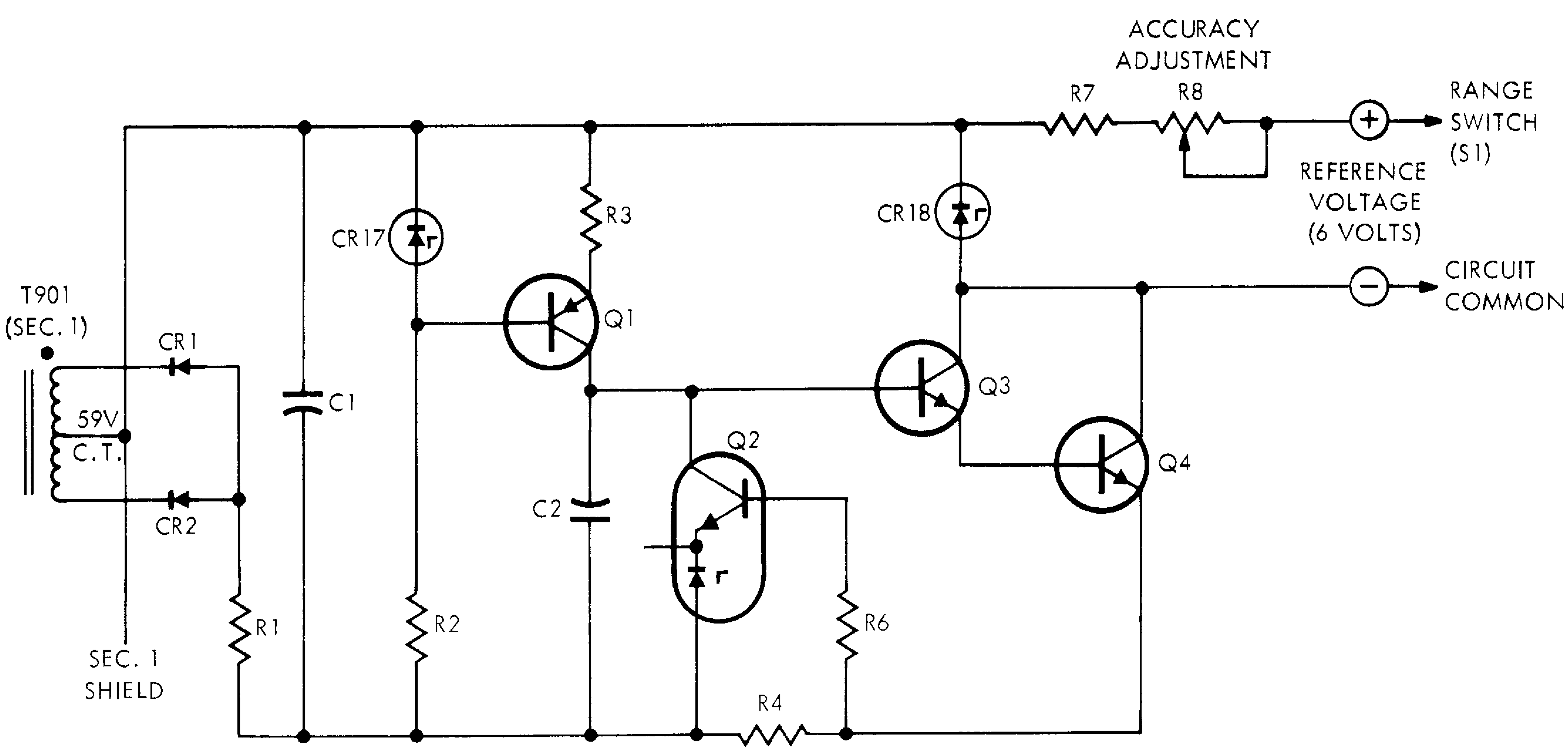


Figure 3-3. Reference Voltage Circuit

+250 volts for the carrier and the wideband amplifiers.

+210 volts for the screen grid of the output tube, and the protective circuit.

+12.5 volts for the filaments of V1 and V2 (6.25 volts each), and the protective circuit.

-10 volts for the protective circuit and the grid-bias voltage-supply circuit.

+6-volt reference voltage.

6.3 volts ac for the filaments of V3 and V4, and for driving the chopper, G1.

3–4. REFERENCE VOLTAGE

The reference-voltage circuit, Figure 3-3, is energized from a full-wave rectifier driven by a 59-volt center-tapped winding on the power transformer, T901. The reference voltage is 6 volts and is applied to the voltage range switch, S1. The reference-voltage circuit includes a temperature-compensated, constant-current preregulator and a constant-current source. A first stage of regulation is provided by Zener diode CR17 and R2. Constant current is provided by Q1 for the reference amplifier Q2, which is a temperature-compensating device. The Q2 circuit has a temperature coefficient of less than 0.005 percent per degree C, operates over the temperature range of 0 to +70 degrees C, and applies an output of approximately 7 volts to the constant-current source Q3/Q4. Feedback, which compensates for changes in current in Q4, is applied by R6 to the base of Q2. Constant current through Zener diode CR18 is supplied by Q3 and Q4. The output voltage of the reference-voltage circuit is adjustable by varying R8.

3–5. VOLTAGE RANGE SWITCHING

The voltage range switching circuit is such that, regardless of the setting of the VOLTAGE RANGE switch, S1, the load on the reference-voltage circuit is constant. This is illustrated in Figure 3-4,

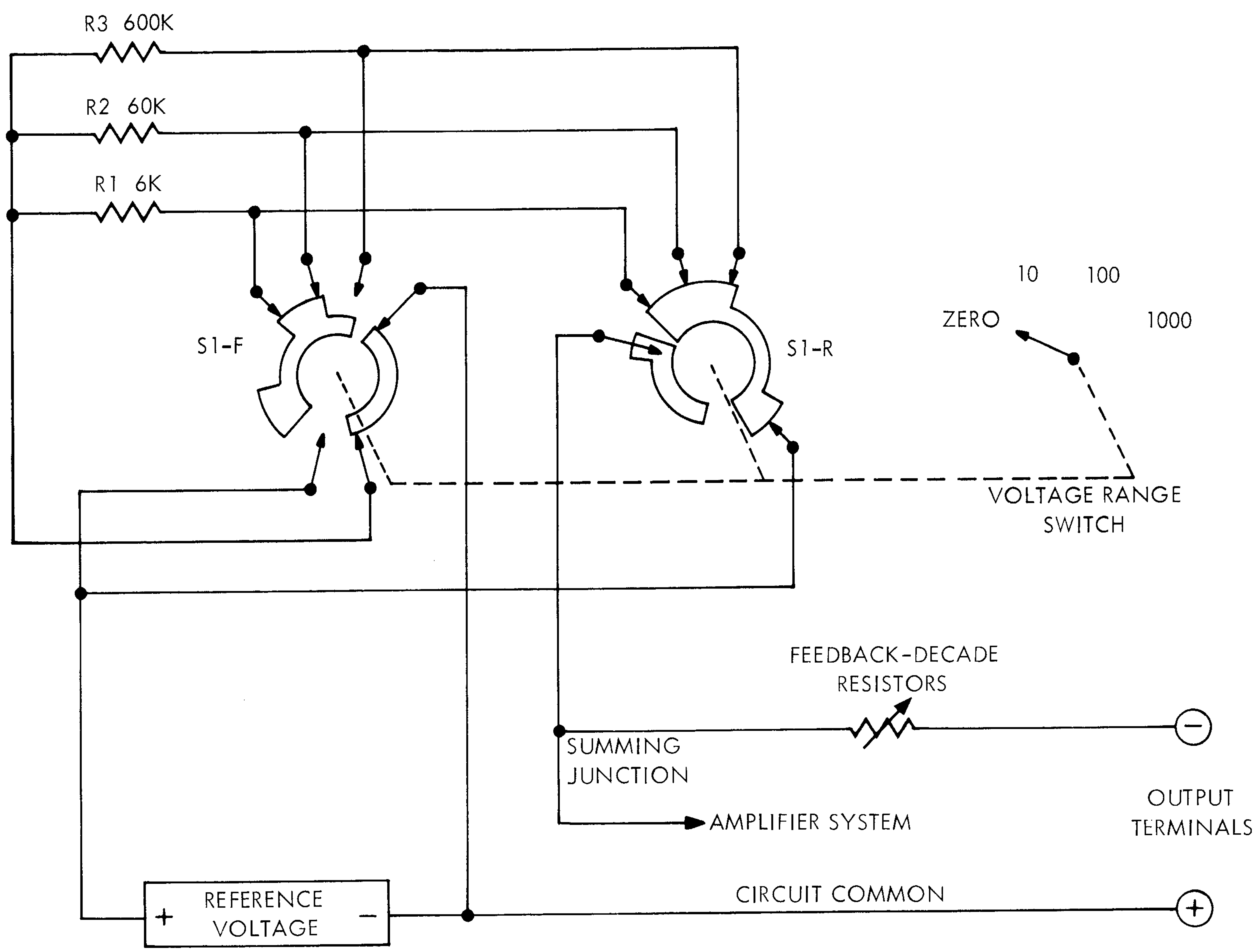


Figure 3-4. Voltage Range Switching Circuit

which shows that in the ZERO position, the range resistors, R1, R2, and R3, are connected in parallel across the reference-voltage circuit, the negative side of which is connected to circuit common. In the other positions, two of the resistors are connected across the reference-voltage circuit, and one resistor is connected between the positive side of the reference-voltage circuit and the summing junction, which is a virtual ground. The load on the reference-voltage circuit is a constant 1.11 milliamperes.

