INSTRUCTION MANUAL

MODEL F210A

DATA ROYAL CORPORATION

SAN DIEGO, CALIFORNIA

INSTRUCTION MANUAL

MODEL F210A

BLDG 77
RM 53

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SECTION I

INTRODUCTION

The Data Royal Model F210A is a high frequency Waveform Generator. The F210A provides continuously variable selection of frequency from .005 Hz to 3MHz by means of 16 possible range switch combinations and a 20:1 vernier control.

The Model F210A provides Square, Sine, Triangle and Ramp outputs of up to 16.25 volts peak-to-peak, selectable by push button function switches on the front panel. In addition, fixed level outputs of all waveforms are simultaneously available on BNC connectors on the rear panel. All rear outputs have 50Ω output impedances, while both 50Ω and 600Ω connectors are provided for the front panel outputs.

A Sync signal output is also provided on a front panel BNC connector. The Sync pulse is a -10 volt pulse of maximum duration of 5 micro-seconds, and is synchronized with the selected frequency.

A Frequency Control Input is provided on the front panel, enabling the F210A to deliver frequency modulated (FM), frequency shift keying (FSK), or "swept" signals. This is accomplished by applying a Sine, Square or Ramp signal, respectively, to the FC Input.

The following F900 Series Accessories can be added:

MODEL F910A ATTENUATOR/METER

For applications requiring more accurately known sine wave amplitudes than are possible to obtain using either the F200 or F300 Series instruments, Model F910A is provided. Although classified as an accessory, it is in itself a useful laboratory and production test instrument. A wide band AC voltmeter provides an accurate means of determining and monitoring sine wave inputs. In addition, a precision voltage divider enables the known voltage to be attenuated from 0 to -90 dB by push button control in -10 dB steps (10, 20, 30, and 30 dB). A fifth push button (-9 dB) allows the output voltage to be determined in rms or p-p.

MODEL F930A POWER AMPLIFIER

Although specifically designed for the F300 Series Sine and Sine/Square Generators, the Model F930A is suitable for use with other sine wave signal sources. For applications which require higher output than 3 V rms, this completely self-contained instrument can provide up to 30 V p-p across 50 ohms. The wide band AC amplifier employed has a frequency response from 10Hz to 100KHz. The same mechanical design concept as employed throughout the F900 Accessory Series enables the Model F930A to be attached to any one of the F300 Sine and Sine/Square Generators to form an integral package to facilitate rack mounting, space reduction and portability.

MODEL F940A TONE BURST GATE

The output of a selected number of cycles (1-100) of a specific frequency from any F300 Series Sine or Sine/Square Generator is enabled by the Model F940A tone burst control unit. Frequency capability extends from 10Hz to 10MHz. Thus, the ability of Data Royal instruments to meet ever changing test and measuring applications is greatly increased. The trigger start and stop point is adjustable over 360° in either polarity. Should the last cycle not be complete at the end of the selected tone burst period, a circuit allows the remainder of that cycle to be generated.

SECTION II

INSPECTION AND INSTALLATION

Your Data Royal Generator is ready for use immediately upon receipt. Make the following checks, however, to assure that no damage has occured during shipment.

1. Inspect the shipping container prior to acceptance from the carrier. Note any damage to the shipping container on the carrier's receipt.

2. Inspect the instrument for damage. Check for dents, scratches, broken knobs, connectors, etc.

3. Remove the top and bottom covers and inspect for broken components or hardware.

4. If damage is not apparent until after the instrument has been accepted , file a claim for concealed damage with the carrier within 15 days after receipt. All packaging material must be kept for inspection by the carrier's agent. A copy of the claim must be forwarded to Data Royal Corporation.

RACK MOUNTING:

Data Royal Generators are ready for bench operation as shipped from the factory. If specifically ordered, the necessary parts for rack mounting are packaged with the instrument. To convert to rack installation refer to Figure 2-1 and proceed as follows:

1. Remove the (4) rubber feet and the instrument bail.
2. Remove the Filler Panels from both sides.
3. Install the Rack Mounting Brackets using the #10 screws provided. The instrument is now ready to mount in a standard (19 inch) rack.

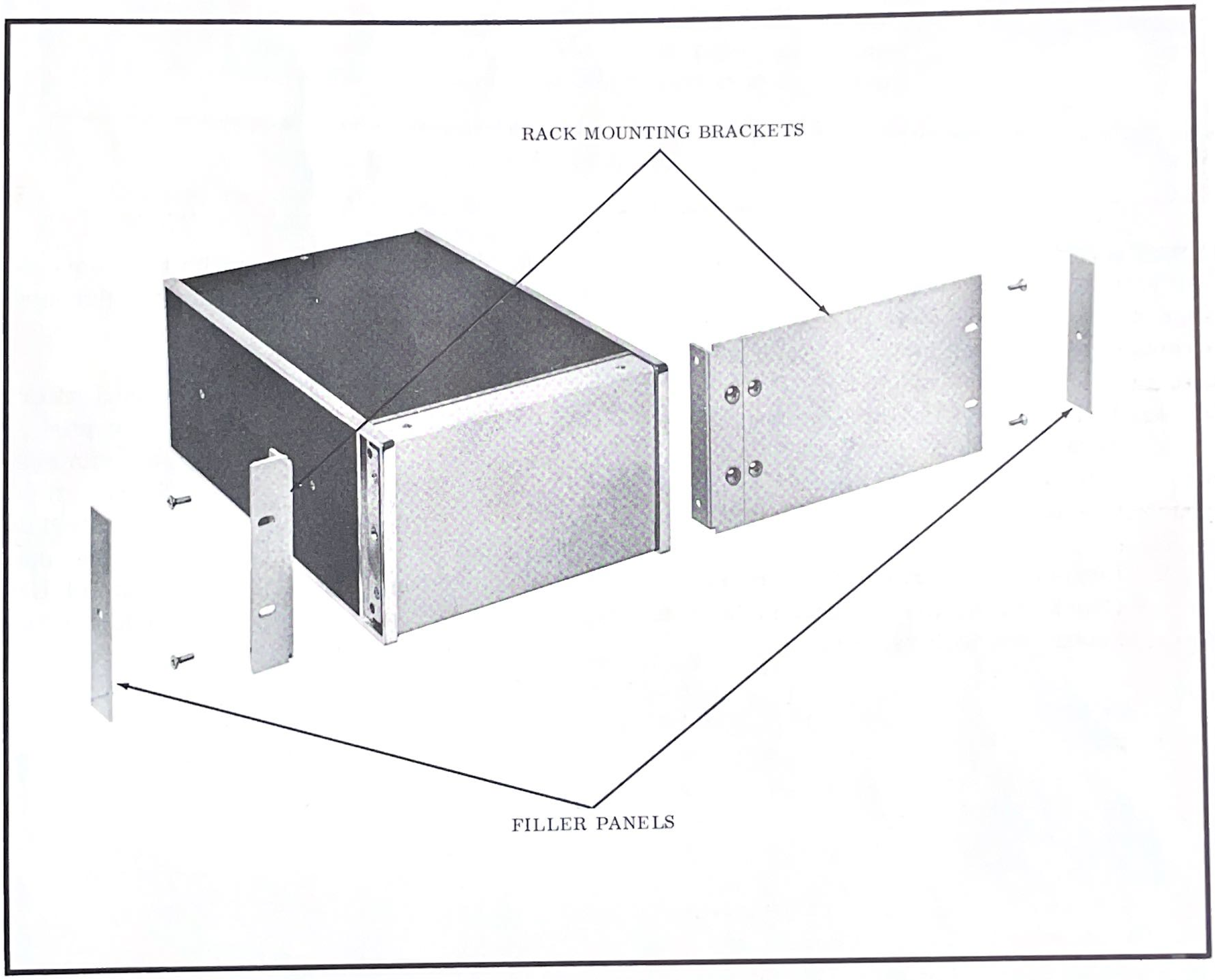


FIGURE 2-1

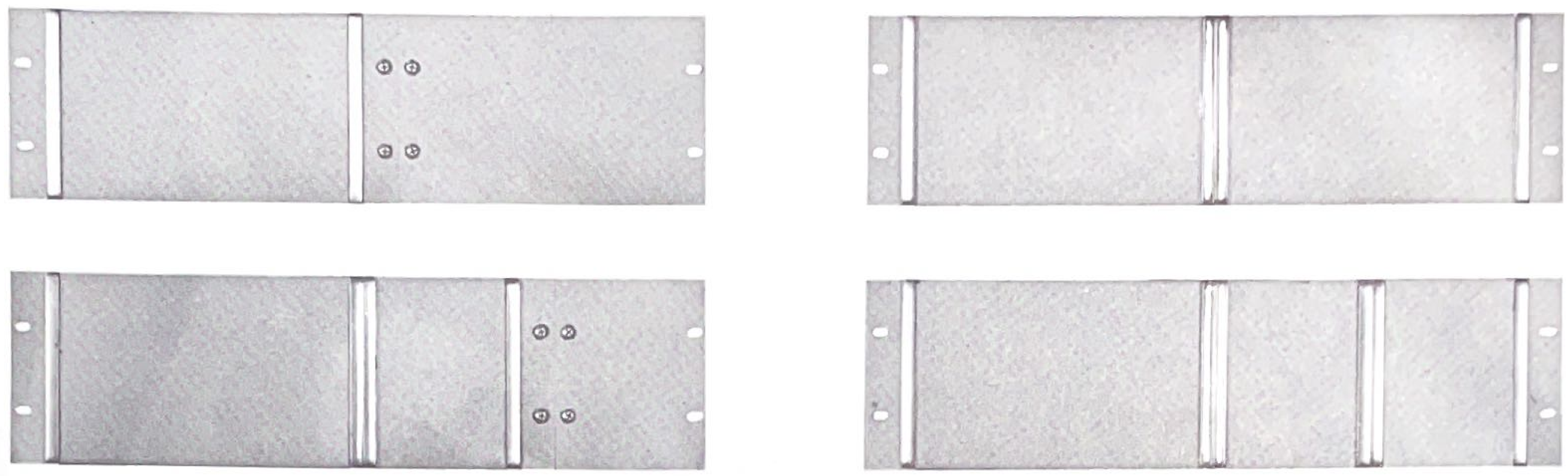


FIGURE	INSTRUMENT/ACCESSORY COMBINATION	MOUNTING KIT PART NO.
1	F210A	26-07650-1
2	F210A + second instrument	26-07652-1
3	F210A + one accessory	26-07651-1
4	F210A + two accessories	26-07652-1

FIGURE 2-2

COMBINATION WITH ACCESSORIES:

Each Generator can be combined with any other Data Royal 1/2 rack instrument, or with any Data Royal Series 900 Accessory, for ease of handling and conservation of space. With the appropriate Rack Mounting Kit, (4) combinations of instruments can be mounted in a single 5 1/4 inch space. (See Figure 2-2).

To combine two instruments, refer to Figure 2-3 and proceed as follows:

1. Remove the top and bottom covers from both instruments.

2. Remove the Filler Panels from the sides to be joined.

3. Remove the Mounting Clips from both instruments. (Under the top flange of front panel, held in place with #6-32 screw through the flange).

4. Remove the Angle mounted on the rear panel.

5. Insert the Mounting Clips in the rectangular holes at the top and bottom of the side rail near the front.

6. Secure the Mounting Clips with #6-32 screws removed in step 3 and spares provided.

7. Mount the Angle on the rear of the adjoining side rails, using the #6-32 screws provided.

8. Replace the top and bottom covers.

The procedure for attaching the Mounting Kit remains unchanged.

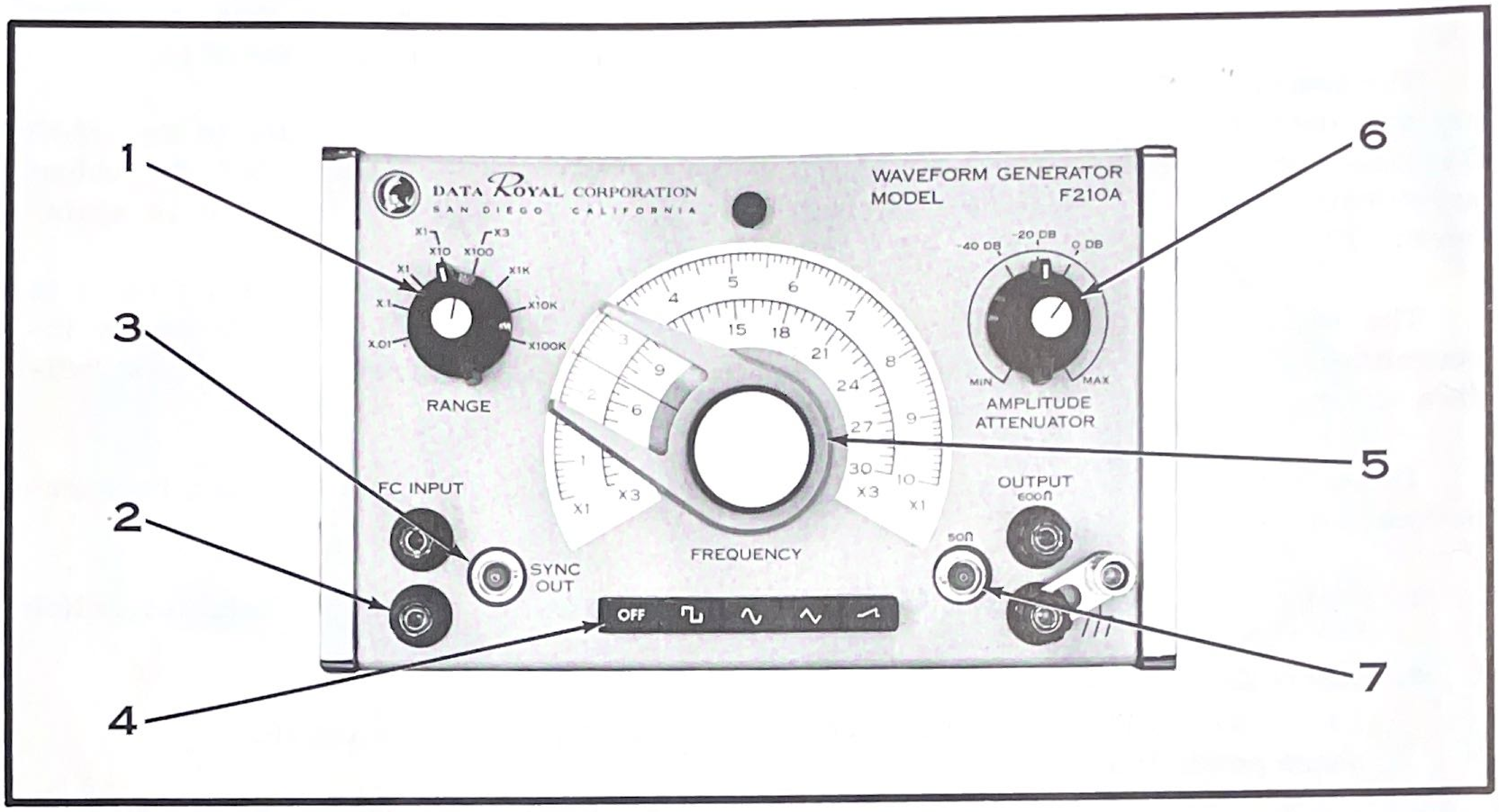


FIGURE 2-4

CONTROLS:

1. Range and Range Multiplier Switch. Concentric switches, which determine the RC networks for the Integrating Amplifier.

2. External Frequency Control Input. Enables the F210A output frequency to be controlled from an outside signal source, thus the F210A can provide Frequency Modulation or Frequency Shift output signals.

3. Sync Output. Provides a Sync signal of -10 volt amplitude, at same frequency as the output signal.

4. Function Switches and Power OFF. Selects the desired waveform as marked on each switch. Power is ON when one of the Function Switches is depressed.

5. Frequency Dial and Control. Marked in X1 and X3 ranges to correspond to the Range and Range Multiplier Switches.

6. Attenuator and Amplitude Controls. Varies the output signal level in fixed steps of 0dB, -20dB, and -40 dB. Amplitude Control varies the output over a range of >20dB.

7. Output Connectors provide 50 Ω and 600 Ω outputs, respectively. Output can be floated from chassis and from Earth Ground, if desired.

SECTION III

CALIBRATION AND SPECIFICATION VALIDATION

SPECIFICATIONS

OUTPUT WAVE FORMS: Sine, Square, Triangle and Ramp wave forms selectable at the front panel with all wave forms simultaneously available at the rear. All outputs are synchronized.

FREQUENCY RANGES: .005Hz to 3MHz in 16 continuously variable ranges of 1 and 3 combinations with a 20:1 frequency ratio. Vernier control provided by 3:1 dial gear ratio.

OUTPUT VOLTAGE:
Front Panel: Continuously variable by fixed output attenuator (0, -20, -40dB) with output amplitude vernier of > -20dB from 0.3-32.5 volts p-p (60dB range) with 50 or 600 ohm output impedance.

Rear Panel: Fixed outputs for each wave form with 50 ohm output impedance are simultaneously available as follows:

Sine	2 volts p-p
Square	5 volts p-p
Triangle	2 volts p-p
Ramp	0 to -1 volt

OUTPUT IMPEDANCE:
Front Panel: Both 50 ohm (BNC Connector) and 600 ohm (binding posts) output impedances are provided for the selected wave form.
Rear Panel: 50 ohm (BNC Connector) output impedance provided for each wave form.

SYNC OUTPUT: > -10 volts (open circuit) pulse for maximum of 5μseconds duration. (Front Panel BNC Connector).

FREQUENCY STABILITY:
Short Term Drift: < ±0.05% of setting for 10 minutes.
Long Term Drift: < ±0.25% of setting for 24 hours.

AMPLITUDE STABILITY:
Short Term: ± 0.05% of maximum output (p-p) for at least 10 minutes.
Long Term: ± 0.25% of maximum output (p-p) for 24 hours.

SYMMETRY (AMPLITUDE): Amplitude of all waveforms is within ± 1% of maximum output (p-p) above ground.

SYMMETRY (TIME):

>99.5%	.005Hz to 100KHz
>99.0%	100KHz to 1MHz
>95.0%	1MHz to 3MHz

SINE WAVE DISTORTION:

<1%,	.005Hz to 100KHz
<2%,	100KHz to 1MHz
<5%,	1MHz to 3MHz

OPERATING TEMPERATURE: 0° C to +50° C

POWER: 115V AC ±10% or 230V AC ±10%, 50 Hz-400Hz; 20 watts.

DIAL ACCURACY: ±1% of full scale, .005Hz to 100 KHz; ±2% of full scale, 100 KHz to 3MHz.

FREQUENCY RESPONSE: Amplitude change of <.1dB, .005Hz to 100KHz; <.5dB 100KHz to 3 MHz.

SQUARE WAVE RISE AND FALL TIME:
< 75 nano-seconds

TILT: <0.5% of p-p amplitude.

OVERSHOOT AND PRESHOOT: <5% of p-p amplitude.

TRIANGLE WAVE AND RAMP LINEARITY:
>99%, .005Hz to 100KHz
>95%, 100KHz to 3MHz

DC OFFSET STABILITY: Within ±.1% of maximum p-p amplitude for 7 days; no external adjustment required.

ISOLATION: Signal output and control input terminals are floating and isolated from case and power line ground; grounding strap provided.

CALIBRATION PROCEDURE

Operational Adjustments.

1. 12 Volt Power Supply Adjustment:

   a. Lift the Generator Board Assembly, exposing the Master Board.

   b. Connect a Digital Voltmeter to the +12 Volt Test Point (Red).

   c. Adjust R20 until the reading is 12.000 Volts.

   d. Check the voltage at the -12 Volt Test Point. Should read 12.000 volts ±.2 volts.

   e. Lower the Generator Board Assembly into place.

2. Square Wave Symmetry Adjustment:

   a. Position the Range Switch to X1K, and the Frequency Dial to 10.

   b. Connect the Oscilloscope to the 50Ω output conncetor on the Front Panel. Terminate the output in a 50Ω load at the input to the Oscilloscope.

   c. Select the Square Wave Function. Set Output Level to 0dB and the vernier fully clockwise.

   d. Set Oscilloscope to - Trigger. Expand the sweep as far as possible, and adjust the Horizontal Position so the positive going edge of the square wave is lined up with a vertical line on the grid.

   e. Switch the Oscilloscope to + Trigger and adjust the UPPER DIAL SYMMETRY Potentiometer so the negative going edge of the square wave lines up with the same vertical line on the grid.

   f. Turn the Frequency Dial to 1.

   g. Repeat Step d.

   h. Switch the Oscilloscope to + Trigger and adjust the LOWER DIAL SYMMETRY Potentiometer so the negative going edge of the square wave lines up with the same vertical line on the grid.

   i. Repeat Steps a. through g. until no further adjustment is required.

3. Frequency Control Amplifier Adjustments:

   a. Short the F.C. input on the Front Panel.

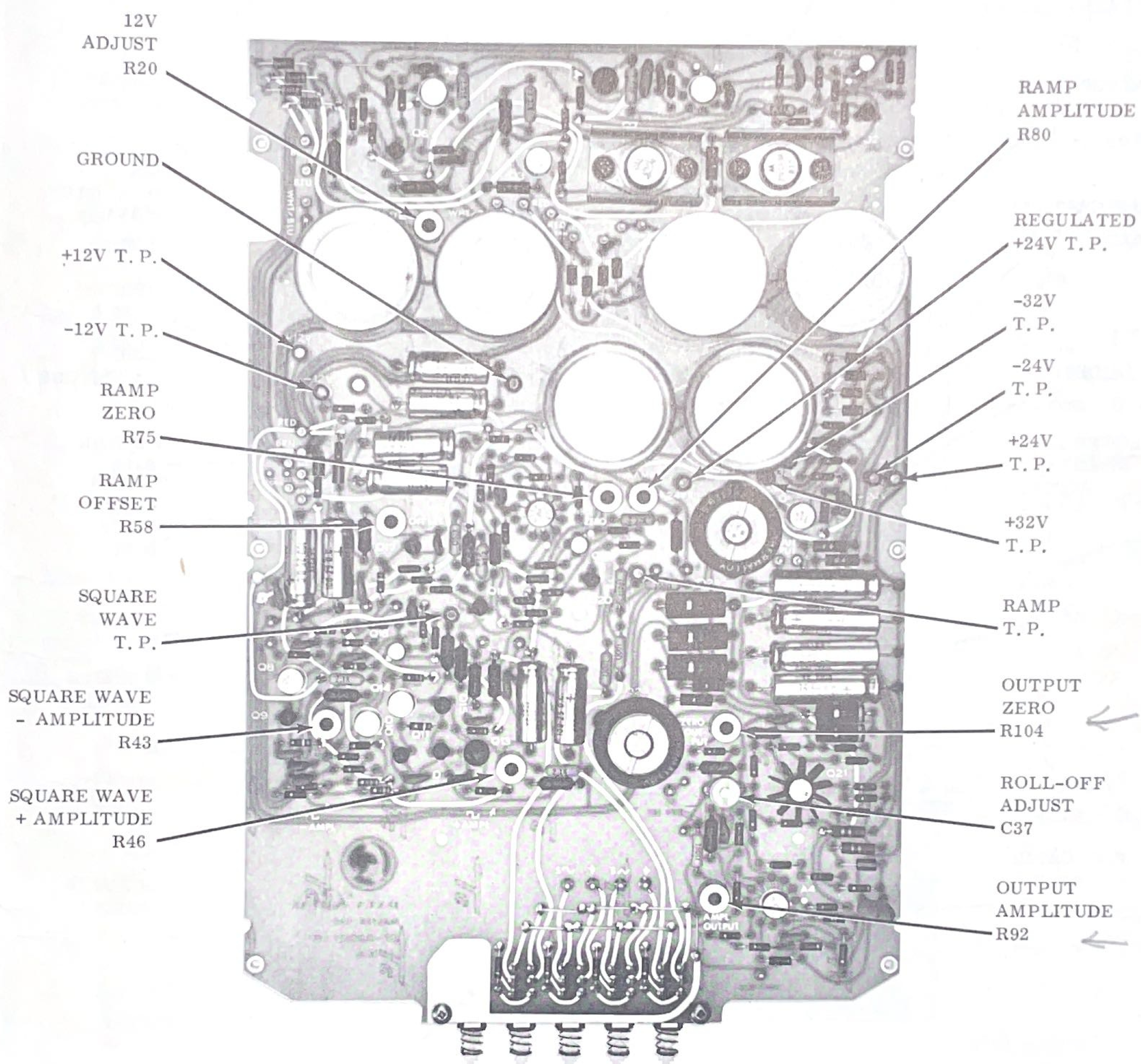


FIGURE 3-1

Master Board - Test Points
and Calibration Adjustments

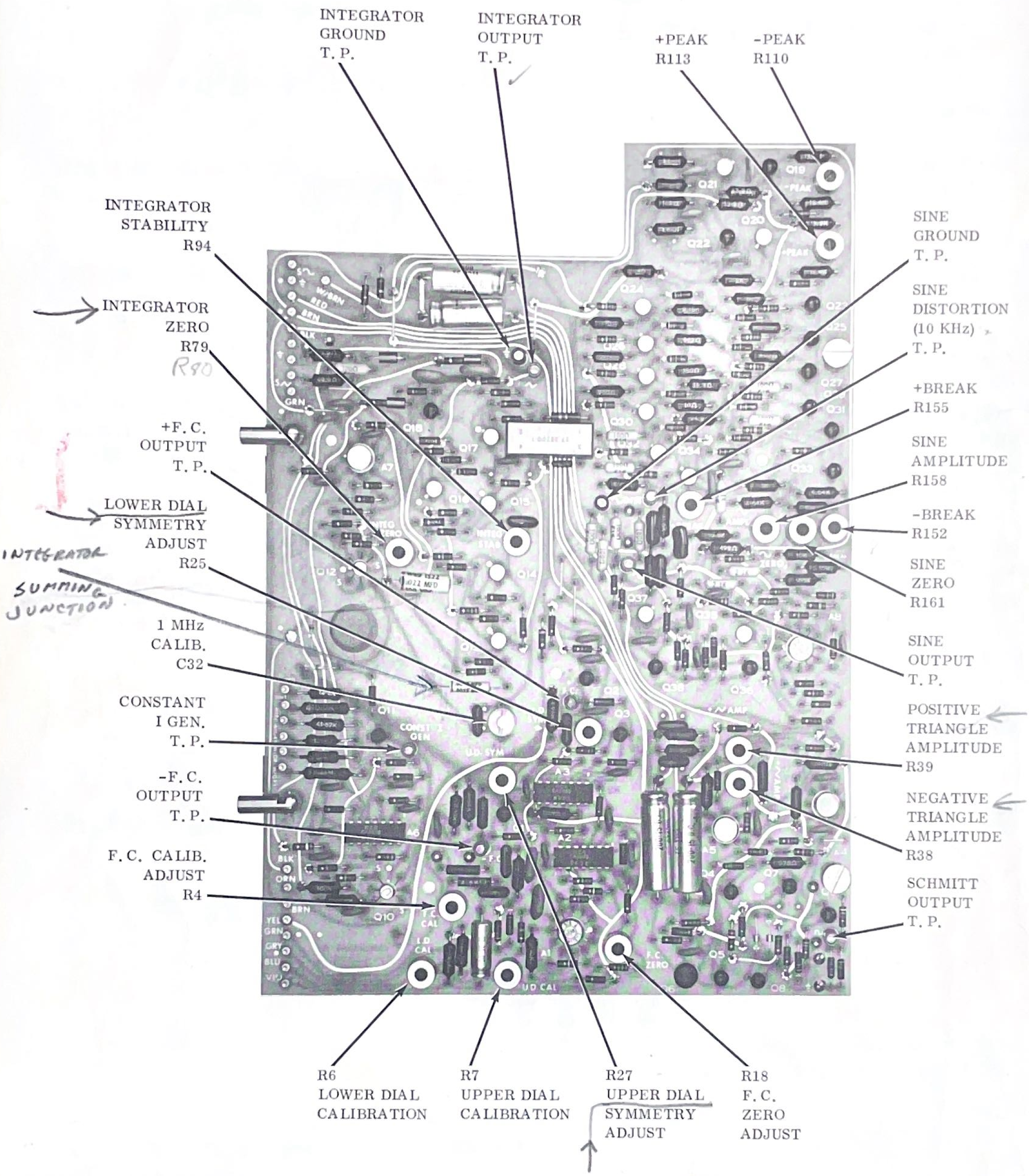


FIGURE 3-2

Generator Board - Test Points and Calibration Adjustments

b. Connect the Digital Voltmeter to the Summing Junction of the Integrator.
LEFT END OF .0022

c. Adjust the INTEGRATOR ZERO Potentiometer for 0 volts DC at the Summing Junction.

d. Disconnect the short from the F. C. input.

4. Schmitt Trigger Adjustments:

a. Connect the Oscilloscope to the Integrater Output Test Point (Green).

b. Adjust the TRIANGLE POSITIVE AMPLITUDE Potentiometer for + 1 volt peak amplitude.

c. Adjust the TRIANGLE NEGATIVE AMPLITUDE Potentiometer for - 1 volt peak amplitude.

5. Sine Generator Adjustments:

a. Position the Range Switch to X1K, and the Frequency Dial to 10.

b. Connect the Oscilloscope to the Sine Distortion Test Point (Green).
Connect dist Analyzer To output-

c. Vary the Frequency Dial slightly for minimum amplitude at the test point.

d. Adjust the NEGATIVE BREAK Potentiometer for minimum signal.

e. Adjust the POSITIVE BREAK Potentiometer for minimum signal.

f. Adjust the NEGATIVE PEAK Potentiometer for minimum signal.

g. Adjust the POSITIVE PEAK Potentiometer for minimum signal.

HAD TO SET AT 10K ?1

h. Repeat Steps d. through h. until no further adjustment is required.

6. Output Amplifier Adjustments:

a. Connect the Oscilloscope to the 50Ω output connector on the Front Panel. Terminate the output in a 50Ω load at the input to the Oscilloscope.

b. Select the Triangle Function and raise the Generator Board Assembly.

c. Make sure the Output Attenuator is at 0dB and the Amplitude Control is fully clockwise.

d. Adjust the OUTPUT AMPLIFIER ZERO Potentiometer for equal peak amplitude above and below 0 volts DC.

e. Adjust the OUTPUT AMPLITUDE Potentiometer for 17 volts peak-to-peak amplitude. USE COAX TO SCOPE

f. Adjust the sensitivity of the Oscilloscope so the signal displayed is a full grid in amplitude.

g. Select the Square Wave Function, and adjust the POSITIVE and NEGATIVE AMPLITUDE Potentiometers for full grid deflection.

h. Select the Sine Wave Function, and lower the Generator Board Assembly into place.

i. Adjust the SINE ZERO Potentiometer for equal amplitude above and below 0 volts DC.

j. Adjust the SINE AMPLITUDE Potentiometer for full grid deflection. OK

k. Select the Ramp Function, and raise the Generator Board Assembly.

l. Adjust the RAMP ZERO Potentiometer so the base of the Ramp is at 0 volts DC. OK

m. Adjust the RAMP OFFSET Potentiometer so the start of the Ramp is at 0 volts DC. OK

n. Adjust the RAMP AMPLITUDE Potentiometer for full positive deflection. ADJ FOR 8½V +

o. Lower the Generator Board Assembly into place.

This completes the Operational Adjustments.

Frequency Calibration.

a. Select the Sine Function.

b. Position the Range Switch to X100, the Range Multiplier to X1, and the Frequency Dial to 0.5.

c. Connect the Frequency Counter to the 50Ω output connector on the Front Panel. Terminate the output in a 50Ω load at the input to the counter.

d. The counter should indicate 50 Hz ±1% of full scale.

e. Adjust the LOWER DIAL CALIBRATION Potentiometer for a reading of 50.00 Hz. (20.00 msec.).

f. Position the Frequency Dial to 10.

g. Adjust the UPPER DIAL CALIBRATION Potentiometer for a reading of 1.000 KHz.

h. Repeat step e to g as required.

i. Position the Range Switch to X1K, and raise the Generator Board Assembly

j. Adjust the variable capacitor on the Range Board (along the left side rail) for a reading of 10.00 KHz.

k. Lower the Generator Board Assembly, and position the Range Switch to X100K.

l. Adjust the variable capacitor in the center of the Generator Board for a reading of 1.000 MHz.

m. Check Step i. There is some interaction between these adjustments; if necessary repeat Step i. through k.

Frequency Control Adjustments:

a. Position the Range Switch to X1K, and the Range Multiplier to X1.

b. Adjust the Frequency Dial until the counter indicates exactly 500 Hz.

c. Short the F.C. Input terminals.

d. If the frequency changes, as shown on the counter, adjust the F.C. ZERO Potentiometer while alternately opening and shorting the F.C. Input terminals, until the frequency no longer changes.

e. Apply an exact +4.7500 volts to the F.C Input.

f. Adjust the F.C. CALIBRATION Potentiometer for a reading of 10.00 KHz.

This completes the Frequency Calibration Procedure.

SPECIFICATION VALIDATION:

Prior to performing the specification validation, ensure that the operational and calibration adjustment procedures have been performed completely.

Before rejecting an instrument for inability to meet all specifications, be certain the test equipment specifications are equal to, or better than, those given in the list of required test equipment.

The following test equipment is required to validate the Model F210A specifications.

Electronic Counter, Hewlett-Packard, Model 5246L, or equivalent.

Time Interval Unit, Hewlett-Packard, Model 5262A, or equivalent.

Distortion Analyzer, Hewlett-Packard, Model 333A, or equivalent.

Distortion Meter, Boonton Electronics Corporation, Model 85B, or equivalent.

Oscilloscope, Tektronix, Model 547, or equivalent.

Differential Amplifier Plug-In, Tektronix, Model 1A5, or equivalent.

RMS-VTVM, Hewlett-Packard, Model 410C or equivalent.

Digital Multimeter, Cimron, Model 7650, or equivalent.

Strip Recorder, Clevite-Brush, Model Mark 220, or equivalent.

