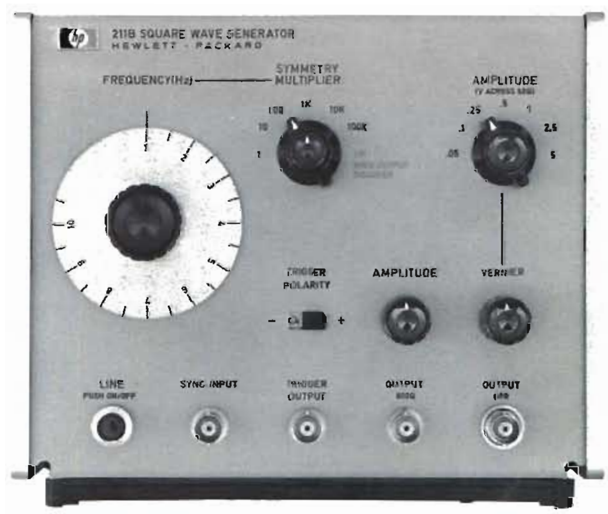
HP211B

OPERATING AND SERVICE MANUAL

SQUARE WAVE GENERATOR
211B



HEWLETT hp PACKARD

HP211B

CERTIFICATION

The Hewlett-Packard Company certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when it was shipped from the factory. The Hewlett-Packard Company further certifies that its calibration measurements are traceable to the U.S. National Bureau of Standards to the extent allowed by the Bureau's calibration facility.

WARRANTY AND ASSISTANCE

This Hewlett-Packard product is warranted against defects in materials and workmanship. This warranty applies for one year from the date of delivery, or, in the case of certain major components listed in the operating manual, for the specified period. We will repair or replace products which prove to be defective during the warranty period provided they are returned to Hewlett-Packard. No other warranty is expressed or implied. We are not liable for consequential damages.

Service contracts or customer assistance agreements are available for Hewlett-Packard products that require maintenance and repair on-site.

For any assistance, contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.

OPERATING AND SERVICE MANUAL

MODEL 211B
SQUARE WAVE GENERATOR

SERIALS PREFIXED: 0817 A–

Refer to Section VII for instruments with other Serial Prefixes.

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HEWLETT-PACKARD COMPANY/COLORADO SPRINGS DIVISION
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TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

Figure 1-1. Model 211B Square Wave Generator

SECTION I

GENERAL INFORMATION

1-1. DESCRIPTION.

1-2. The Hewlett-Packard Model 211B Square Wave Generator (Figure 1-1) is a fully-transistorized, general-purpose instrument that provides negative square-wave output signals of variable frequency, width, and amplitude. In addition, trigger output signals of reversible polarity are provided for synchronizing external circuits or instruments. The Model 211B Square Wave Generator (hereafter referred to as the Model 211B) is a free-running instrument. It may be synchronized with an external signal. The frequency range of the Model 211B is from 1 Hz to 10 MHz when terminated in a 50-ohm load. The amplitude of the signal is variable from 0 volt to −5 volts with an adjustable pulse width of 25% to 75% of the period. The risetime or falltime of the output pulse is less than 5 nanoseconds. When the output of the instrument is terminated in a 600-ohm load, the frequency range is from 1 Hz to 1 MHz with a variable amplitude from 0 volt to −30 volts. The adjustable pulse width is the same as for the 50-ohm termination. The risetime or falltime of the 600-ohm output pulse is less than 70 nanoseconds. Complete performance specifications are given in Table 1-1.

1-3. A separate facility for trigger output pulses is also provided. The trigger output pulses are coincidental with the leading edge of the output pulses at the 50-ohm connector. The trigger output circuit is used for synchronizing external circuits or instruments. Polarity of the trigger pulses is selective (either positive or negative) and their amplitude is greater than 2 volts. The pulse width is less than 10 nanoseconds when terminated in a 50-ohm load.

Table 1-1. Specifications

REPETITION RATE AND TRIGGERING

INTERNAL

50-ohm output: 1 Hz to 10 MHz, 7 ranges.
600-ohm output: 1 Hz to 1 MHz, 6 ranges.
Period Jitter: < 0.2% at any duty cycle and repetition rate setting.

EXTERNAL

Sync Input: sine waves or positive pulses from 1 Hz to 10 MHz; frequency of synchronizing signal must be from 105% to 140% of frequency dial setting.
Sensitivity: dc coupled, positive pulses, 2V pk; sine waves, 4V pk-to-pk.
Input Resistance: approximately 500 ohms.