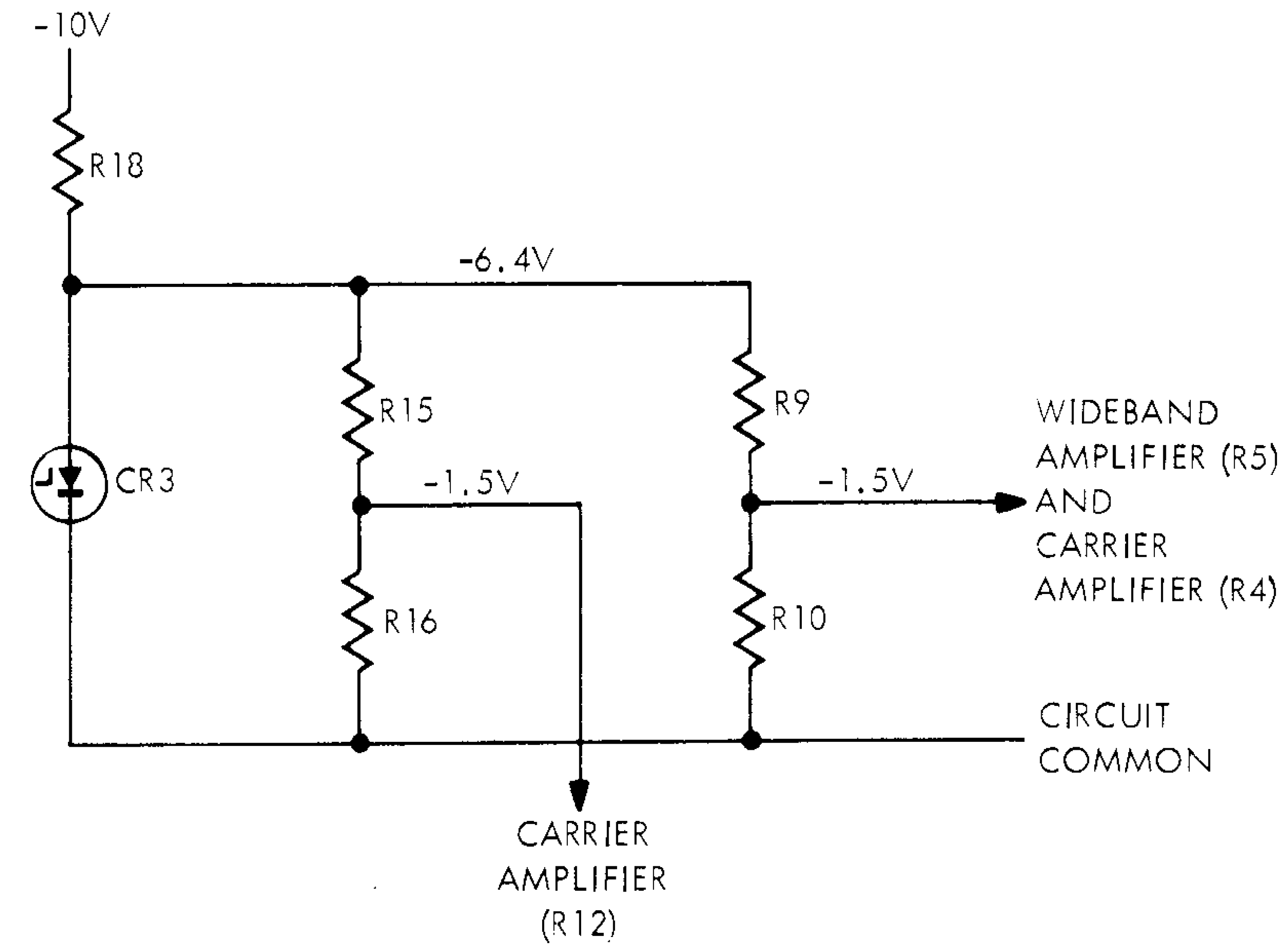


Figure 3-5. Control Grid Bias Supply Circuit for V1 and V2A

3-6. FEEDBACK-DECADE NETWORK

The feedback-decade network is shown in the main schematic diagram, Figure 4-4 or 4-5. The network, which has six decades of resistance, provided by R4 through R27, and six decade switches, S2 through S7, is the dc feedback circuit for the amplifier system. One of three currents, as determined by the voltage range switching circuit, flows in the resistors selected by setting the decade switches. The current in the selected resistors is as follows: 10-volt range, 0.01 milliampere; 100-volt range, 0.1 milliampere, 1000-volt range, 1 milliampere.

The product of the resistance and the current in the selected resistors equals the voltage indicated by the range and decade dials. With the output voltage (within the specified accuracy) as indicated by the settings of the dials, the summing junction is virtually at zero potential with respect to circuit common (positive output terminal). Any difference between the voltage developed across the selected resistors and the output voltage ap-

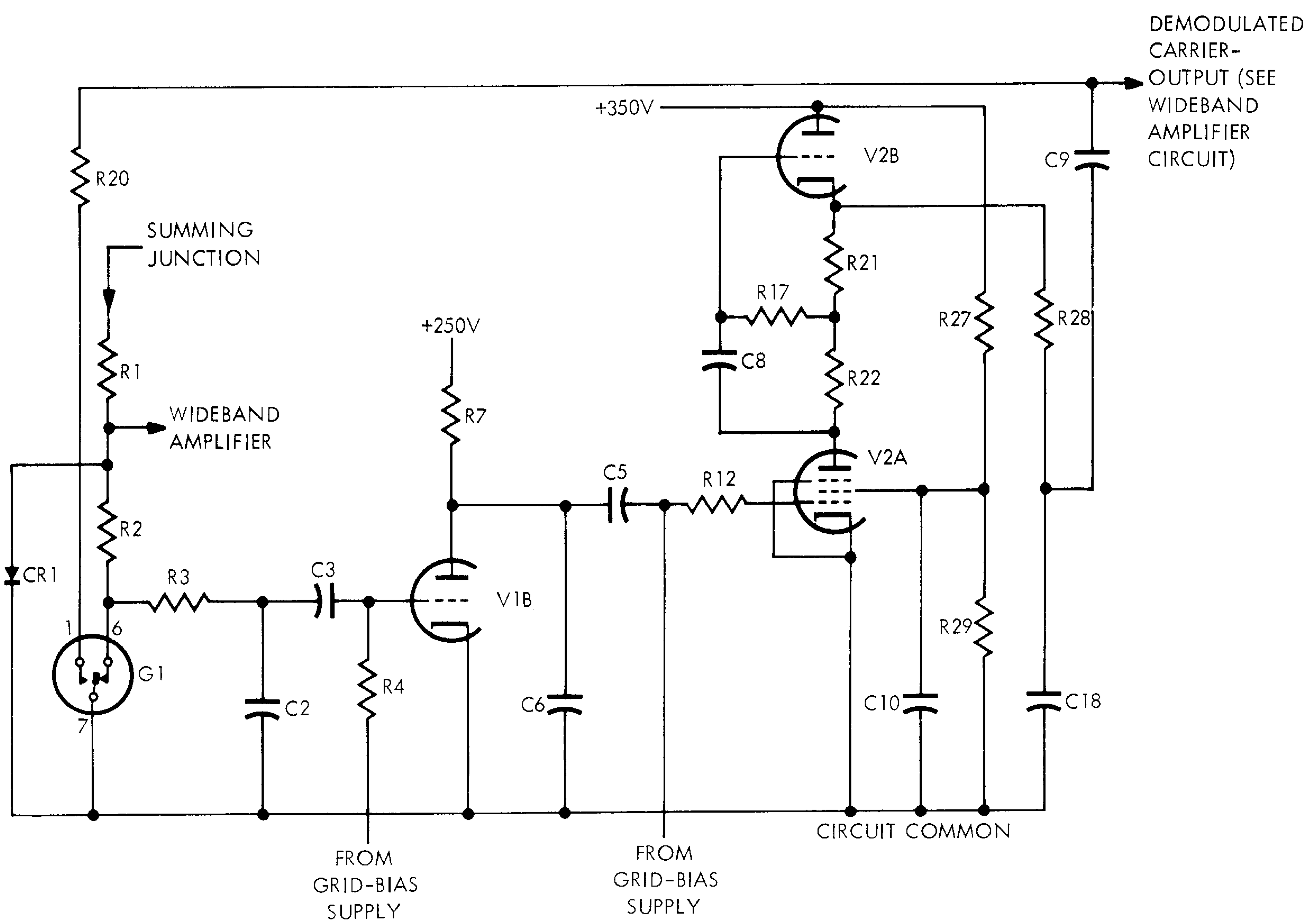


Figure 3-6. Carrier Amplifier Circuit

pears as an error voltage at the summing junction. The error voltage, which is applied to the carrier and wideband amplifiers, is rapidly reduced to negligible proportions by the large loop gain of the amplifier system, and the output voltage is driven to the prescribed level.

3–7. V1, V2A CONTROL-GRID BIAS

The bias voltage for the control grids of V1A, V1B, and V2A is provided by the circuit shown in Figure 3-5. The -10-volt output of the power supply is applied to a divider network, which supplies bias voltage of -1.5 volts. The bias voltage is applied to R12 and R4 for the control grids of V2A and V1B respectively in the carrier amplifier, and to R5 for the control grid of V1A in the wideband amplifier. Zener diode CR3 regulates the bias voltage.

3–8. CARRIER AMPLIFIER

The carrier amplifier circuit, Figure 3-6, consists of a chopper (contact modulator), G1, and two stages of amplification, V1B and V2A/V2B. The chopper is activated by 6.3 volts ac supplied by the power transformer. Chopper contacts 6 and 7 modulate the dc and the lower frequency component of the error voltage at the summing junction. The modulated signal, which has a rectangular waveform of the same frequency as the ac voltage activating the chopper (50 to 60 Hz), is amplified by V1B and V2A/V2B. The output stage, V2A/V2B, is a bootstrap circuit, and provides an output of high gain which is in phase with the input of V1B. The output of V2 is demodulated by chopper contacts 1 and 7. The input of the direct-coupled amplifier from the carrier amplifier is via a frequency response shaping network, which is shown in Figure 3-7.

3–9. WIDEBAND AMPLIFIER AND MISCELLANEOUS CIRCUITS

The circuit of the wideband amplifier is shown in Figure 3-7, which also includes miscellaneous circuits not covered by other diagrams in this section. The wideband amplifier consists of a single stage, V1A, which amplifies the higher frequency component of the error voltage at the summing junction. The output of the wideband amplifier is combined with the demodulated output of the carrier amplifier and applied to the control grid of V3A in the direct-coupled amplifier.