Frequency Range and Calibration Accuracy:

1. Interconnect the equipment as shown in Figure 3-3, observing signal and ground connections carefully.

2. Position F210A controls as follows:

a.	Function	Sine
b.	Frequency Range	X.01
c.	Range Multiplier	X1
d.	Frequency Dial	1
e.	Attenuator	0dB
f.	Amplitude	Mid-range

3. Observe that the counter indicates a time interval of 100.0 seconds ±1% of full scale.

4. Position the Range Switch to X.1

5. Observe that the counter indicates a time interval of 10.00 seconds ±1% of full scale.

6. Position the Range Switch to X1.

7. Observe that the counter indicates a time interval of 1.000 second ±1% of full scale.

8. Position the Range Switch to X10.

9. Observe that the counter indicates a time interval of 100.0 msec ±1% of full scale.

10. Position the Range Switch to X100.

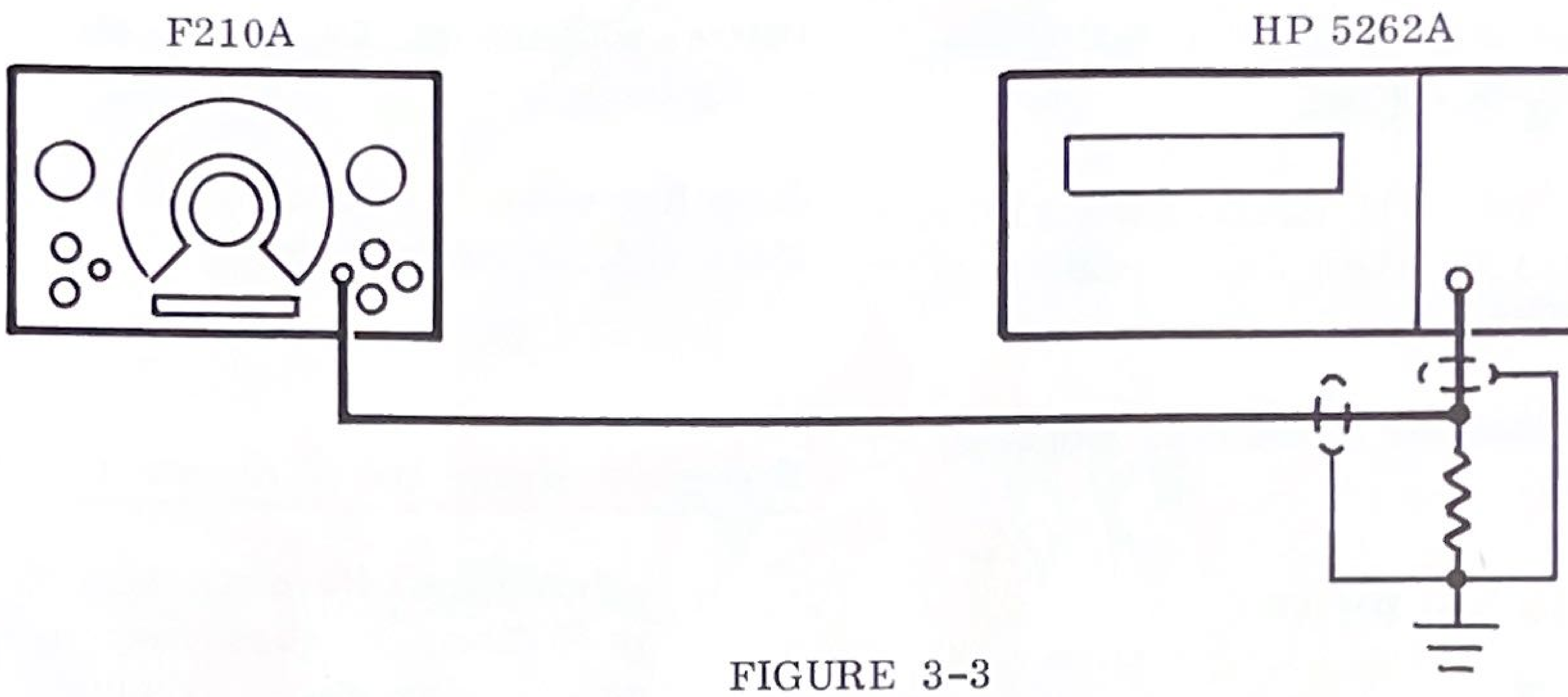


FIGURE 3-3

11. Observe that the counter indicates a time interval of 10.00 msec ±1% of full scale.

12. Position the Frequency Dial to 10.

13. Observe that the counter indicates a time interval of 1.000 msec ±1%.

14. Position the Range Switch to X10.

15. Observe that the counter indicates a time interval of 10.00 msec ±1%.

16. Position the Range Switch to X1.

17. Observe that the counter indicates a time interval of 100.0 msec ±1%.

18. Position the Range Switch to X.1

19. Observe that the counter indicates a time interval of 1.000 second ±1%.

20. Position the Range Switch to X.01.

21. Observe that the counter indicates a time interval of 10.00 seconds ±1%.

22. Position the Range Multiplier Switch to X3.

23. Observe that the counter indicates a time interval of 3.333 seconds ±1% of full scale.

24. Position the Range Switch to X.1

25. Observe that the counter indicates a time interval of 333.3 msec ±1% of full scale.

26. Position the Range Switch to X1.

27. Observe that the counter indicates a time interval of 33.33 msec ±1% of full scale.

28. Position the Range Switch to X10.

29. Observe that the counter indicates a time interval of 3.333 msec ±1% of full scale.

30. Interconnect the equipment as shown in Figure 3-4, observing signal and ground connections carefully.

31. Position the Range Switch to X100.

32. Position the Range Multiplier Switch to X1.

33. Observe that the counter indicates a frequency of 1.000 KHz ±1%.

34. Position the Range Switch to X1K.

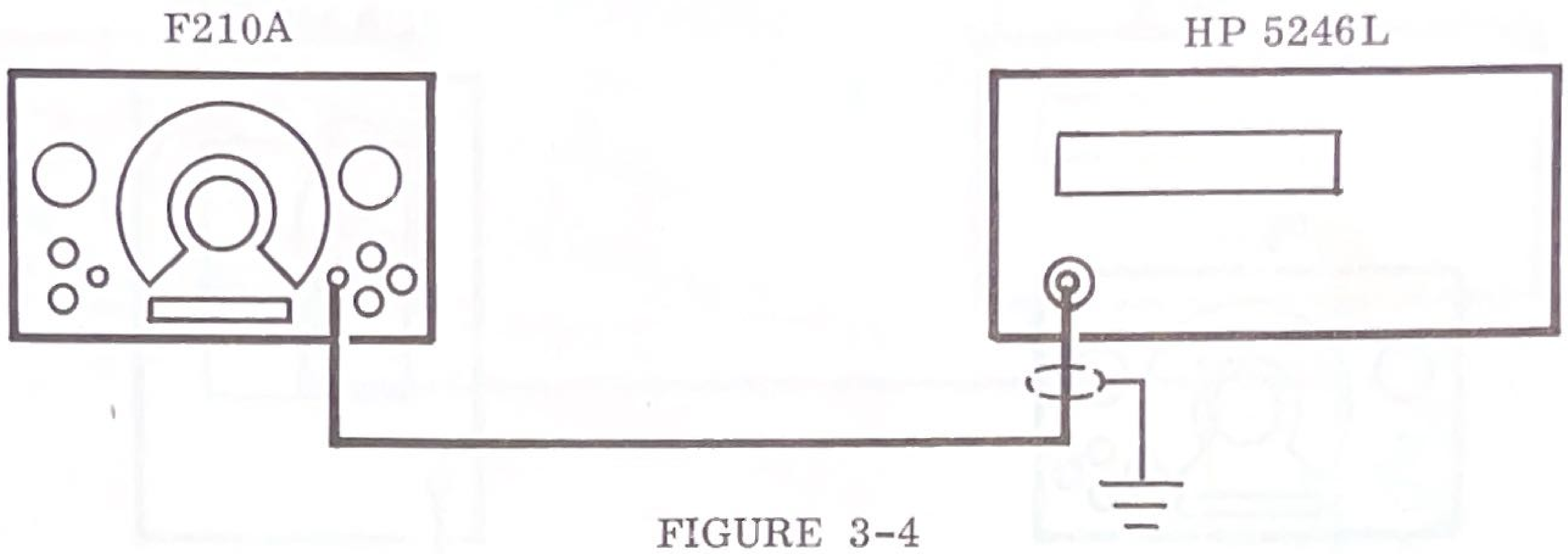


FIGURE 3-4

35. Observe that the counter indicates a frequency of 10.00 KHz ±1%.

36. Position the Range Switch to X10K.

37. Observe that the counter indicates a frequency of 100.0 KHz ±1%.

38. Position the Range Switch to X100K.

39. Observe that the counter indicates a frequency of 1.000 MHz ±2%.

40. Position the Range Multiplier Switch to X3.

41. Observe that the counter indicates a frequency of 3.000 MHz ±2%.

42. Position the Range Switch to X10K.

43. Observe that the counter indicates a frequency of 300.0 KHz ±1%.

44. Position the Range Switch to X1K.

45. Observe that the counter indicates a frequency of 30.00 KHz ±1%.

46. Position the Range Switch to X100.

47. Observe that the counter indicates a frequency of 3.000 KHz ±1%.

48. Position the Range Multiplier Switch to X1.

49. Position the Frequency Dial to 1.

50. Observe that the counter indicates a frequency of 100.0 Hz ±1% of full scale.

51. Position the Range Switch to X1K.

52. Observe that the counter indicates a frequency of 1.000 KHz ±1% of full scale.

53. Position the Range Switch to X10K.

54. Observe that the counter indicates a frequency of 10.00 KHz ±1% of full scale.

55. Position the Range Switch to X100K.

56. Observe that the counter indicates a frequency of 100.0 KHz ±1% of full scale.

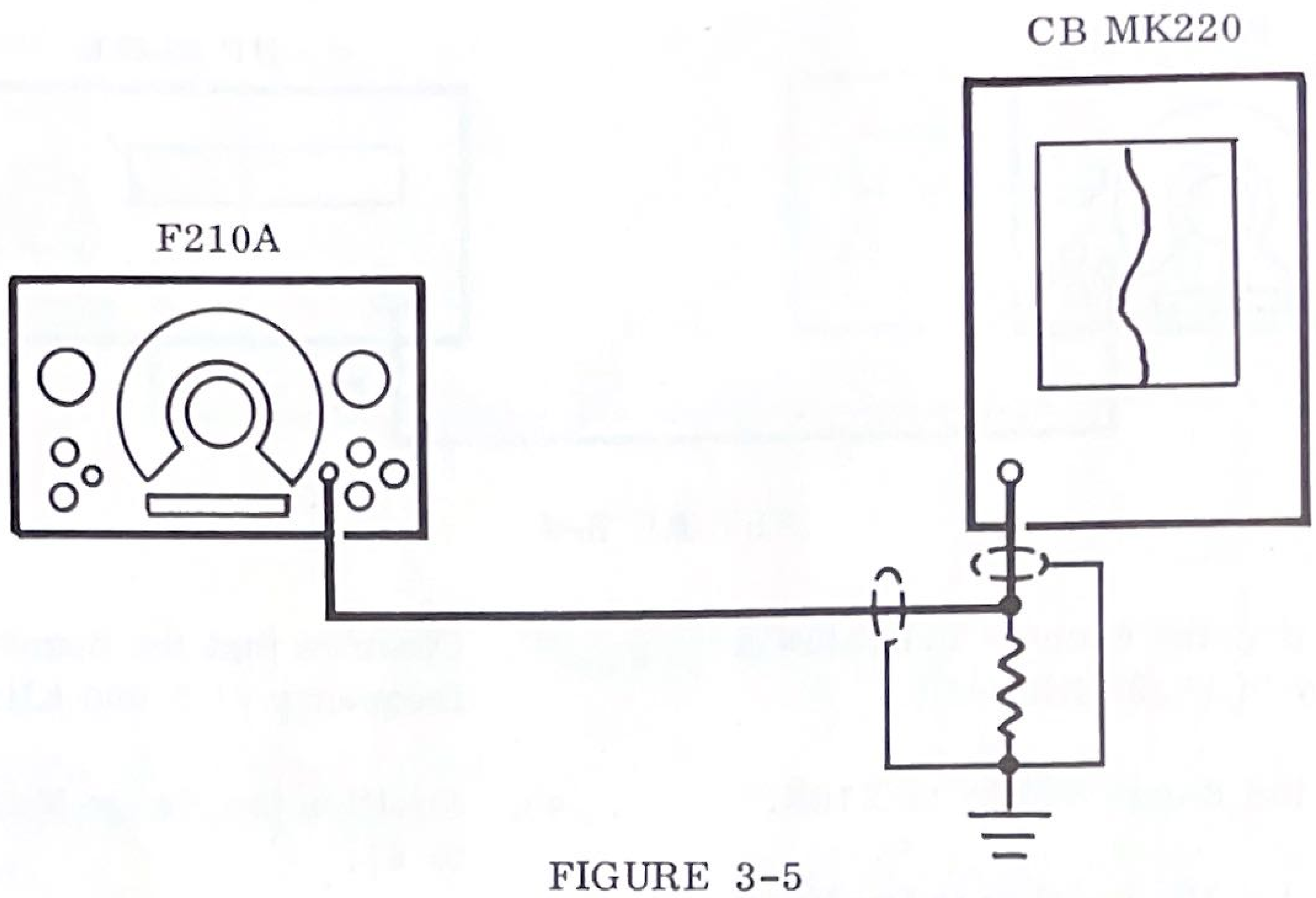


FIGURE 3-5

Frequency Response:

1. Position F210A controls as follows:

a.	Function	Sine
b.	Frequency Range	X1
c.	Range Multiplier	X1
d.	Frequency Dial	10
e.	Attenuator	0dB
f.	Amplitude	Mid-range

2. Interconnect the equipment as shown in Figure 3-5, observing signal and ground connections carefully.

3. Adjust the Recorder for 95% deflection of the pen.

4. Position the Range Switch to X.1

5. Observe that the amplitude is within .1dB.

6. Position the Range Switch to X.01.

7. Observe that the amplitude is within .1dB.

8. Position the Frequency Dial to 1.

9. Observe that the amplitude is within .1dB.

10. Position controls as in Step 1 above.

11. Interconnect the equipment as shown in Figure 3-6, observing signal and ground connections carefully.

12. Adjust the output of the Model F210A for an indication on the Digital Multimeter of 1.000 volts.

13. Position the Range Switch to X10.

14. Observe that the amplitude is within .1dB.

15. Position the Range Switch to X100.

16. Observe that the amplitude is within .1dB.

17. Position the Range Switch to X1K.

18. Observe that the amplitude is within .1dB.

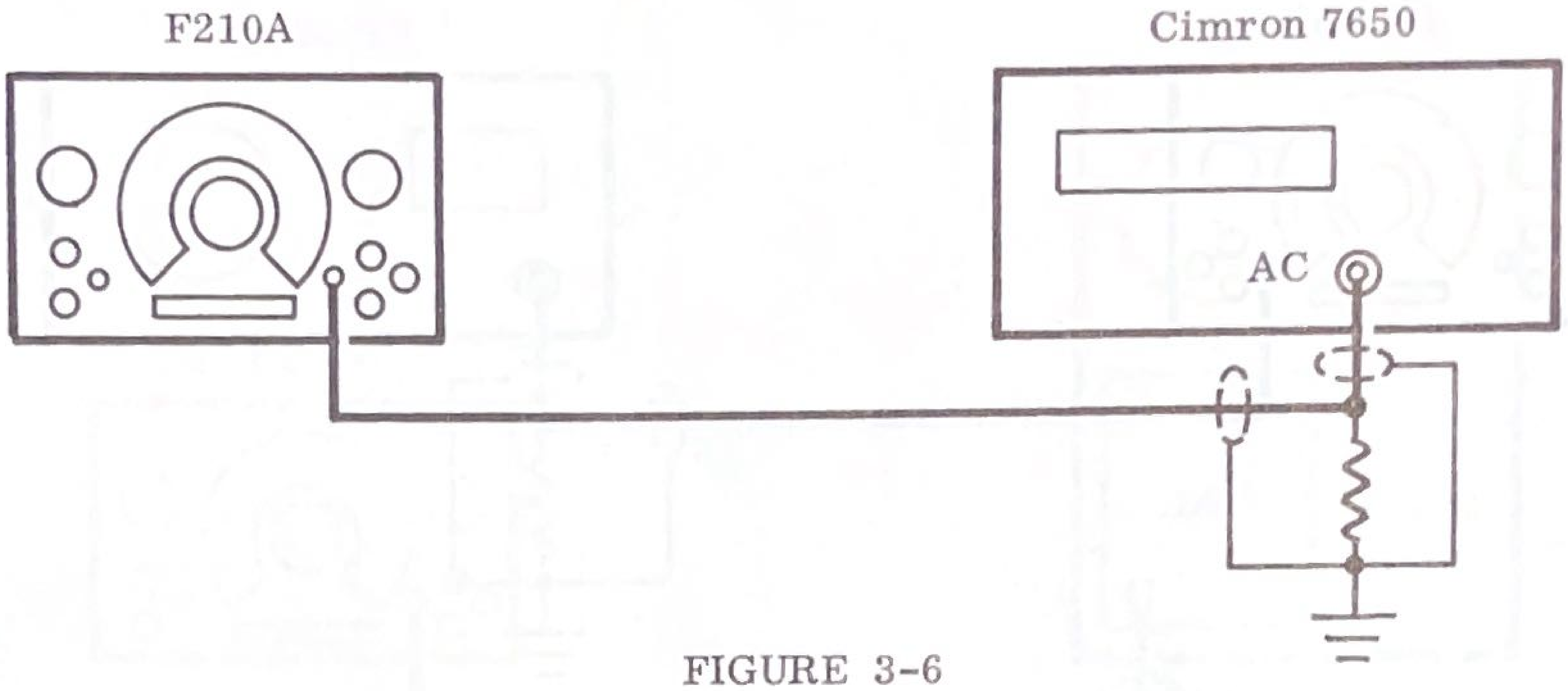


FIGURE 3-6

19. Interconnect the equipment as shown in Figure 3-7, observing signal and ground connections carefully.

20. Adjust the output of the Model F210A for an indication on the Digital Multimeter of 1.000 volts.

21. Position the Range Switch to X10K.

22. Observe that the amplitude is within .1dB.

23. Position the Range Switch to X100K.

24. Observe that the amplitude is within .5dB.

25. Position the Range Multiplier Switch to X3.

26. Observe that the amplitude is within .5dB.

<u>Distortion (Sine):</u>

1. Position F210A controls as follows:

a.	Function	Sine
b.	Frequency Range	X1
c.	Range Multiplier	X1
d.	Frequency Dial	5
e.	Attenuator	0dB
f.	Amplitude	Clock-wise

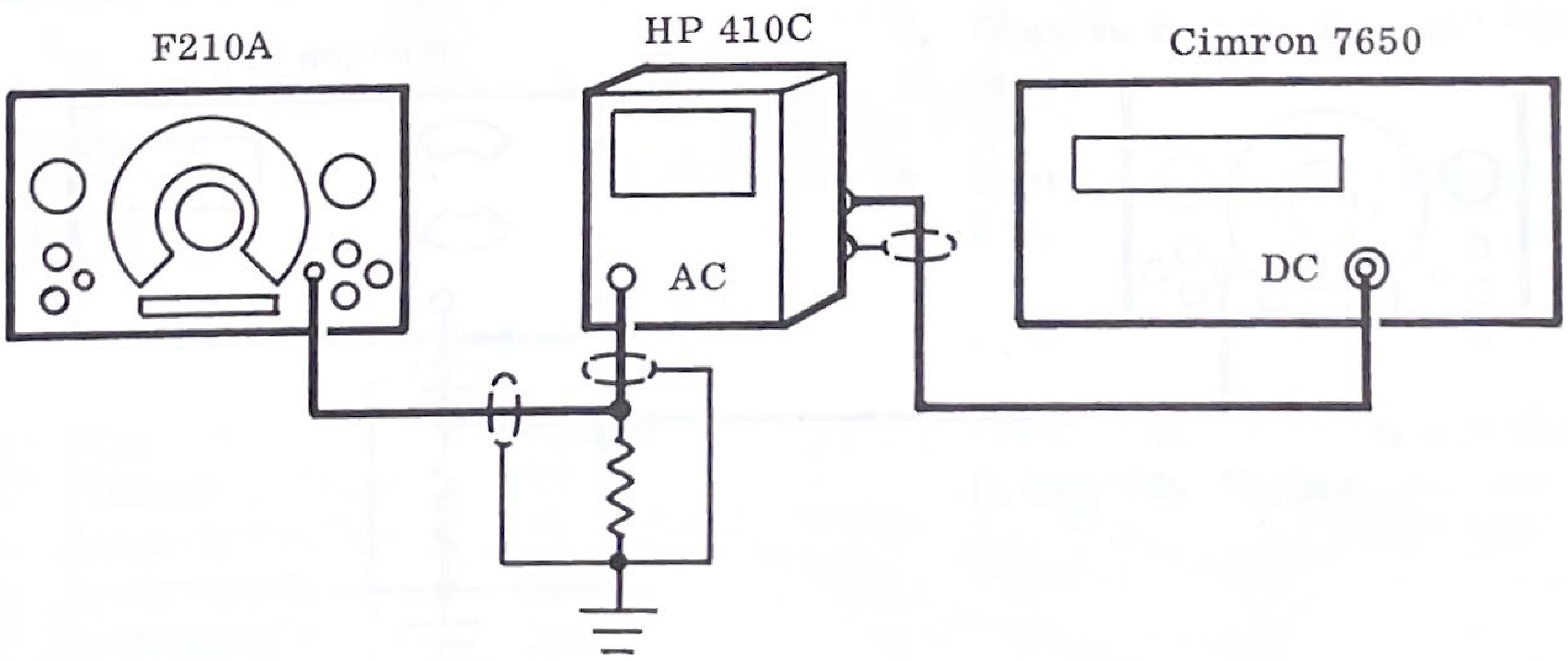


FIGURE 3-7

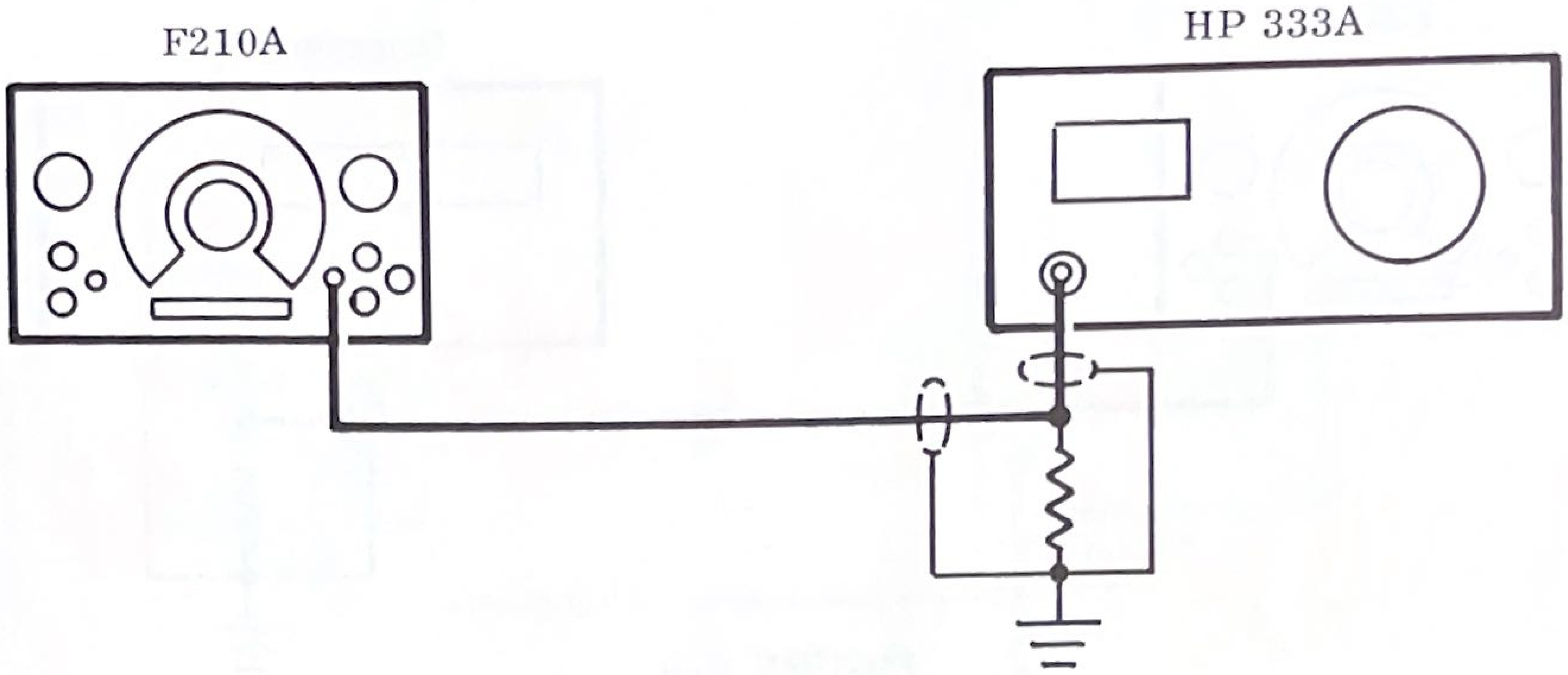


FIGURE 3-8

2. Interconnect the equipment as shown in Figure 3-8, observing signal and ground connections carefully.

3. Measure the distortion.

4. Observe that the distortion does not exceed 1%.

5. Position the Range Switch to X10.

6. Repeat Steps 3 and 4.

7. Position the Range Switch to X100.

8. Repeat Steps 3 and 4.

9. Position the Range Switch to X1K.

10. Repeat Steps 3 and 4.

11. Position the Range Switch to X10K.

12. Repeat Steps 3 and 4.

13. Position the Range Switch to X100K.

14. Measure the distortion.

15. Observe that the distortion does not exceed 2%.

16. Reduce the output amplitude of the F210A.

17. Interconnect the equipment as shown in Figure 3-9, observing signal and

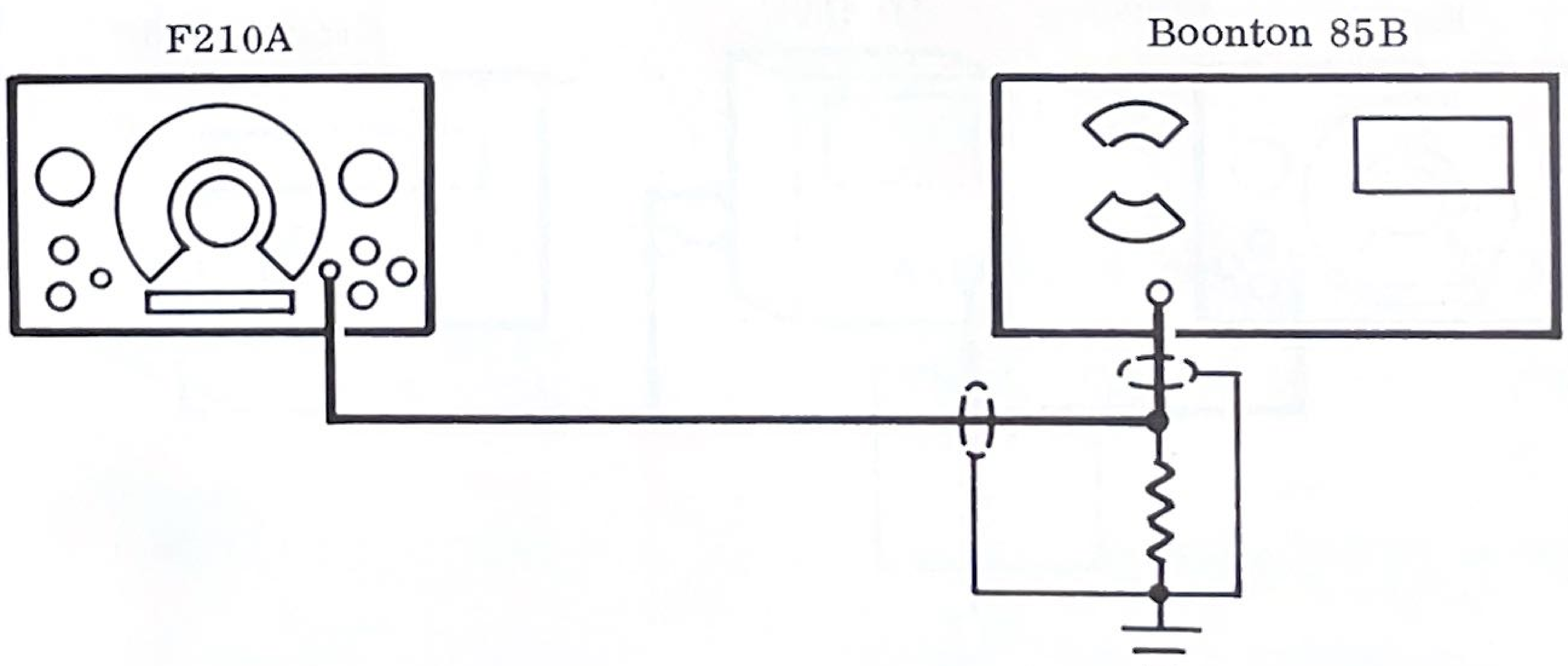


FIGURE 3-9

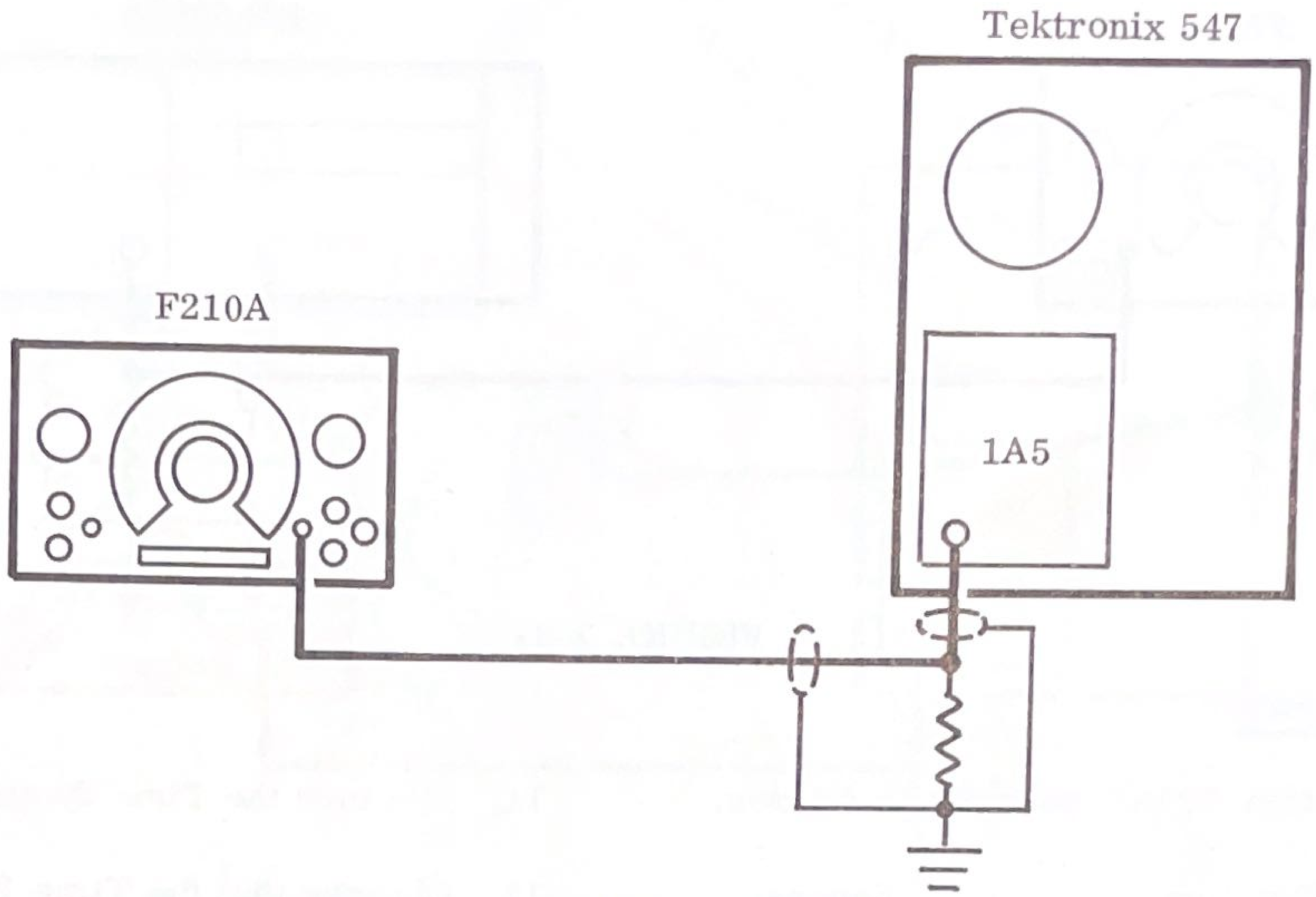


FIGURE 3-10

ground connections carefully.