TRIGGER OUTPUT

Width: 10 (±5) ns at 50% point.
Amplitude: at least 2V into 50 ohms.
Timing: coincident with leading edge of 50-ohm pulse.
Polarity: positive or negative.

OUTPUT

Symmetry: variable from 25% to 75% duty cycle.
Polarity: negative.

50-OHM SOURCE

Pulse Shape: (measured at 5V into 50 ohms).
Risetime and Falltime: < 5 ns.
Amplitude: peak 5V into 50 ohms, 10V into an open circuit; output circuit protected, cannot be damaged by shorting.
Attenuator: 0.05V to 5V, in a 1, 2.5, 5 sequence.
Vernier: provides continuous adjustment between ranges.

600-OHM SOURCE

Risetime and Falltime: < 70 ns into 600 ohms; < 140 ns into an open circuit; decreased amplitude will improve risetime.
Amplitude: at least 30V peak into 600 ohms; at least 60V into an open circuit.
Attenuator: provides continuous adjustment from full output to less then 0.3V into 600 ohms.

GENERAL

Power: 115V or 230V (+10%-15%), 50 to 400 Hz, 23W.

Dimensions: 7-3/4 in. wide 6-1/8 in. high, 11 in. deep overall (190 by 155 by 279 mm).

Weight: net 9 lbs (4 kg); shipping 11 lbs (5 kg).

1-4. INSTRUMENT APPLICATION.

1-5. With its variable pulse amplitude and width characteristics, the Model 211B is useful as a general-purpose laboratory or production-line instrument. Due to its compact size and ease of operation, it is an ideal single-unit instrument for test applications where synchronization triggering and pulse generator facilities are desired simultaneously.

1-6. EQUIPMENT AVAILABLE BUT NOT SUPPLIED.

1-7. A complete line of electronic test equipment is available from Hewlett-Packard Company for use in making test measurements with or maintaining the Model 211B. Also available are cables, connectors, adapters, and other accessory items for use in various test or measurement applications. For information on specific items consult the Hewlett-Packard catalog or the nearest Hewlett-Packard Sales/Service Office.

1-8. INSTRUMENT AND MANUAL IDENTIFICATION.

1-9. This manual applies directly to Model 211B instruments with a serial prefix as listed on the title page. The serial prefix is the first four digits of the serial number (0000-A-00000) used to identify each HP instrument.

1-10. As changes or refinements are made in the Model 211B, newer instruments may have higher serial prefixes assigned. Check the serial prefix of the instrument (serial tag usually located on the rear of chassis). If the serial prefix of the instrument is a number higher than listed on the title page, a MANUAL CHANGES sheet will be provided to update the manual to correspond with the newer instrument. If the serial prefix of the instrument is a number lower than listed, refer to Section VII for backdating information.

1-11. Any known corrections to the manual due to errors that existed when it was printed are called errata. These corrections (if any) will also appear on a MANUAL CHANGES sheet.

1-12. INQUIRIES.

1-13. Refer any questions regarding MANUAL CHANGES sheets, the manual, or the instrument in general to the nearest HP Sales/Service Office. Always identify the instrument by both model number and complete serial number (nine digits) in all correspondence. Refer to the inside rear cover of the manual for a world-wide listing of HP Sales/Service Offices.

CAUTION

The warranty may be void for instruments having a mutilated serial number tag.

SECTION II

INSTALLATION

2-1. INITIAL INSPECTION.

2-2. MECHANICAL CHECK. Inspect the Model 211B upon receipt for any damage which may have occurred in transit. Check for external damage such as broken knobs, bent or broken connectors, and dents or scratches on the panel surface. If damage is found, refer to Paragraph 2-11 for recommended claim procedure. Retain packing material for possible future use.

2-3. ELECTRICAL CHECK. Check the electrical performance of the Model 211B as soon as possible after receipt (refer to Section V for recommended performance checks). These checks verify that the Model 211B is operating within the specifications listed in Table 1-1. The performance check is a good test procedure for incoming quality-control inspection. Initial performance and accuracy of the instrument are certified as stated on the inside front cover of this manual. If the Model 211B does not operate as specified, refer to Paragraph 2-11 for claim procedure.

2-4. PREPARATION FOR USE.

2-5. THREE-CONDUCTOR POWER CORD.