A negative feedback path from the plate of V3A to the wideband amplifier output is provided by C12 and R30. The network consisting of R24, R25,

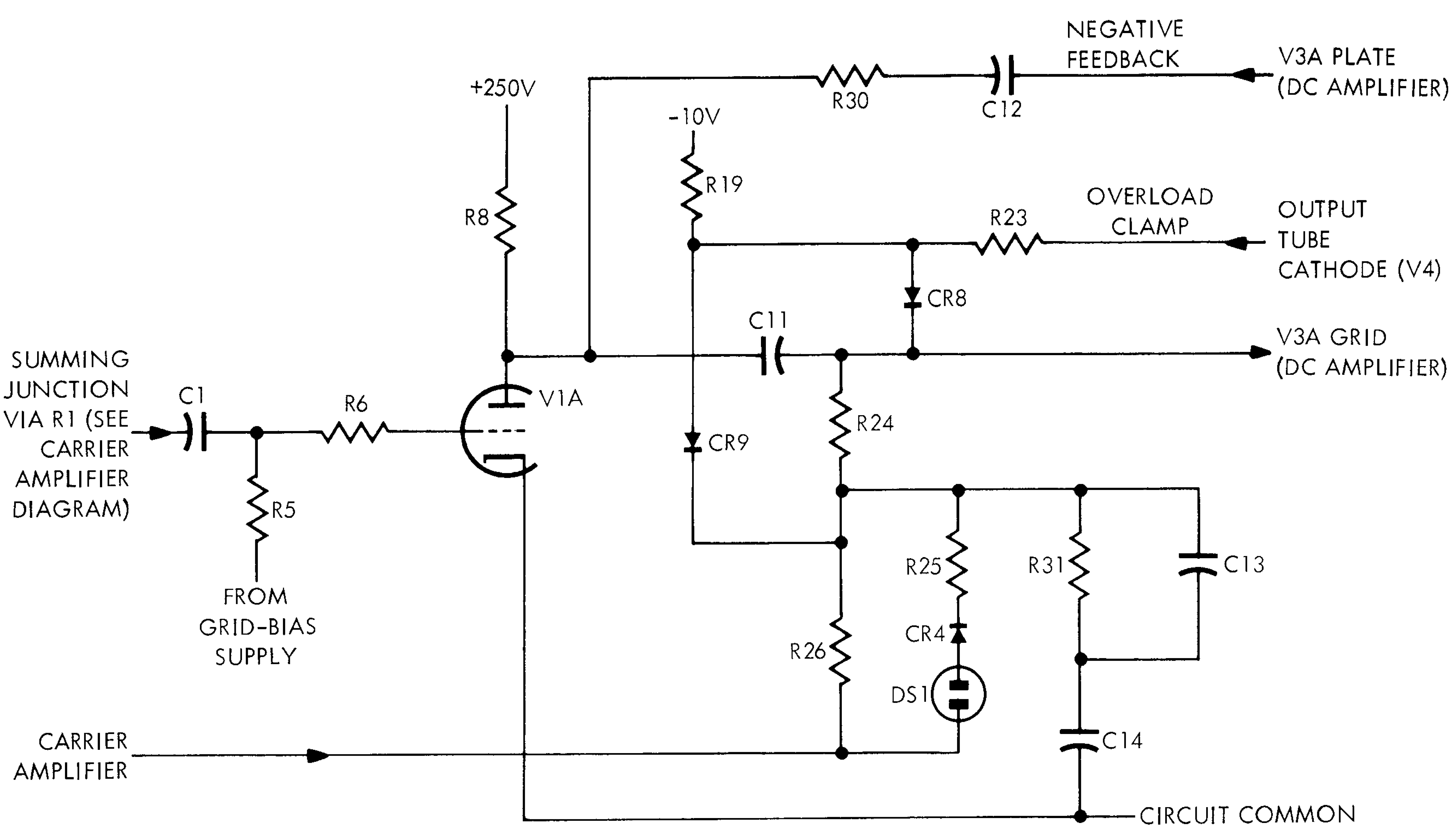


Figure 3-7. Wideband Amplifier and Miscellaneous Circuits

R26, R31, C13, and C14 controls the high frequency response of the carrier amplifier and the low frequency response of the wideband amplifier

When the protective circuit opens the main regulating loop the output tube cathode voltage overcomes the back bias on CR8, which conducts causing V3A in the dc amplifier to saturate. When V3A saturates, the dc amplifier drives the output tube to cutoff. When the main regulating loop is opened a large error signal develops at the summing junction. The error signal causes the normally zero-volt output of the carrier amplifier to go to a negative level, which is limited by the neon lamp, DS1, conducting. When the loop is closed C14 quickly discharges through CR9, thereby providing fast recovery from overload.

3-10. DIRECT-COUPLED AMPLIFIER

The circuit of the direct-coupled amplifier, Figure 3-8, consists of a pentode amplifier stage, V3A, and a cathode follower output stage, V3B. The combined outputs of the carrier amplifier and the wideband amplifier are applied to the control grid of the pentode. The cathode follower drives the control grid of the output tube. The bias voltage for the control grid of the output tube is provided by the -300-volt supply via R40.

A very small amount of positive feedback is provided by V3B via R39 to the cathode of V3A. The positive feedback increases the dc and the low frequency gain of V3A.

Potentiometer R36 adjusts the voltage at the screen grid of V3A to obtain dc balance, that is, zero volts at the control grid of V3A. Obtaining a dc balance also sets the instrument at zero volts for a zero-volt output.

3-11. OUTPUT TUBE

The output tube circuit is shown in Figure 3-9. The output tube, V4, is controlled by the direct-coupled amplifier.

Connected in series with the output tube are the 1400-volt dc plate supply, the output current

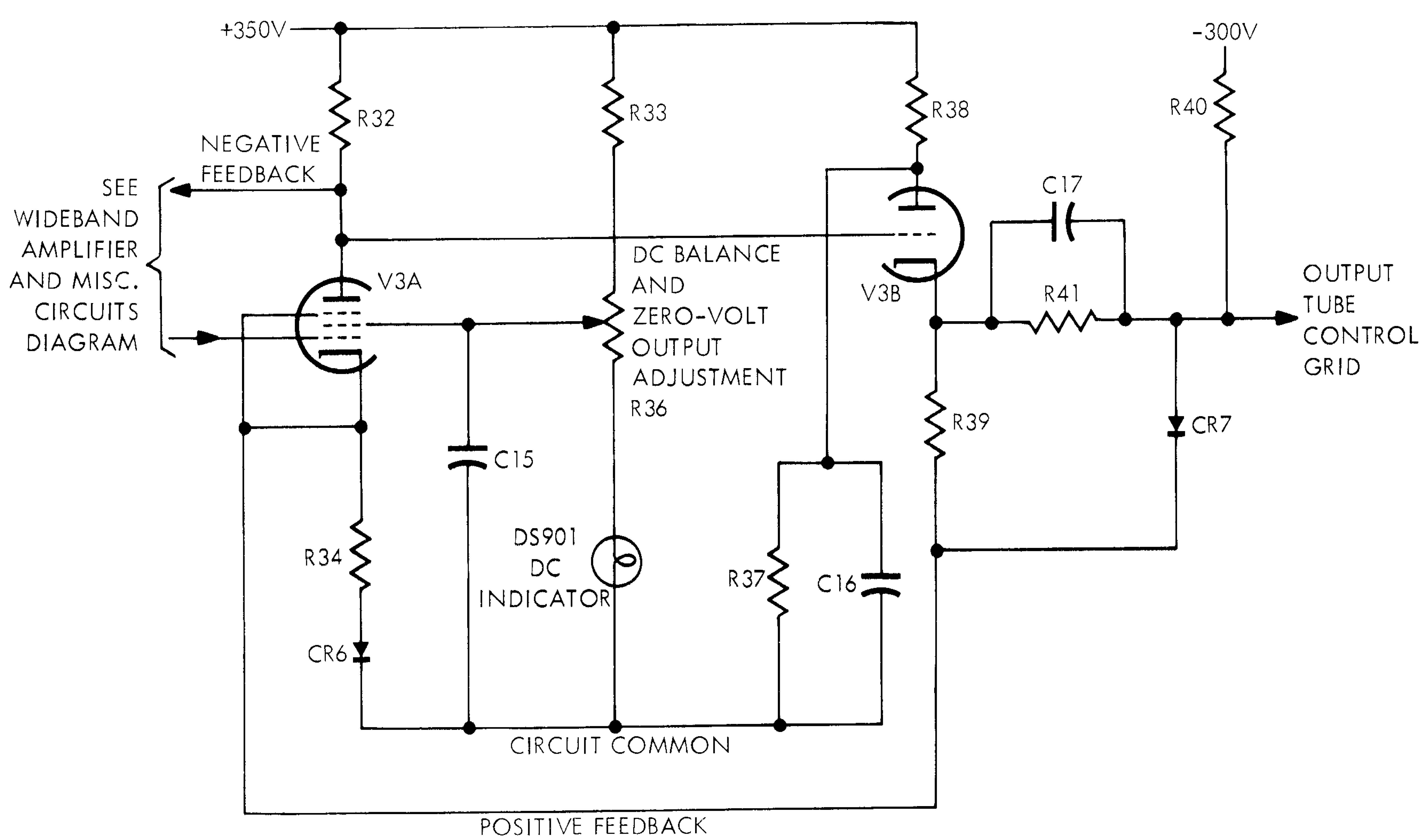


Figure 3-8. Direct-Coupled Amplifier Circuit

sensing resistor for the protective circuit, and the load on the instrument which is the plate load resistor of the output tube. The plate supply and the load are transposed so that the output tube functions as an amplifier rather than as a cathode follower. The 1400-volt supply is not referenced to circuit common, thus permitting the positive output terminal of the instrument to be common to the amplifier system and the cathode circuit of the output tube. This circuit arrangement reduces the voltage swing required of the dc amplifier to less than 50 volts rather than over 1000 volts.

Resistors R43, R44, and R45 permit a bleed current, from the +350-volt supply, to pass through the output tube to prevent it from being completely cut off when the instrument is set for zero-volts output.

When the protective circuit opens the V4 cathode circuit the cathode voltage rises to approximately +20 volts. Under this condition the cathode voltage is high enough to cause CR8 to conduct (refer to the last subparagraph in paragraph 3-9).

3–12. PROTECTIVE CIRCUIT

Whenever the output current of the instrument exceeds a nominal 25 milliamperes, the protective circuit cycles, thereby reducing the current through the output tube, V4. The cycling maintains an average current, dependent on the external load, low enough to prevent damage to the instrument. The protective circuit is shown in Figure 3-9 and pertinent waveforms and voltages are shown on the schematic diagrams, Figures 4-4 and 4-5.