18. Position the Frequency Dial to 10.

19. Measure the distortion.

20. Observe that the distortion does not exceed 5%.

21. Position the Range Multiplier Switch to X3.

22. Measure the distortion.

23. Observe that the distortion does not exceed 5%.

Rise and Fall Time:

1. Position F210A controls as follows:

a.	Function	Square
b.	Frequency Range	X10K
c.	Range Multiplier	X1
d.	Frequency Dial	10
e.	Attenuator	0dB
f.	Amplitude	Clock-wise

2. Interconnect the equipment as shown in Figure 3-10, observing signal and ground connections carefully.

3. Measure the Rise and Fall Time.

4. Observe that the Rise and Fall Time is less than 75 nsec.

5. Position the Range Switch to X100K.

6. Measure the Rise and Fall Time.

7. Observe that the Rise and Fall Time is less than 75 nsec.

8. Position the Range Multiplier Switch to X3.

9. Measure the Rise and Fall Time.

10. Observe that the Rise and Fall Time is less than 75 nsec.

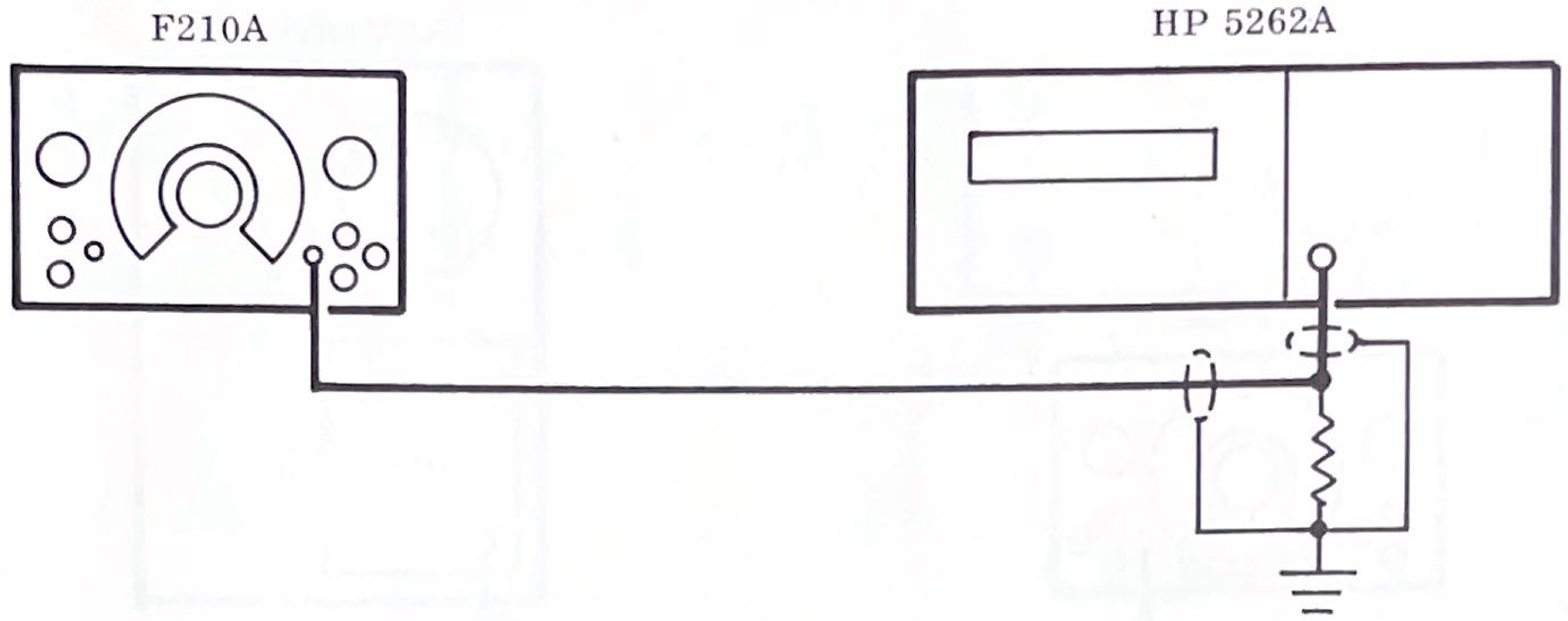


FIGURE 3-11

Time Symmetry:

1. Position F210A controls as follows:

a.	Function	Square
b.	Frequency Range	X100K
c.	Range Multiplier	X3
d.	Frequency Dial	10
e.	Attenuator	0dB
f.	Amplitude	Clock-wise

2. Interconnect the equipment as shown in Figure 3-10, observing signal and ground connections carefully.

3. Measure the Time Symmetry.

4. Observe that the Time Symmetry is 95% or better.

5. Position the Range Multiplier Switch to X1.

6. Measure the Time Symmetry.

7. Observe that the Time Symmetry is 99% or better.

8. Position the Range Switch to X10K.

9. Repeat Steps 5 and 6.

10. Position the Range Switch to X1K.

11. Measure the Time Symmetry.

12. Observe that the Time Symmetry is 99.5% or better.

13. Position the Range Switch to X100.

14. Repeat Steps 11 and 12.

15. Interconnect the equipment as shown in Figure 3-11, observing signal and ground connections carefully.

16. Position the Range Switch to X10.

17. Repeat Steps 11 and 12.

18. Position the Range Switch to X1.

19. Repeat Steps 11 and 12.

20. Position the Range Switch to X.1

21. Repeat Steps 11 and 12.

22. Position the Range Switch to X.01.

23. Repeat Steps 11 and 12.

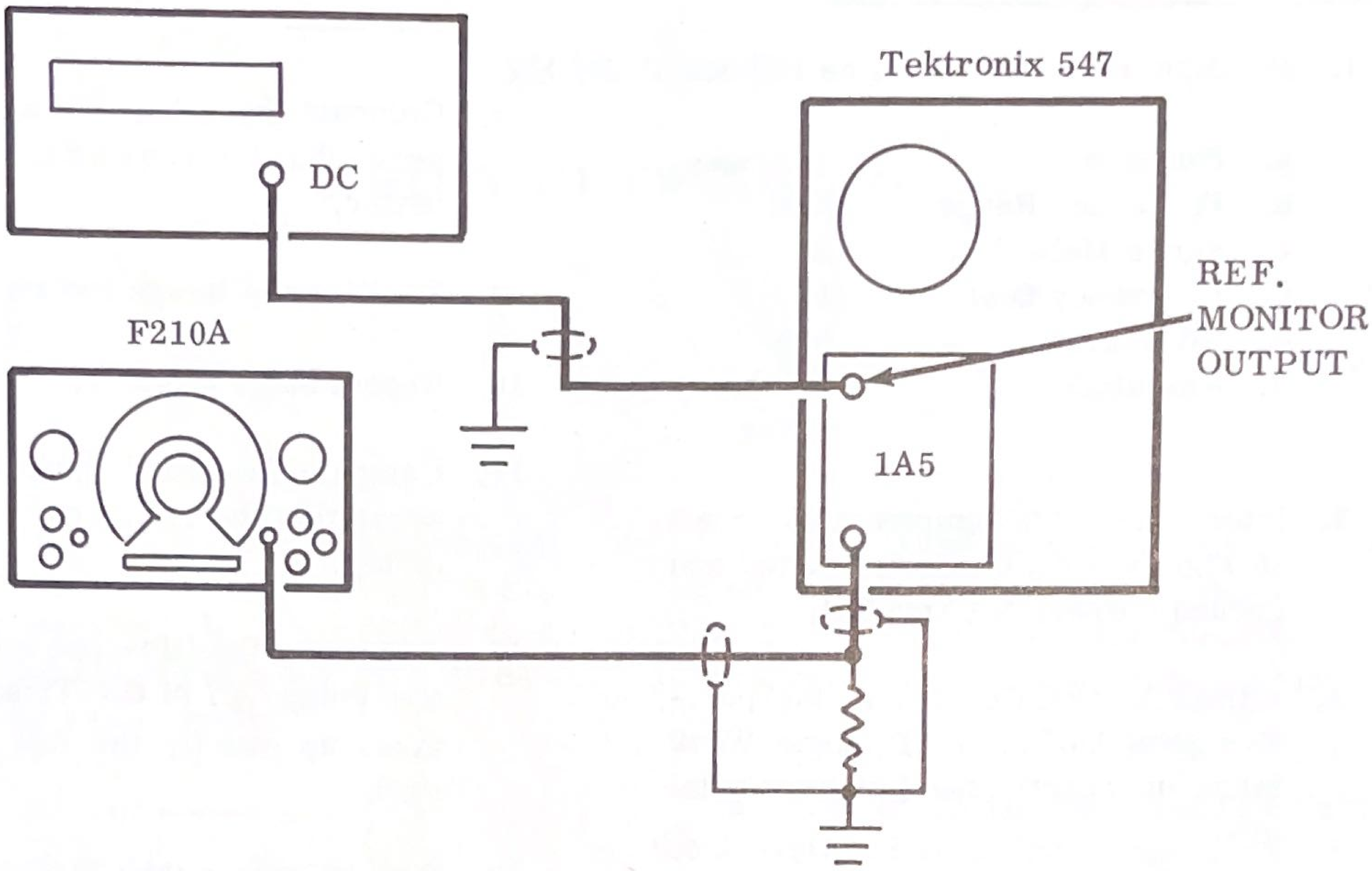


FIGURE 3-12

Amplitude Symmetry, Overshoot, Preshoot and Tilt:

1. Position F210A controls as follows:

a.	Function	Triangle
b.	Frequency Range	X1K
c.	Range Multiplier	X1
d.	Frequency Dial	10
e.	Attenuator	0dB
f.	Amplitude	Clockwise

2. Interconnect the equipment as shown in Figure 3-10, observing signal and ground connections carefully.

3. Select the 100 mv/cm range on the 1A5, and adjust the Reference Supply for 0 indication at the positive peak of the waveform.

4. Switch the Reference Supply to -.

5. Observe that the negative peak is less than 1% of the peak-to-peak amplitude from the 0 line.

6. Select the Sine Function.

7. Repeat Steps 3 thru 5.

8. Select the Square Function.

9. Repeat Steps 3 thru 5.

10. Observe that the Overshoot and Preshoot do not exceed 5% of the maximum output of the F210A.

11. Observe that the Tilt does not exceed 0.5% of the maximum output of the F210A.

Triangle Wave and Ramp Linearity:

1. Position F210A controls as follows:

a.	Function	Triangle
b.	Frequency Range	X1K
c.	Range Multiplier	X1
d.	Frequency Dial	10
e.	Attenuator	0dB
f.	Amplitude	Clock-wise

2. Interconnect the equipment as shown in Figure 3-12, observing signal and ground connections carefully.

3. Adjust the Oscilloscope so the positive going half of the Triangle Wave takes up exactly the full horizontal grid.

4. Select the 100 mv/cm range on the 1A5, and adjust the Reference Supply for 0 indication at the start of the waveform.

5. Note and record the reading on the Digital Multimeter.

6. Increase the Reference Supply until the waveform intersects the next major vertical mark.

7. Repeat Steps 5 and 6 until the desired number of check points have been recorded.

8. Compute the actual linearity and observe that the linearity is 99% or better.

9. Position the Range Switch to X100K.

10. Repeat Steps 3 thru 7.

11. Compute the actual linearity and observe that the linearity is 95% or better.

12. Adjust the Oscilloscope so the negative going half of the Triangle Wave takes up exactly the full horizontal grid.

13. Repeat Steps 4 thru 11.

14. Select the Ramp Function.

15. Position the Range Switch to X1K.

16. Adjust the Oscilloscope so the Ramp takes up exactly the full horizontal grid.

17. Repeat Steps 4 thru 11.

This completes the Specification Validation.

SECTION IV

THEORY OF OPERATION

The generation of a triangular wave form is fundamental to all other wave forms in a waveform generator. It is generated as a function of the characteristics of a circuit referred to as an integrator.

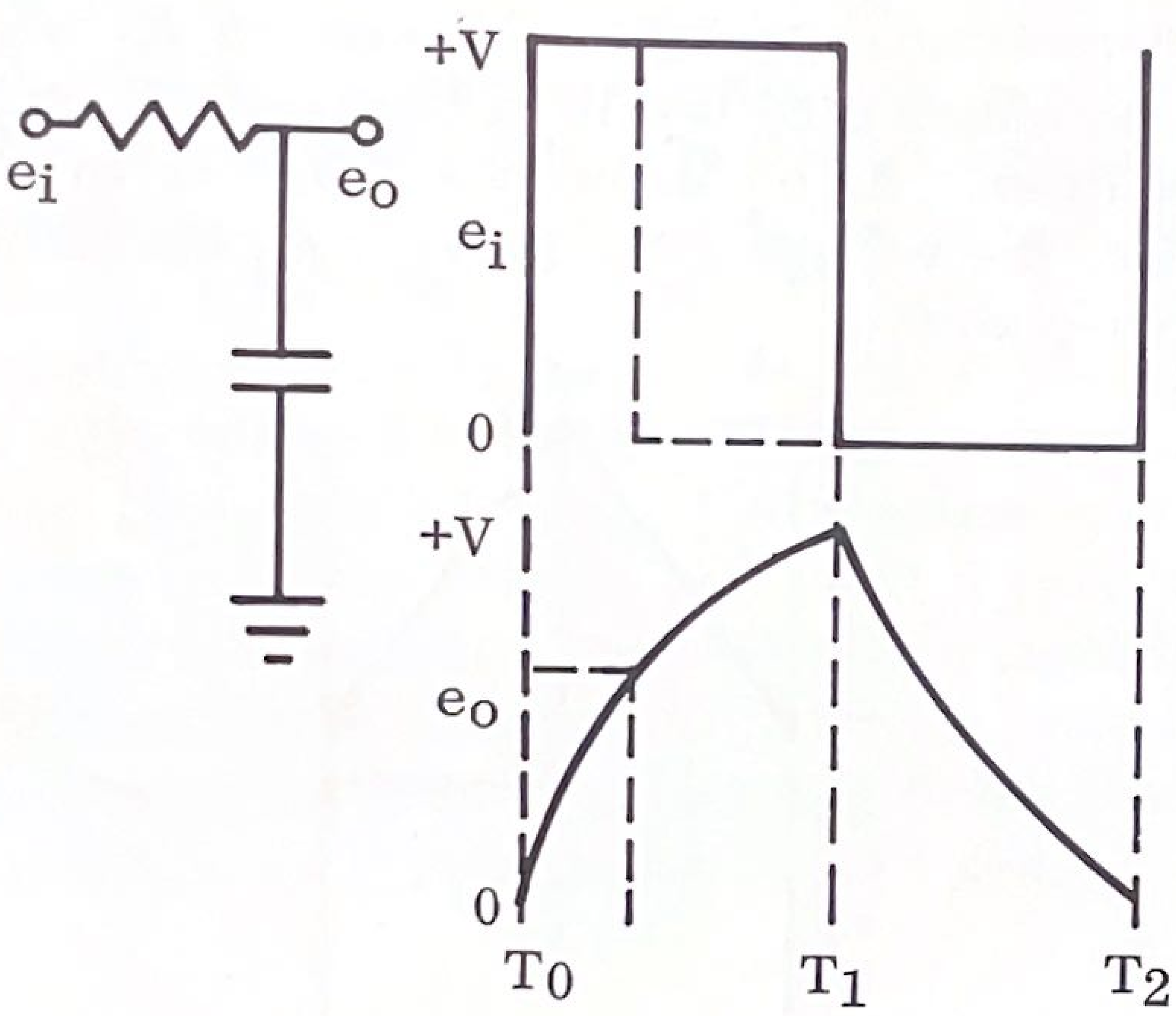


FIGURE 4-1

Figure 4-1 depicts a passive integrator. Assuming a step change in voltage to some positive value occurs at time T_0, the voltage drop across C_1 in the above circuit is equal to zero. As time T_1 approaches, the charge across C_1 increases and the voltage drop across R_1 decreased. In accordance with Ohm's law, the current through R_1 varies in direct proportion to the voltage across R_1. Therefore, as the charging rate of C_1 decreases, the current through R_1 also decreases. During the first increment of time the charging rate of C_1 is fairly linear.

The quality of integration improves as RC and/or frequency is increased. As illustrated in Figure 4-1, the linearity of E_0 is inversely proportional to the amount of E_0

In order to utilize this characteristic, the operational amplifier integrator of Fig. 4-2 is used.

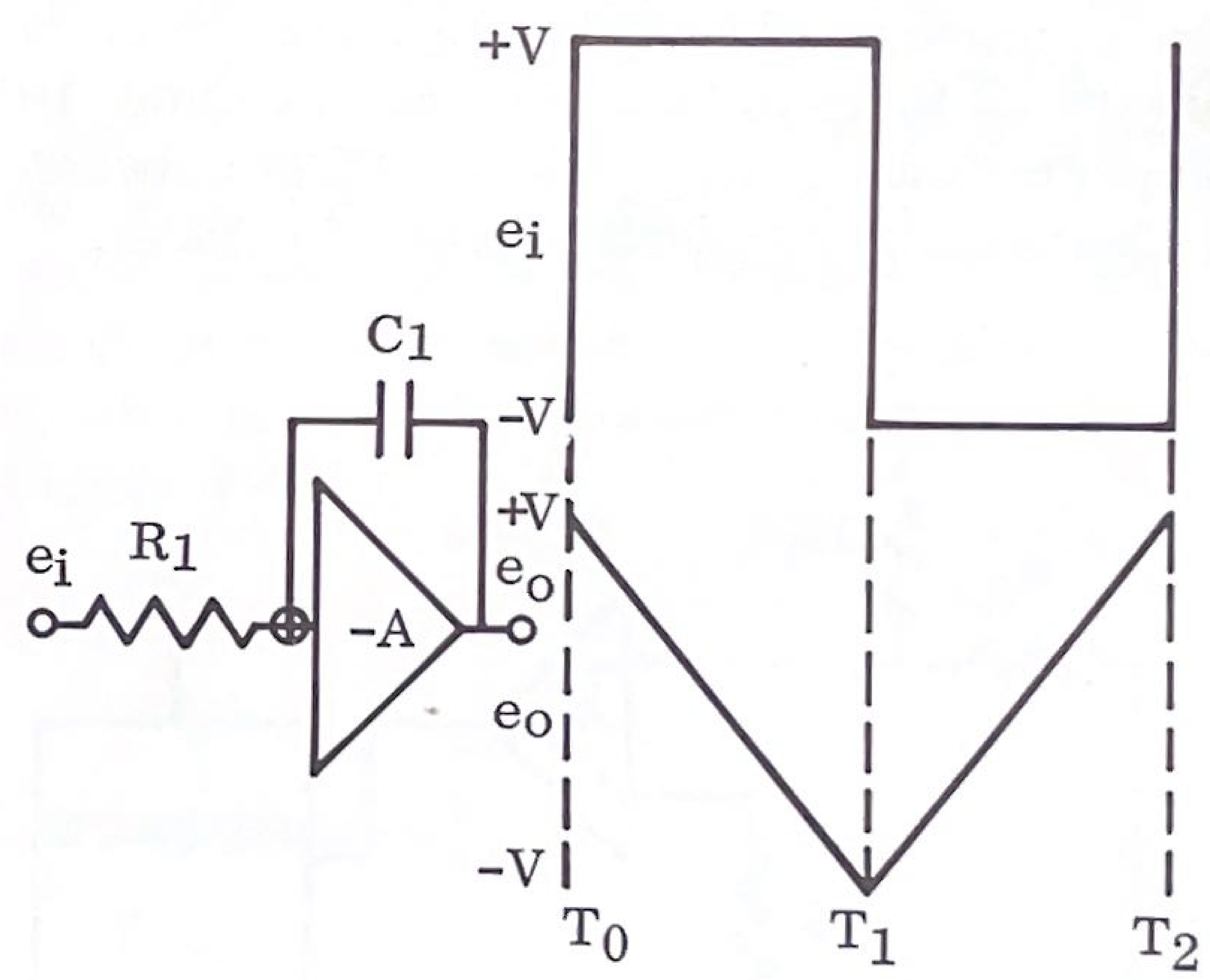


FIGURE 4-2

The rate of integration is approximately the same as the initial rate of integration of a passive integrator. However, the addition of an operational amplifier serves to maintain the charge of C_1 at a constant rate. In an operational amplifier the voltage appearing at the summing junction is equal to zero. Therefore, the voltage drop across R_1 is equal to the applied voltage, and the current through R_1 is constant. Assuming a perfect amplifier of infinite input resistance is used, the current through R_1 serves as the charging current for C_1. R_1 is usually a high precision, low temperature coefficient resistor.

For larger capacitor values, the integrating capacitor is usually made of poly-styrene or other very low leakage material. Amplifier gain should be high enough to assure that the summing junction is maintained as close to zero as practical; movement around zero results in non-linearities in the output voltage. On the other hand, extremely high gain should be avoided to assure proper stabilization.

Referring to Figure 4-2, it can be seen that the output voltage varies inversely as the integral of the applied voltage, the result of the phase inversion experienced in the amplifier. The triangle wave form is developed by switching the input voltage to an operational integrating amplifier between a positive and negative source of voltage.

Square wave generation is accomplished through the use of a level detector in conjunction with the triangle wave form from the integrator. A basic circuit is depicted in Figure 4-3.

In the circuit, A_1 and A_2 represent differential amplifiers having gains in excess of 1000. The typical output voltage swing is usually limited from 0 to +4 volts. With such a relationship, it can be seen that an input voltage change of more than 4mV will cause the output voltage to limit at 0 or +4 volts. It is this feature that is utilized in the level detector. The amplifiers are referenced through resistors R_3 and R_6 to ground, respectively. In one case the inverting (-) input is used and in the other the non-inverting (+) input. Resistors R_1 and R_4 establish bias levels at the input of each amplifier. As e_i increases from -1 to +1 volts, the voltage at the input of A_2 becomes more positive.

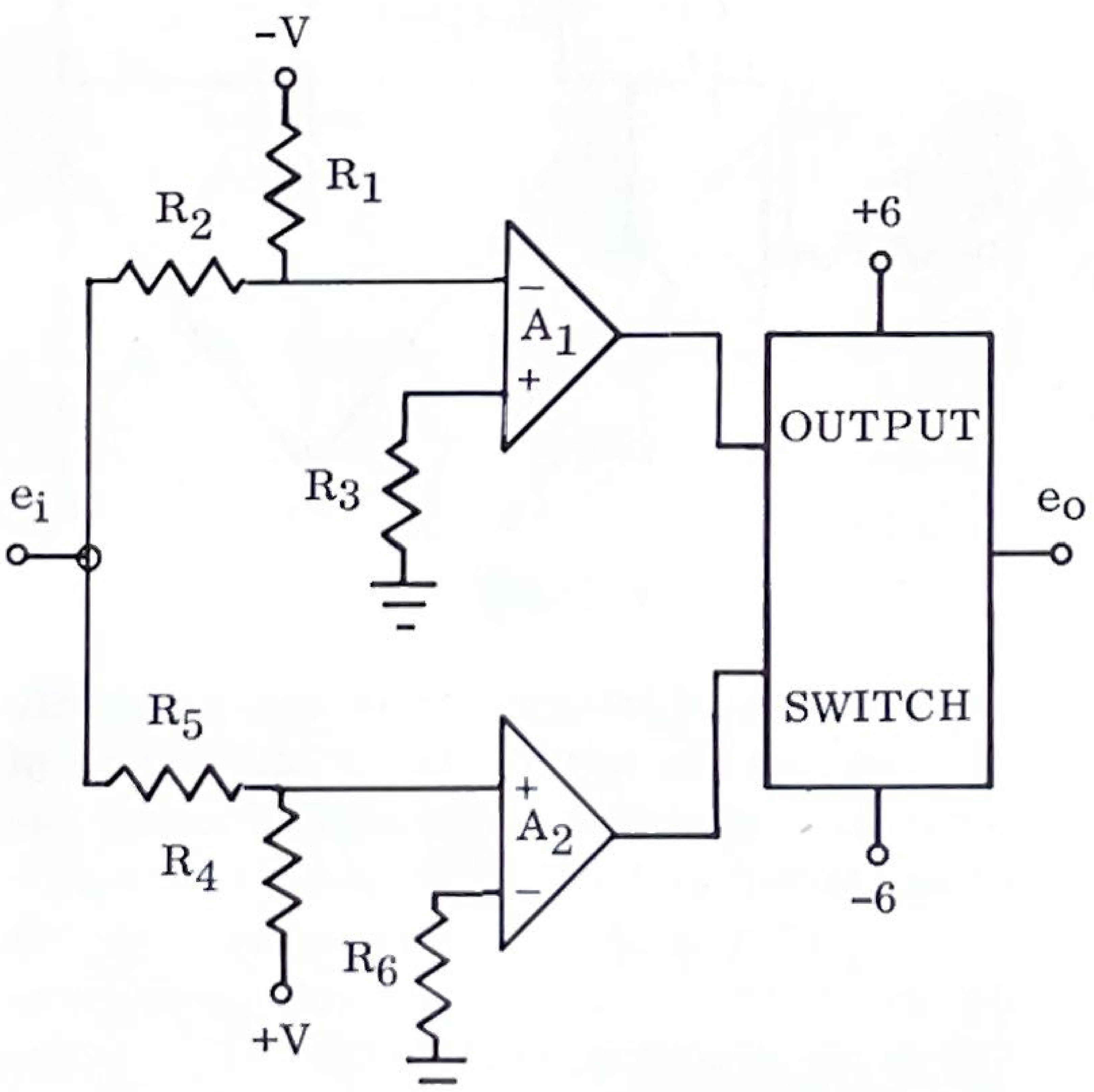


FIGURE 4-3

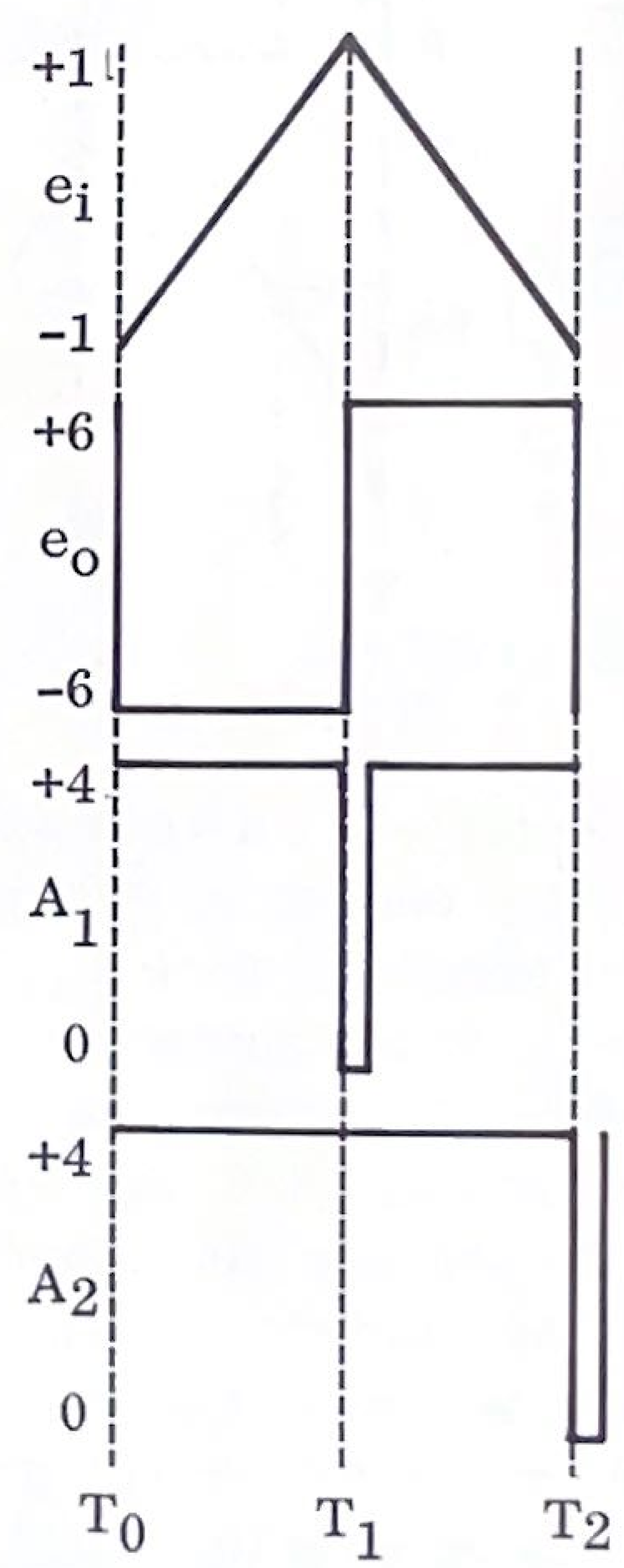


FIGURE 4-4

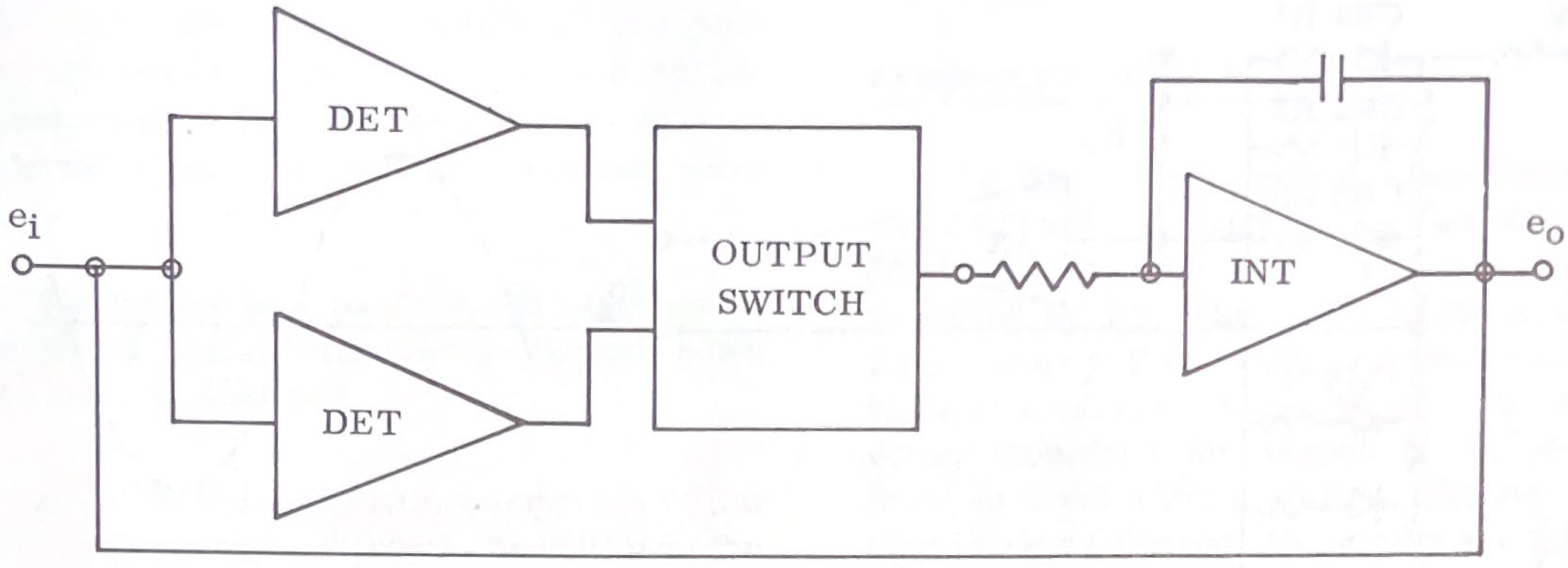


FIGURE 4-5

During the transition from -1 to +1 volts, the outputs of A_1 and A_2 are held positive. At time T_1, e_i reaches +1 volt and the voltage appearing at the inverting (-) input of A_1 becomes equal to 0 volts. The output of A_1 drops to 0 volts, where it remains until e_i reverses direction and begins to approach -1 volts. At time T_2 the procedure is reversed. The output voltage of A_2 drops to 0 volts during the period of time e_i equals -1 volt. The negative going pulses from the outputs of A_1 and A_2 are in turn used to switch a tunnel diode/transistor combination to produce a 12V p-p square wave with the phase relationship to the input waveform as illustrated in Figure 4-4.

It will be noted that the generation of the triangle wave form is the result of supplying a square wave to the input of the integrating amplifier. Figure 4-5.