2-6. The National Electrical Manufacturers Association (NEMA) recommends the instrument panel and case be grounded to protect operating personnel. The Model 211B is equipped with a detachable three-conductor power cord which grounds the instrument panel and case when connected to the appropriate three-conductor outlet. When operating the Model 211B from a two-conductor outlet, a three-conductor to two-conductor adapter must be used. Grounding the adapter at the electrical outlet will preserve the safety feature.

2-7. POWER REQUIREMENTS.

2-8. The Model 211B requires either 115 or 230 Vac +10%-15%, single-phase, 50 to 400 Hz power source capable of delivering 23 watts.

CAUTION

Before applying power, ensure that the rear panel power switch is in the proper position.

2-9. 115-VOLT AC OPERATION. Ensure that the slide switch on the rear panel of the Model 211B indicates 115V. The proper fuse (0.5A) for 115-Volt ac operation is factory installed.

2-10. 230-VOLT AC OPERATION. Ensure that the slide switch on the rear panel of the Model 211B indicates 230V. Operating the Model 211B from a power source of 230-Volt ac when the slide switch is in the 115V position will result in severe damage to the instrument. Fuse the Model 211B with a 0.25A slo-blo fuse when operating on 230-Volts ac.

2-11. CLAIMS.

2-12. The warranty statement applicable to all Hewlett-Packard Company instruments and products is provided inside the front cover of this manual. If physical damage is found or if operation is not as specified when the instrument is first received, notify the carrier and the nearest Hewlett-Packard Sales/Service Office immediately (refer to list in back of manual for addresses). The HP Sales/Service Office will arrange for repair or replacement without waiting for settlement of the claim with the carrier.

2-13. REPACKAGING FOR SHIPMENT.

2-14. If the Model 211B is to be shipped to a Hewlett-Packard Sales/Service Office for service or repair, attach a tag showing owner (with address), instrument serial number (all nine digits), and a description of the service or repair required.

2-15. The original shipping carton and packaging material may be reusable. The HP Sales/Service Office will provide information and recommendations on materials to be used if the original packaging material is not available. Materials used for shipping an instrument should include the following:

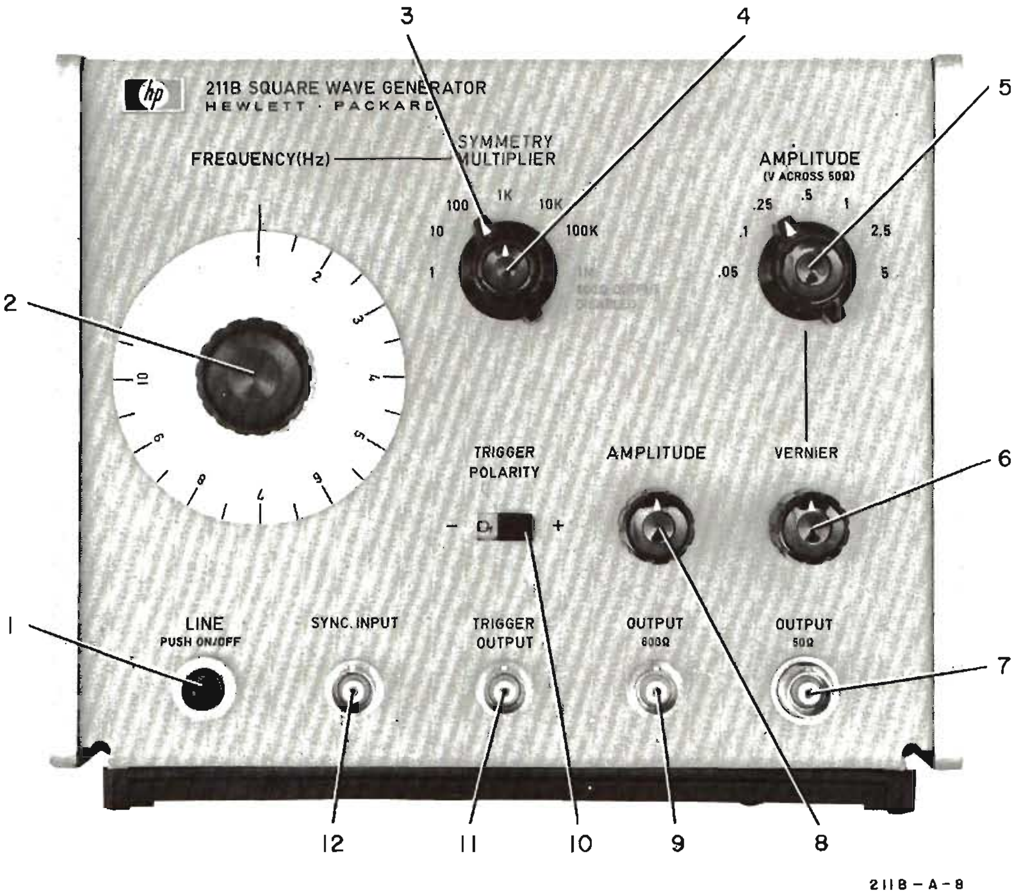
a. a double-walled carton; refer to Table 2-1 for test strength required.