The protective circuitry includes a Schmitt trigger circuit, Q5/Q6, and two switch circuits, Q9 and Q7. The hysteresis of the Schmitt trigger circuit is controlled by feedback capacitor C12. Normally, Q5 and Q7 are conducting and Q6 and Q9 are non-conducting. If an overcurrent condition occurs, the increased current in the cathode circuit of V4 causes the voltage developed across R36 to rise to a level that cuts off Q5. When Q5 cuts off it causes Q6 to switch on, which switches on Q9; this in turn switches off Q7. With Q7 switched off, the cathode circuit of V4 is open circuit, and the current through V4 is reduced to practically zero.

With no significant V4 cathode current, the voltage across R36 falls to a level (almost zero) that permits Q5 to return to the normal state; this, in turn, causes Q6, Q9, and Q7 to also return to the normal states. With Q7 again conducting, if the overcurrent condition still exists, the increased

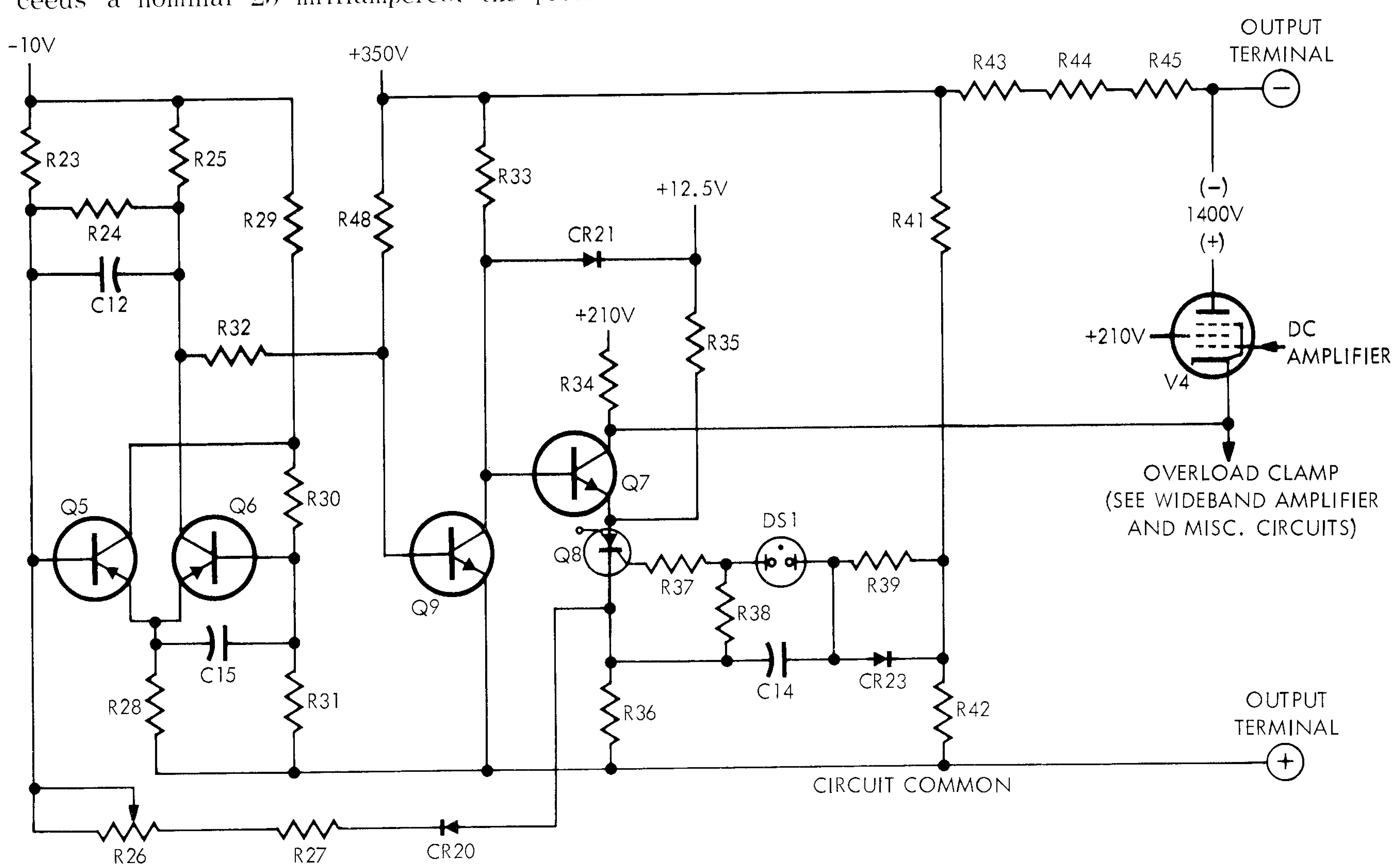


Figure 3-9. Protective and Output Tube Circuits

cathode current causes Q5, Q6, Q9, and Q7 to change states as previously described. This cycle of operations will continue so long as the overcurrent condition exists. When the overcurrent condition is removed the protective circuit stops cycling and returns to the normal state.

The output current level which starts protective circuit cycling is set by the potentiometer, R26. The range of adjustment of R26 is approximately from 21 to 29 milliamperes.

The protective circuit also includes a network that protects the instrument and the load from overcurrent when the instrument is first turned on or particularly when it is turned off and then immediately turned on again. When the instrument is turned on, the output voltage is zero because the cathode circuit of the output tube, V4, is open circuit at the silicon controlled switch, Q8. After the instrument is turned on, C14 slowly charges through R39 until the voltage across the capacitor is sufficient to fire the neon lamp, DS1. When DS1 conducts, Q8 switches on closing the cathode circuit of V4, and the output voltage of the instrument rises to the set level. When the instrument is turned off, C14 rapidly discharges through CR23 so that if the instrument is immediately turned on again the V4 cathode circuit is open at Q8; this prevents uncontrolled current flow through the output tube circuit and the load until the amplifier warms up and starts to control the output tube.

After the instrument is first turned on, the DC indicator, DS901 (see Figure 3-8), lights for approximately 5 seconds, which is the warm-up time of V3A in the dc amplifier. As V3A warms up it is driven into saturation and its screen grid voltage falls to a level (approximately +50 volts) that causes DS901 to extinguish. The tube saturates because the V4 cathode circuit is open at Q8 and the cathode voltage causes CR8 to conduct (refer to the last subparagraph in paragraph 3-9). With V3A saturated, V4 is driven to cutoff. The output tube, V4, remains cut off until C14 has charged sufficiently (approximately 15 seconds) to fire DS1, which then causes Q8 to close the V4 cathode circuit. With the cathode circuit completed, the cathode voltage falls to a level (dependent on the output current) which stops CR8 from conducting. When CR8 stops conducting, V3A conducts normally and its screen-grid voltage rises to a level (approximately +75 volts) which permits the DC indicator to light. With V3A conducting normally, V4 is no longer cut off and conducts as required according to the output voltage and the load on the instrument

Section IV
MAINTENANCE

4–1. INTRODUCTION

This section contains information and instructions for disassembly, parts location, preventive and corrective maintenance, troubleshooting, internal adjustments, and calibration. Maintenance support data includes the circuit descriptions and diagrams in Section III, a main schematic diagram marked with normal-operation waveforms and voltages, and a list of replacement parts.

4–2. DISASSEMBLY

WARNING

Do not attempt disassembly when the instrument is energized. If the case is removed shock hazard may exist unless certain precautions are taken (refer to paragraph 4-13).

Access to the circuits is obtained simply by removing the case from the instrument. The case is secured by four screws at the rear and two at the bottom near the front edge of the instrument. To facilitate access to the components mounted on or immediately behind the front panel, the front section of the chassis can be tilted down after removing two screws, one on each side of the chassis. The plug-in amplifier board can be removed by sliding it upward in its guide rails after removing a screw near the center of the upper edge of the board.

4–3. PARTS LOCATION

The locations of the subassemblies and some of the components are indicated in Figures 4-1 and 4-2. The printed circuit boards are marked with the circuit reference designations of the components mounted thereon.

4–4. PREVENTIVE MAINTENANCE

The instrument requires little routine maintenance other than cleaning and inspection. Inspect the interior periodically for cleanliness. After cleaning the instrument it is advisable to make a visual inspection for signs of deterioration.

4–5. GENERAL CLEANING

Clean the interior of the instrument at intervals determined by experience to minimize the accumulation of dust. If available, compressed air is suitable for cleaning, otherwise use a soft-hair brush and a bench vacuum cleaner. However, if the former is used, take care not to cause damage by the use of excessive pressure. Cleaning of the front panel terminals should not be overlooked.

4–6. FAN MOTOR

The fan motor should be lubricated at frequent intervals, particularly when used in ambient temperatures above 100 degrees Fahrenheit, with a premium grade of detergent or non-detergent SAE 20 or SAE 30 oil. It is better to lubricate the motor too frequently rather than not frequently enough. The motor has no brushes or commutator and therefore no harm is likely to result from over-lubrication.

4–7. SWITCHES

Under normal operating conditions the switches require no maintenance other than lubrication. Most maintenance methods are actually harmful and will shorten the life of a switch. Therefore, leave the switches alone unless maintenance due to adverse ambient conditions is absolutely necessary. In an excessively dusty or contaminated atmosphere occasional cleaning may be beneficial. The contacts should be cleaned with a good degreasing solution such as carbon tetrachloride, allowed to dry, and then lightly lubricated with Oak No. 2008 grease or equivalent. It is recommended that the index assembly be lubricated after approximately every 1000 hours of operation.