Aberrations at the top or bottom of the square wave effect the linearity of the triangle wave form since the rate of integration is dependent upon the amplitude of input signal. To remedy this situation, the square wave is used only to steer the charging current of the integrator to a constant current generator. The manner in which this is accomplished is depicted in Figure 4-6

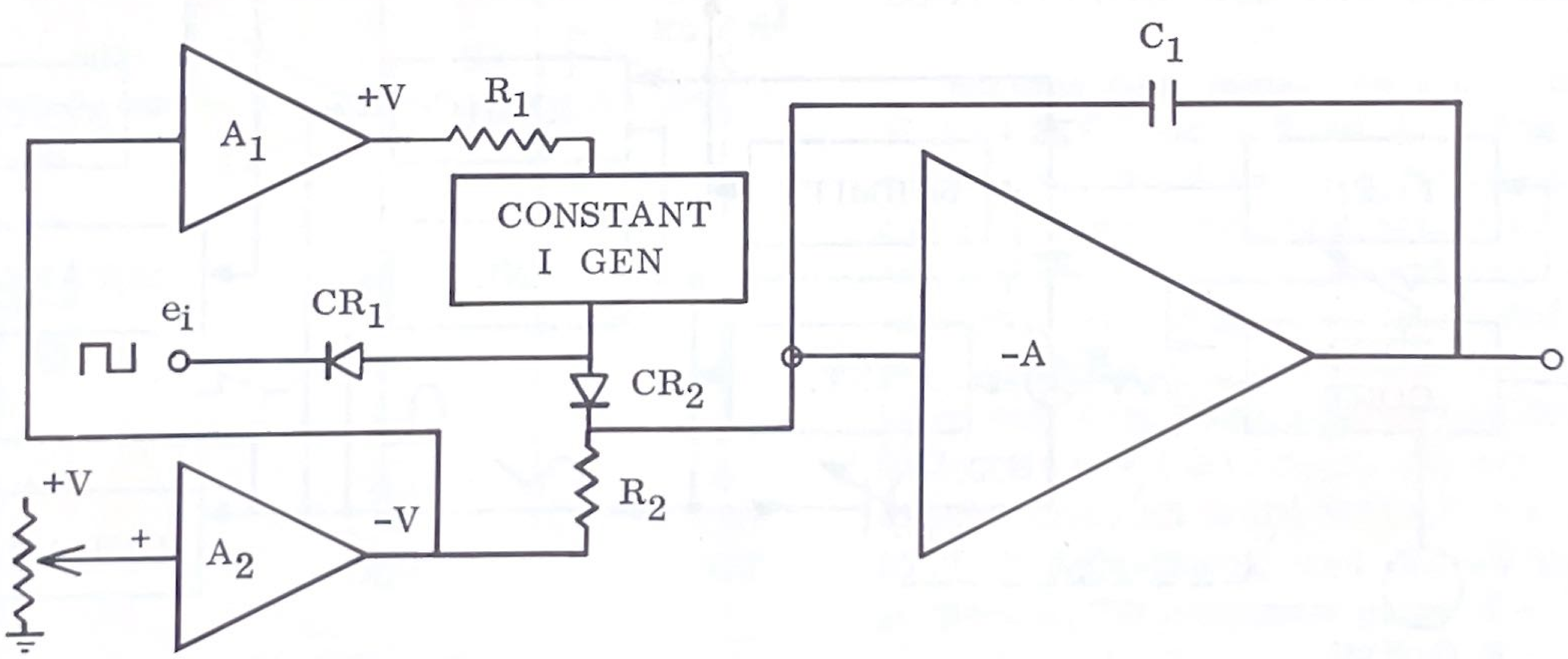


FIGURE 4-6

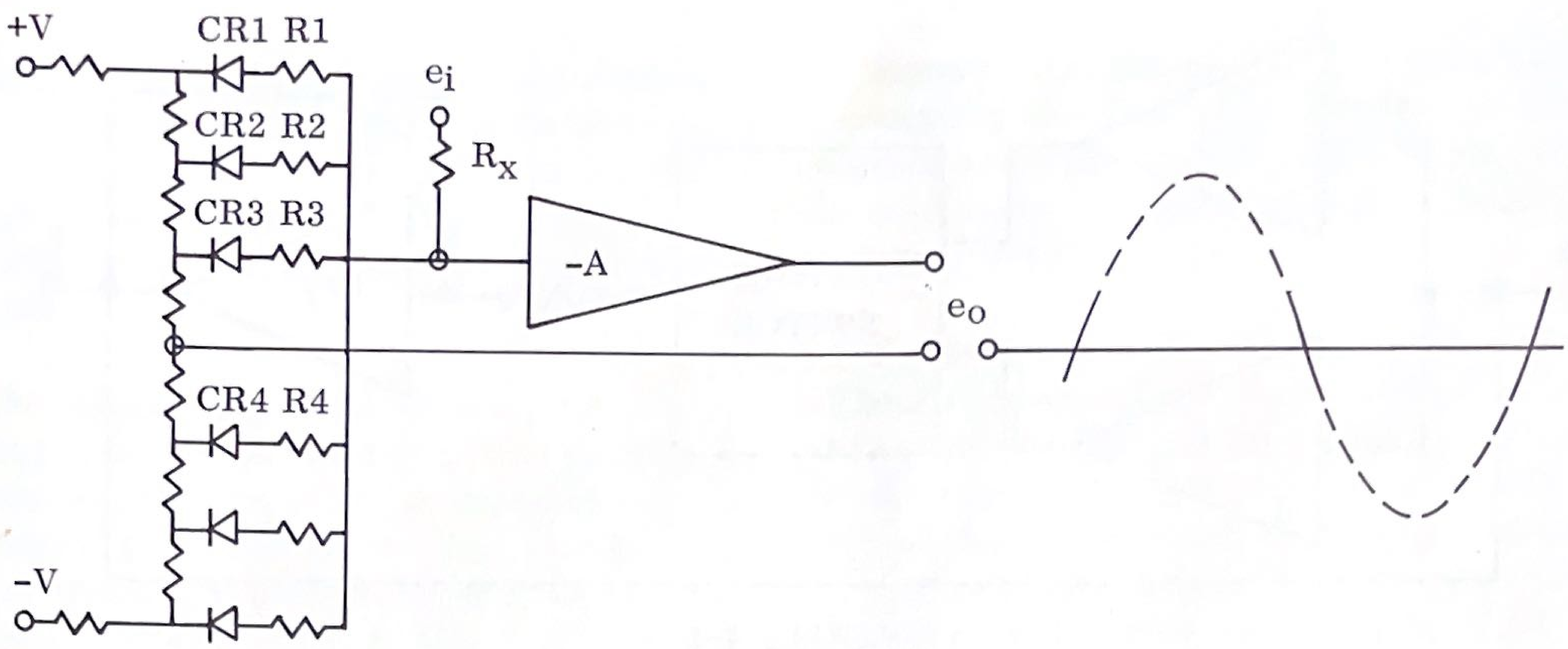


FIGURE 4-7

During the period of time input voltage e_i is at some positive value, diode CR_1 is reversed biased. Diode CR_2 is forward biased due to the polarity of the voltage appearing at the output of the voltage control amplifiers A_1 and A_2. The constant current generator maintains the current through R_1 at a value equal to twice the current through R_2. The additional current is supplied from the integrator, causing C_1 to discharge at a linear rate. During the period of time e_i is at some negative value, diode CR_1 is forward biased and CR_2 is reversed biased. current through R_1 is supplied from the input. C_1 charges at a rate determined by the current through R_2. Variations in the square wave amplitude are thus eliminated as a source of distortion.

The triangular wave form is synthesized into a sine wave by means of the circuit shown in Figure 4-7.

Diodes CR_1 CR_2 and CR_3 are biased at different levels as determined by their respective positions along a voltage divider. As the input voltage increases from 0 to some positive value of voltage the diodes CR_1 and CR_2 sequentially conduct. A voltage division occurs between R_x and the respective resistor associated with each diode

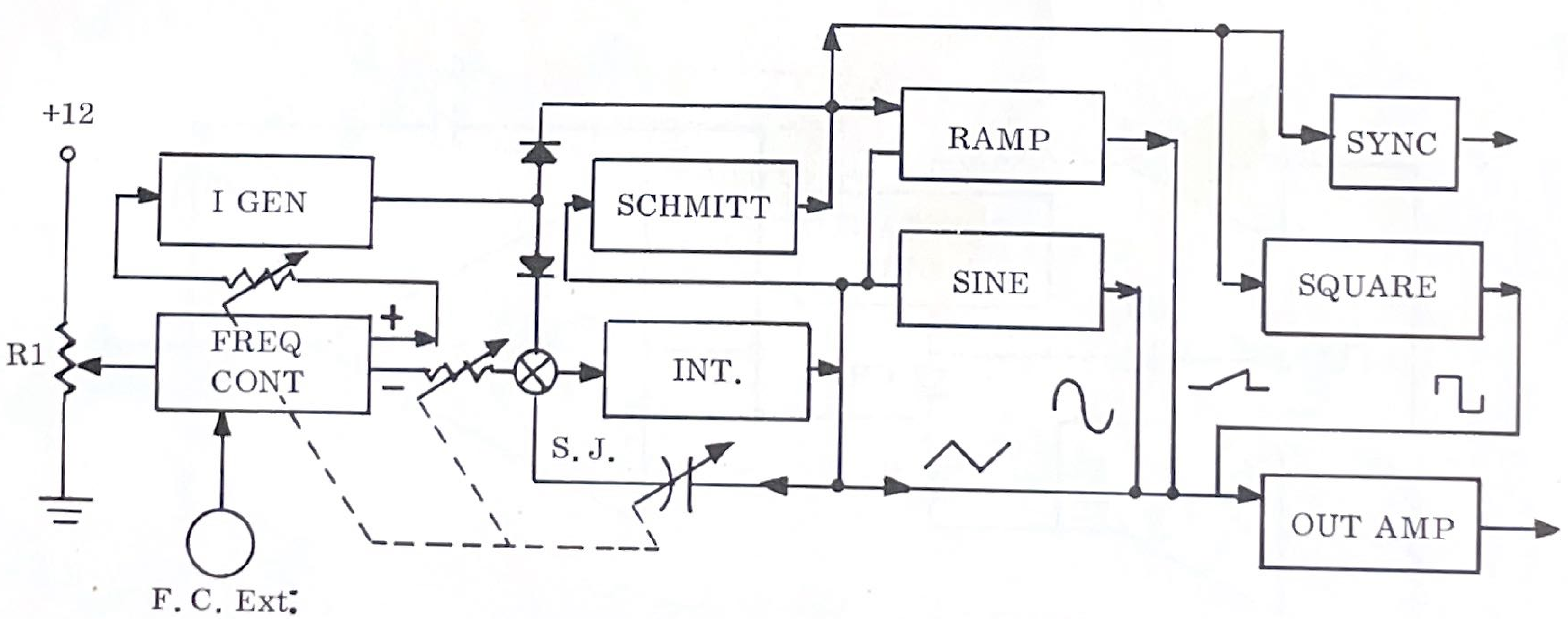


FIGURE 4-8

which changes the slope of the voltage applied to the input of an amplifier. The sine wave output is approximated from a series of segments. The number of segments used determines the purity of the resulting wave form.

Figure 4-8 is a basic block diagram of the Model F210A which can be broken down into several sections.

a. The Generator, comprised of the Frequency Control Amplifiers, the Integrating Amplifier, the Schmitt Trigger, and a Constant Current Generator.

b. Shaping Amplifiers for the Sine, Square and Ramp Functions.

c. A separate amplifier provided to deliver a Sync signal.

d. The Output Amplifier, which is necessary to deliver the required output power, and the proper impedance matching.

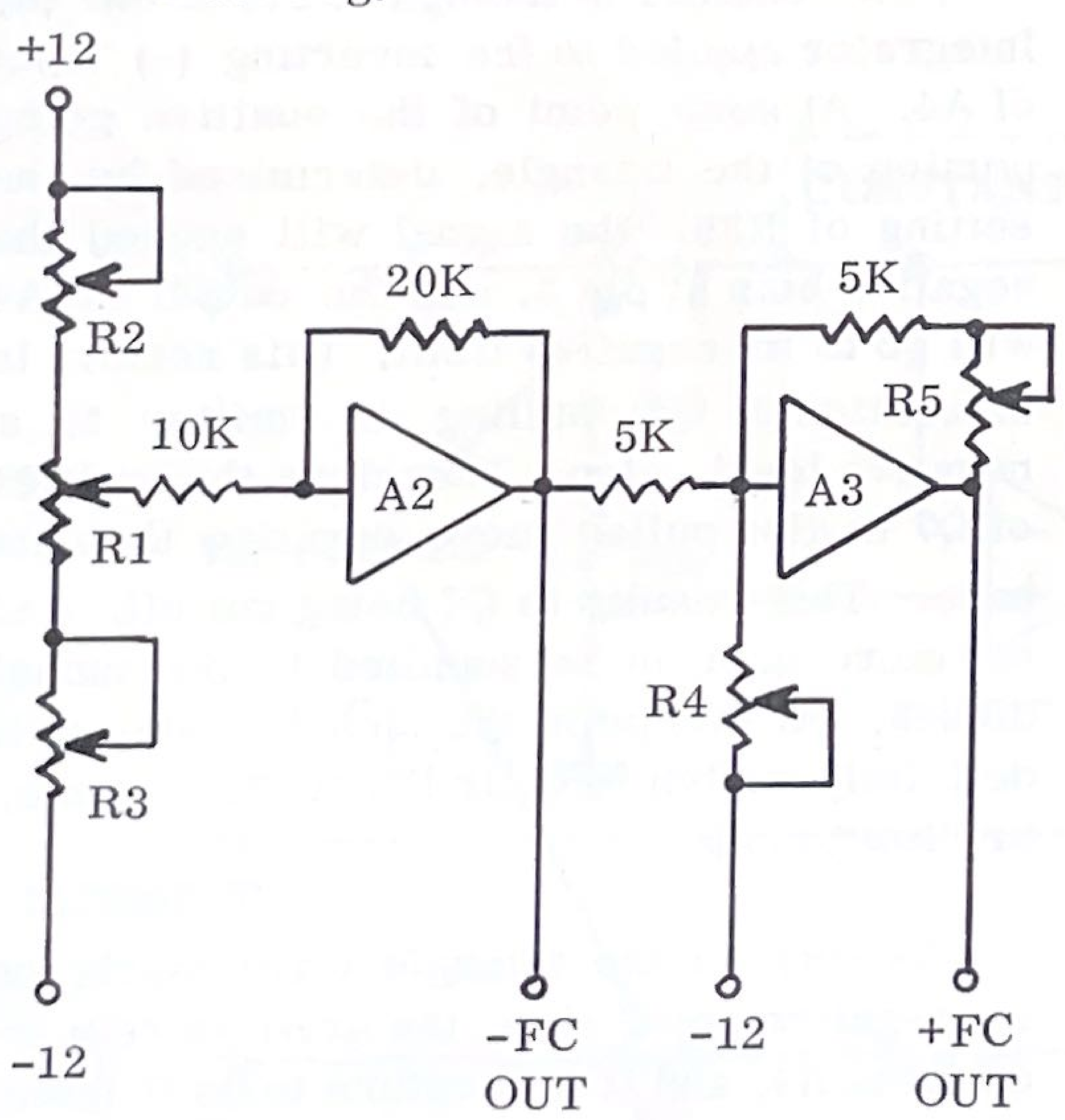


FIGURE 4-9

GENERATOR

Frequency Control Amplifiers:

The Frequency Control Amplifiers are essentially a pair of inverting DC amplifiers (Figure 4-9). The input signal is varied by R1, which is the Front Panel Frequency Control Potentiometer. This voltage is variable from +0.25 volts to +5 volts, therefore the output of A1 swings from -0.5 volts to -10 volts. The signal is also inverted through A3, giving a + voltage output from A3.

R2 is the UPPER DIAL CALIBRATION Adjustment, and simply determines the maximum positive voltage available at the top of the Frequency Control Potentiometer, and therefore the highest frequency. R3, likewise, determines the minimum voltage available at the bottom of the Frequency Control Potentiometer, and is the LOWER DIAL CALIBRATION Adjustment.

The output from A2 (-F.C.) swings from -0.5 volts to -10 volts, and is applied through a resistor to the Summing Junction of the Integrating Amplifier. The same signal is also applied to the input of A3. The input to A3, however, is offset by approximately -5 volts through R4, which is the LOWER DIAL SYMMETRY Adjustment.

R4 thus determines the minimum point of the + F.C. output from A3. The - F.C. output from A2 delivers a fixed amount of current to the Summing Junction during the half cycle when the integrating capacitor is charging. R4, therefore, is needed to ensure that the same amount of current is taken out of the Summing Junction during the half cycle when the integrating capacitor is discharging. R5 is the UPPER DIAL SYMMETRY Adjustment, and serves the same purpose at the maximum point of + F.C.

Schematic #1 (Section V) is the complete schematic of this circuit. Terminals "E", "G" and "F" are the connections to the Frequency Control Potentiometer. "F" is the arm of the pot. The control voltage is applied through R5 to pin 9 of A1, which is a pair of dual emitter followers, providing isolation between the control voltage source and the Frequency Control Amplifiers. The voltage level from A1 is coupled into the inverting (-) input of A2. The non-inverting (+) input of A2 is referenced back to Ground through R11 and the other half of A1. Pin 6 of A1 might be called the differential input, and its DC level is determined by the FREQUENCY CONTROL ZERO Adjustment, R18.

The output from A2 is coupled through CR3, which shifts the DC level of the signal to the proper operating point of Q1. Q1 is an emitter follower supplying the required current for the - F. C. network. The output from Q1 is also taken back through R16 to the input, pin 9 of A1. R16 is equal to R5, therefore the overall gain of A1, A2 and Q1 is unity.

A3 gets its input from Q1, through approximately 5KΩ, R22, to the inverting (-) input, and the non-inverting (+) input is referenced back to Ground through R26. The output from A3, through emitter follower Q3 and DC level shift diode CR4 is fed back to the input through approximately 5KΩ, R27 and R28. The input resistance equals the feedback resistance, therefore the gain of A3 is unity. This output level is used to drive the +F. C. network. Q2 is the current source for CR4 and Q3.

<u>Schmitt Trigger:</u>

The Schmitt Trigger is essentially a level detector, with a few refinements to ensure a square wave output, whose rise time is extremely fast, see Figure 4-5. Because aberrations at the top and/or bottom of the square wave would affect the linearity of the triangle wave form from the Integrator, the chief concern is that the Schmitt Trigger deliver a pulse when its input reaches a pre-determined level, and that the pulse has a fast rise time.

Schematic #2 (Section V) is the complete schematic of the Schmitt Trigger.

Assume a static condition of the circuit, when the outputs of both A4 and A5 are positive. A4 being positive will hold Q4 in its cut-off state, and A5 holds Q5 cut off. Q4 holds the emitter of Q7 at some voltage approaching the + supply. Q5 holds the base of Q7 at some voltage, determined by the voltage division of R49 and R50, but which is negative with respect to the emitter of Q7. A certain amount of current, therefore, is supplied by Q7 to the Tunnel Diodes, CR7 and CR8. Whether the tunnel diodes are in their "high" or "low" mode at this point can not be determined.

Now consider a triangle wave from the Integrator applied to the inverting (-) input of A4. At some point of the positive going portion of the triangle, determined by the setting of R39, the signal will exceed the negative bias at pin 3, and the output of A4 will go to its negative limit. This results in saturation of Q4, pulling its emitter to a negative level, also. Therefore the emitter of Q7 is also pulled more negative than its base. This results in Q7 being cut off, and no more current is supplied to the tunnel diodes. At this point the tunnel diodes will definitely switch to their low voltage state, or "low" mode.

As soon as the triangle wave starts on its negative going side, the drive is removed from A4, and it will return to its original state, i.e. the output is positive. While this will ultimately turn Q7 on again, the amount of current supplied to the tunnel diodes is not sufficient to switch them to the "high" mode.

When the triangle wave reaches the negative peak and overcomes the reverse bias on A5, the output of A5 goes negative, pulling the base of Q5 negative, thereby turning Q5 on. This results in the emitter of Q5 going to the same negative level, supplying more base current to Q7. The current through Q7 increases and switches the tunnel diodes to their "high" mode.

Because of the tunnel diode action, Q8 acts effectively as a Flip-Flop. When the tunnel diodes are in their "low" mode, Q8 is cut off, and the output is positive. When the tunnel diodes are in their "high" mode, base current is supplied to Q8, and its output is negative.

The switching time of the tunnel diodes is on the order of nano-seconds, so that the square wave output from the Schmitt Trigger does have the fast rise time which is essential for linear integration.

Constant Current Generator:

Figure 4-10 shows the Constant Current Generator and the circuitry associated with the current switching to the Integrator.

A6 is a standard differential amplifier, (See Schematic #3) whose output is 0 volts, as long as both inputs are equal. The non-inverting (-) input side is held constant at +5 volts by a simple voltage divider from the +12 volt supply. Q11 is a P-channel FET, which is biased so that it behaves as a variable resistor.

Assume that the voltage at + F.C. changes in a negative direction for some reason, This will result in a negative going signal at the inverting (-) input to A6, and the output of A6 will go in a positive direction. This decreases the conduction of Q11, effectively raising the resistance of Q11. The voltage division between R1 and Q11 is changed, raising the voltage at the inverting (-) input to A6.

The square wave output from the Schmitt

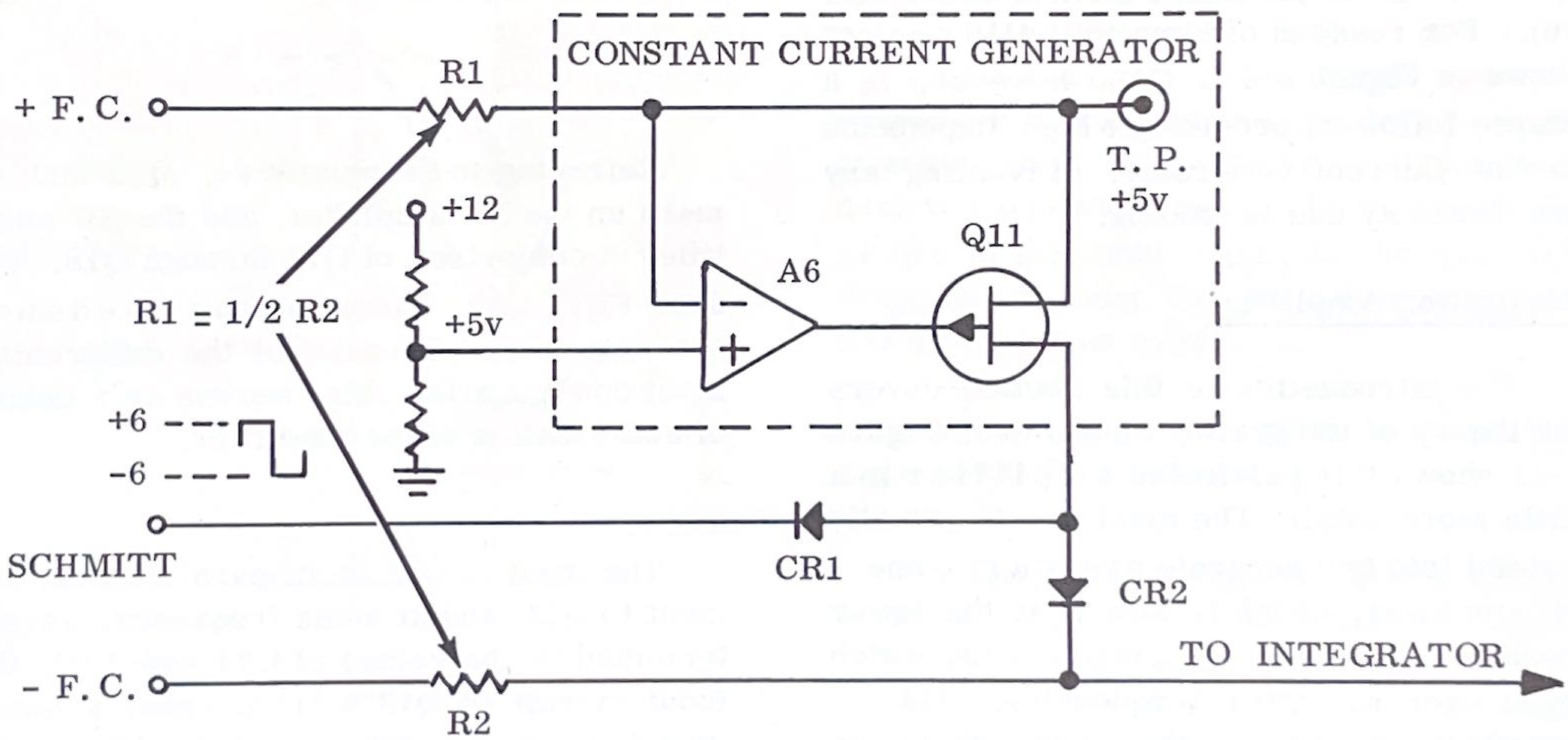


FIGURE 4-10

Trigger is fed into the cathode of CR1, thus when the input is at +6 volts CR1 is back-biased. R1 is 1/2 the resistance of R2, as noted in Figure 4-10. Therefore, regardless of the potential difference between + F.C. and - F.C. the current through R1 is always double the amount of current through R2. When CR1 is reverse biased, the Constant Current Generator maintains the current through R1 at a level equal to twice the current through R2.

The additional current, then, must be supplied from the Integrator, causing the integrating capacitor to discharge at a linear rate.

Similarly, when the input is at -6 volts, CR1 is forward biased, and therefore CR2 is reverse biased. The current through R1 is now supplied from the input, and the integrating capacitor charges at a rate determined by the current through R2.

Referring now to Schematic #3, it will be seen that the resistance between Q11 and + F.C. is a varying value, depending on the range selected. (The resistors are selected by level "B" of the Range Switch, Schematic #6). For reasons of simplicity Q10 was not shown in Figure 4-10. Q10, however, is a source follower, providing a high impedance to the Current Generator, preventing any non-linearity due to loading.

Integrating Amplifier:

The introduction to this section covers the theory of integrating amplifiers. Figure 4-11 shows this particular amplifier in a little more detail. The amplifier is actually divided into two separate amplifiers, one a DC amplifier, which is active at the lower frequencies, and an AC amplifier, which takes over at higher frequencies. This is necessary because of the bandwidth of the F210A (.005Hz to 3MHz.).

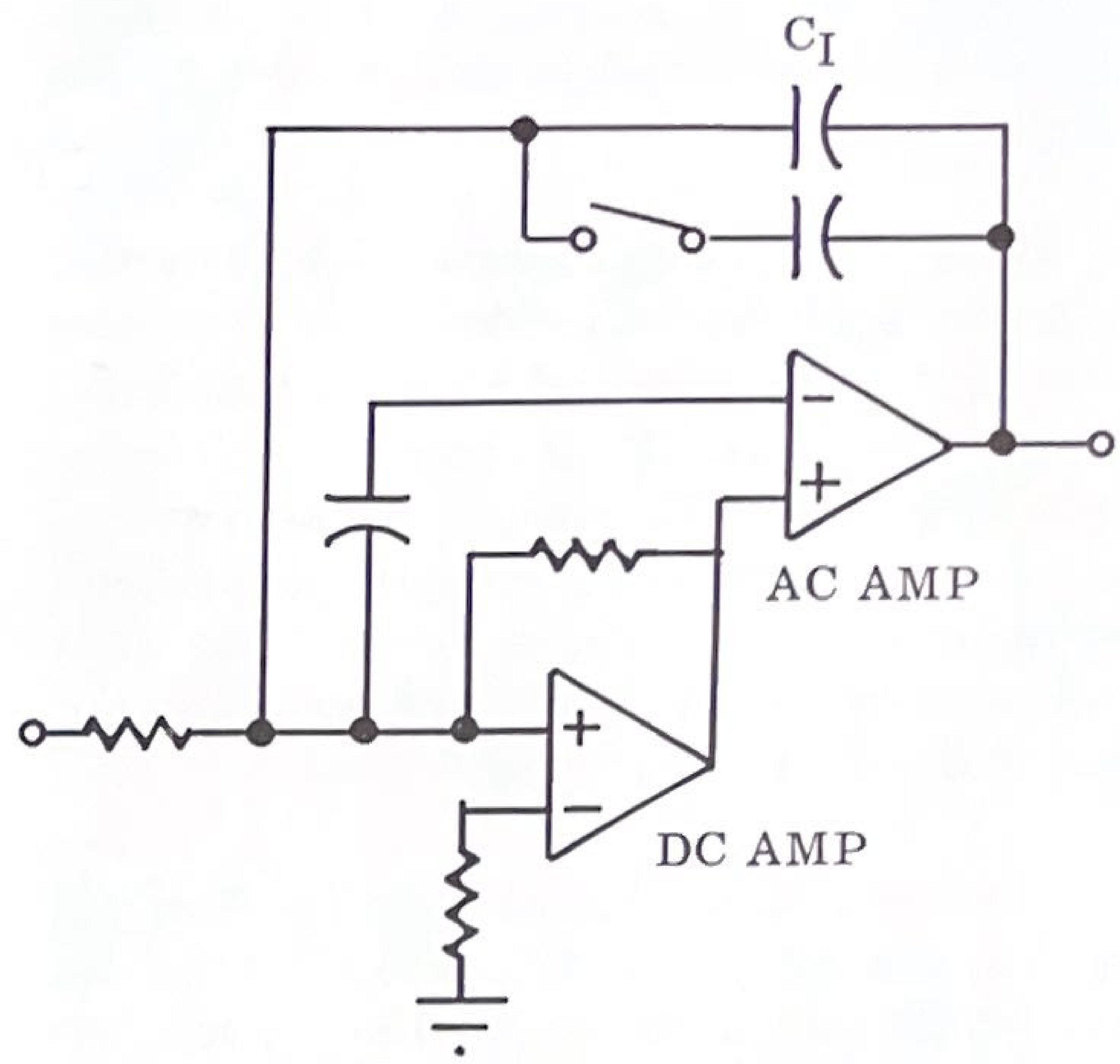


FIGURE 4-11

C1 is the integrating capacitor. The fixed value shown is in the circuit at all times, while the switched value indicates different values being added on various ranges. This is done for reasons of ease of design, as it eliminates the necessity of using extremely large values of either resistance or capacitance.

Referring to Schematic #4, Q12 and A7 make up the DC amplifier, and the AC amplifier is comprised of Q13 through Q18. The dual-FET, Q12, serves as an impedance converter, and because of the differential input configuration, also serves as a means of stabilization of the amplifier.

The input to Q12 is in parallel with the input to Q13, and at some frequency, as determined by the values of C34 and R86, the input circuit to Q13 will present a lower impedance to the signal, and the AC amplifier takes over at this point.

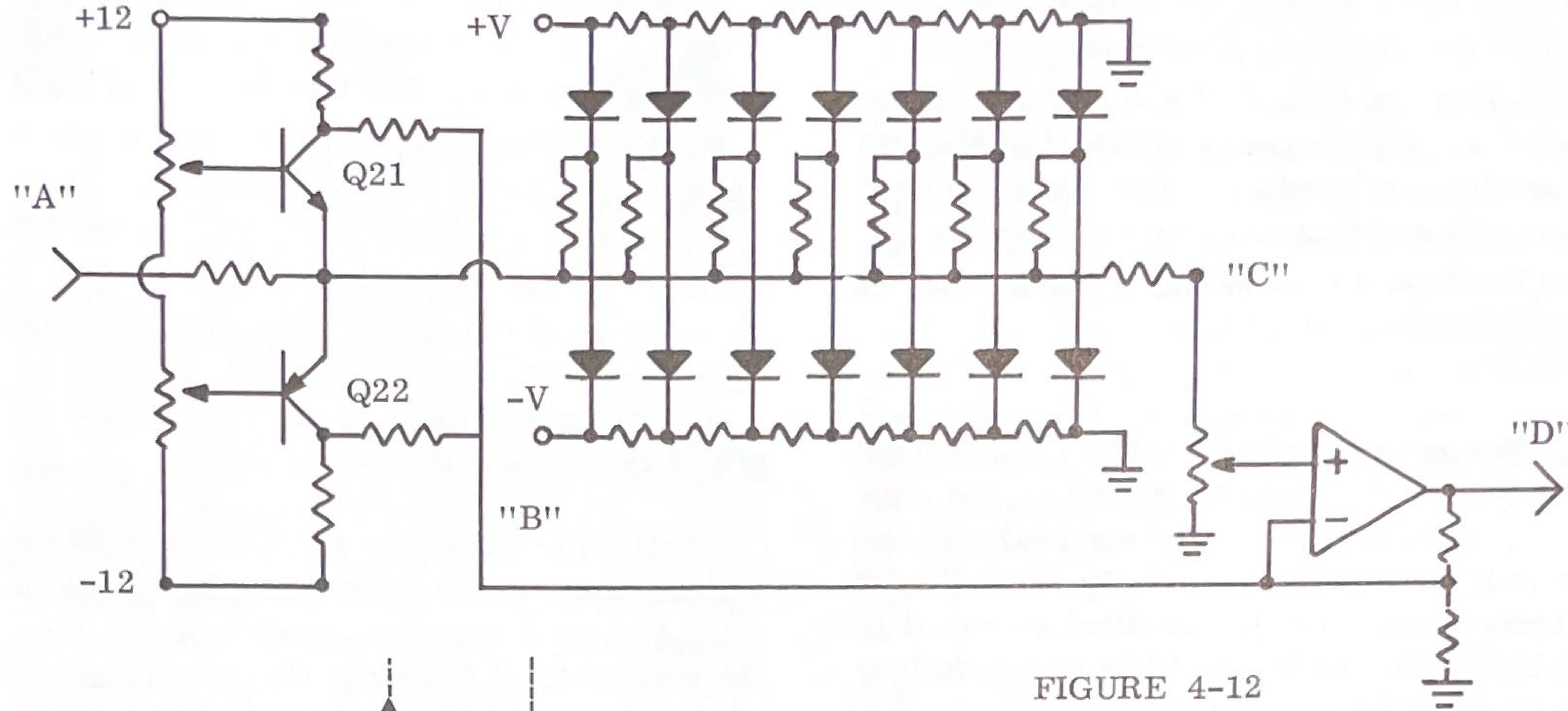
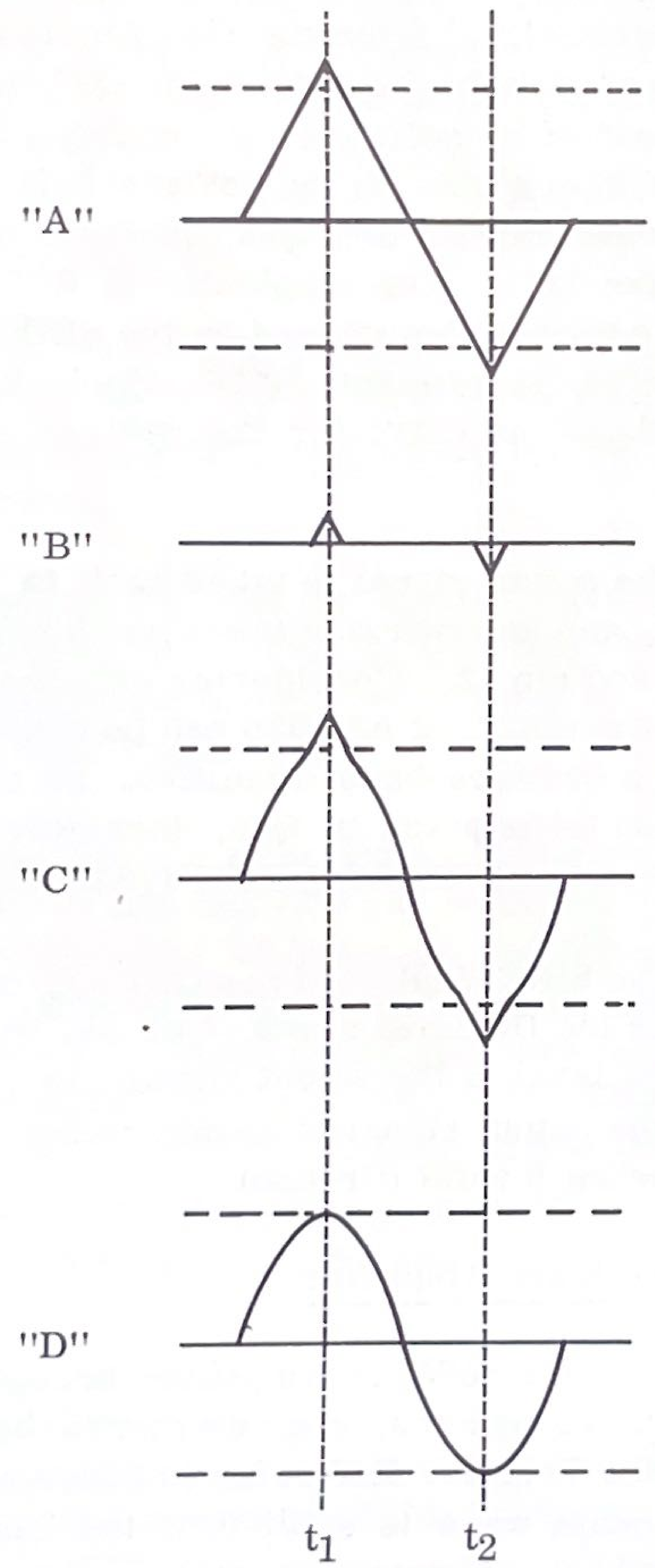


FIGURE 4-12



SHAPING CIRCUITS

Sine Generator:

As shown in Figure 4-7, the Sine Generator is a synthesizing circuit, which has a triangle wave as its input. CR1 through CR_n are biased at different DC voltages, determined by their relative position along the voltage divider connected between the + and - power supplies.