b. heavy paper or sheets of cardboard to protect all instrument surfaces; use a nonabrasive material such as polyurethane or cushioned paper such as Kimpak around all projecting parts.

c. a mimumum of 4 inches of tightly-packed, industry-approved, shock-absorbing material such as extra-firm polyurethane foam.

Table 2-1. Shipping Carton Test Strength

Gross Weight (lbs)	Carton Test Strength (lbs)
up to 10	200
10 to 30	275
30 to 120	350
120 to 140	500
140 to 160	600



1. LINE. Applies ac power to the instrument. Indicator lamp lights when power is applied.

2. FREQUENCY (Hz). Selects the output frequency within the range determined by the MULTIPLIER setting.

3. MULTIPLIER. Selects the operating range for the FREQUENCY (Hz) dial.

4. SYMMETRY. Varies the duty cycle of the pulse period.

5. AMPLITUDE. Selects the voltage range of the 50-ohm output pulse.

6. VERNIER. Provides continuous adjustment for the voltage range of the 50-ohm output pulse. Maximum cw position gives maximum voltage for the range selected by the AMPLITUDE switch.

7. OUTPUT 50-ohm. Supplies 50-ohm output pulse.

8. AMPLITUDE. Controls voltage amplitude of the 600-ohm output pulse.

9. OUTPUT 600-ohm. Supplies 600-ohm output pulse.

10. TRIGGER POLARITY. Selects either negative or positive trigger output pulse.

11. TRIGGER OUTPUT. Supplies trigger output pulse.

12. SYNC INPUT. Input connector for external synchronization signals.

Figure 3-1. Front-Panel Controls and Connectors

SECTION III

OPERATION

3-1. INTRODUCTION.

3-2. This section includes explanation of front-panel controls and adjustments, available modes of operation, triggering considerations and step-by-step operating instructions for most applications.

3-3. CONTROLS AND CONNECTORS.

3-4. Although the functions described in Figure 3-1 are brief, they provide a ready reference for the operator. A more detailed description of some of the controls and connectors is given in the following paragraphs.

3-5. SYMMETRY CONTROL. The SYMMETRY control on the front panel of the Model 211B varies the duty cycle of the output pulse without affecting the frequency. The duty cycle is variable between 25% and 75% of the pulse period and is unaffected by external triggering and repetition rate.

3-6. 50-OHM AMPLITUDE CONTROL. The amplitude of the 50-ohm output pulses is controlled by an AMPLITUDE switch and a VERNIER control. The AMPLITUDE control is a seven-position attenuator switch covering an output voltage range from −0.05 volt to −5 volts. The voltage range selected by the attenuator setting is variable by the VERNIER control (from near zero volt to maximum output for the particular range selected).

3-7. 600-OHM AMPLITUDE CONTROL. The amplitude of the 600-ohm output pulse is controlled by the AMPLITUDE control located directly above the 600-ohm output connector. The amplitude is continuously variable from zero volt to −30 volts when terminated in a 600-ohm load.

3-8. OPERATING CONSIDERATIONS.

3-9. EXTERNAL SYCHRONIZATION.

CAUTION

Input synchronization signal must not exceed 20 volts peak and power must be less than 0.25 watt.

3-10. The Model 211B may be synchronized by either a +2-volt minimum pulse or a 4-volt minimum peak sine wave applied to the SYNC INPUT connector. The frequency of the synchronization signal must be between 105% and 140% of the internal frequency setting. If difficulty is encountered when synchronizing with an external source, recheck the dial frequency setting, the synchronization frequency, and the amplitude of the synchronization signal.

3-11. TRIGGER OUTPUT.

3-12. The positive or negative trigger pulses which are available at the TRIGGER OUTPUT connector have an amplitude greater than 2 volts (across a 50-ohm load), approximately 10 nanoseconds in width, and are coincidental with the leading edge of the 50-ohm output pulse.