4–8. CHOPPER

In addition to the fan motor the only other continuously moving part in the instrument is the chopper. Output noise and stability characteristics may be seriously degraded by a malfunctioning chopper. The most valid test of the chopper's performance is to replace it with one known to be good. How-

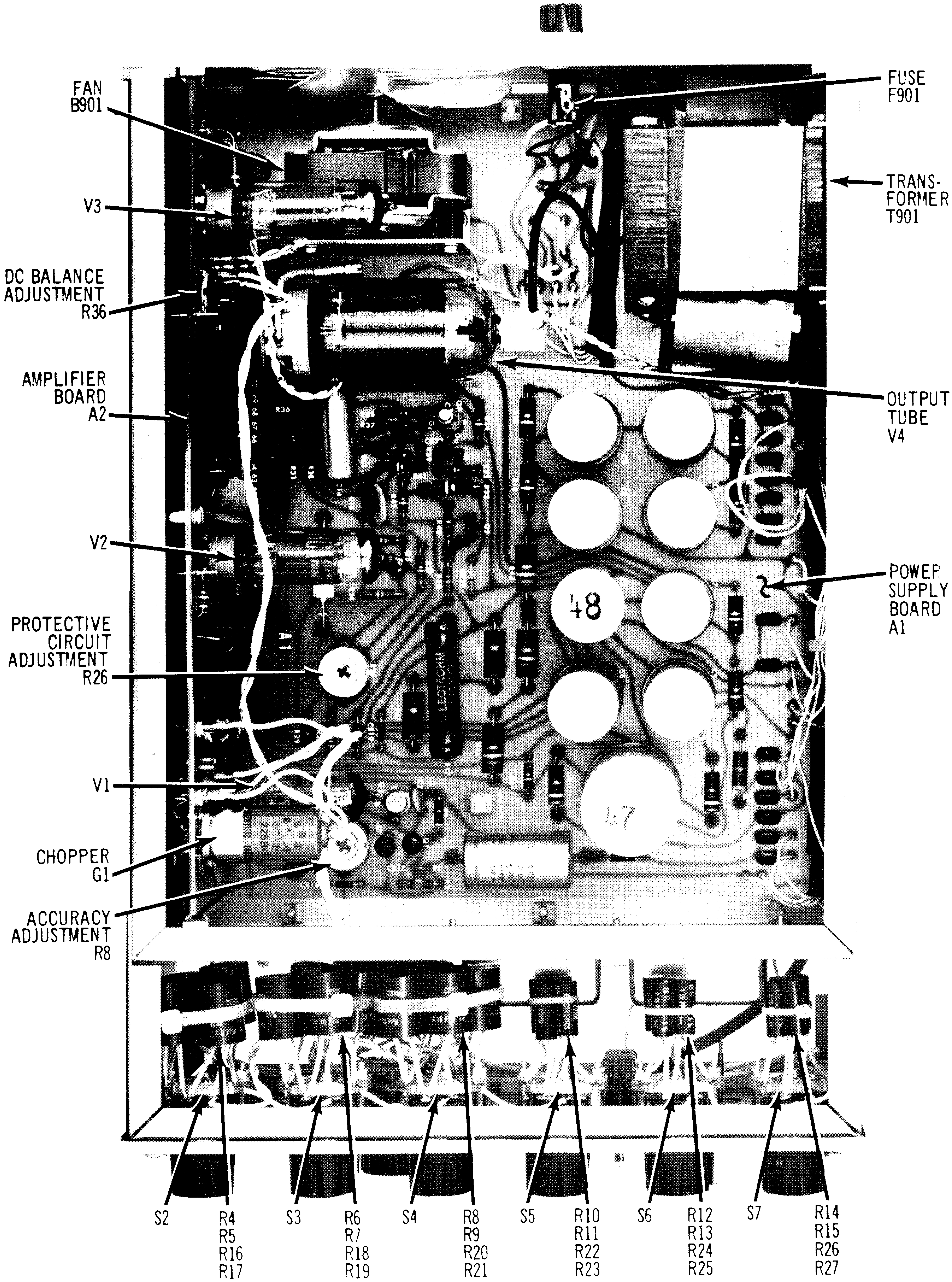
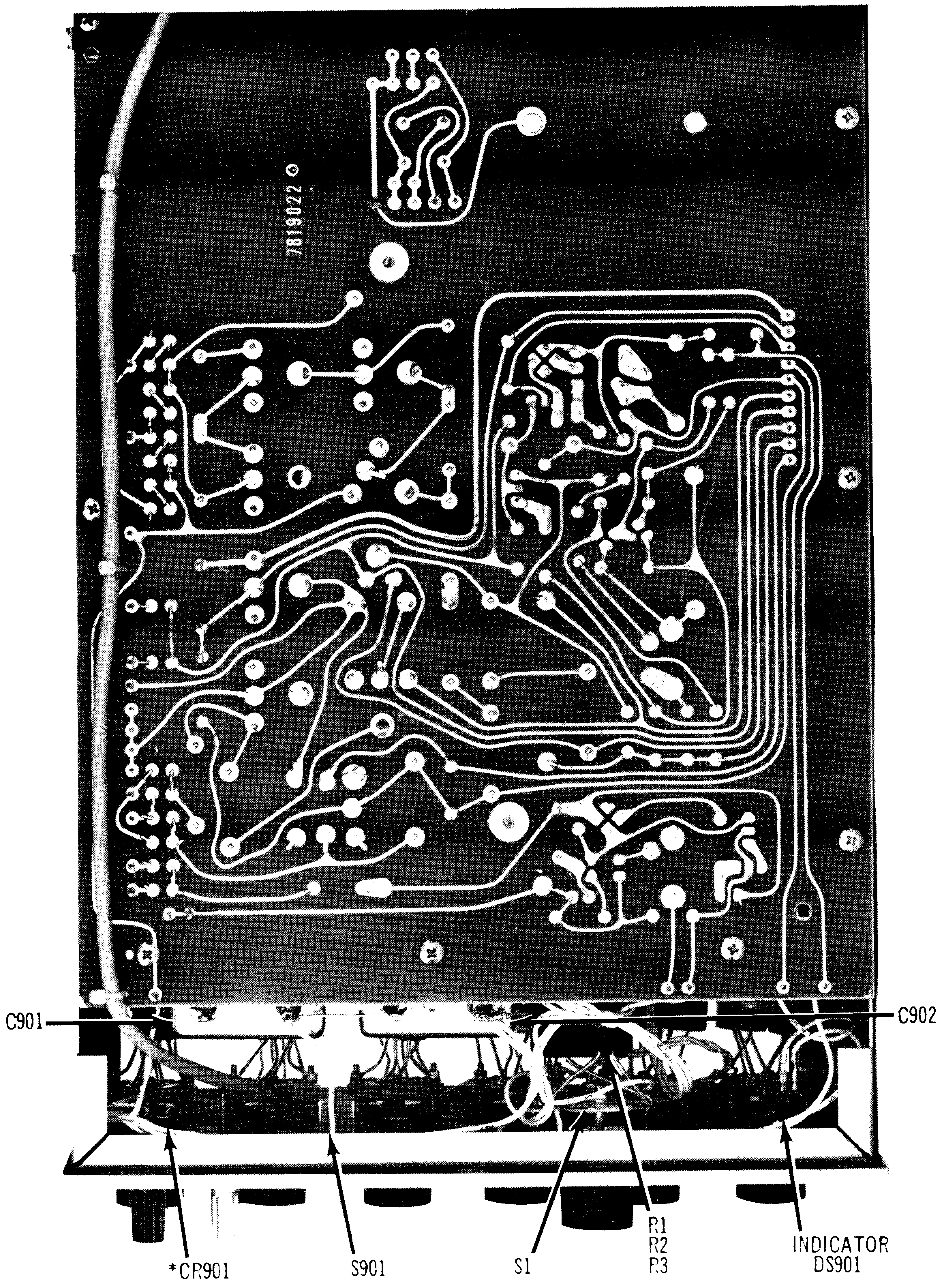


Figure 4-1. Subassembly and Component Locations, Top View



*THIS DIODE IS LOCATED AS INDICATED IN UNITS 1-0001 THROUGH 1-0085.
IN UNITS 1-0086 AND HIGHER CR901 IS REPLACED BY CR24 AND CR25 ON THE POWER SUPPLY BOARD.

Figure 4-2. Subassembly and Component Locations, Bottom View ever, more information on the nature and function of choppers is presented in COHU Service Notes, Code No. 13-57A, "Chopper Checkout Procedures for COHU Equipment."

4–9. PERFORMANCE CHECK

The instrument may be checked using the procedure in paragraph 2-9. The procedure functionally checks the instrument using output voltages up to 10 volts. In addition, the instrument may be checked at higher output voltages using appropriate test equipment. The accuracy of the output voltage may be checked by performing the calibration procedure.

4–10. CALIBRATION

Two adjustments are made to calibrate the instrument. First the dc balance adjustment is made to obtain zero-volt output and then the output voltage is adjusted for accuracy. To make the accuracy adjustment, a stable dc source with an output voltage accuracy better than that of the instrument being calibrated is required. A saturated standard cell is suitable for this purpose.

4–11. CALIBRATION EQUIPMENT

The following equipment is required for calibrating the instrument:

a. A stable and accurate source of dc voltage such as a certified standard cell, a COHU 300 series dc voltage standard, or other instrument of comparable stability and accuracy.

b. A galvanometer or a center-zero voltmeter, such as a COHU Model 203A, 203AR, 204A, 204AR, or 208R, or other instrument of comparable sensitivity.

c. A small, insulated screwdriver, or other tool suitable for adjusting trimming resistors.

4–12. CALIBRATION PROCEDURE

Perform the calibration procedure in the following order:

a. Preliminary Procedure

1. Slide the instrument out of its case sufficiently to permit access to the internal adjustment points.

2. Set each decade dial to 0.

3. Set the VOLTAGE RANGE dial to ZERO.

4. Turn on the instrument and the test equipment.

5. Allow at least 30 minutes for warm-up.

b. DC Balance Adjustment

1. Connect the null indicator, properly zeroed on its 100-μV end scale range, to the output terminals.

2. Set the VOLTAGE RANGE dial to 10.

3. Adjust R36 (on amplifier board) for 0 ±25 microvolts.

c. Accuracy Adjustment

1. Connect the instrument to the test equipment as shown in Figure 4-3.

2. Set the decade dials to indicate the value of the standard voltage, with the VOLTAGE RANGE dial set to the lowest appropriate range. Properly zero the null indicator on the appropriate range.