Diodes CR1....... CR_n break down and conduct at increasing voltage levels as the triangle input increases from its negative peak to its positive peak. Therefore the slope of the input signal to the amplifier changes, causing the amplifier output to appear as a sine waveform.

Figure 4-12 shows a more detailed diagram of the Sine Generator.

For ease of drawing, the Sine Amplifier is shown as a simple differential amplifier. In theory the input signal to the non-inverting (+) input side is a sine wave. In practice, however, the signal at point "C" contains a certain amount of peaking. Therefore the input triangle wave is applied to a pair of non-inverting (Common Base) amplifiers, Q21 and Q22. Q21 and Q22 are biased such that only the peaks of the triangle will cause them to conduct. The output signals from Q21 and Q22 are summed at point "B" and fed into the inverting (-) input side of the differential amplifier.

The input signal at point "C" is distorted by the amount of peaking riding on the sine wave, so by applying only the peaks to the inverting input, the net effect will be that of a subtracting circuit. The final output, thus will be a sine wave with little or no distortion remaining.

Schematic #5 is the complete schematic of the Sine Generator. Q19 and Q20 are the supplies for Q21 and Q22, respectively. As described above, R110 is the NEGATIVE PEAK Adjustment, and determines the point at which Q21 starts conducting. Likewise, R113 is the POSITIVE PEAK Adjustment.

Both sides of the synthesizing network are identical in operation, therefore only the positive side will be discussed. The bases of Q24, 26, 28, 30, 32 and 34 are held at some bias potential, determined by the POSITIVE BREAK Adjustment, R155. The arm of R155 is at +0.7 volts, typically, so the base of Q24 will be at approximately +0.35 volts. The emitters of all these transistors are returned to the -12 volt supply, so the transistors are always conducting. When Q24 is conducting, the voltage across the emitter-base junction is 0.7 volts, so the emitter of Q24 is at approximately -0.35 volts. The drop across CR21 is also 0.7 volts, therefore CR21 will start to conduct, when the input exceeds +0.35 volts. Similarly, CR23 conducts when the input level reaches +0.5 volts, and so on down the line, until at +0.7 volts CR31 conducts.

The Sine Amplifier is a differential amplifier. A8 is connected in a differential pair configuration. Pin 6 is the signal input from the synthesizing network, while pin 9 is equivalent to the inverting input in Figure 4-12. Pin 9 receives the signal from the peak detectors, as discussed above. Pin 9 also accepts a portion of the output from the Sine Amplifier, so one half of A8 serves as a stabilizing device, because the signal at pin 12 is degenerative (See below).

Following the signal from pin 6 of A8, it will be seen that an inversion takes place in A8. Another inversion occurs in Q36, thus the output signal from the Sine Amplifier is in phase with the input to pin 6. Q37 and Q38 is a pair of complimentary emitter followers. Q37 conducts on the positive half of the sine wave signal, and Q38 conducts on the negative half. The amplitude of the sine wave output is determined by the SINE AMPLITUDE Adjustment, R158, which divides the signal at CR31 for the desired output level.

The output signal is taken back to pin 9 of A8, and an inversion takes place between pin 9 and pin 12. Considering only the signal from pin 12 of A8, Q36 can be considered as a common-base amplifier, so no inversion takes place in Q36, therefore, the net result is that of degenerative feedback.

The SINE ZERO Adjustment, R161, varies the DC level at pin 9 of A8, shifting the DC level of the output signal, to ensure that the output signal is symmetrical above and below 0 volts (Ground).

Square Wave Amplifier:

The Square Wave Amplifier accepts the ±6 volt square wave generated by the Schmitt Trigger. Referring to Schematic #7 the square wave is applied to the bases of Q8 and Q9. Assume a negative going signal at the base of Q8. Q8 is an emitter follower therefore the base of Q11 will be pulled in a negative direction, and Q11 will saturate.

Q10 is a series regulator, the voltage output of which is determined by the setting of the POSITIVE AMPLITUDE Adjustment, R43. Thus, when Q11 saturates, its collector will rise to the maximum positive voltage available at the emitter. Q11 in turn drives an emitter follower, Q14, which provides the low output impedance and the current to drive the Output Amplifier.

Similarly, when the input square wave goes positive, Q12 saturates at the maximum negative voltage, as determined by the setting of the NEGATIVE AMPLITUDE Adjustment, R46.

Ramp Generator:

The square wave signal at the emitters of Q8 and Q9 of the Square Wave Amplifier is also used as a gating signal for the Ramp Generator.

During the time the square wave signal is positive, the bases of Q17 and Q18 are held at approximately +0.7 volts by CR18 and CR19, respectively.

The triangle wave from the Integrator is applied to R58 and R59 and to the emitter of Q17. Because of the bias established by CR18, Q17 will remain cut off, as long as the signal at the emitter is more negative than 0 volts. R58, the RAMP OFFSET Adjustment, varies the voltage at the emitter of Q17 to 0 volts DC, so that the triangle input will be entirely negative.

Keeping in mind the phase relationship of the triangle and square wave (Figure 4-4) the triangle wave changes from its positive peak to its negative peak during the time the square wave is positive. Thus, the signal at the emitter of Q17 is a negative going ramp, the emitter returning to 0 volts DC instantaneously as the square wave gate signal goes negative. The negative level of the square wave is -6 volts and the triangle wave amplitude is on the order of 2 volts peak-to-peak, so the triangle voltage can never overcome the forward bias of Q17 as established by the negative half of the square wave. Therefore, during the transition of the triangle from its negative peak to its positive peak, the emitter of Q17 is effectively clamped to Ground.

Q18 serves essentially the same purpose as Q17, but provides more positive clamping of the ramp signal. Also, Q18 is not driven as hard as Q17, therefore, any transient pulses from the edges of the square wave are isolated from the Ramp Amplifier.

The Ramp Amplifier is identical in operation to the Sine Amplifier. As in the Sine Amplifier, IC3 is connected in a differential pair configuration with the incoming ramp signal applied to pin 6, and a portion of the output signal applied to the differential side, pin 3. The RAMP ZERO Adjustment, R75, determined the DC level of the output signal by varying the DC level at the differential input, pin 3. A portion of the output signal is taken back to pin 3, through the RAMP AMPLITUDE Adjustment, R80. The output signal from the Ramp Amplifier is a negative going ramp.

SYNC GENERATOR

The square wave signal at the emitters of Q8 and Q9 is used as the source signal for the Sync Generator.

The positive going edge of the square wave is differentiated through R52 and C32 and this pulse is applied to the base fo Q16. Q16 provides a -10 volt pulse with a maximum duration of 5 μseconds, coincident with the leading edge of the square wave output.

OUTPUT AMPLIFIER

The Output Amplifier is also very nearly identical to the Sine Amplifier. The difference being that the Output Amplifier is an inverting amplifier, with part of the output signal taken back to the input, rather than to the differential side of an input pair. The OUTPUT ZERO Adjustment, R104, varies the DC level of the low side of the signal received from the Integrator and the Shaping Amplifiers. The low side of these signals is fed into the differential side of the input stage, IC4, in turn enabling the output signal to be varied around 0 volts DC, in order to achieve amplitude symmetry.

POWER SUPPLIES

All power supplies are located on the Master Board Assembly.

The +12 volt and -12 volt supplies are regulated supplies, the -12 volt supply slaved to the +12 volt supply. The supplies are identical in operation, therefore only the +12 volt supply will be discussed.

Regulation of the +12 volt supply is accomplished by the passing transistor, Q4. The output voltage is divided down through R19, R20 and R21 to provide a variable control voltage at the inverting (-) input of a differential amplifier, IC1.

The output voltage is also the source for Q24, which is connected as a zener diode. Q24 breaks down at +6.7 volts, and keeps a constant voltage at the non-inverting (+) input of IC1.

A drop in output voltage causes a less positive voltsge at the inverting (-) input of IC1, which results in a more positive voltage at the output, pin 6. This voltage is applied to the gate of FET, Q5, causing it to conduct more, which pulls the base of Q4 more negative. This results in increased conduction through Q4, which in turn raises the output voltage.

The 24 volt regulated supply is a simple series regulator. The collector of Q1 is supplied from the unregulated +32 volt supply. The base of Q1 is held at a constant voltage by CR12, which holds the conduction of Q1 constant, thereby keeping the emitter voltage constant. The current requirement of the +24 volt supply is very slight, as it is used only for bias voltage for current generators in other parts of the unit.

The +24 volt and -24 volt unregulated supplies, and the +32 volt and -32 volt supplies are derived from respective bridge rectifiers with a single section capacitive filter in each case. These supplies are used only to supply the necessary power for the Output Amplifier, and need not be regulated because of the relatively large amount of feedback used in the Output Amplifier.

SECTION V

MAINTENANCE

General:

This section contains information relative to preventive and corrective maintenance. The portion dealing with corrective maintenance contains troubleshooting and corrective procedures.

Parts identification is provided on photographs of each circuit board or sub-assembly. Each photograph is on the page facing the schematic of the assembly in question.

A complete parts list for each assembly is contained on the page(s) immediately preceding each photograph.

The majority of electronic parts used in this instrument are standard, commercial parts, and replacement parts may be obtained locally. Precision components and mechanical parts, however, should be obtained through Data Royal Corporation's representative in your area.

Preventive Maintenance:

In general, no preventive maintenance, as such, is required. Occasional cleaning is recommended, and can be accomplished in conjunction with routine calibration.

A calibration cycle of six months is recommended for areas of normal operating conditions.

Re-calibration is necessary because the calibration of any instrument changes with age, use and operating conditions. Also, problems which may not be apparent during normal use will show up during a calibration check. See Section III for complete calibration procedure.

Corrective Maintenance:

Figure 5-1 is the logical representation of the procedure designed to assist in the location of any problem. This procedure is based on a systematic analysis of the instrument circuits in order to localize the problem.

This procedure should be undertaken only after it has been established that the problem can not be corrected by following the Adjustment and Calibration Procedures, as detailed in Section III. It should also be determined that the problem is not caused by conditions outside the Model F210A.

Table 5-1 contains a list of the normal indications for each of the checks listed in Figure 5-1. The steps outlined in Figure 5-1 are intended only to help localize the problem to an area within the instrument. Therefore, additional measurements will be required to completely isolate the problem within a specific circuit.

Table 5-2 contains a list of typical voltages as measured at a number of active components throughout the instrument.

Component parameters will vary from one instrument to the next, therefore, the voltage levels listed may not exactly equal readings obtained during the troubleshooting procedure.

NORMAL INDICATIONS

1. All outputs, corresponding to the Function Switch selected.

2. All outputs, as marked at each BNC connector.

3. -10 volt pulse, 2 μseconds wide.

4. Varying the Frequency Control should vary the output over a 20:1 frequency span within any given range.

5. Applying 1.000 volts should raise the output frequency by 20% of full scale on any range.

6. Each consecutive position should change the output frequency by a factor of 10, the Range Multiplier in either X1 or X3.

7. Fixed steps of -20dB and -40dB attenuation of the output signal.

8. Vernier amplitude control of the output signal.

9. Normal signal at the Triangle T.P. is a ±1 volts triangle waveform (2v peak-to-peak), which is the output of the integrating amplifier. As described in Section IV, the Integrator, the Schmitt Trigger and the Constant Current Generator constitute a "closed loop". All three circuits, therefore, must work in order to get a triangle output.

   To troubleshoot the Integrator, ground the Summing Junction (left end of the .0022 capacitor, C34). Now vary the Integrator Zero pot (R79) from CCW to CW. The DC level at the Triangle T.P. should vary from approximately -5 volts to +5 volts.

10. To troubleshoot the Schmitt Trigger ground the Integrator Summing Junction as in 9 above. Vary the Integrator Zero pot as in 9, while monitoring the Schmitt output. (Green T.P. in right corner at the front of the Generator Board. The Schmitt output should swing from -0.6 volts to +0.6 volts.

    The Current Generator either works or it doesn't. If it works, the Green T.P. near Q11 will measure approximately +5 volts. The actual voltage is not extremely critical, but whatever it is, it must be stable.

TABLE 5-1

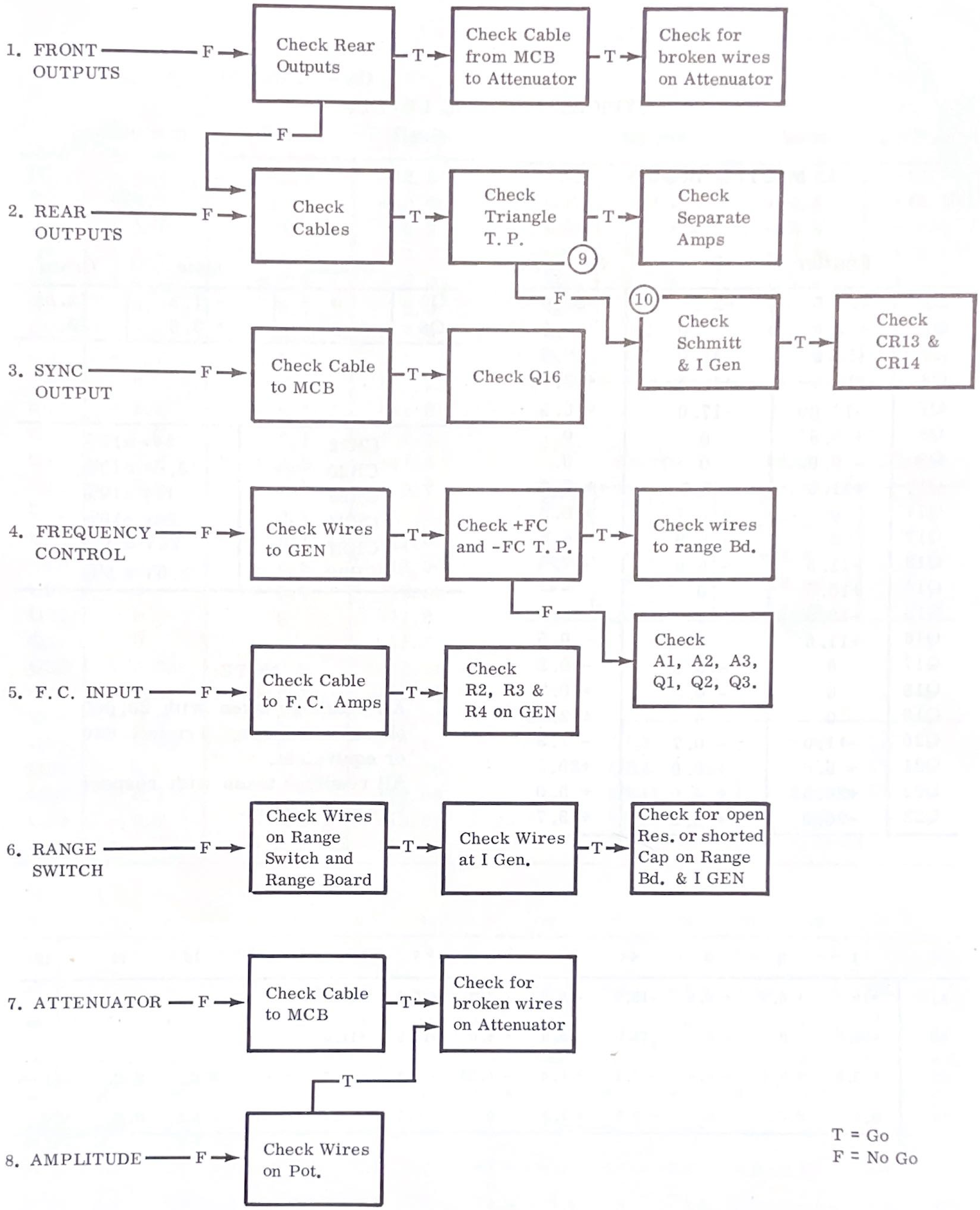

1. FRONT OUTPUTS
Check Rear Outputs
Check Cable from MCB to Attenuator
Check for broken wires on Attenuator
2. REAR OUTPUTS
Check Cables
Check Triangle T. P.
Check Separate Amps
9
10
Check Schmitt & I Gen
Check CR13 & CR14
3. SYNC OUTPUT
Check Cable to MCB
Check Q16
4. FREQUENCY CONTROL
Check Wires to GEN
Check +FC and -FC T. P.
Check wires to range Bd.
Check A1, A2, A3, Q1, Q2, Q3.
5. F. C. INPUT
Check Cable to F. C. Amps
Check R2, R3 & R4 on GEN
6. RANGE SWITCH
Check Wires on Range Switch and Range Board
Check Wires at I Gen.
Check for open Res. or shorted Cap on Range Bd. & I GEN
7. ATTENUATOR
Check Cable to MCB
Check for broken wires on Attenuator
8. AMPLITUDE
Check Wires on Pot.
T
F
T = Go
F = No Go

FIGURE 5-1

TABLE 5-2

TYPICAL VOLTAGE LEVELS

1. MASTER BOARD

	Emitter	Base	Collector
Q1	+23.5	+24.0	+32.0
Q2	+17.5	+17.0	+16.5
Q3	-17.5	-17.0	-16.5
Q4	+17.5	+16.5	+12.00
Q7	-12.00	-17.0	-16.5
Q8	+ 8.5	0	0
Q9	- 9.0	0	0
Q10	+11.5	+ 6.7	+ 7.2
Q11	0	+ 6.7	+ 6.3
Q12	0	- 6.9	- 6.5
Q13	-11.5	- 6.9	- 7.4
Q14	+10.5	0	---
Q15	-10.5	0	---
Q16	+11.5	0	- 0.5
Q17	0	- 0.2	- 0.2
Q18	0	- 0.3	- 0.2
Q19	0	0	+12.00
Q20	-11.0	- 0.7	- 1.3
Q21	+ 5.0	+30.0	+29.5
Q22	+26.5	+ 4.0	+ 5.0
Q23	-26.0	+ 4.2	+ 3.7

	Source	Gate	Drain
Q5	0	- 1.2	+12.5
Q6	0	+ 3.8	-13.0

CR12	24v ±10%
CR20	5.6v ±10%
CR23	12v ±10%
CR24	24v ±10%
CR27	20V ±10%
CR28	3.6V ± 5%

NOTE:

All readings taken with 20,000 ohms/volt meter, Triplett 630 or equivalent.
All readings taken with respect to TP2 (Ground).

	1	2	3	4	5	6	7	8	9	10	11	12
A1	+10.0	+ 6.9	+ 6.8	-15.5	-15.0	- 1.2	+15.5	+11.5				
A2	+10.0	0	0	-15.5	-15.0	+ 4.0	+15.5	+11.5				
A3	+ 5.5	+ 6.4	- 0.4	- 1.1	+ 6.4	- 0.25	- 1.1	+ 6.7	N.C.	N.C.	N.C.	-12.00
A4	N.C.	N.C.	0	- 0.7	+ 7.3	0	- 0.7	+ 8.5	N.C.	- 4.3	N.C.	N.C.

2. GENERATOR BOARD

	Emitter	Base	Collector
Q1	- 5.0	- 5.9	-12.00
Q2	+19.0	+18.0	+10.0
Q3	+ 1.7	+ 1.0	-10.8
Q4	+ 4.0	+ 3.8	- 6.0
Q5	+ 3.3	+ 2.8	- 6.0
Q6	- 6.0	- 6.7	- 9.2
Q7	+ 4.0	+ 3.3	- 5.6
Q8	- 6.0	- 5.6	0
Q9	0	0	+11.6
Q13	- 1.0	- 0.1	+11.6
Q14	- 1.0	- 0.1	+ 8.5
Q15	+ 7.8	+ 8.5	+11.6
Q16	- 5.5	- 4.7	- 0.7
Q17	0	+ 0.7	+11.6
Q18	0	- 0.7	-11.6
Q19	0	- 0.6	-12.00
Q20	0	+ 0.7	+12.00
Q21	0	0	+11.8
Q22	0	0	-11.8
Q23	+ 0.25	- 0.35	-12.00
Q24	- 0.3	+ 0.35	+12.00
Q25	+ 0.05	- 0.5	-12.00
Q26	- 0.05	+ 0.5	+12.00
Q27	- 0.1	- 0.75	-12.00
Q28	+ 0.1	+ 0.75	+12.00
Q29	- 0.2	- 0.8	-12.00
Q30	+ 0.2	+ 0.8	+12.00

	Emitter	Base	Collector
Q31	- 0.2	- 0.8	-12.00
Q32	+ 0.2	+ 0.8	+12.00
Q33	- 0.2	- 0.8	-12.00
Q34	+ 0.2	+ 0.8	+12.00
Q35	+ 7.8	+ 8.4	+11.6
Q36	+ 7.5	+ 6.8	+ 0.7
Q37	0	+ 0.7	+10.2
Q38	- 0.2	- 0.7	-10.2

	Source	Gate	Drain
Q10	+ 6.0	+ 4.8	+23.7
	+ 6.0	+ 5.0	+23.7
Q11	+ 5.0	+ 8.6	+ 0.25
Q12	+ 1.1	+12.00	0
	+ 1.1	+12.00	- 0.05

CR3	6.8v ± 5%
CR4	8.7v ± 5%
CR11	6.8v ± 5%
CR15	12v ±10%
CR18	6.2v ±10%

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
A1	- 1.4	- 0.7	- 0.7	- 1.4	+ 4.0	0	- 0.7	+ 4.0	0	-12.0	+ 4.0	+ 4.0	N.C.	N.C.
A2	+ 0.5	0	- 1.3	- 1.4	N.C.	-12.0	N.C.	-12.0	+ 0.5	+ 7.0	+ 2.0	+ 1.0	+12.0	+ 3.7
A3	+ 0.5	0	0	0	0	-12.0	N.C.	-12.0	+ 0.5	+ 6.6	+ 1.7	+ 1.0	+12.0	+ 4.4
A4	0	0	- 0.3	- 6.0	N.C.	N.C.	+ 3.0	+11.5	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.
A5	0	+ 0.3	0	- 6.0	N.C.	N.C.	+ 2.8	+11.6	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.
A6	+11.7	+11.2	+ 5.6	+ 5.6	N.C.	0	N.C.	N.C.	+11.7	+18.5	+18.0	+12.0	+23.5	+15.7
A7	+ 7.4	+ 1.0	+ 1.0	-12.0	-11.3	0	+12.0	+ 8.4	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.
A8	- 1.5	- 0.75	- 0.75	- 1.5	+ 6.8	0	- 0.75	+11.8	0	- 4.8	+11.8	+ 8.4	N.C.	N.C.

PARTS LIST

DATA ROYAL ASSEMBLY: F210A GENERATOR BOARD ASSEMBLY — DATA ROYAL PART NO. 29-02026

SCHEMATIC DESIGNATION	DESCRIPTION VALUE	TYPE	RATING	MANUFACTURER CODE	PART NO.	DATA ROYAL PART NO.
CAPACITORS						
C1	100pf	CER DISC	1000V	56289	DD101	21-57007-0
C2	10μf	ELECT	25V	56289	TE-1204	21-57202-0
C3	68pf	CER DISC	1000V	56289	DD680	21-57013-0
C4	68pf	CER DISC	1000V	56289	DD680	21-57013-0
C5	.01μf	CER DISC	50V	56289	TG-S10	21-57001-0
C6	.05μf	CER DISC	50V	56289	TG-S50	21-57003-0
C7	5pf	CER DISC	1000V	56289	DD-050	21-57009-0
C8	.05μf	CER DISC	50V	56289	TG-S50	21-57003-0
C9	.01μf	CER DISC	50V	56289	TG-S10	21-57001-0
C10	5pf	CER DISC	1000V	56289	DD-050	21-57009-0
C11	68pf	CER DISC	1000V	56289	DD-680	21-57013-0
C12	68pf	CER DISC	1000V	56289	DD-680	21-57013-0
C13	.01μf	CER DISC	50V	56289	TG-S10	21-57001-0
C14	.01μf	CER DISC	50V	56289	TG-S10	21-57001-0
C15	.01μf	CER DISC	50V	56289	TG-S10	21-57001-0
C16	75pf	MICA	500V	04062	DM-15-100J	21-57613-0
C17	68pf	CER DISC	1000V	56289	DD-680	21-57013-0
C18	.01μf	CER DISC	50V	56289	TG-S10	21-57001-0
C19	.01μf	CER DISC	50V	56289	TG-S10	21-57001-0
C20	.01μf	CER DISC	50V	56289	TG-S10	21-57001-0
C21	.01μf	CER DISC	50V	56289	TG-S10	21-57001-0
C22	200μf	ELECT	15V	56289	TE-1164	21-57201-0
C23	.01μf	CER DISC	50V	56289	TG-S10	21-57001-0
C24	200μf	ELECT	15V	56289	TE-1164	21-57201-0
C25	.01μf	CER DISC	50V	56289	TG-S10	21-57001-0
C26	.01μf	CER DISC	50V	56289	TG-S10	21-57001-0
C27	.01μf	CER DISC	50V	56289	TG-S10	21-57001-0
C28	68pf	CER DISC	1000V	56289	DD-680	21-57013-0
C29	68pf	CER DISC	1000V	56289	DD-680	21-57013-0
C30	.01μf	CER DISC	50V	56289	TG-S10	21-57001-0
C31	SELECTED					
C32	2-8pf	VAR CER		72982	538-002-89	21-63201-0
C33	82pf	MICA	500V	04062	DM-15-820F	21-57630-0
C34	.0022μf	MYLAR	100V	14655	WMF-1022	21-57412-0
C35	5pf	CER DISC	1000V	56289	DD-050	21-57009-0
C36	100pf	CER DISC	1000V	56289	DD-101	21-57007-0
C37	.022μf	MYLAR	100V	14655	WMF-1S22	21-57408-0
C38	47pf	MICA	500V	04062	DM-15-470J	21-57627-0
C39	.005μf	CER DISC	50V	56289	TG-D50	21-57005-0
C40	.05μf	CER DISC	50V	56289	TG-S50	21-57003-0
C41	.05μf	CER DISC	50V	56289	TG-S50	21-57003-0
C42	.01μf	CER DISC	50V	56289	TG-S10	21-57001-0
C43	.01μf	CER DISC	50V	56289	TG-S10	21-57001-0
C44	.01μf	CER DISC	50V	56289	TG-S10	21-57001-0
C45	.01μf	CER DISC	50V	56289	TG-S10	21-57001-0
C46	SELECTED					
C47	SELECTED					
C48	.01μf	CER DISC	50V	56289	TG-S10	21-57001-0
C49	.01μf	CER DISC	50V	56289	TG-S10	21-57001-0
C50	560pf	CER DISC	1000V	56289	DD-561	21-57002-0
C51	10pf	CER DISC	1000V	56289	DD-100	21-57004-0
C52	.01μf	CER DISC	50V	56289	TG-S10	21-57001-0

PARTS LIST

DATA ROYAL ASSEMBLY: F210A GENERATOR BOARD ASSEMBLY — DATA ROYAL PART NO. 29-02026

SCHEMATIC DESIGNATION	DESCRIPTION VALUE	TYPE	RATING	MANUFACTURER CODE	PART NO.	DATA ROYAL PART NO.
CAPACITORS (Continued)						
C53	5pf	CER DISC	1000V	56289	DD-050	21-57009-0
C54	.01μf	CER DISC	50V	56289	TG-S10	21-57001-0
C55	500pf	MICA	300V	04062	DM-15-501F	21-57611-0
C56	1000pf	MICA	100V	04062	DM-15-102F	21-57612-0
C57	500pf	MICA	300V	04062	DM-15-501F	21-57611-0
C58	100μf	ELECT	25V	56289	TE-1211	21-57217-0
C59	100μf	ELECT	25V	56289	TE-1211	21-57217-0
C60	.01μf	CER DISC	50V	56289	TG-S10	21-57001-0
C61	.01μf	CER DISC	50V	56289	TG-S10	21-57001-0
RESISTOR						
R1	182Ω	FILM	1/4W 1%	07115	NA-60-1820F	27-42797-0
R2	5KΩ	FILM	1W 1%	04387	RS-1A	27-48007-0
R3	4.5KΩ	FILM	1W 1%	04387	RS-1A	27-48006-0
R4	1KΩ	VAR	1/2W 10%	01121	SV1021	27-49500-0
R5	20KΩ	FILM	1/4W 1%	12126	M1/4-20K	27-42927-0
R6	100Ω	VAR	1/2W 10%	01121	SV1011	27-49510-0
R7	200Ω	VAR	1/2W 10%	01121	SV2011	27-49511-0
R8	6.8KΩ	COMP	1/4W 5%	01121	CB6825	27-39284-0
R9	100KΩ	COMP	1/4W 5%	01121	CB1045	27-39294-0
R10	22KΩ	COMP	1/4W 5%	01121	CB2235	27-39288-0
R11	22KΩ	COMP	1/4W 5%	01121	CB2235	27-39288-0
R12	100KΩ	COMP	1/4W 5%	01121	CB1045	27-39294-0
R13	10KΩ	COMP	1/4W 1%	12126	M1/4-10K	27-42912-0
R14	220Ω	COMP	1/4W 5%	01121	CB2215	27-39265-0
R15	220Ω	COMP	1/4W 5%	01121	CB2215	27-39265-0
R16	20KΩ	FILM	1/4W 1%	12126	M1/4-20K	27-42927-0
R17	33KΩ	COMP	1/4W 5%	01121	CB3335	27-39311-0
R18	10KΩ	VAR	1/2W 10%	01121	SV1031	27-49513-0
R19	1KΩ	COMP	1/4W 5%	01121	CB1025	27-39273-0
R20	100Ω	COMP	1/4W 5%	01121	CB1015	27-39261-0
R21	100Ω	COMP	1/4W 5%	01121	CB1015	27-39261-0
R22	4.99KΩ	FILM	1/4W 1%	12126	M1/4-4.99K	27-42887-0
R23	4.64KΩ	FILM	1/4W 1%	12126	M1/4-4.64K	27-42884-0
R24	7.15KΩ	FILM	1/4W 1%	12126	M1/4-7.15K	27-42900-0
R25	500Ω	VAR	1/2W 10%	01121	SV5011	27-49512-0
R26	2KΩ	FILM	1/4W 1%	12126	M1/4-2K	27-42860-0
R27	500Ω	VAR	1/2W 10%	01121	SV5011	27-49512-0
R28	4.75KΩ	FILM	1/4W 1%	12126	M1/4-4.75K	27-42885-0
R29	220Ω	COMP	1/4W 5%	01121	CB2215	27-39265-0
R30	220Ω	COMP	1/4W 5%	01121	CB2215	27-39265-0
R31	330Ω	COMP	1/4W 5%	01121	CB3315	27-39267-0
R32	18KΩ	COMP	1/4W 5%	01121	CB1835	27-39310-0
R33	5.6KΩ	COMP	1/4W 5%	01121	CB5625	27-39283-0
R34	750Ω	COMP	1/4W 5%	01121	CB7515	27-39309-0
R35	1KΩ	FILM	1/4W 1%	12126	M1/4-1K	27-42846-0
R36	1KΩ	FILM	1/4W 1%	12126	M1/4-1K	27-42846-0
R37	11.5KΩ	FILM	1/4W 5%	12126	M1/4-11.5K	27-42914-0
R38	1KΩ	VAR	1/2W 10%	01121	SV1021	27-49500-0
R39	1KΩ	VAR	1/2W 10%	01121	SV1021	27-49500-0
R40	11.5KΩ	FILM	1/4W 1%	12126	M1/4-11.5K	27-42914-0