3-13. OPERATING PROCEDURES.

3-14. The Model 211B is capable of generating any frequency from 1 Hz to 10 MHz (maximum of 1 MHz at the 600-ohm connector). The frequency is established by setting the MULTIPLIER switch to any of seven ranges and adjusting the FREQUENCY (Hz) control to the specific frequency desired. The Model 211B is free-running at the frequency indicated by the front-panel frequency controls. To operate the instrument, proceed as follows:

a. To apply power, press the LINE switch. The power lamp should light.

b. Set the MULTIPLIER switch to the correct frequency range and adjust the FREQUENCY (Hz) control to the desired frequency.

c. Adjust the SYMMETRY control for the required pulse width as observed on an oscilloscope.

d. When using the 50-ohm output circuit, select the proper voltage attenuator range with the AMPLITUDE selector switch. Adjust the VERNIER control for the exact voltage required. Refer to Table 1-1 for output termination characteristics.

e. When using the 600-ohm output circuit, adjust the AMPLITUDE control for the required voltage amplitude. Refer to Table 1-1 for termination characteristics.

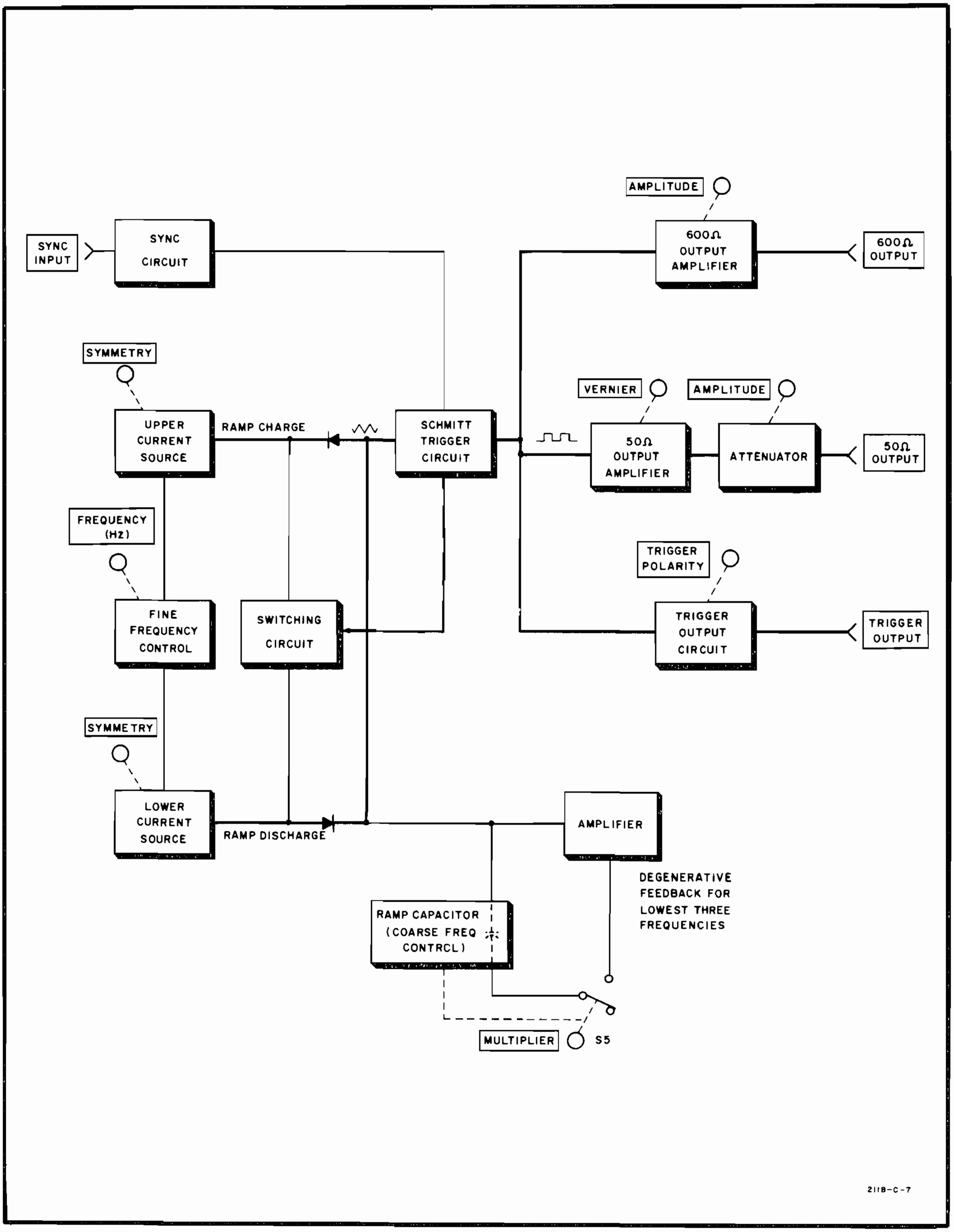


Figure 4-1. Model 211B Block Diagram

SECTION IV

PRINCIPLES OF OPERATION

4-1. INTRODUCTION.

4-2. This section presents the theory of operation for the Model 211B Square Wave Generator. The first portion contains a general description of circuit functions using a block diagram (Figure 4-1) to supplement the written description. The second portion provides a detailed description of the operational theory written for use with the schematics which are located in Section VIII of this manual.

4-3. BLOCK DIAGRAM DESCRIPTION.

4-4. The Model 211B consists of a fine-frequency control, two current sources, a coarse-frequency control, and a Schmitt trigger circuit. The output of the Schmitt trigger is applied to three amplifier circuits. The amplifier circuits produce symetrical output pulses which are present at the 50-ohm, 600-ohm, and TRIGGER OUTPUT connectors.

4-5. FINE–FREQUENCY CONTROL.

4-6. The front-panel control, FREQUENCY (Hz), establishes the pulse repetition rate of the square-wave generator by adjusting the bias applied to the two current sources.

4-7. CURRENT SOURCES.

4-8. The current sources (referred to as the upper and lower current sources in the block diagram) operate as current regulators for the coarse-frequency control circuit. The upper current source provides the current for charging the selected ramp capacitor in the coarse-frequency control circuit and the lower current source establishes the rate of discharge.