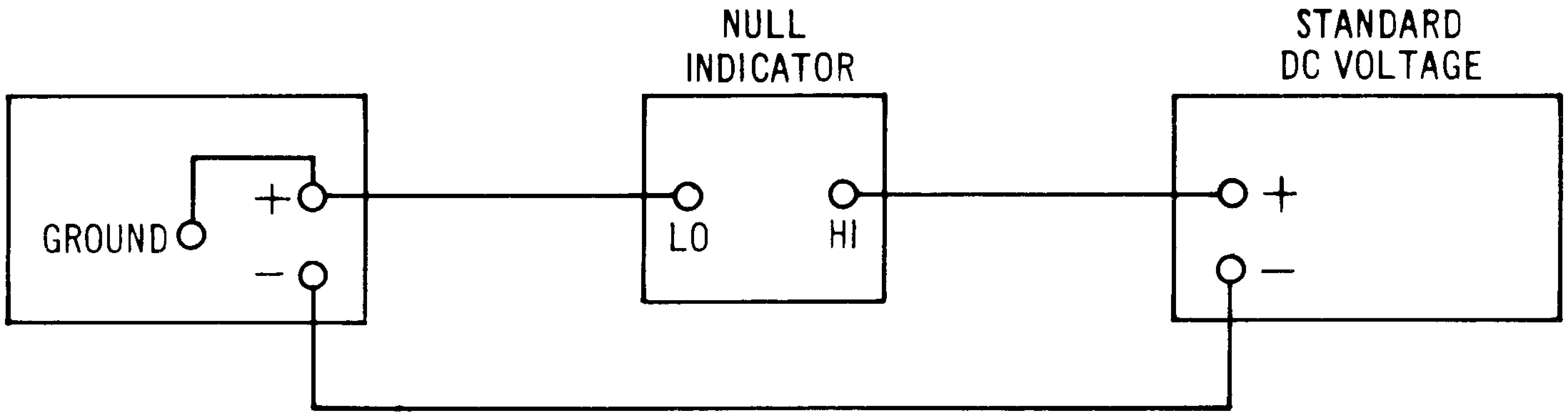


Figure 4-3. Calibration Setup

3. Adjust R8 (on power supply board) to obtain a null indication within 20 parts per million.

4-13. TROUBLESHOOTING

WARNING

To minimize shock hazard when troubleshooting with the instrument energized, connect the positive terminal to the metal terminal (ground). This provides a negative output and ensures that the output voltage is not present between the chassis and the front panel.

Familiarity with the theory of operation and the circuits of the instrument is advisable before troubleshooting is attempted. Knowing how the instrument functions, the general area within which a fault exists sometimes can be determined simply by operating the controls and noting the results. Try this as a first step and attempt to locate the fault by checking for overheated components, discolored resistors, broken wires, cold electron tubes, etc. If this method fails to give some indication of the cause of the trouble a systematic check of the circuits may be necessary.

4-14. LOCALIZING TROUBLE

Before making a systematic check of the circuits it would be advisable to first check the protective circuit. The protective circuit could cycle because of an internal overload or it could malfunction because of a fault within the protective circuit itself. It the instrument is not externally overloaded and the DC indicator is flashing on and off, the protective circuit is functioning properly and is cycling because of an internal overload. If the DC indicator is extinguished, and it is not due to the indicator being open circuit, the protective circuit could be faulty causing a loss of output. An open circuit DC indicator, a defective output tube, loss of voltage at the output tube, loss of reference voltage, or an open range resistor could also cause an absence of output.

Troubleshooting should be done with the aid of the schematic diagram, Figure 4-4 or 4-5, and the circuit descriptions and the diagrams in Section III. Systematically check the circuits and all supply voltages, and trace signals to localize the trouble to a particular area. To aid troubleshooting, the schematic diagrams in Figures 4-4 and 4-5 are marked with normal-operation waveforms and voltages.

4-15. LOCATING FAULTS

When the trouble has been localized to a particular area, such as the power supply, protective circuit, or one of the amplifiers, locate the fault by employing the usual troubleshooting methods of tracing signals, checking waveforms, measuring voltages, and testing components; no special techniques are required.

4-16. INTERNAL ADJUSTMENTS

Adjustments can be made to the dc balance and the protective circuit. The dc balance adjustment, R36, sets the voltage for the screen grid of V3A in the dc amplifier; this obtains a dc balance, 0 volts, at the control grid of V3A. The protective circuit adjustment, R26, sets the level of bias voltage for the base of Q5, which is part of the Schmitt trigger circuit, and determines the tripping level of the protective circuit.

4-17. DC BALANCE ADJUSTMENT

The dc balance should be adjusted if tube V3 is replaced. This adjustment is made by connecting a galvanometer or a center-zero voltmeter to the output terminals and adjusting R36 to obtain 0 ± 25 microvolts. (Refer to paragraph 4-12, procedures a and b.)

4-18. PROTECTIVE CIRCUIT ADJUSTMENT

This adjustment should be made after repair to the protective circuit or if the tripping level of the protective circuit is too high or too low. The procedure, which requires the use of an external load, such as a 100-ohm, 5 percent resistor, is as follows:

NOTE

The protective circuit can be adjusted to trip within the range of approximately 21 to 29 milliamperes. The following procedure adjusts the protective circuit to trip when the instrument is overloaded by at least 1 milliampere. To adjust the circuit to trip at a different level, set the decade dials to the appropriate voltages in steps d, h, i, and j.

a. If the ac-line voltage is particularly high or low use a Variac set for the appropriate line voltage.

b. Set the VOLTAGE RANGE dial to ZERO.

c. Turn on the instrument and let it warm up.

d. Connect a 100-ohm resistor across the output terminals and set the decade dials to 2.60000. (This represents a load of 26 milliamperes; 1 milliampere overload.)

e. Turn R26 fully counterclockwise.

f. Set the VOLTAGE RANGE dial to 10.

g. Slowly turn R26 clockwise until the DC indicator starts to flash on and off. (Do not turn R26 beyond this point.)

h. Set the decade dials for 2.5 volts (this fully loads the instrument at the nominal 25 milliamperes). The DC indicator should stop flashing.

i. Set the decade dials for 2.6 volts and the DC indicator should flash.

j. Check the operation of the protective circuit on the 100-volt and the 1000-volt ranges.

4-19. CORRECTIVE MAINTENANCE

When troubleshooting or performing corrective maintenance the following points should be borne in mind:

a. The chopper is of the plug-in type and easily replaceable. The most valid performance test of a chopper is to replace it with one known to be good. Do not replace the chopper when the instrument is energized.

b. If troubleshooting indicates that the amplifier board is faulty, and a tube is not the cause, replacing the board with a spare will usually be the quickest way to restore the instrument to service.

c. Observe the usual precautions when handling or soldering the etched-circuit boards.

d. If tube V3 is replaced R36 may require readjustment (refer to paragraph 4-17).

e. After repair of the protective circuit R26 may require readjustment (refer to paragraph 4-18).

4-20. REPLACEMENT PARTS

A list of replacement parts, arranged alphanumerically according to circuit reference designations, is contained in Table 4-1.

NOTE

If the type, value, etc., of a component to be replaced is different from that given in Table 4-1, make the replacement using the component listed in the table.

Table 4-1. Replacement Parts

CIRCUIT REF.	DESCRIPTION	COHU PART NO.
*A1	ASSEMBLY, POWER SUPPLY BOARD	7819022-001
**A1	ASSEMBLY, POWER SUPPLY BOARD	7819025-001
A1	ASSEMBLY, POWER SUPPLY BOARD	7819028-001
A1C1	CAPACITOR, ELECTROLYTIC, 200UF, 50V	0510124-038
A1C2	CAPACITOR, CERAMIC DISC, .002UF, 500V	0401048
A1C3	CAPACITOR, ELECTROLYTIC, 2X1000UF, 15V	0510007
A1C4	CAPACITOR, ELECTROLYTIC, 80/40/20 UFD, 450V	0510022
A1C5	CAPACITOR, ELECTROLYTIC, 40UF, 500V	0510061-007
A1C6	CAPACITOR, ELECTROLYTIC, 40UF, 500V	0510061-007
A1C7	CAPACITOR, ELECTROLYTIC, 20UF, 450V	0510122-002
A1C8	CAPACITOR, ELECTROLYTIC, 20UF, 450V	0510122-002
A1C9	CAPACITOR, ELECTROLYTIC, 20UF, 450V	0510122-002
A1C10	CAPACITOR, ELECTROLYTIC, 20UF, 450V	0510122-002
A1C11	CAPACITOR, ELECTROLYTIC, 20UF, 450V	0510122-002
A1C12	CAPACITOR, ELECTROLYTIC, 1UFD, 50V	0510150-001
A1C14	CAPACITOR, MYLAR, .68UF, 100V	0610109-118
A1C15	CAPACITOR, CERAMIC, .1 UF, 50V	0410009-104
A1CR1	DIODE, RECTIFIER, TYPE ST-18	3510068-004
A1CR2	DIODE, RECTIFIER, TYPE ST-18	3510068-004
A1CR3	DIODE, RECTIFIER, TYPE ST-18	3510068-004
A1CR4	DIODE, RECTIFIER, TYPE ST-18	3510068-004
A1CR5	DIODE, RECTIFIER, TYPE ST-18	3510068-004
A1CR6	DIODE, RECTIFIER, TYPE ST-18	3510068-004
A1CR7	DIODE, RECTIFIER, TYPE ST-18	3510068-004
A1CR8	DIODE, RECTIFIER, TYPE ST-18	3510068-004
A1CR9	DIODE, RECTIFIER, TYPE ST-18	3510068-004
A1CR10	DIODE, RECTIFIER, TYPE ST-18	3510068-004
A1CR11	DIODE, RECTIFIER, TYPE ST-18	3510068-004
A1CR12	DIODE, RECTIFIER, TYPE ST-18	3510068-004
A1CR13	DIODE, RECTIFIER, TYPE ST-18	3510068-004
A1CR14	DIODE, RECTIFIER, TYPE ST-18	3510068-004
A1CR15	DIODE, RECTIFIER, TYPE ST-18	3510068-004
A1CR16	DIODE, RECTIFIER, TYPE ST-18	3510068-004
A1CR17	DIODE, ZENER, TYPE RS-6	3510022-004
A1CR18	DIODE, ZENER, TYPE IN825	3510060-001
†A1CR19	DIODE, ZENER, TYPE IN714	3510042-012
A1CR19	DIODE, ZENER, TYPE VR22	3510049-016
A1CR20	DIODE, SILICON, TYPE 74	3510050-001
A1CR21	DIODE, GERMANIUM, TYPE IN270	3510042-023
A1CR23	DIODE, RECTIFIER, TYPE ST-18	3510068-004
††A1CR24	DIODE, RECTIFIER, TYPE ST-18	3510068-004
††A1CR25	DIODE, RECTIFIER, TYPE ST-18	3510068-004
A1DS1	LAMP, NEON, TYPE NE-2E	1704151-001
A1Q1	TRANSISTOR, TYPE 2N3638	7210069-001
A1Q2	TRANSISTOR, TYPE RA1A	7210067-001
A1Q3	TRANSISTOR, TYPE TI-412	7210064-002
A1Q4	TRANSISTOR, TYPE TI-412	7210064-002
A1Q5	TRANSISTOR, TYPE 2N3638	7210069-001
A1Q6	TRANSISTOR, TYPE 2N3638	7210069-001