PARTS LIST

DATA ROYAL ASSEMBLY: F210A GENERATOR BOARD ASSEMBLY   DATA ROYAL PART NO. 29-02026

SCHEMATIC DESIGNATION	DESCRIPTION			MANUFACTURER		DATA ROYAL PART NO.
	VALUE	TYPE	RATING	CODE	PART NO.	
RESISTORS (Continued)						
R41	10Ω	COMP	1/4W 5%	01121	CB1005	27-39250-0
R42	560Ω	COMP	1/4W 5%	01121	CB5615	27-39270-0
R43	340Ω	FILM	1/4W 1%	12126	M1/4-340	27-42807-0
R44	82KΩ	COMP	1/4W 5%	01121	CB8235	27-39293-0
R45	560Ω	COMP	1/4W 5%	01121	CB5615	27-39270-0
R46	340Ω	FILM	1/4W 1%	12126	M1/4-340	27-42807-0
R47	82KΩ	COMP	1/4W 5%	01121	CB8235	27-39293-0
R48	22KΩ	COMP	1/4W 5%	01121	CB2235	27-39288-0
R49	3.9KΩ	COMP	1/4W 5%	01121	CB3925	27-39281-0
R50	1.5KΩ	COMP	1/4W 5%	01121	CB1525	27-34275-0
R51	976Ω	FILM	1/4W 1%	12126	M1/4-976	27-42845-0
R52	1KΩ	COMP	1/4W 5%	01121	CB1025	27-39273-0
R53	1KΩ	COMP	1/4W 5%	01121	CB1025	27-39273-0
R54	1.2KΩ	COMP	1/4W 5%	01121	CB1225	27-39274-0
R55	470Ω	COMP	1/4W 5%	01121	CB4715	27-39269-0
R56	82Ω	COMP	1/4W 5%	01121	CB8205	27-39260-0
R57	330Ω	COMP	1/4W 5%	01121	CB3315	27-39267-0
R58	100KΩ	FILM	1/4W 1%	12126	M1/4-100K	27-42958-0
R59	71.5KΩ	FILM	1/4W 1%	12126	M1/4-71.5K	27-42956-0
R60	22KΩ	COMP	1/4W 5%	01121	CB2235	27-39288-0
R61	22KΩ	COMP	1/4W 5%	01121	CB2235	27-39288-0
R62	3.3KΩ	COMP	1/4W 5%	01121	CB3325	27-39280-0
R63	3.9KΩ	COMP	1/4W 5%	01121	CB3925	27-39281-0
R64	220Ω	COMP	1/4W 5%	01121	CB2215	27-39265-0
R65	220Ω	COMP	1/4W 5%	01121	CB2215	27-39265-0
R66	2.2KΩ	COMP	1/4W 5%	01121	CB2225	27-39278-0
R67	22KΩ	COMP	1/4W 5%	01121	CB2235	27-39288-0
R68	220Ω	COMP	1/4W 5%	01121	CB2215	27-39265-0
R69	12.5KΩ	FILM	1/4W 1%	12126	M1/4-12.5K	27-46502-0
R70	4.167KΩ	FILM	1/4W 1%	12126	M1/4-4.167K	27-46500-0
R71	125KΩ	FILM	1/4W 1%	12126	M1/4-125K	27-46507-0
R72	41.67KΩ	FILM	1/4W 1%	12126	M1/4-41.67K	27-46505-0
R73	1.25MΩ	FILM	1/4W 1%	12126	M1/4-1.25M	27-46511-0
R74	416.7KΩ	FILM	1/4W 1%	12126	M1/4-416.7K	27-46509-0
R75	22KΩ	COMP	1/4W 5%	01121	CB2235	27-39288-0
R76	22KΩ	COMP	1/4W 5%	01121	CB2235	27-39288-0
R77	1KΩ	COMP	1/4W 5%	01121	CB1025	27-39273-0
R78	100Ω	COMP	1/4W 5%	01121	CB1015	27-39261-0
R79	22KΩ	COMP	1/4W 5%	01121	CB2235	27-39288-0
R80	10KΩ	VAR	1/2W 10%	01121	SV1031	27-49513-0
R81	1KΩ	COMP	1/4W 5%	01121	CB1025	27-39273-0
R82	100KΩ	COMP	1/4W 5%	01121	CB1045	27-39294-0
R83	1.5KΩ	COMP	1/4W 5%	01121	CB1525	27-39275-0
R84	10Ω	COMP	1/4W 5%	01121	CB1005	27-39250-0
R85	560Ω	COMP	1/4W 5%	01121	CB5615	27-39270-0
R86	10KΩ	COMP	1/4W 5%	01121	CB1035	27-39286-0
R87	10KΩ	COMP	1/4W 5%	01121	CB1035	27-39286-0
R88	10Ω	COMP	1/4W 5%	01121	CB1005	27-39250-0
R89	15Ω	COMP	1/4W 5%	01121	CB1505	27-39252-0
R90	3.3KΩ	COMP	1/4W 5%	01121	CB3325	27-39280-0
R91	2.2KΩ	COMP	1/4W 5%	01121	CB2225	27-39278-0
R92	15Ω	COMP	1/4W 5%	01121	CB1505	27-39252-0
R93	560Ω	COMP	1/4W 5%	01121	CB5615	27-39270-0

PARTS LIST

DATA ROYAL ASSEMBLY: F210A GENERATOR BOARD ASSEMBLY — DATA ROYAL PART NO. 29-02026

SCHEMATIC DESIGNATION	DESCRIPTION			MANUFACTURER		DATA ROYAL PART NO.
	VALUE	TYPE	RATING	CODE	PART NO.	
RESISTORS (Continued)						
R94	200Ω	VAR	1/2W 10%	01121	SV2011	27-49511-0
R95	10Ω	COMP	1/4W 5%	01121	CB1005	27-39250-0
R96	470Ω	COMP	1/4W 5%	01121	CB4715	27-39269-0
R97	2KΩ	COMP	1/4W 5%	01121	CB2025	27-39277-0
R98	10Ω	COMP	1/4W 5%	01121	CB1005	27-39250-0
R99	2KΩ	COMP	1/4W 5%	01121	CB2025	27-39277-0
R100	1.5Ω	COMP	1/2W 5%	01121	EB15G5	27-39508-0
R101	100Ω	COMP	1/4W 5%	01121	CB1015	27-39261-0
R102	12Ω	COMP	1/4W 5%	01121	CB1205	27-39251-0
R103	12Ω	COMP	1/4W 5%	01121	CB1205	27-39251-0
R104	100Ω	COMP	1/4W 5%	01121	CB1015	27-39261-0
R105	560Ω	COMP	1/4W 5%	01121	CB5615	27-39270-0
R106	49.9Ω	FILM	1/4W 1%	12126	M1/4-49.9	27-42764-0
R107	100Ω	FILM	1/4W 1%	12126	M1/4-100	27-42784-0
R108	49.9Ω	FILM	1/4W 1%	12126	M1/4-49.9	27-42764-0
R109	15.4KΩ	FILM	1/4W 1%	12126	M1/4-15.4K	27-42922-0
R110	1KΩ	VAR	1/2W 10%	01121	SV1025	27-49500-0
R111	13.3KΩ	FILM	1/4W 1%	12126	M1/4-13.3K	27-42918-0
R112	13.3KΩ	FILM	1/4W 1%	12126	M1/4-13.3K	27-42918-0
R113	1KΩ	VAR	1/2W 10%	01121	SV1021	27-49500-0
R114	15.4KΩ	FILM	1/4W 1%	12126	M1/4-15.4K	27-42922-0
R115	5.6KΩ	COMP	1/4W 5%	01121	CB5625	27-39283-0
R116	182Ω	FILM	1/4W 1%	12126	M1/4-182	27-42797-0
R117	5.6KΩ	COMP	1/4W 5%	01121	CB5625	27-39283-0
R118	33.2Ω	FILM	1/4W 1%	12126	M1/4-33.2	27-42758-0
R119	33.2Ω	FILM	1/4W 1%	12126	M1/4-33.2	27-42758-0
R120	182Ω	FILM	1/4W 1%	12126	M1/4-182	27-42797-0
R121	1.65KΩ	FILM	1/4W 1%	07115	VA60-1651F	27-42857-0
R122	2KΩ	FILM	1/4W 1%	12126	M1/4-2K	27-42860-0
R123	2KΩ	FILM	1/4W 1%	12126	M1/4-2K	27-42860-0
R124	1.65KΩ	FILM	1/4W 1%	07115	NA60-1651F	27-42857-0
R125	12KΩ	COMP	1/4W 5%	01121	CB1235	27-39287-0
R126	1KΩ	FILM	1/4W 1%	12126	M1/4-1K	27-42846-0
R127	2.15KΩ	FILM	1/4W 1%	12126	M1/4-2.15K	27-42862-0
R128	1KΩ	FILM	1/4W 1%	12626	M1/4-1K	27-42846-0
R129	12KΩ	COMP	1/4W 5%	01121	CB1235	27-39287-0
R130	12KΩ	COMP	1/4W 5%	01121	CB1235	27-39287-0
R131	604Ω	FILM	1/4W 1%	12126	M1/4-604	27-42827-0
R132	562Ω	FILM	1/4W 1%	12126	M1/4-562	27-42974-0
R133	604Ω	FILM	1/4W 1%	12126	M1/4-604	27-42827-0
R134	12KΩ	COMP	1/4W 5%	01121	CB1235	27-39287-0
R135	12KΩ	COMP	1/4W 5%	01121	CB1235	27-39287-0
R136	200Ω	FILM	1/4W 1%	12126	M1/4-200	27-42798-0
R137	150Ω	FILM	1/4W 1%	12126	M1/4-150	27-42793-0
R138	200Ω	FILM	1/4W 1%	12126	M1/4-200	27-42798-0
R139	12KΩ	COMP	1/4W 5%	01121	CB1235	27-39287-0
R140	12KΩ	COMP	1/4W 5%	01121	CB1235	27-39287-0
R141	100Ω	FILM	1/4W 1%	12126	M1/4-100	27-42784-0
R142	38.3Ω	FILM	1/4W 1%	12126	M1/4-38.3	27-42759-0
R143	100Ω	FILM	1/4W 1%	12126	M1/4-100	27-42784-0
R144	12KΩ	COMP	1/4W 5%	01121	CB1235	27-39287-0
R145	6.8KΩ	COMP	1/4W 5%	01121	CB6825	27-39284-0
R146	24.9Ω	FILM	1/4W 1%	12126	M1/4-24.9	27-42755-0

PARTS LIST

DATA ROYAL ASSEMBLY: F210A GENERATOR BOARD ASSEMBLY — DATA ROYAL PART NO. 29-02026

SCHEMATIC DESIGNATION	DESCRIPTION VALUE	TYPE	RATING	MANUFACTURER CODE	PART NO.	DATA ROYAL PART NO.
RESISTORS (Continued)						
R147	10Ω	FILM	1/4W 1%	12126	M1/4-10	27-42750-0
R148	6.8KΩ	COMP	1/4W 5%	01121	CB6825	27-39284-0
R149	6.8KΩ	COMP	1/4W 5%	01121	CB6825	27-39284-0
R150	6.8KΩ	COMP	1/4W 5%	01121	CB6825	27-39284-0
R151	6.49KΩ	FILM	1/4W 1%	12126	M1/4-6.49K	27-42896-0
R152	1KΩ	VAR	1/2W 10%	01121	SV1021	27-49500-0
R153	4.64KΩ	FILM	1/4W 1%	12126	M1/4-4.64K	27-42884-0
R154	4.64KΩ	FILM	1/4W 1%	12126	M1/4-4.64K	27-42884-0
R155	1KΩ	VAR	1/2W 10%	01121	SV1021	27-49500-0
R156	6.49KΩ	FILM	1/4W 1%	12126	M1/4-6.49K	27-42896-0
R157	1KΩ	FILM	1/4W 1%	12126	M1/4-1K	27-42846-0
R158	5KΩ	VAR	1/2W 10%	01121	SV5021	27-49506-0
R159	2.1KΩ	FILM	1/4W 1%	12126	M1/4-2.1K	27-42861-0
R160	10KΩ	FILM	1/4W 1%	12126	M1/4-10K	27-42912-0
R161	10KΩ	VAR	1/2W 10%	01121	SV1031	27-49513-0
R162	10KΩ	FILM	1/4W 1%	12126	M1/4-10K	27-42912-0
R163	10Ω	COMP	1/4W 5%	01121	CB1005	27-39250-0
R164	10Ω	COMP	1/4W 5%	01121	CB1005	27-39250-0
R165	1.5KΩ	COMP	1/4W 5%	01121	CB1525	27-39275-0
R166	1.5KΩ	COMP	1/4W 5%	01121	CB1525	27-39275-0
R167	27Ω	COMP	1/4W 5%	01121	CB2705	27-39254-0
R168	22KΩ	COMP	1/4W 5%	01121	CB2235	27-39288-0
R169	22Ω	COMP	1/4W 5%	01121	CB2205	27-39253-0
R170	22Ω	COMP	1/4W 5%	01121	CB2205	27-39253-0
R171	2.2KΩ	COMP	1/4W 5%	01121	CB2225	27-39278-0
R172	22KΩ	COMP	1/4W 5%	01121	CB2235	27-39288-0
R173	4.7KΩ	COMP	1/4W 5%	01121	CB4725	27-39284-0
R174	6.8KΩ	COMP	1/4W 5%	01121	CB6825	27-39284-0
R175	100KΩ	FILM	1/4W 1%	12126	M1/4-100K	27-42958-0
R176	2.1KΩ	FILM	1/4W 1%	12126	M1/4-2.1K	27-42861-0
R177	100Ω	COMP	1/4W 5%	01121	CB1015	27-39261-0
R178	10Ω	COMP	1/4W 5%	01121	CB1005	27-39250-0
R179	20Ω	COMP	1/4W 5%	01121	CB2005	27-39308-0
R180	1KΩ	COMP	1/4W 5%	01121	CB1025	27-39273-0
R181	220Ω	COMP	1/4W 5%	01121	CB2215	27-39265-0
R182	22Ω	COMP	1/4W 5%	01121	CB2205	27-39253-0
R183	22Ω	COMP	1/4W 5%	01121	CB2205	27-39253-0
R184	220Ω	COMP	1/4W 5%	01121	CB2215	27-39265-0
R185	220Ω	COMP	1/4W 5%	01121	CB2215	27-39265-0
R186	31.6KΩ	FILM	1/4W 1%	12126	M1/4-31.6K	27-42936-0
R187	31.6KΩ	FILM	1/4W 1%	12126	M1/4-31.6K	27-42936-0
R188	15.8KΩ	FILM	1/4W 1%	12126	M1/4-15.8K	27-42923-0
R189	2.1KΩ	FILM	1/4W 1%	12126	M1/4-2.1K	27-42861-0
R190	499Ω	FILM	1/4W 1%	12126	M1/4-499	27-42821-0
R191	49.9Ω	FILM	1/4W 1%	12126	M1/4-49.9	27-42764-0
R192	49.9Ω	FILM	1/4W 1%	12126	M1/4-49.9	27-42764-0
R193	100Ω	FILM	1/4W 1%	12126	M1/4-100	27-42784-0
R194	100Ω	FILM	1/4W 1%	12126	M1/4-100	27-42784-0

PARTS LIST

DATA ROYAL ASSEMBLY: F210A GENERATOR BOARD ASSEMBLY   DATA ROYAL PART NO. 29-02026

SCHEMATIC DESIGNATION	DESCRIPTION VALUE	TYPE	RATING	MANUFACTURER CODE	PART NO.	DATA ROYAL PART NO.
SEMICONDUCTOR						
CR1		DIODE		JEDEC	1N914	27-95001-0
CR2		DIODE		JEDEC	1N914	27-95001-0
CR3		ZENER		JEDEC	1N5235B	27-95258-0
CR4		ZENER		JEDEC	1N5238B	27-95260-0
CR5		DIODE		JEDEC	1N914	27-95001-0
CR6		DIODE		JEDEC	1N914	27-95001-0
CR7		TUNNEL DIODE		JEDEC	1N3719	27-95003-0
CR8		TUNNEL DIODE		JEDEC	1N3719	27-95003-0
CR9		DIODE		JEDEC	1N914	27-95001-0
CR10		DIODE		JEDEC	1N914	27-95001-0
CR11		ZENER		JEDEC	1N5235B	27-95258-0
CR12		MS7000		21845		27-95254-0
CR13		MS7000		21845		27-95254-0
CR14		DIODE		JEDEC	1N914	27-95001-0
CR15		ZENER		JEDEC	1N5242B	27-95258-0
CR16		DIODE		JEDEC	1N914	27-95001-0
CR17		DIODE		JEDEC	1N914	27-95001-0
CR18		DIODE		JEDEC	1N914	27-95001-0
CR19		DIODE		JEDEC	1N914	27-95001-0
CR20		DIODE		JEDEC	1N914	27-95001-0
CR21		DIODE		JEDEC	1N914	27-95001-0
CR22		DIODE		JEDEC	1N914	27-95001-0
CR23		DIODE		JEDEC	1N914	27-95001-0
CR24		DIODE		JEDEC	1N914	27-95001-0
CR25		DIODE		JEDEC	1N914	27-95001-0
CR26		DIODE		JEDEC	1N914	27-95001-0
CR27		DIODE		JEDEC	1N914	27-95001-0
CR28		DIODE		JEDEC	1N914	27-95001-0
CR29		DIODE		JEDEC	1N914	27-95001-0
CR30		DIODE		JEDEC	1N914	27-95001-0
CR31		DIODE		JEDEC	1N914	27-95001-0
CR32		DIODE		JEDEC	1N914	27-95001-0
CR33		DIODE		JEDEC	1N914	27-95001-0
CR34		DIODE		JEDEC	1N914	27-95001-0
CR35		DIODE		JEDEC	1N914	27-95001-0
TRANSISTOR						
Q1				JEDEC	2N4121	29-04506-0
Q2				JEDEC	2N4121	29-04506-0
Q3				JEDEC	2N4121	29-04506-0
Q4				JEDEC	2N3640	29-04504-0
Q5				JEDEC	2N3640	29-04504-0
Q6				JEDEC	2N3640	29-04504-0
Q7				JEDEC	2N4274	29-04508-0
Q8				JEDEC	2N4274	29-04508-0
Q9				JEDEC	2N3638	29-04503-0
Q10				JEDEC	2N3956	29-04514-0
Q11				JEDEC	2N4360	29-04513-0
Q12				JEDEC	2N3956	29-04514-0
Q13				JEDEC	2N5179	29-04512-0
Q14				JEDEC	2N5179	29-04512-0

PARTS LIST

DATA ROYAL ASSEMBLY: F210A GENERATOR BOARD ASSEMBLY — DATA ROYAL PART NO. 29-02026

SCHEMATIC DESIGNATION	DESCRIPTION VALUE	TYPE	RATING	MANUFACTURER CODE	PART NO.	DATA ROYAL PART NO.
TRANSISTORS (Continued)						
Q15				JEDEC	2N5179	29-04512-0
Q16				JEDEC	2N5179	29-04512-0
Q17				JEDEC	2N5179	29-04512-0
Q18				JEDEC	2N4121	29-04506-0
Q19				JEDEC	2N4121	29-04506-0
Q20				JEDEC	2N5179	29-04512-0
Q21				JEDEC	2N5179	29-04512-0
Q22				JEDEC	2N4121	29-05506-0
Q23				JEDEC	2N4121	29-04506-0
Q24				JEDEC	2N5179	29-04512-0
Q25				JEDEC	2N4121	29-04506-0
Q26				JEDEC	2N5179	29-04512-0
Q27				JEDEC	2N4121	29-04506-0
Q28				JEDEC	2N5179	29-04512-0
Q29				JEDEC	2N4121	29-04506-0
Q30				JEDEC	2N5179	29-04512-0
Q31				JEDEC	2N4121	29-04506-0
Q32				JEDEC	2N5179	29-04512-0
Q33				JEDEC	2N4121	29-04506-0
Q34				JEDEC	2N5179	29-04512-0
Q35				JEDEC	2N5179	29-04512-0
Q36				JEDEC	2N4121	29-04506-0
Q37				JEDEC	2N5179	29-04512-0
Q38				JEDEC	2N4121	29-04506-0
INTEGRATED CIRCUIT						
A1		CA-3018		49671		25-08705-0
A2 - 3		CA-3030		49671		25-08706-0
A4 - 5		μA-710		17227		25-08701-0
A6		CA-3030		49671		25-08705-0
A7		μA-709		17227		25-08700-0
A8		CA-3018		49671		25-08705-0

PARTS LIST

DATA ROYAL ASSEMBLY: F210A GENERATOR BOARD ASSEMBLY — DATA ROYAL PART NO. 29-02026

SCHEMATIC DESIGNATION	DESCRIPTION VALUE	TYPE	RATING	MANUFACTURER CODE	PART NO.	DATA ROYAL PART NO.
TRANSISTORS (Continued)						
Q15				JEDEC	2N5179	29-04512-0
Q16				JEDEC	2N5179	29-04512-0
Q17				JEDEC	2N5179	29-04512-0
Q18				JEDEC	2N4121	29-04506-0
Q19				JEDEC	2N4121	29-04506-0
Q20				JEDEC	2N5179	29-04512-0
Q21				JEDEC	2N5179	29-04512-0
Q22				JEDEC	2N4121	29-05506-0
Q23				JEDEC	2N4121	29-04506-0
Q24				JEDEC	2N5179	29-04512-0
Q25				JEDEC	2N4121	29-04506-0
Q26				JEDEC	2N5179	29-04512-0
Q27				JEDEC	2N4121	29-04506-0
Q28				JEDEC	2N5179	29-04512-0
Q29				JEDEC	2N4121	29-04506-0
Q30				JEDEC	2N5179	29-04512-0
Q31				JEDEC	2N4121	29-04506-0
Q32				JEDEC	2N5179	29-04512-0
Q33				JEDEC	2N4121	29-04506-0
Q34				JEDEC	2N5179	29-04512-0
Q35				JEDEC	2N5179	29-04512-0
Q36				JEDEC	2N4121	29-04506-0
Q37				JEDEC	2N5179	29-04512-0
Q38				JEDEC	2N4121	29-04506-0
INTEGRATED CIRCUIT						
A1		CA-3018		49671		25-08705-0
A2 - 3		CA-3030		49671		25-08706-0
A4 - 5		μA-710		17227		25-08701-0
A6		CA-3030		49671		25-08705-0
A7		μA-709		17227		25-08700-0
A8		CA-3018		49671		25-08705-0

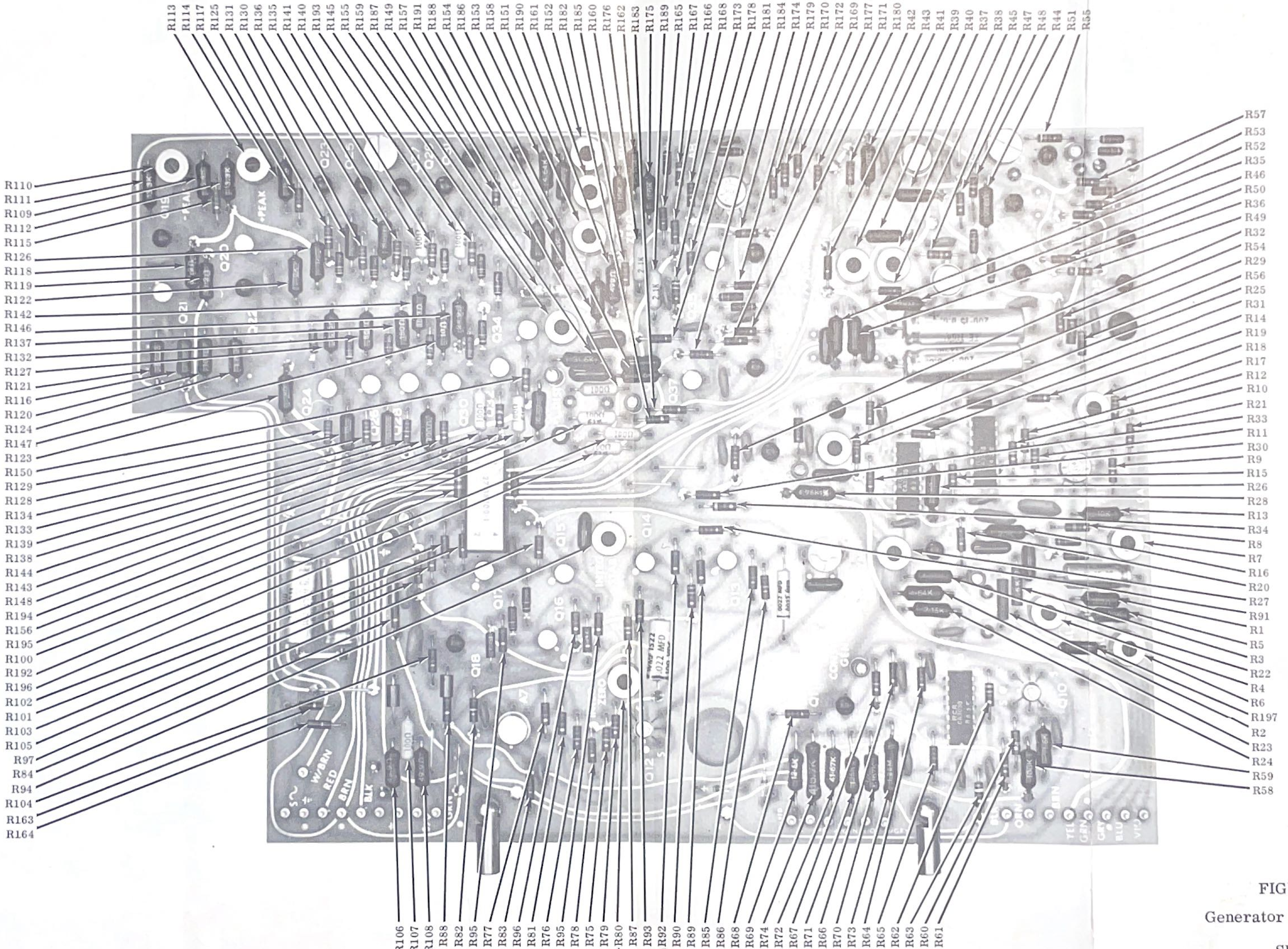


FIGURE 5-2

Generator Board Assembly

SHEET 1

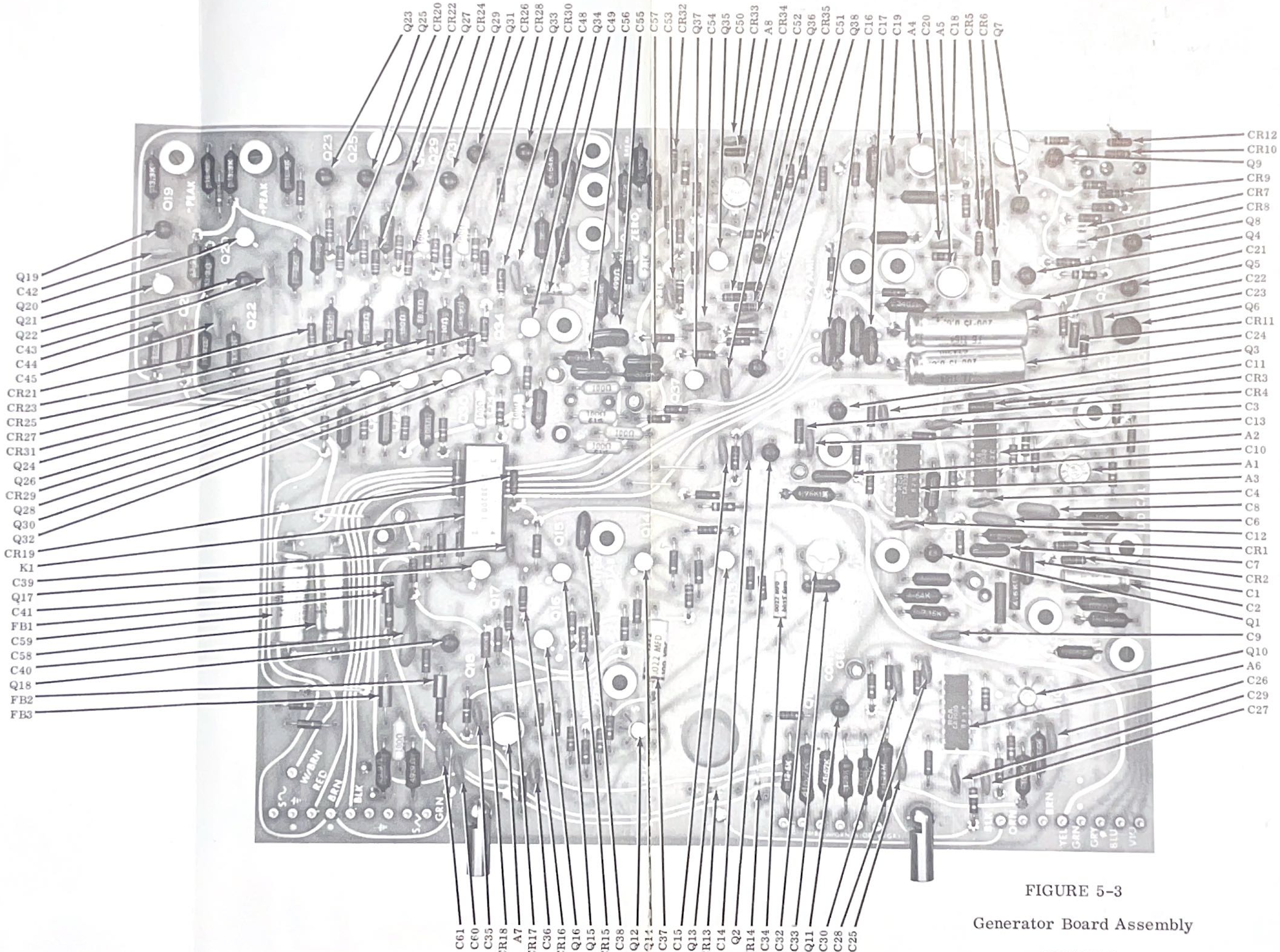
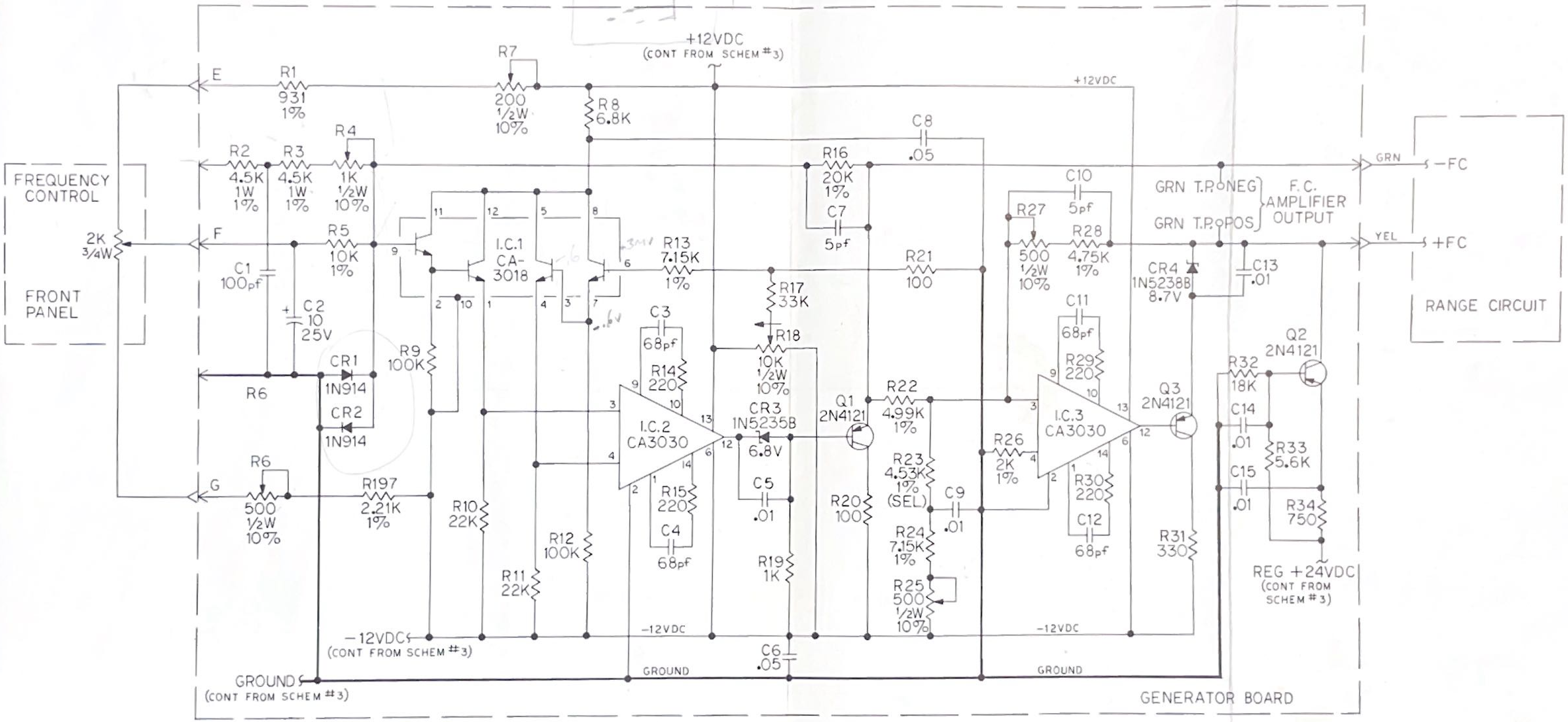


FIGURE 5-3

Generator Board Assembly

SHEET 2

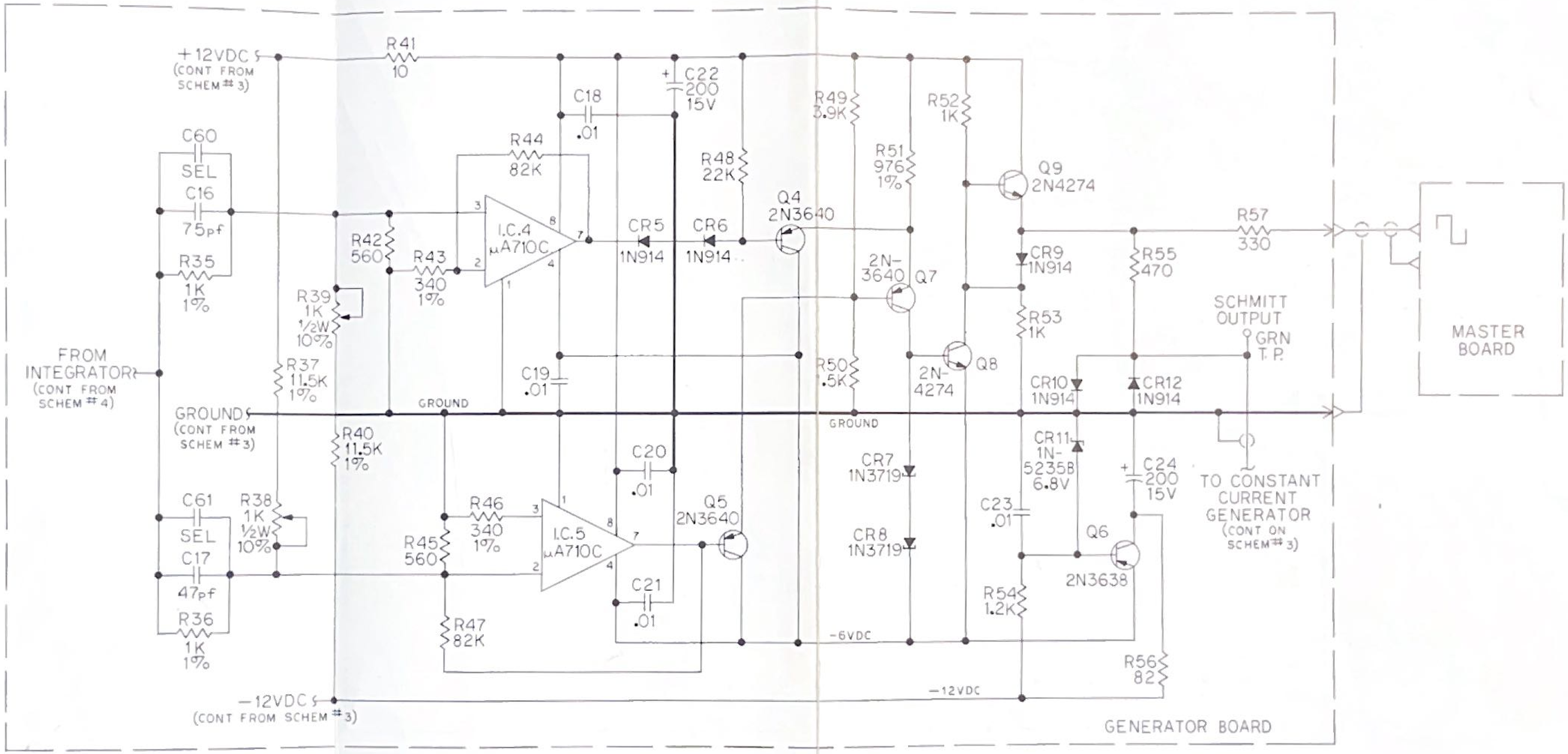


NOTES~UNLESS OTHERWISE SPECIFIED:

1. CAPACITANCE IN MICROFARADS, RESISTANCE IN OHMS.
2. RESISTORS ARE 1/4W, 5%.
3. VALUE OF SELECTED COMPONENTS IS NOMINAL.

SCHEMATIC #1

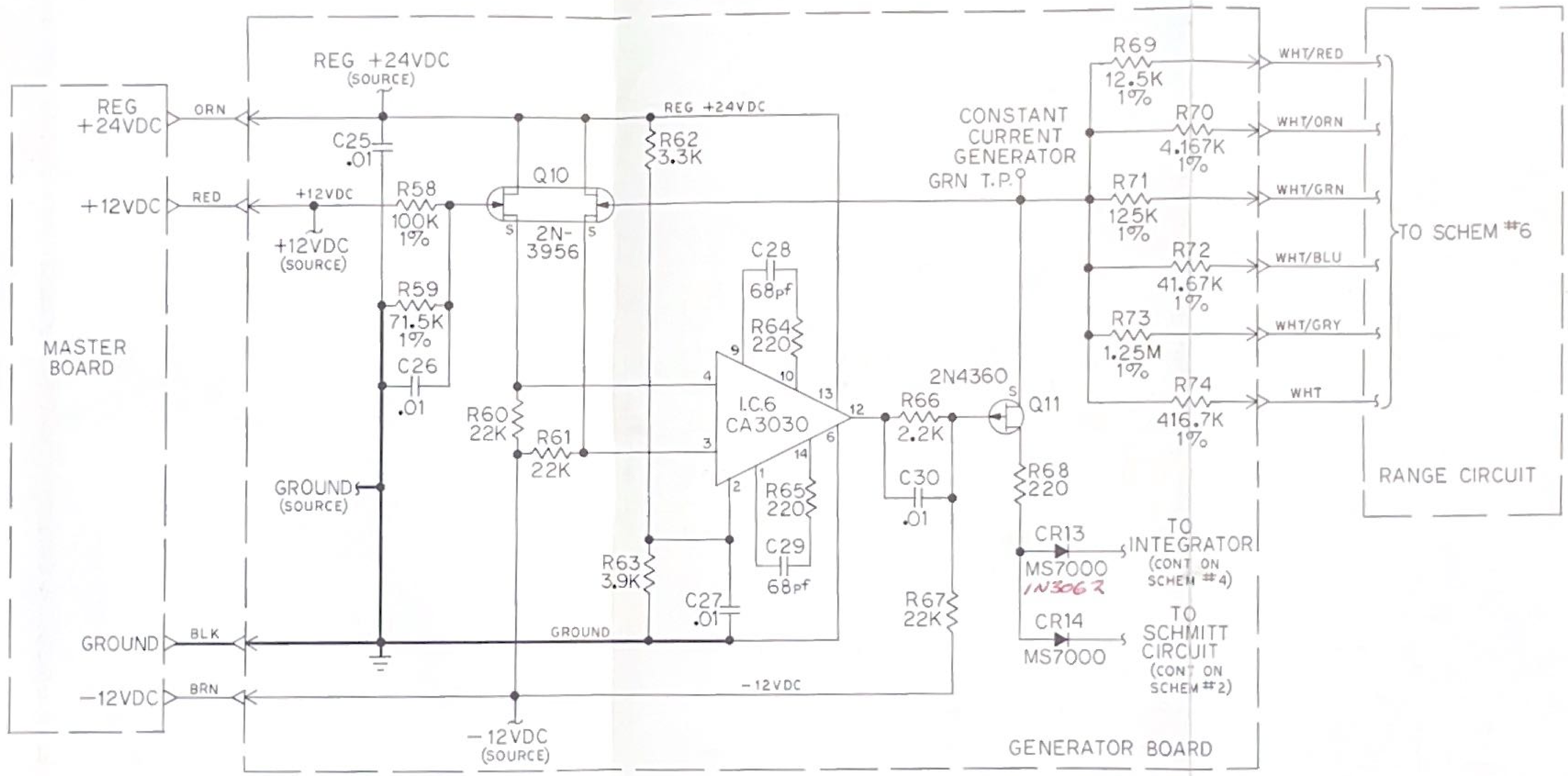
Frequency Control Amplifiers



NOTES~UNLESS OTHERWISE SPECIFIED:
1. CAPACITANCE IN MICROFARADS, RESISTANCE IN OHMS.
2. RESISTORS ARE ¼W, 5%.

SCHEMATIC #2

Schmitt Trigger



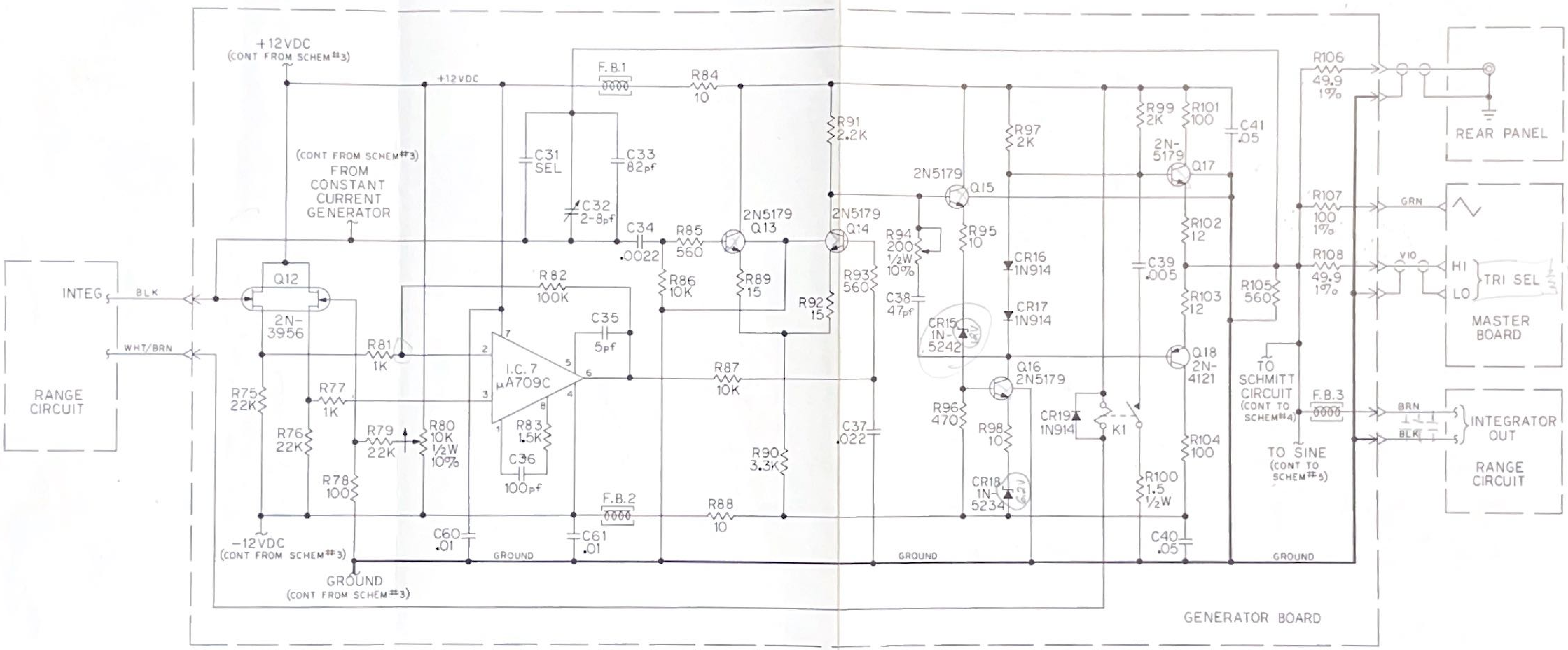
NOTES~UNLESS OTHERWISE SPECIFIED:

1. CAPACITANCE IN MICROFARADS, RESISTANCE IN OHMS.
2. RESISTORS ARE 1/4W, 5%.

SCHEMATIC #3

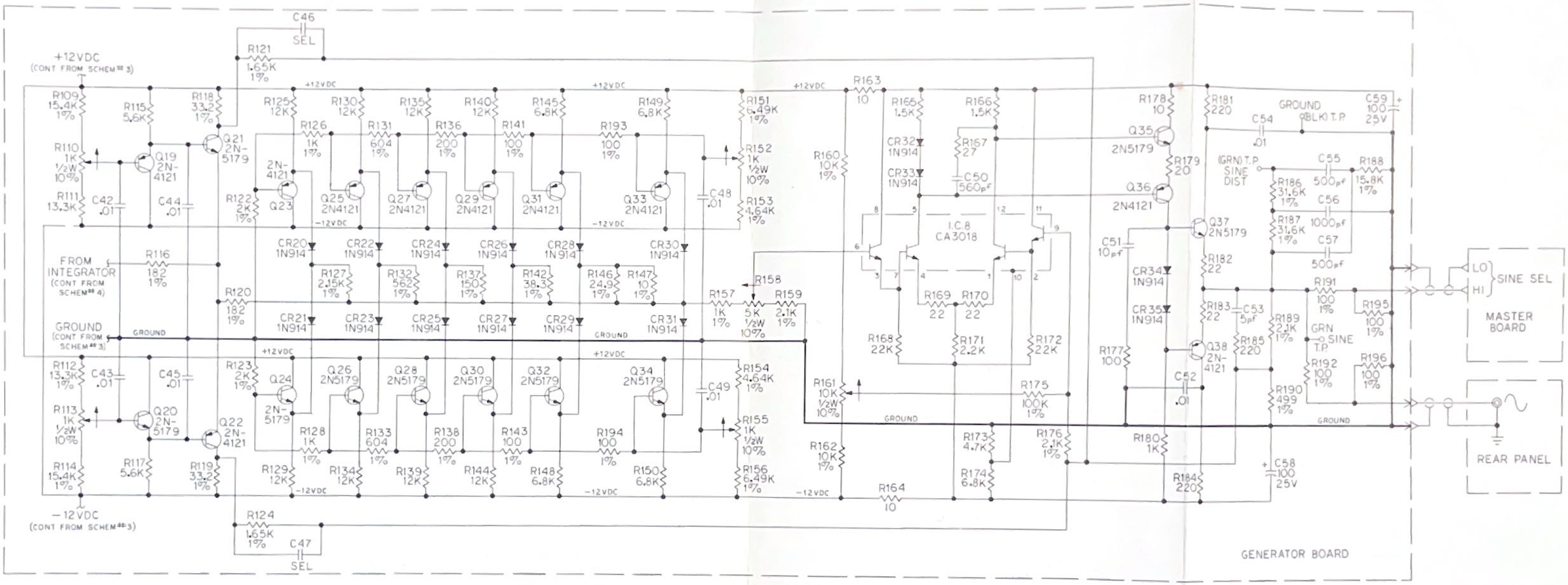
Constant Current Generator

CR15 IS A REPEAT TROUBLE



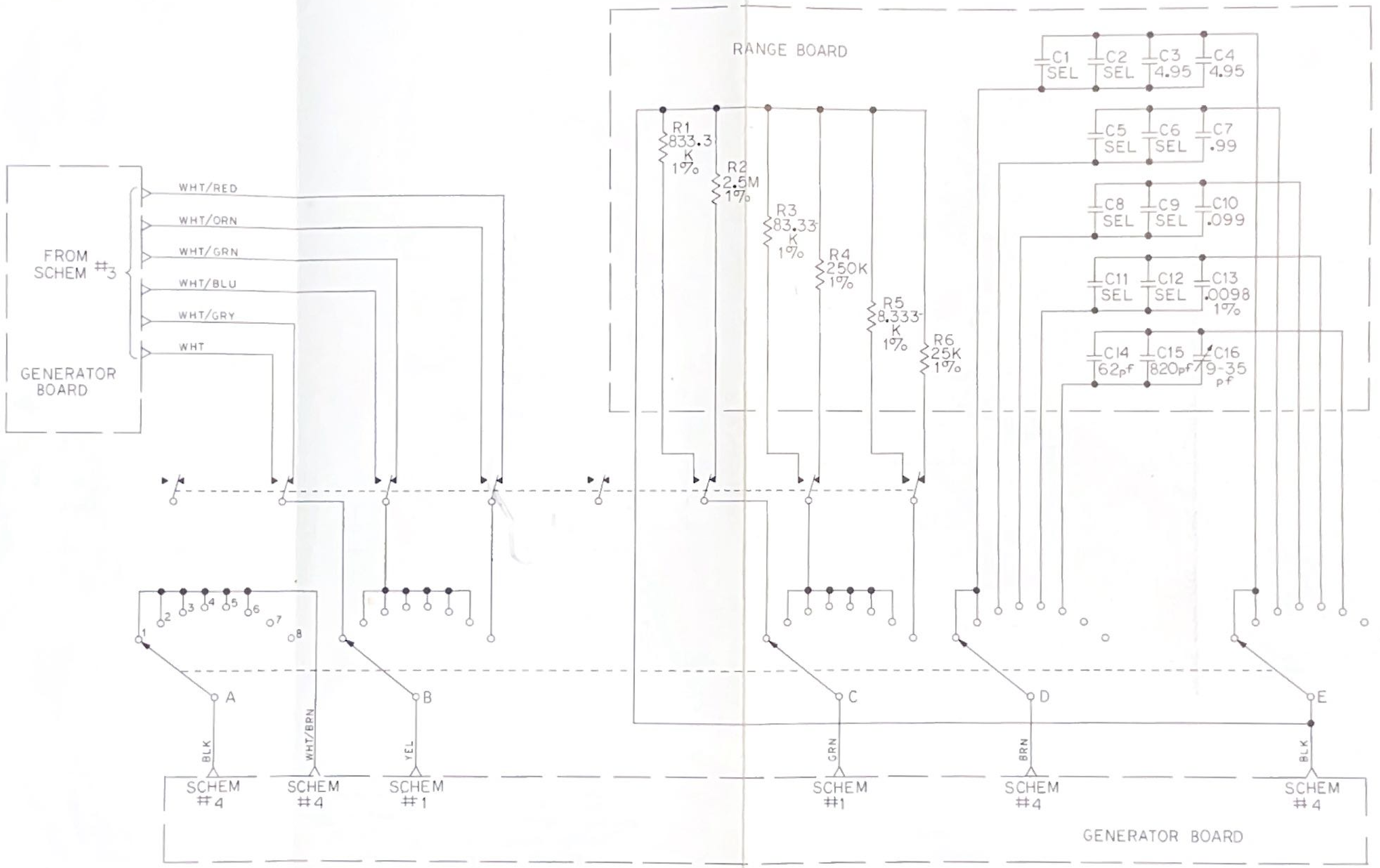
NOTES~UNLESS OTHERWISE SPECIFIED:
1. CAPACITANCE IN MICROFARADS, RESISTANCE IN OHMS.
2. RESISTORS ARE 1/4W, 5%.

SCHEMATIC #4
Integrating Amplifier



NOTES~UNLESS OTHERWISE SPECIFIED:
1. CAPACITANCE IN MICROFARADS, RESISTANCE IN OHMS.
2. RESISTORS ARE 1/4W, 5%.

SCHEMATIC #5
Sine Generator



SCHEMATIC #6

Range Board

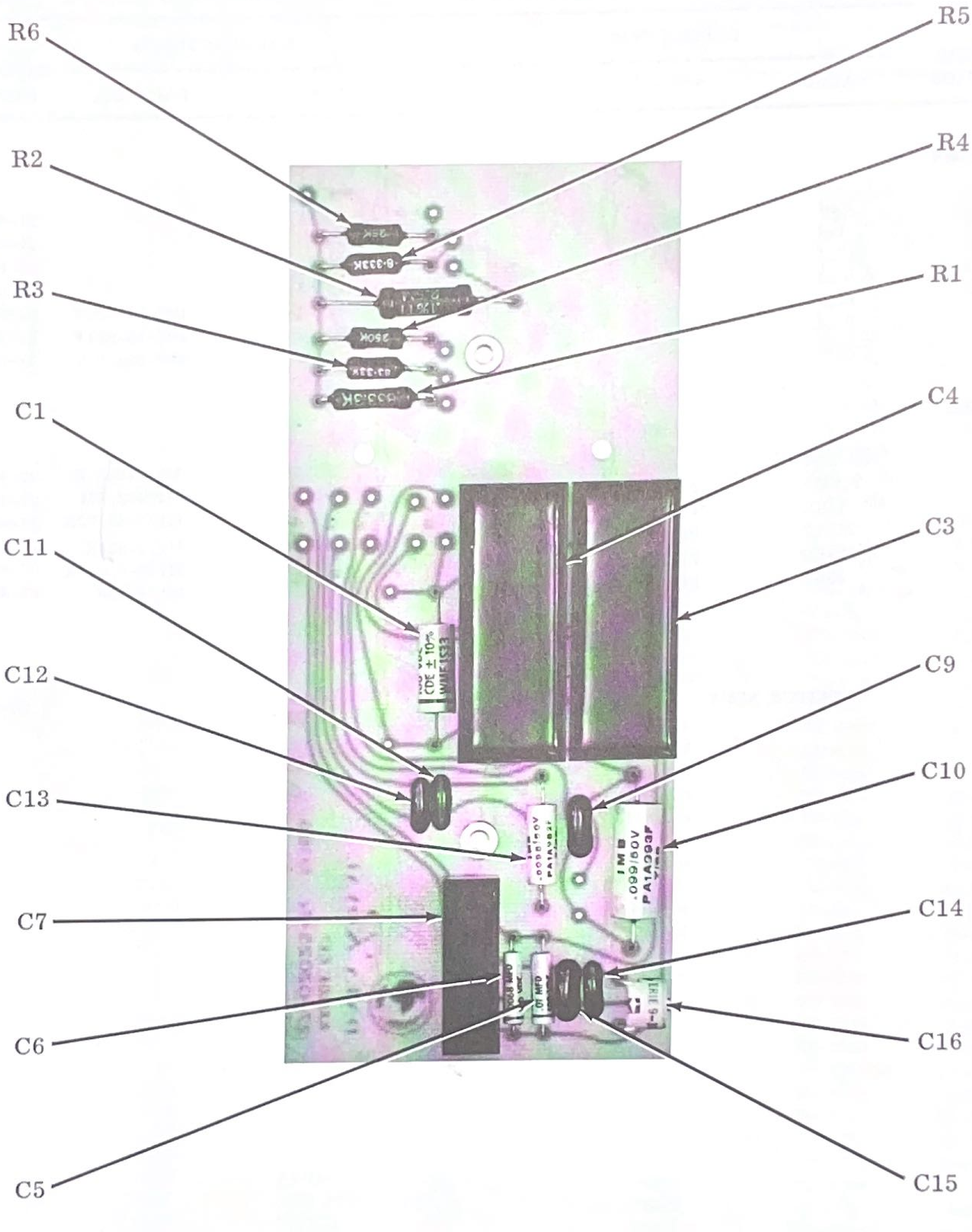


FIGURE 5-4

Range Board Assembly

PARTS LIST

DATA ROYAL ASSEMBLY: F210A RANGE BOARD ASSEMBLY — DATA ROYAL PART NO. 29-02025

SCHEMATIC DESIGNATION	DESCRIPTION VALUE	TYPE	RATING	MANUFACTURER CODE	PART NO.	DATA ROYAL PART NO.
CAPACITORS						
C1 - C4	10μf	KIT		29085		21-64000-1
C5 - C7	1.0μf	KIT		29085		21-64001-1
C8 - C10	0.1μf	KIT		29085		21-64002-1
C11 - 13	0.01μf	KIT		29085		21-64003-1
C14	62pf	MICA	500V	04062	DM-15-620F	21-57622-0
C15	82pf	MICA	300V	04062	DM-15-821F	21-75623-0
C16	9-35pf	VAR		72982	338-002-940	21-63204-0
RESISTORS						
R1	833.3KΩ	FILM	1/4W 1%	12126	M1/4-833.K	27-46510-0
R2	2.5MΩ	FILM	1/4W 1%	12126	M1/4-2.5M	27-46512-0
R3	83.33KΩ	FILM	1/4W 1%	12126	M1/4-83.33K	27-46506-0
R4	250KΩ	FILM	1/4W 1%	12126	M1/4-250K	27-46508-0
R5	8.333KΩ	FILM	1/4W 1%	12126	M1/4-8.333K	27-46501-0
R6	25KΩ	FILM	1/4W 1%	12126	M1/4-25K	27-46504-0
SWITCH						
S1	SWITCH ASS'Y			29085		28-64002-1

PARTS LIST

DATA ROYAL ASSEMBLY: F210A MASTER BOARD ASSEMBLY DATA ROYAL PART NO. 29-02001

SCHEMATIC DESIGNATION	DESCRIPTION			MANUFACTURER		DATA ROYAL PART NO.
	VALUE	TYPE	RATING	CODE	PART NO.	
CAPACITOR						
C1	2700µf	ELECT	25V	56289	TE-1164	21-57200-0
C2	2700µf	ELECT	25V	56289	TE-1164	21-57200-0
C3	.01µf	CER DISC	50V	56289	TG-S10	21-57001-0
C4	.01µf	CER DISC	50V	56289	TG-S10	21-57001-0
C5	220pf	CER DISC	1000V	56289	DD-220	21-57014-0
C6	.01µf	CER DISC	50V	56289	TG-S10	21-57001-0
C7	220pf	CER DISC	1000V	56289	DD-220	21-57014-0
C8	.01µf	CER DISC	50V	56289	TG-S10	21-57001-0
C9	.05µf	CER DISC	50V	56289	TG-S50	21-57003-0
C10	100µf	ELECT	25V	56289	TE-1211	21-57217-0
C11	100µf	ELECT	25V	56289	TE-1211	21-57217-0
C12	1300µf	ELECT	50V	56289	36D132G 050AA6B	21-57213-0
C13	1300µf	ELECT	50V	56289	36D132G 050AA6B	21-57213-0
C14	.01µf	CER DISC	50V	56289	TG-S10	21-57001-0
C15	2500µf	ELECT	35V	00853	500-1954-01	21-57221-0
C16	2500µf	ELECT	35V	00853	500-1954-01	21-57221-0
C17	.01µf	CER DISC	50V	56289	TG-S10	21-57001-0
C18	.01µf	CER DISC	50V	56289	TG-S10	21-57001-0
C19	100µf	ELECT	25V	56289	TE-1211	21-57217-0
C20	.01µf	CER DISC	50V	56289	TG-S10	21-57001-0
C21	.01µf	CER DISC	50V	56289	TG-S10	21-57001-0
C22	100µf	ELECT	25V	56289	TE-1211	21-57217-0
C23	47pf	CER DISC	1000V	56289	DD-470	21-57016-0
C24	47pf	CER DISC	1000V	56289	DD-470	21-57016-0
C25	.01µf	CER DISC	50V	56289	TG-S10	21-57001-0
C26	.01µf	CER DISC	50V	56289	TG-S10	21-57001-0
C27	100µf	ELECT	25V	56289	TE-1211	21-57217-0
C28	.01µf	CER DISC	50V	56289	TG-S10	21-57001-0
C29	100µf	ELECT	25V	56289	TE-1211	21-57217-0
C30	.01µf	CER DISC	50V	56289	TG-S10	21-57001-0
C31	.01µf	CER DISC	50V	56289	TG-S10	21-57001-0
C32	470pf	CER DISC	1000V	56289	DD-471	21-57006-0
C33	22pf	CER DISC	1000V	56289	DD-220	21-57012-0
C34	15pf	CER DISC	1000V	56289	DD-150	21-57017-0
C35	100µf	ELECT	25V	56289	TE-1211	21-57217-0
C36	100µf	ELECT	25V	56289	TE-1211	21-57217-0
C37	2-8pf	VAR CER		72982	538-002-89	21-63201-0
C38	.01µf	CER DISC	50V	56289	TG-S10	21-57001-0
C39	.01µf	CER DISC	50V	56289	TG-S10	21-57001-0
C40	5pf	CER DISC	1000V	56289	DD-050	21-57009-0
C41	2pf	MICA	500V	04062	DM-15-020D	21-57600-0
C42	75µf	ELECT	50V	56289	TE-1308	21-57220-0
C43	100pf	CER DISC	1000V	56289	DD-101	21-57007-0
C44	75µf	ELECT	50V	56289	TE-1308	21-57220-0
C45	75µf	ELECT	50V	56289	TE-1308	21-57220-0
C46	75µs	ELECT	50V	56289	TE-1308	21-57220-0

5-24 is blank

PARTS LIST

DATA ROYAL ASSEMBLY: F210A MASTER BOARD ASSEMBLY — DATA ROYAL PART NO. 29-02001

SCHEMATIC DESIGNATION	DESCRIPTION VALUE	TYPE	RATING	MANUFACTURER CODE	PART NO.	DATA ROYAL PART NO.
RESISTORS (Continued)						
R54	86.6Ω	FILM	1/4W 1%	12126	M1/4-86.6	27-42779-0
R55	121Ω	FILM	1/4W 1%	12126	M1/4-121	27-32787-0
R56	301Ω	FILM	1/4W 1%	12126	M1/4-301	27-42804-0
R57	60.4Ω	FILM	1/4W 1%	12126	M1/4-60.4	27-42771-0
R58	200Ω	VAR	1/2W 10%	01121	SV2011	27-49511-0
R59	374Ω	FILM	1/4W 1%	12126	M1/4-374	27-42810-0
R60	390Ω	COMP	1/4W 5%	01121	CB3915	27-39268-0
R61	1.5KΩ	COMP	1/4W 5%	01121	CB1525	27-39275-0
R62	499Ω	FILM	1/4W 1%	12126	M1/4-499	27-42821-0
R63	12.1KΩ	FILM	1/4W 1%	12126	M1/4-12.1K	27-42916-0
R64	2.1KΩ	FILM	1/4W 1%	12126	M1/4-2.1K	27-42861-0
R65	2.21KΩ	FILM	1/4W 1%	12126	M1/4-2.21K	27-42863-0
R66	10Ω	COMP	1/4W 5%	01121	CB1005	27-39250-0
R67	10Ω	COMP	1/4W 5%	01121	CB1005	27-39250-0
R68	2.7KΩ	COMP	1/4W 5%	01121	CB2725	27-39279-0
R69	2.7KΩ	COMP	1/4W 5%	01121	CB2725	27-39279-0
R70	270Ω	COMP	1/4W 5%	01121	CB2715	27-39257-0
R71	47Ω	COMP	1/4W 5%	01121	CB4705	27-39257-0
R72	47Ω	COMP	1/4W 5%	01121	CB4705	27-39257-0
R73	2.7KΩ	COMP	1/4W 5%	01121	CB2725	27-39279-0
R74	68KΩ	COMP	1/4W 5%	01121	CB6835	27-39292-0
R75	10KΩ	VAR	1/2W 10%	01121	SV1031	27-49513-0
R76	2.7KΩ	COMP	1/4W 5%	01121	CB2725	27-39279-0
R77	100Ω	COMP	1/4W 5%	01121	CB1015	27-39261-0
R78	22Ω	COMP	1/4W 5%	01121	CB2205	27-39253-0
R79	3.32KΩ	FILM	1/4W 1%	12126	M1/4-3.32K	27-42872-0
R80	1KΩ	VAR	1/2W 10%	01121	SV1021	27-49500-0
R81	4.12KΩ	FILM	1/4W 1%	12126	M1/4-4.12K	27-42880-0
R82	22Ω	COMP	1/4W 5%	01121	CB2205	27-39253-0
R83	100Ω	COMP	1/4W 5%	01121	CB1015	27-39261-0
R84	100Ω	FILM	1/4W 1%	12126	M1/4-100	27-42784-0
R85	100Ω	FILM	1/4W 1%	12126	M1/4-100	27-42784-0
R86	100Ω	FILM	1/4W 1%	12126	M1/4-100	27-42784-0
R87	100Ω	FILM	1/4W 1%	12126	M1/4-100	27-42784-0
R88	150Ω	COMP	1/4W 5%	01121	CB1515	27-39263-0
R89	150Ω	COMP	1/4W 5%	01121	CB1515	27-39263-0
R90	150Ω	COMP	1/4W 5%	01121	CB1515	27-39263-0
R91	150Ω	COMP	1/4W 5%	01121	CB1515	27-39263-0
R92	100Ω	VAR	1/2W 10%	01121	SV1011	27-49510-0
R93	100Ω	FILM	1/4W 1%	12126	M1/4-100	27-42784-0
R94	SELECTED					
R95	3.01KΩ	FILM	1/4W 1%	12126	M1/4-3.01K	27-42869-0
R96	1.5KΩ	COMP	1/4W 5%	01121	CB1525	27-39275-0
R97	1.5KΩ	COMP	1/4W 5%	01121	CB1525	27-39275-0
R98	1.5KΩ	COMP	1/4W 5%	01121	CB1525	27-39275-0
R99	15Ω	COMP	1/4W 5%	01121	CB1505	27-39252-0
R100	15Ω	COMP	1/4W 5%	01121	CB1505	27-39252-0
R101	820Ω	COMP	1/4W 5%	01121	CB8215	27-39271-0
R102	182Ω	FILM	1/4W 1%	12126	M1/4-182	27-42797-0
R103	22KΩ	COMP	1/4W 5%	01121	CB2235	27-39288-0
R104	10KΩ	VAR	1/2W 10%	01121	SV1031	27-49513-0
R105	10Ω	COMP	1/4W 5%	01121	CB1005	27-39250-0

PARTS LIST

DATA ROYAL ASSEMBLY: F210A MASTER BOARD ASSEMBLY — DATA ROYAL PART NO. 29-02001

SCHEMATIC DESIGNATION	DESCRIPTION			MANUFACTURER		DATA ROYAL PART NO.
	VALUE	TYPE	RATING	CODE	PART NO.	
RESISTORS (Continued)						
R106	180Ω	COMP	1/4W 5%	01121	CB1815	27-39264-0
R107	1.5Ω	COMP	1/2W 5%	01121	EB15G5	27-39508-0
R108	10Ω	COMP	1/4W 5%	01121	CB1005	27-39250-0
R109	10Ω	COMP	1/4W 5%	01121	CB1005	27-39250-0
R110	150Ω	COMP	1/4W 5%	01121	CB1515	27-39263-0
R111	750Ω	COMP	1W 5%	01121	GB7515	27-40006-0
R112	750Ω	COMP	1W 5%	01121	GB7515	27-40006-0
R113	1.5Ω	COMP	1/2W 5%	01121	EB15G5	27-39508-0
R114	12Ω	COMP	1/2W 5%	01121	EB1205	27-39510-0
R115	12Ω	COMP	1/2W 5%	01121	EB1205	27-39510-0
R116	150Ω	COMP	2W 5%	01121	HB1515	27-40251-0
R117	150Ω	COMP	2W 5%	01121	HB1515	27-40251-0
R118	150Ω	COMP	2W 5%	01121	HB1515	27-40251-0
R119	1.5Ω	COMP	1/2W 5%	01121	EB15G5	27-39508-0
R120	5.6KΩ	COMP	1/4W 5%	01121	CB5625	27-39283-0
R121	10KΩ	COMP	1/4W 5%	01121	CB1035	27-39286-0
R122	82Ω	COMP	1/4W 5%	01121	CB8205	27-39260-0
SEMICONDUCTOR						
CR1		DIODE		14099	SCE-2	27-95000-0
CR2		DIODE		14099	SCE-2	27-95000-0
CR3		DIODE		14099	SCE-2	27-95000-0
CR4		DIODE		14099	SCE-2	27-95000-0
CR5		DIODE		JEDEC	1N914	27-95001-0
CR6		DIODE		JEDEC	1N914	27-95001-0
CR7		DIODE		JEDEC	1N914	27-95001-0
CR8		DIODE		14099	SCE-2	27-95000-0
CR9		DIODE		14099	SCE-2	27-95000-0
CR10		DIODE		14099	SCE-2	27-95000-0
CR11		DIODE		14099	SCE-2	27-95000-0
CR12		ZENER		JEDEC	1N5252	27-95261-0
CR13		DIODE		14099	SCE-2	27-95000-0
CR14		DIODE		14099	SCE-2	27-95000-0
CR15		DIODE		14099	SCE-2	27-95000-0
CR16		DIODE		14099	SCE-2	27-95000-0
CR17		DIODE		JEDEC	1N914	27-95001-0
CR18		DIODE		JEDEC	1N914	27-95001-0
CR19		DIODE		JEDEC	1N914	27-95001-0
CR20		ZENER		JEDEC	1N5232B	27-95255-0
CR21		DIODE		JEDEC	1N914	27-95001-0
CR22		DIODE		JEDEC	1N914	27-95001-0
CR23		ZENER		JEDEC	1N5242	27-95259-0
CR24		ZENER		JEDEC	1N5252	27-95261-0
CR25		DIODE		JEDEC	1N914	27-95001-0
CR26		DIODE		JEDEC	1N914	27-95001-0
CR27		ZENER		JEDEC	1N5250	27-95264-0
CR28		ZENER		JEDEC	1N5227B	27-95263-0
CR29		DIODE		JEDEC	1N914	27-95001-0
CR30		DIODE		JEDEC	1N914	27-95001-0