*UNITS 1-0001 THRU 1-0010 ONLY **UNITS 1-0011 THRU 1-0085 ONLY †UNITS 1-0001 THRU 1-0085 ONLY ††UNITS 1-0086 AND ON

Table 4-1. Replacement Parts (Contd)

CIRCUIT REF.	DESCRIPTION	COHU PART NO.
A1Q7	TRANSISTOR, TYPE 2N3568	7210069-003
A1Q8	TRANSISTOR, TYPE 3N84	7210066-001
A1Q9	TRANSISTOR, TYPE TI-412	7210064-002
A1R1	RESISTOR, 1/2 WATT, 5%, 560 OHM	0310030-561
A1R2	RESISTOR, 1/2 WATT, 5%, 4.7 KILOHM	0310030-472
A1R3	RESISTOR, 1/2 WATT, 5%, 10 KILOHM	0310030-103
A1R4	RESISTOR, PRECISION, 1%, 770 OHM	5210080-048
A1R6	RESISTOR, 1/2 WATT, 5%, 1 KILOHM	0310030-102
A1R7	RESISTOR, WIREWOUND, NI, *** OHM	5210080-***
A1R8	RESISTOR, VARIABLE, 8 OHM	5010075-002
A1R10	RESISTOR, 1 WATT, 5%, 470 OHM	0310031-471
A1R11	RESISTOR, 1 WATT, 5%, 390 OHM	0310031-391
A1R12	RESISTOR, 1/2 WATT, 5%, 150 KILOHM	0310030-154
A1R14	RESISTOR, 1 WATT, 5%, 390 OHM	0310031-391
A1R15	RESISTOR, 1 WATT, 5%, 120 KILOHM	0310031-124
A1R16	RESISTOR, 1 WATT, 5%, 56 KILOHM	0310031-563
A1R17	RESISTOR, WIREWOUND, 20W, 10 KILOHM	5102100
A1R18	RESISTOR, 1 WATT, 5%, 270 KILOHM	0310031-274
A1R19	RESISTOR, 1 WATT, 5%, 270 KILOHM	0310031-274
A1R20	RESISTOR, 1 WATT, 5%, 270 KILOHM	0310031-274
A1R21	RESISTOR, 1 WATT, 5%, 270 KILOHM	0310031-274
†A1R23	RESISTOR, 1/2 WATT, 5%, 33 KILOHM	0310030-333
A1R23	RESISTOR, 1/2 WATT, 5%, 68 KILOHM	0310030-683
A1R24	RESISTOR, 1/2 WATT, 5%, 150 KILOHM	0310030-154
†A1R24	RESISTOR, 1/2 WATT, 5%, 82 KILOHM	0310030-823
†A1R25	RESISTOR, 1/2 WATT, 5%, 1.8 KILOHM	0310030-182
A1R25	RESISTOR, 1/2 WATT, 5%, 3.9 KILOHM	0310030-392
A1R26	RESISTOR, VARIABLE, 1.25W, 5 KILOHM	5010209-003
†A1R27	RESISTOR, 1/2 WATT, 5%, 10 KILOHM	0310030-103
A1R27	RESISTOR, 1/2 WATT, 5%, 6.8 KILOHM	0310030-682
A1R28	RESISTOR, 1/2 WATT, 5%, 120 OHM	0310030-121
†A1R29	RESISTOR, 1/2 WATT, 5%, 2.2 KILOHM	0310030-222
A1R29	RESISTOR, 1/2 WATT, 5%, 4.7 KILOHM	0310030-472
†A1R30	RESISTOR, 1/2 WATT, 5%, 12 KILOHM	0310030-123
A1R30	RESISTOR, 1/2 WATT, 5%, 22 KILOHM	0310030-223
†A1R31	RESISTOR, 1/2 WATT, 5%, 10 KILOHM	0310030-103
A1R31	RESISTOR, 1/2 WATT, 5%, 18 KILOHM	0310030-183
†A1R32	RESISTOR, 1/2 WATT, 5%, 18 KILOHM	0310030-183
A1R32	RESISTOR, 1/2 WATT, 5%, 47 KILOHM	0310030-473
A1R33	RESISTOR, 1 WATT, 5%, 270 KILOHM	0310031-274
A1R34	RESISTOR, 1/2 WATT, 5%, 680 KILOHM	0310030-684
A1R35	RESISTOR, 1/2 WATT, 5%, 10 KILOHM	0310030-103
A1R36	RESISTOR, 1/2 WATT, 5%, 120 OHM	0310030-121
A1R37	RESISTOR, 1/2 WATT, 5%, 22 KILOHM	0310030-223
A1R38	RESISTOR, 1/2 WATT, 5%, 22 KILOHM	0310030-223
A1R39	RESISTOR, 1/2 WATT, 5%, 22 MEGOHM	0310030-226
A1R41	RESISTOR, 1/2 WATT, 5%, 180 KILOHM	0310030-184
A1R42	RESISTOR, 1/2 WATT, 5%, 120 KILOHM	0310030-124
A1R43	RESISTOR, 2 WATT, 5%, 180 KILOHM	0310032-184

†UNITS 1-0001 THRU 1-0085 ONLY ***VALUE DETERMINED IN TEST

Table 4-1. Replacement Parts (Contd)

CIRCUIT REF.	DESCRIPTION	COHU PART NO.
A1R44	RESISTOR, 2 WATT, 5%, 180 KILOHM	0310032-184
A1R45	RESISTOR, 2 WATT, 5%, 180 KILOHM	0310032-184
A1R46	RESISTOR, 2 WATT, 5%, 10 OHM	0310032-100
A1R47	RESISTOR, 2 WATT, 5%, 10 OHM	0310032-100
A1R48	RESISTOR, 1/2 WATT, 5%, 1 MEGOHM	0310030-105
** A2	ASSEMBLY, AMPLIFIER BOARD	7819030-001
* A2	ASSEMBLY, AMPLIFIER BOARD	7819032-001
A2	ASSEMBLY, AMPLIFIER BOARD	7819037-001
A2C1	CAPACITOR, MYLAR, .10UF, 400V	0610018-027
A2C2	CAPACITOR, CERAMIC DISC, 50PF, 1KV	0401016
A2C3	CAPACITOR, MYLAR, .01UF, 400V	0610018-015
A2C5	CAPACITOR, MYLAR, .01UF, 400V	0610018-015
A2C6	CAPACITOR, MYLAR, .01UF, 400V	0610018-015
A2C8	CAPACITOR, MYLAR, .01UF, 200V	0610017-015
A2C9	CAPACITOR, MYLAR, .0047UF, 400V	0610018-011
A2C10	CAPACITOR, MYLAR, .47UF, 200V	0610017-035
A2C11	CAPACITOR, MYLAR, .033UF, 400V	0610018-021
A2C12	CAPACITOR, CERAMIC DISC, 50PF, 1KV	0401016
A2C13	CAPACITOR, CERAMIC DISC, .01UF, 500V	0401056
A2C14	CAPACITOR, MYLAR, .33UF, 200V	0610133-025
A2C15	CAPACITOR, MYLAR, .01UF, 400V	0610018-015
A2C16	CAPACITOR, MYLAR, .10UF, 400V	0610018-027
A2C17	CAPACITOR, CERAMIC DISC, .01UF, 500V	0401056
A2C18	CAPACITOR, CERAMIC DISC, .01UF, 500V	0401056
A2CR1	DIODE, SILICON, TYPE HC71	3510053-005
†A2CR3	DIODE, ZENER, TYPE RS-6	3510022-004
A2CR3	DIODE, ZENER, TYPE VR6	3510049-017
A2CR4	DIODE, SILICON, TYPE 74	3510050-001
A2CR6	DIODE, RECTIFIER, TYPE ST-18	3510068-004
A2CR7	DIODE, RECTIFIER, TYPE ST-18	3510068-004
A2CR8	DIODE, SILICON, TYPE 1N628	3510004
A2CR9	DIODE, SILICON, TYPE 1N628	3510004
A2DS1	LAMP, NEON, TYPE NE-2E	1704151-001
A2G1	CHOPPER, SPDT, 6.3V, 50-60HZ	6310020-001
A2R1	RESISTOR, 1 WATT, 5%, 10 KILOHM	0310031-103
A2R2	RESISTOR, 1/2 WATT, 5%, 560 KILOHM	0310030-564
A2R3	RESISTOR, 1/2 WATT, 5%, 1 KILOHM	0310030-102
A2R4	RESISTOR, 1/2 WATT, 5%, 3.3 MEGOHM	0310030-335
A2R5	RESISTOR, 1/2 WATT, 5%, 10 MEGOHM	0310030-106
A2R6	RESISTOR, 1/2 WATT, 5%, 10 KILOHM	0310030-103
A2R7	RESISTOR, 1/2 WATT, 5%, 220 KILOHM	0310030-224
A2R8	RESISTOR, 1/2 WATT, 5%, 220 KILOHM	0310030-224
†A2R9	RESISTOR, 1/2 WATT, 5%, 3.3 KILOHM	0310030-332
A2R9	RESISTOR, 1/2 WATT, 5%, 6.8 KILOHM	0310030-682
†A2R10	RESISTOR, 1/2 WATT, 5%, 1 KILOHM	0310030-102
A2R10	RESISTOR, 1/2 WATT, 5%, 2.2 KILOHM	0310030-222
A2R11	RESISTOR, 1/2 WATT, 5%, 3.3 MEGOHM	0310030-335
A2R12	RESISTOR, 1/2 WATT, 5%, 2.7 MEGOHM	0310030-275
†A2R15	RESISTOR, 1/2 WATT, 5%, 3.3 KILOHM	0310030-332

*UNITS 1-0001 THRU 1-0010 ONLY **UNITS 1-0011 THRU 1-0085 ONLY †UNITS 1-0001 THRU 1-0085 ONLY

Table 4-1. Replacement Parts (Contd)