PARTS LIST

DATA ROYAL ASSEMBLY: F210A MASTER BOARD ASSEMBLY — DATA ROYAL PART NO. 29-02001

SCHEMATIC DESIGNATION	DESCRIPTION VALUE	TYPE	RATING	MANUFACTURER CODE	PART NO.	DATA ROYAL PART NO.
TRANSISTOR						
Q1				JEDEC	2N2218	29-04500-0
Q2				JEDEC	2N4916	29-04530-0
Q3				JEDEC	2N2218	29-04500-0
Q4				JEDEC	2N4898	29-04510-0
Q5		RCA-40468		49671		29-04516-0
Q6				JEDEC	2N4360	29-04513-0
Q7		RCA-40250		49671		29-04515-0
Q8				JEDEC	2N2218	29-04500-0
Q9				JEDEC	2N4916	29-04530-0
Q10				JEDEC	2N2218	29-04500-0
Q11				JEDEC	2N4258	29-04507-0
Q12				JEDEC	2N4274	29-04508-0
Q13				JEDEC	2N3638	29-04503-0
Q14				JEDEC	2N2218	29-04500-0
Q15				JEDEC	2N4916	29-04530-0
Q16				JEDEC	2N5179	29-04512-0
Q17				JEDEC	2N3640	29-04504-0
Q18				JEDEC	2N3640	29-04504-0
Q19				JEDEC	2N5179	29-04512-0
Q20				JEDEC	2N4916	29-04530-0
Q21				JEDEC	2N5160	29-04525-0
Q22				JEDEC	2N3866	29-04522-0
Q23				JEDEC	2N4890	29-04524-0
Q24				JEDEC	2N3638	29-04503-0
INTEGRATED CIRCUIT						
A1 - 2		μA-709		17227		25-08700-0
A3 - 4		CA3018		49671		25-08705-0
SWITCH						
S1 - 5		PUSH BUTTON ASS'Y		29085		28-63003-1

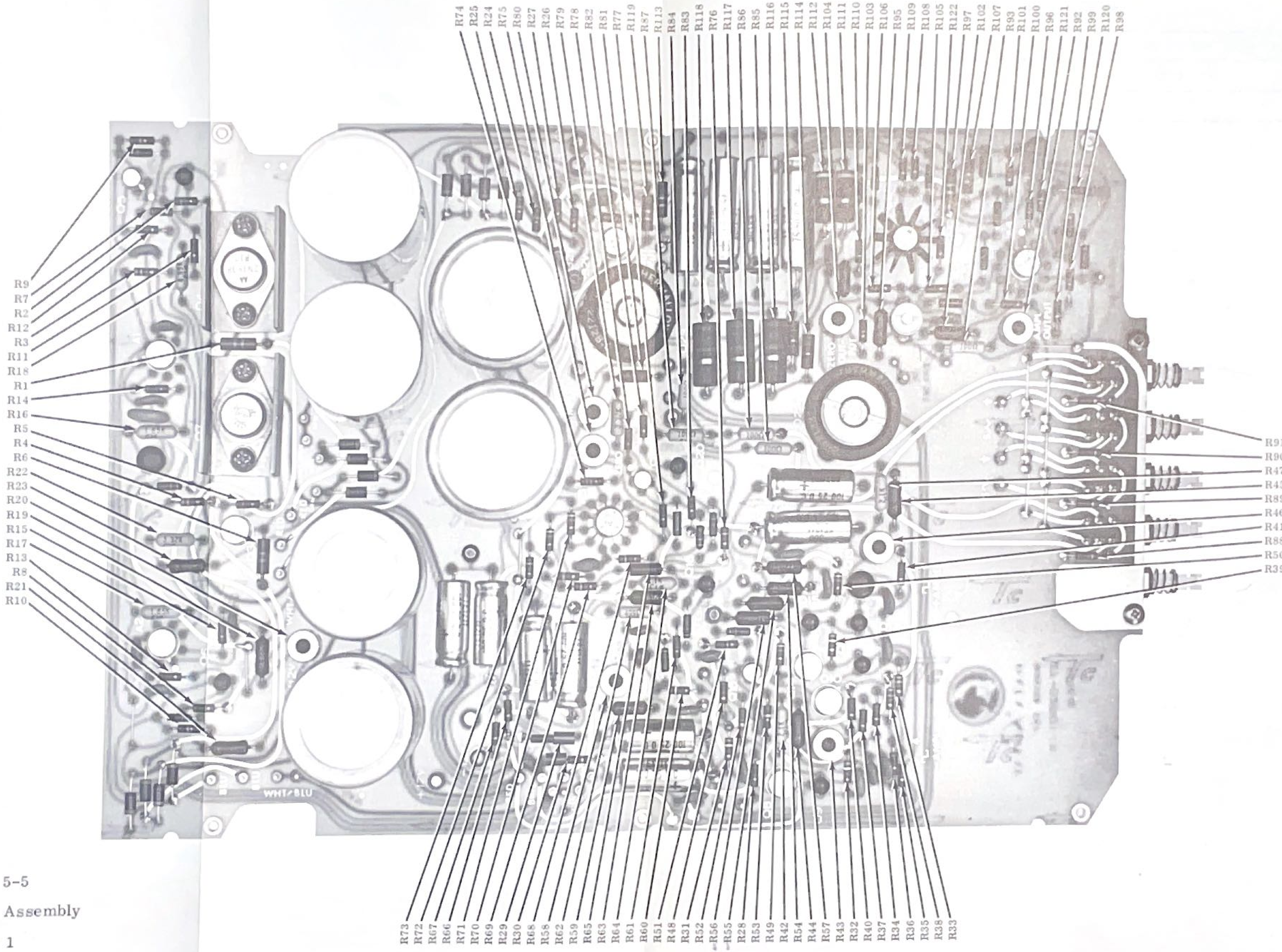


FIGURE 5-5

Master Board Assembly

SHEET 1

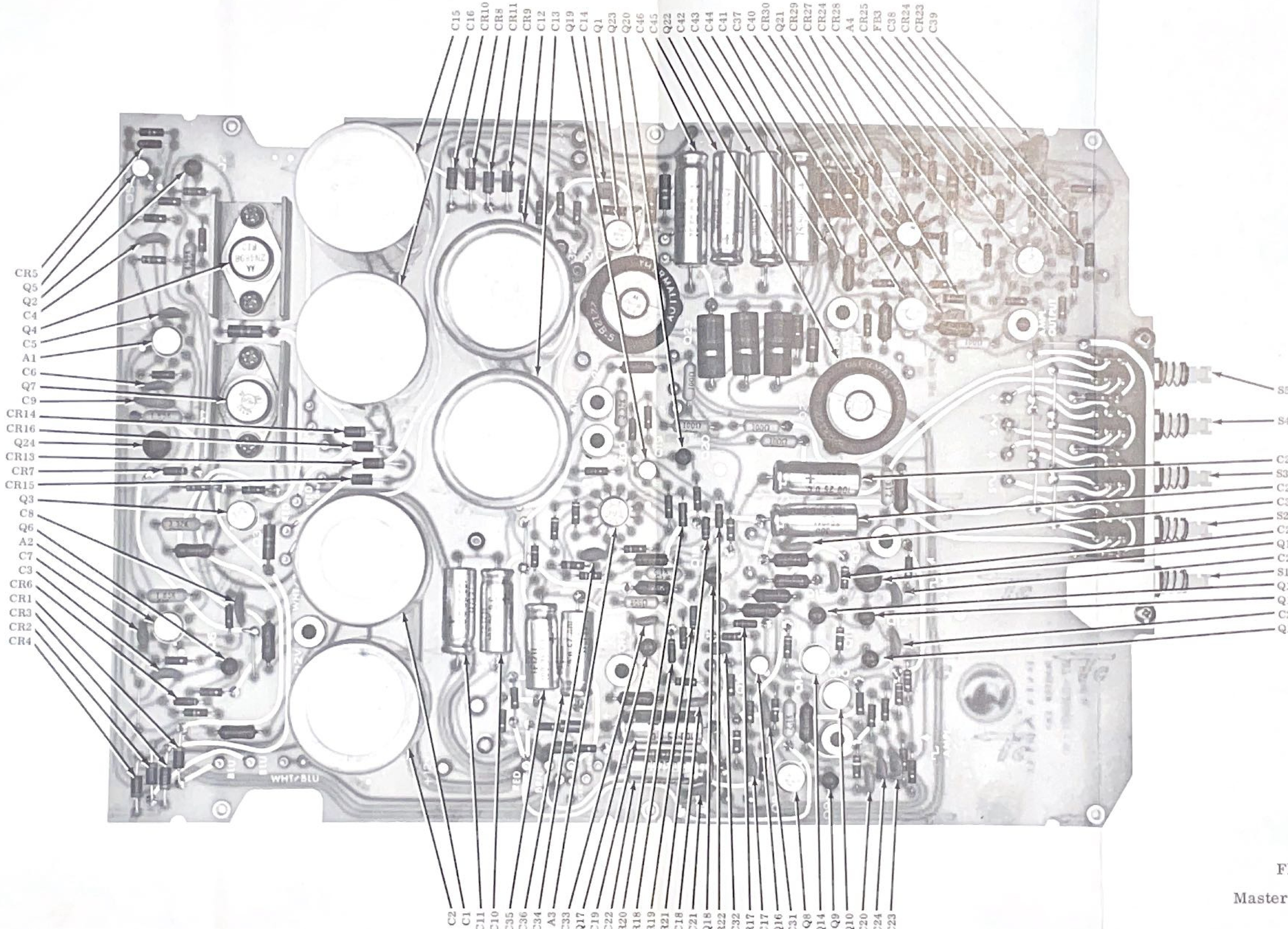
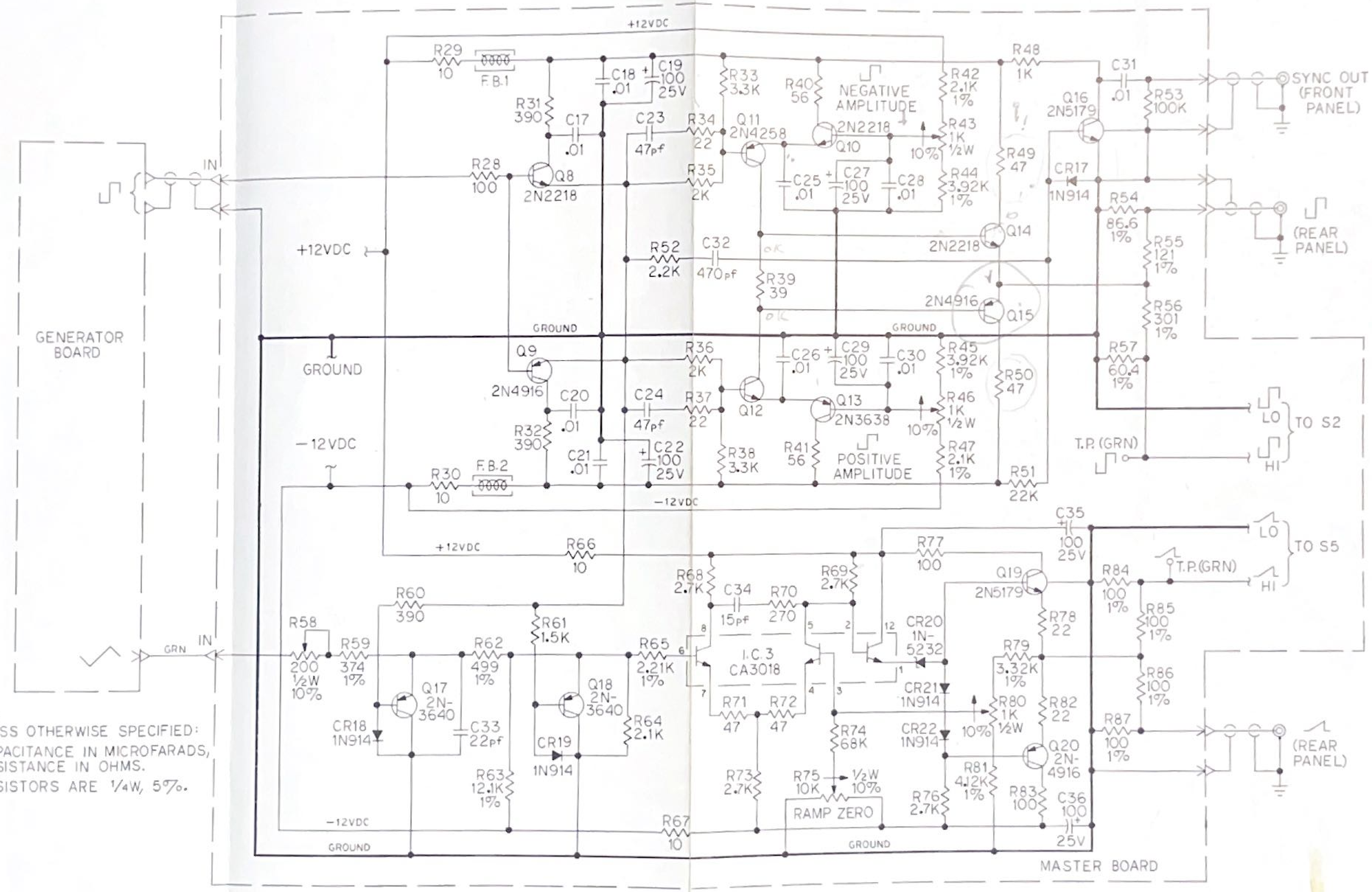


FIGURE 5-6

Master Board Assembly

SHEET 2



NOTES~
UNLESS OTHERWISE SPECIFIED:
1. CAPACITANCE IN MICROFARADS, RESISTANCE IN OHMS.
2. RESISTORS ARE 1/4W, 5%.

SCHEMATIC #7

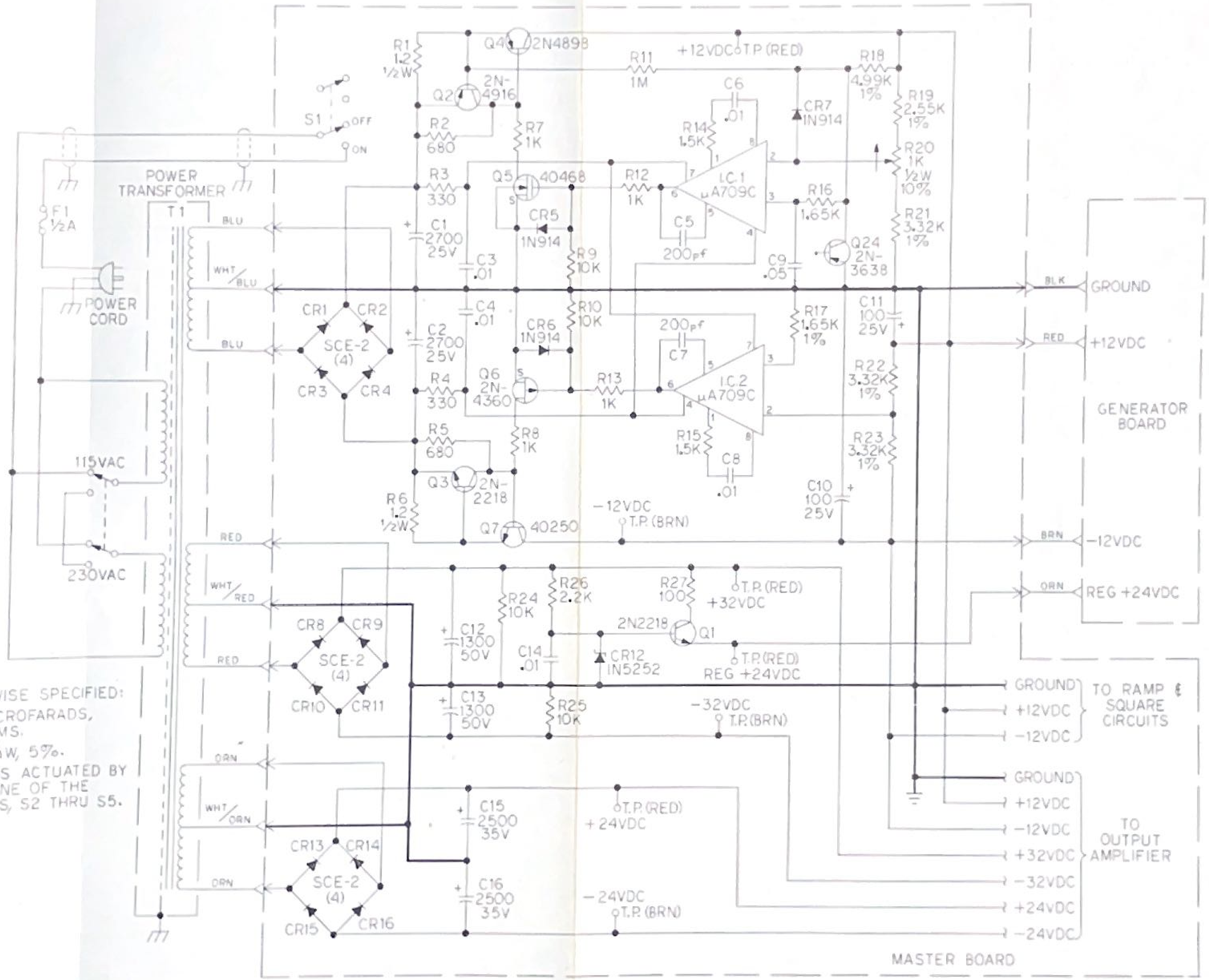
Ramp & Square Circuits

NOTES~UNLESS OTHERWISE SPECIFIED:

1. CAPACITANCE IN MICROFARADS, RESISTANCE IN OHMS.
2. RESISTOR ARE 1/4W, 5%

SCHEMATIC #8

Output Amplifier



NOTES–UNLESS OTHERWISE SPECIFIED:
1. CAPACITANCE IN MICROFARADS, RESISTANCE IN OHMS.
2. RESISTORS ARE ¼W, 5%.
3. POWER SWITCH, S1, IS ACTUATED BY DEPRESSING ANY ONE OF THE FUNCTION SWITCHES, S2 THRU S5.

SCHEMATIC #9

Power Supplies

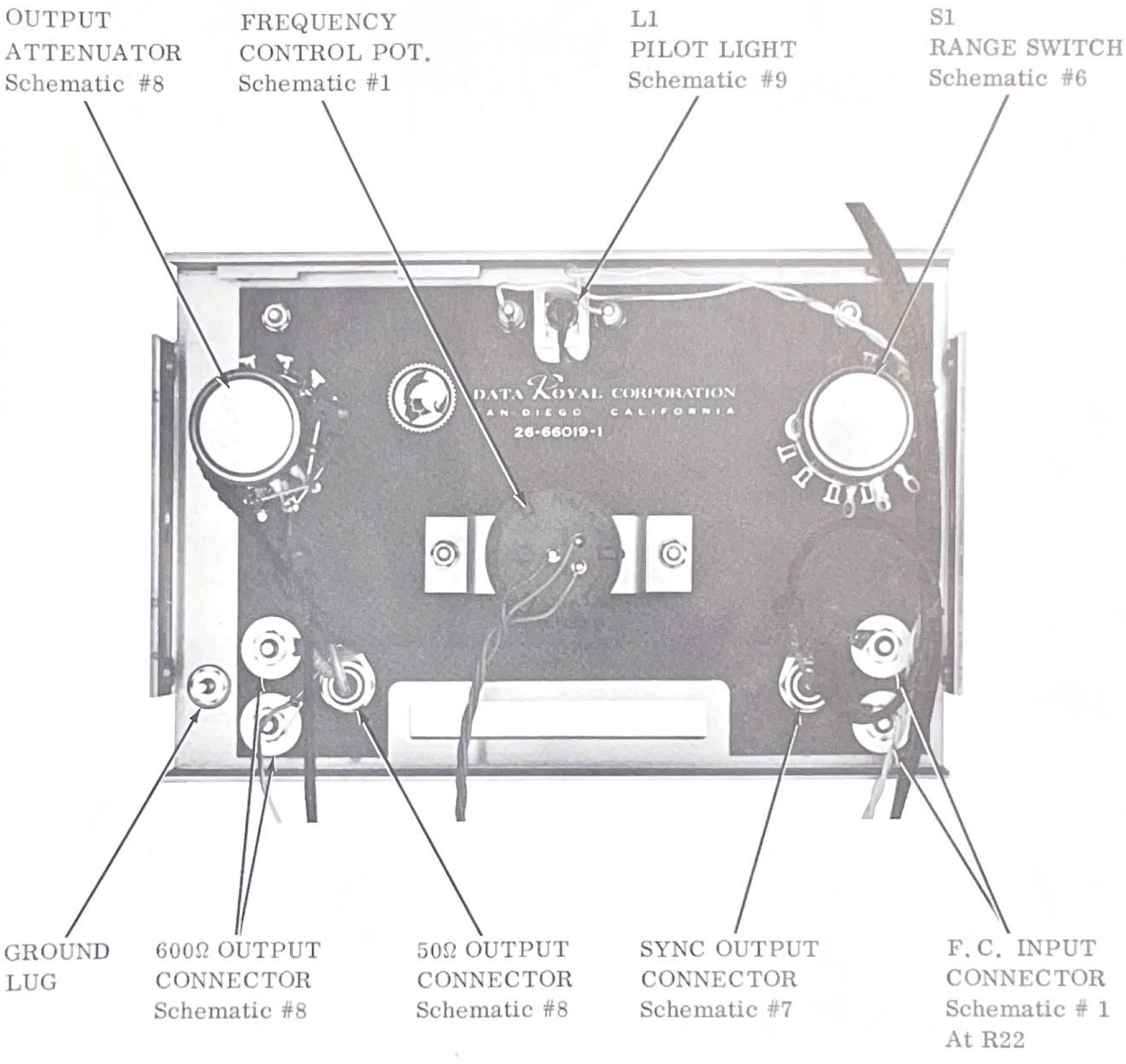


FIGURE 5-7

Front Sub-Panel Assembly

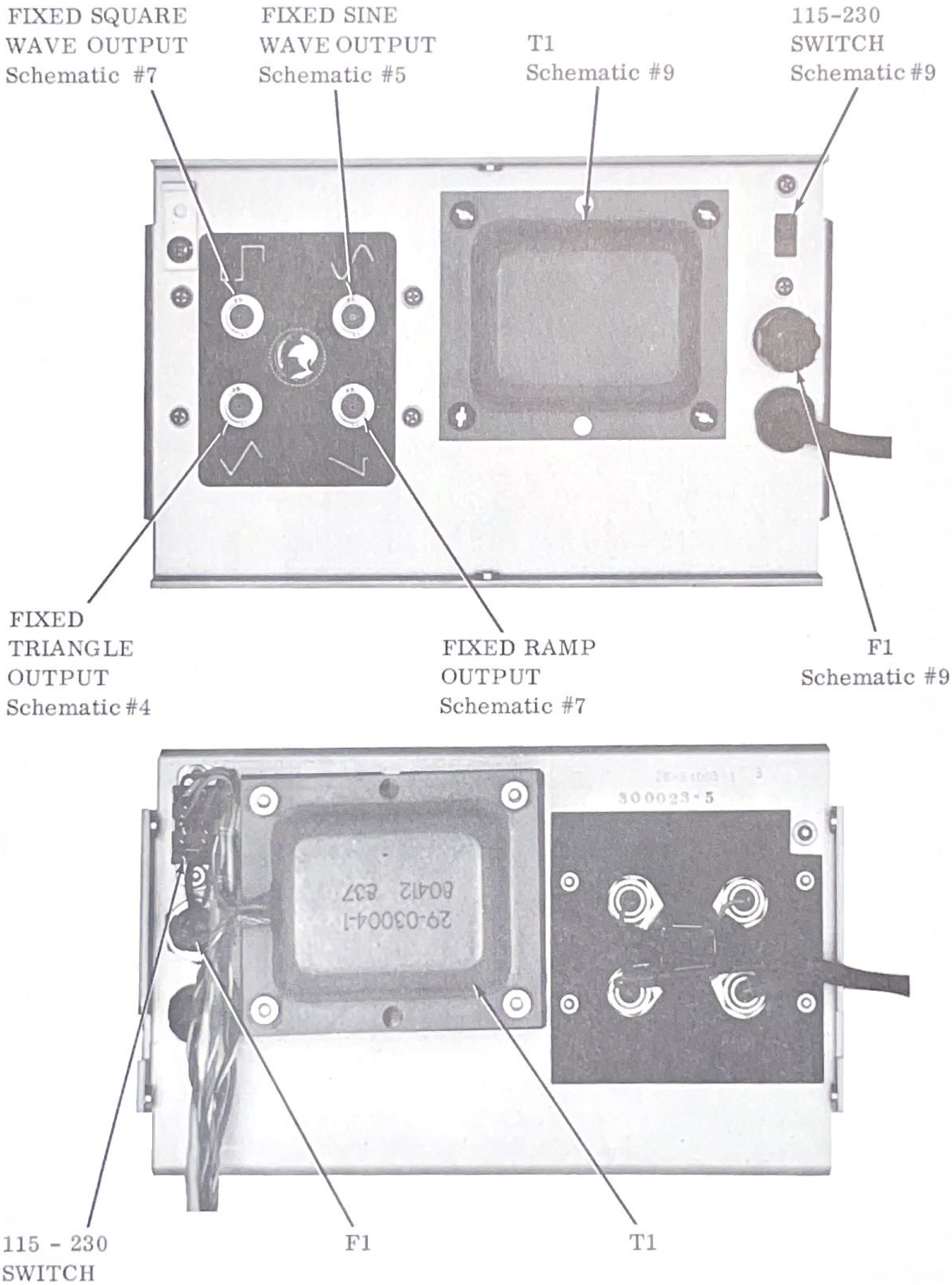


FIGURE 5-8
Rear Panel Assembly

SECTION VI

RECOMMENDED SPARE PARTS

The following is a list of the recommended spare parts required to maintain a specific number of instruments at a satisfactory level of performance for one year in an isolated area.

PART DESCRIPTION	PART NUMBER	1 UNIT	5 UNITS	10 UNITS
Fuse, 1/2 Amp, Slo-Blo	24-08000-0	2	4	6
Capacitor, Elect. 2700μf 25V	21-57200-0	2	4	6
Capacitor, Elect. 1300μf 50V	21-57213-0	2	4	6
Capacitor, Elect. 100μf 25V	21-57217-0	2	4	6
Capacitor, Elect. 2500μf 35V	21-57221-0	2	4	6
Tunnel Diode, 1N3719	27-95003-0	2	4	6
Diode, Zener, 1N5234	27-95251-0	1	2	3
Diode, Zener, 1N5232B	27-95255-0	1	2	3
Diode, Zener, 1N5235B	27-95258-0	1	2	3
Diode, Zener, 1N5242B	27-95259-0	1	2	3
Diode, Zener, 1N5252	27-95261-0	1	2	3
Diode, Zener, 1N5227B	27-95263-0	1	2	3
Diode, Zener, 1N5250	27-95264-0	1	2	3
Diode, MS-7000	27-95254-0	2	4	6
Integrated Circuit, μA709	25-08700-0	2	4	6
Integrated Circuit, μA710	25-08701-0	1	2	3
Integrated Circuit, CA-3018	25-08705-0	2	4	6
Integrated Circuit, CA-3030	25-08706-0	1	2	3
Transistor, 2N2218	29-04500-0	1	2	3
Transistor, 2N3638	29-04503-0	1	2	3
Transistor, 2N3640	29-04504-0	1	2	3
Transistor, 2N4258	29-04507-0	1	2	3
Transistor, 2N4274	29-04508-0	1	2	3
Transistor, 2N4898	29-04510-0	1	2	3
Transistor, RCA 40235 or 2N5179	29-04512-0	3	6	9
Transistor, 2N4360	29-04513-0	1	2	3
Transistor, Dual FET, 2N3956	29-04514-0	1	2	3
Transistor, RCA 40250	29-04515-0	1	2	3
Transistor, RCA 40468	29-04516-0	1	2	3
Transistor, 2N 3866	29-04522-0	1	2	3
Transistor, 2N 4890	29-04524-0	1	2	3
Transistor, 2N 5160	29-04525-0	1	2	3
Transistor, 2N4121 or 2N4916	29-04530-0	3	6	9

TABLE 6-1

LIST OF MANUFACTURERS

FEDERAL SUPPLY CODE TO NAME

FEDERAL SUPPLY CODE	MANUFACTURER	ADDRESS
00853	Sangamo Electric Company	Pickens, South Carolina
01121	Allen Bradley Company	Milwaukee, Wisconsin
04062	Elmenco Products Company	New York, New York
04387	Dale Electronics Inc.	Burbank, California
07115	Corning Glass, Electronic Components	Bradford, Pennsylvania
12126	Kidco, Inc.	Medford, New Jersey
12406	Elpac, Inc.	Fullerton, California
14099	Semtech Corporation	Newbury Park, California
14655	Cornell-Dubilier Electric Corporation	Newark, New Jersey
17227	Raytheon Company	Mountain View, California
17856	Siliconix, Inc.	Sunnyvale, California
21845	Solitron Devices, Inc.	Riviera Beach, Florida
29085	Data Royal Corporation	San Diego, California
44655	Ohmite Manufacturing Company	Skokie, Illinois
49671	Radio Corporation of America	New York, New York
56289	Sprague Electric Company	North Adams, Massachusetts
72982	Erie Technological Products	Erie, Pennsylvania
84171	Arco Electronics Company	Great Neck, New York

ONE YEAR UNCONDITIONAL

WARRANTY

DATA ROYAL CORPORATION hereby warrants to each original purchaser of all instruments of Data Royal Corporation manufacture as follows:

I. At the time of delivery of all instruments to the original purchaser thereof, Data Royal Corporation UNCONDITIONALLY WARRANTS that all of such instruments shall be free from defects in parts, materials, and workmanship; and

II. Commencing with the date of delivery of all instruments to the original purchaser thereof, which delivery date for purposes of this warranty shall be deemed to be Data Royal Corporation's original shipment date, AND FOR A PERIOD EXPIRING ONE (1) YEAR FROM SAID DATE, Data Royal Corporation UNCONDITIONALLY WARRANTS that all such instruments shall remain free from defects in parts, materials and workmanship.

In the event any instrument shall fail to meet the terms of this warranty, Data Royal Corporation agrees that if the original purchaser of any such instrument shall:

(1) Give to Data Royal Corporation's customer service department prompt notice in writing of the nature of any suspected defects; and

(2) Upon receipt of written authorization and shipping instructions from Data Royal Corporation, return the instrument with suspected defects, transportation charges prepaid, to Data Royal Corporation's main plant located in San Diego, California; then Data Royal Corporation shall replace any and all defective parts or materials and shall repair any and all defective workmanship and shall return the instrument, TRANSPORTATION CHARGES COLLECT, in good working order and state of repair to the original purchaser thereof, or in the alternative, Data Royal Corporation shall have the option to replace any such defective instrument by substituting a new instrument of the same type therefor, ALL WITHOUT ANY CHARGE WHATSOEVER:

The warranties herein contained shall not obligate Data Royal Corporation in any manner whatsoever with respect to, and shall not be applicable to, any defects which after an inspection of the instrument by Data Royal Corporation are not to Data Royal Corporation's reasonable satisfaction demonstrably the result of defective parts, materials or workmanship.

Data Royal Corporation reserves the right to modify or change the design or appearance of any of its instruments as it deems desirable. Nothing herein contained shall preclude such right or create any obligation to effect such changes on units previously purchased.

The remedies herein specified in the event of a breach of any of the warranties herein contained shall be the sole and exclusive remedies for such breach.

The warranties herein contained are intended to be and shall be construed as being in addition to and cumulative to all implied warranties contained in the Uniform Commercial Code, provided, however, that in the event of any breach by Data Royal Corporation of any of the implied warranties contained in the Uniform Commercial Code neither the purchaser of any Data Royal Corporation product, nor any other person, shall be entitled to recover by reason of such breach any incidental damages or consequential damages as those terms are defined in subsection 2-715 of the Uniform Commercial Code.

All warranties herein contained shall run only in favor of the original purchaser of Data Royal Corporation's instruments and all such warranties shall immediately terminate and become null and void and of no further force or effect whatsoever upon the sale or other transfer of any such instrument by the original purchaser. The warranties herein contained constitute the sole and exclusive warranties made by Data Royal Corporation of its instruments and no other express warranties not herein contained are given and no affirmation of fact, promise or representation made by any agent, employee or representative of Data Royal Corporation shall constitute a warranty. No agent, employee or representative of Data Royal Corporation has any authority to bind Data Royal Corporation in any affirmation of fact, promise, representation or warranty not herein expressly contained.

The above statements and warranty constitute a part of Data Royal Corporation's Standard Terms and Conditions of Sale as published in our Order Acknowledgement which together is Data Royal Corporation's warranty in its entirety.