CIRCUIT REF.	DESCRIPTION	COHU PART NO.
A2R15	RESISTOR, 1/2 WATT, 5%, 6.8 KILOHM	0310030-682
†A2R16	RESISTOR, 1/2 WATT, 5%, 1 KILOHM	0310030-102
A2R16	RESISTOR, 1/2 WATT, 5%, 2.2 KILOHM	0310030-222
A2R17	RESISTOR, 1/2 WATT, 5%, 1 MEGOHM	0310030-105
A2R18	RESISTOR, 1/2 WATT, 5%, 1.2 KILOHM	0310030-122
†A2R18	RESISTOR, 1/2 WATT, 5%, 390 OHM	0310030-391
A2R19	RESISTOR, 1/2 WATT, 5%, 100 KILOHM	0310030-104
A2R20	RESISTOR, 1/2 WATT, 5%, 470 KILOHM	0310030-474
A2R21	RESISTOR, 1/2 WATT, 5%, 680 OHM	0310030-681
A2R22	RESISTOR, 1/2 WATT, 5%, 22 KILOHM	0310030-223
A2R23	RESISTOR, 1/2 WATT, 5%, 68 KILOHM	0310030-683
A2R24	RESISTOR, 1/2 WATT, 5%, 4.7 MEGOHM	0310030-475
A2R25	RESISTOR, 1/2 WATT, 5%, 3.3 MEGOHM	0310030-335
A2R26	RESISTOR, 1/2 WATT, 5%, 18 MEGOHM	0310030-186
A2R27	RESISTOR, 1/2 WATT, 5%, 220 KILOHM	0310030-224
A2R28	RESISTOR, 1/2 WATT, 5%, 100 KILOHM	0310030-104
A2R29	RESISTOR, 1/2 WATT, 5%, 68 KILOHM	0310030-683
A2R30	RESISTOR, 1/2 WATT, 5%, 39 KILOHM	0310030-393
A2R31	RESISTOR, 1/2 WATT, 5%, 470 KILOHM	0310030-474
A2R32	RESISTOR, 2 WATT, 5%, 180 KILOHM	0310032-184
A2R33	RESISTOR, 2 WATT, 5%, 330 KILOHM	0310032-334
A2R34	RESISTOR, 1/2 WATT, 5%, 390 OHM	0310030-391
A2R36	RESISTOR, VARIABLE, PC, 25 KILOHM	5010086-006
A2R37	RESISTOR, 1 WATT, 5%, 120 KILOHM	0310031-124
A2R38	RESISTOR, 2 WATT, 5%, 33 KILOHM	0310032-333
A2R39	RESISTOR, 1 WATT, 5%, 47 KILOHM	0310031-473
A2R40	RESISTOR, 1/2 WATT, 5%, 6.8 MEGOHM	0310030-685
A2R41	RESISTOR, 1/2 WATT, 5%, 2.7 MEGOHM	0310030-275
A2V1	ELECTRON, TUBE, TYPE 6EU7	7010058-001
A2V2	ELECTRON TUBE, TYPE 6AW8A	7007419
A2V3	ELECTRON TUBE, TYPE 6AW8A	7007419
A2V4	ELECTRON TUBE, TYPE 8068	7010045-001
†A3	ASSEMBLY, DECADE AND RANGE RESISTORS	7819035-001
A3	ASSEMBLY, DECADE AND RANGE RESISTORS	7819036-001
A3R1	RESISTOR, WIREWOUND, NI, 600 KILOHM, 0.005%	5210111-019
A3R2	RESISTOR, WIREWOUND, NI, 60 KILOHM, 0.005%	5210111-020
A3R3	RESISTOR, WIREWOUND, NI 6 KILOHM, 0.005%	5210111-021
A3R4	RESISTOR, WIREWOUND, NI, 200 KILOHM, 0.005%	5210111-002
A3R5	RESISTOR, WIREWOUND, NI, 100 KILOHM, 0.005%	5210111-001
A3R6	RESISTOR, WIREWOUND, NI, 20 KILOHM, 0.01%	5210111-005
A3R7	RESISTOR, WIREWOUND, NI, 10 KILOHM, 0.01%	5210111-004
A3R8	RESISTOR, WIREWOUND, NI, 2 KILOHM, 0.01%	5210111-008
A3R9	RESISTOR, WIREWOUND, NI, 1 KILOHM, 0.01%	5210111-007
A3R10	RESISTOR, WIREWOUND, NI, 200 OHM, 0.015%	5210111-011
A3R11	RESISTOR, WIREWOUND, NI, 100 OHM, 0.015%	5210111-010
A3R12	RESISTOR, WIREWOUND, NI, 20 OHM, 0.5%	5210111-014
A3R13	RESISTOR, WIREWOUND, NI, 10 OHM, 0.5%	5210111-013
A3R14	RESISTOR, WIREWOUND, NI, 2 OHM, 1%	5210111-017
A3R15	RESISTOR, WIREWOUND, NI, 1 OHM, 1%	5210111-016

†UNITS 1-0001 THRU 1-0085 ONLY

Table 4-1. Replacement Parts (Contd)

CIRCUIT REF.	DESCRIPTION	COHU PART NO.
A3R16	RESISTOR, WIREWOUND, NI, 400 KILOHM, 0.005%	5210111-003
A3R17	RESISTOR, WIREWOUND, NI, 400 KILOHM, 0.005%	5210111-003
A3R18	RESISTOR, WIREWOUND, NI, 40 KILOHM, 0.01%	5210111-006
A3R19	RESISTOR, WIREWOUND, NI, 40 KILOHM, 0.01%	5210111-006
A3R20	RESISTOR, WIREWOUND, NI, 4 KILOHM, 0.01%	5210111-009
A3R21	RESISTOR, WIREWOUND, NI, 4 KILOHM, 0.01%	5210111-009
A3R22	RESISTOR, WIREWOUND, NI, 400 OHM, 0.015%	5210111-012
A3R23	RESISTOR, WIREWOUND, NI, 400 OHM, 0.015%	5210111-012
A3R24	RESISTOR, WIREWOUND, NI, 40 OHM, 0.5%	5210111-015
A3R25	RESISTOR, WIREWOUND, NI, 40 OHM, 0.5%	5210111-015
A3R26	RESISTOR, WIREWOUND, NI, 4 OHM, 1%	5210111-018
A3R27	RESISTOR, WIREWOUND, NI, 4 OHM, 1%	5210111-018
A3S1	SWITCH, ROTARY, 4P4T, NON-SHORTING	6210145-001
A3S2	SWITCH, ROTARY 4-4-2-1 BCD, SHORTING	6290136-002
A3S3	SWITCH, ROTARY 4-4-2-1 BCD, SHORTING	6290136-002
A3S4	SWITCH, ROTARY 4-4-2-1 BCD, SHORTING	6290136-002
A3S5	SWITCH, ROTARY 4-4-2-1 BCD, SHORTING	6290136-002
A3S6	SWITCH, ROTARY 4-4-2-1 BCD, SHORTING	6290136-002
A3S7	SWITCH, ROTARY 4-4-2-1 BCD, SHORTING	6290136-002
B901	MOTOR, FAN, DYAB 569-116	3103838
†CR901	DIODE, SILICON, TYPE IN3563/IN3752/SC10A	3510053-006
C901	CAPACITOR, POLYSTYRENE, .1 UF, 1500 V	0610108-002
C902	CAPACITOR, POLYSTYRENE, .1 UF, 1500 V	0610108-002
DS901	LAMP ASSEMBLY, NEON, TYPE A1B	1710152-005
F901	FUSE, CARTRIDGE, F02 SLO-BLO, 1.50 AMP	1710040-122
S901	SWITCH, TOGGLE, SPST	6103563
T901	TRANSFORMER, POWER, 115/230V, 50/60 HZ	7819020-001

†UNITS 1-0001 THRU 1-0085 ONLY (REPLACED BY A1CR24 AND A1CR25 IN UNITS 1-0086 AND ON)

Recommended Spare Parts for COHU Model 324 DC Voltage Calibrator

		KIT NUMBER		
		78191 PK001	78191 PK005	78191 PK025
		STOCK LEVEL		
COHU PART NO.	DESCRIPTION	1 unit	5 units	25 units
0510122-002	Capacitor, Electrolytic, 20 μF, 450V	1	3	5
0610018-015	Capacitor, Mylar, .01 μF, 400V	1	3	5
0610018-027	Capacitor, Mylar, .10 μF, 400V	1	3	5
0610108-002	Capacitor, Polystyrene, .1 μF, 1500V	1	3	5
1704151-001	Lamp, Neon, Type NE-2E	1	3	5
1710040-122	Fuse, Cartridge, F02 Slo-Blo, 1.50 Amp	1	3	5
1710152-005	Lamp Assembly, Neon, Type A1B	1	3	5
3510022-004	Diode, Zener, Type RS-6	0	1	3
3510049-016	Diode, Zener, Type VR22	1	3	5
3510068-004	Diode, Rectifier, Type ST-18	5	10	20
6290136-002	Switch, Rotary 4-4-2-1 BCD, Shorting	5	12	25
6310020-001	Chopper, SPDT, 6.3V, 50-60 Hz	1	3	5
7007419	Electron Tube, Type 6AW8A	2	5	12
7010045-001	Tlectron Tube, Type 8068	0	1	3
7010058-001	Electron, Tube, Type 6EU7	1	3	5
7210069-001	Transistor, Type 2N3638	1	3	5
7819020-001	Transformer, Power, 115-230V, 50-60 Hz	0	0	1
7819028-001	Assembly, Power Supply Board	0	0	1
7819037-001	Assembly, Amplifier Board	0	0	1

WARRANTY

COHU ELECTRONICS, INC., warrants equipment manufactured to be free from defects of material and workmanship. Any part or parts will be repaired or replaced when proven by COHU examination to have been defective within one year (90 days for batteries, fuses, transistors and tubes) from date of shipment to the original purchaser. All warranty repairs will be performed at the factory or as otherwise authorized by COHU in writing. Transportation charges shall be prepaid by purchaser.

This warranty does not extend to COHU equipment subjected to misuse, accident, neglect or improper application; nor repaired or altered by other than COHU or those authorized by COHU in writing.

This warranty is in lieu of all other warranties express or implied. COHU shall not be liable for collateral or consequential damages.

For customer convenience, service departments are maintained throughout the United States by COHU Field Engineering Representatives.

COHU ELECTRONICS, INC
SAN DIEGO CALIFORNIA

BOX 623, SAN DIEGO, CALIFORNIA 92112 • PHONE 714-277-6700 • TWX 910-335-1244