4-9. COARSE-FREQUENCY CONTROL.

4-10. The MULTIPLIER switch, located on the front panel of the Model 211B, selects various resistance-capacitance networks which determine the slope of the ramp waveform. The various sawtooth waveforms developed by the ramp capacitance networks establish the repetition rate for the Schmitt trigger circuit.

4-11. SCHMITT TRIGGER.

4-12. The sawtooth waveform from the ramp capacitance network alternately crosses the upper and lower hysteresis limits of the Schmitt trigger. This results in a square-wave output at a repetition rate established by the coarse and fine frequency control circuits. The Schmitt-trigger output is applied to the output amplifiers.

4-13. SWITCHING CIRCUITRY.

4-14. The switching circuit is controlled by a signal fed back from the Schmitt trigger. It regulates the charge or discharge state of the selected ramp capacitor.

4-15. OUTPUT CIRCUITS.

4-16. The square-wave signal from the Schmitt trigger is amplified and shaped by the 50-ohm and 600-ohm output circuits. The trigger circuit differentiates the output of the Schmitt trigger and reshapes the pulses. Polarity of the trigger pulses is selectable by switch action.

4-17. SYNCHRONIZATION CIRCUIT.

4-18. The Model 211B may be synchronized from an external source. The synchronization signal is differentiated and applied to the Schmitt trigger circuit.

4-19. CIRCUIT DETAILS.

4-20. Refer to the timing sequence in Figure 4-2 and the schematics located in Section VIII of this manual when using the detailed theory of operation.

4-21. COARSE-FREQUENCY CONTROL.

4-22. The coarse-frequency circuit is controlled by the seven-position MULTIPLIER switch S5. Each position of the MULTIPLIER switch selects the appropriate ramp capacitor (A2C11 through A2C16) for the designated frequency range. When the 1M frequency range is selected, a network consisting of A2C8, A2C9, A2C10 and A2R31 is used to develop the higher frequency involved.

4-23. The selected ramp capacitor will charge and discharge at a rate determined by current-source transistors A2Q6 and A2Q7. Transistor A2Q6 functions as a series regulator in the current path that charges the selected capacitor. The charging rate of the ramp capacitor forms the negative slope of the sawtooth waveform. The output current of A2Q6 is directed to the ramp capacitor by diode A2CR11. Transistor A2Q7 functions as a series regulator in the discharge path of the selected ramp capacitor. The discharging rate of the ramp capacitor forms the positive slope of the sawtooth waveform. Diode A2CR12 directs the discharge current from the ramp capacitor through A2Q7 to ground.

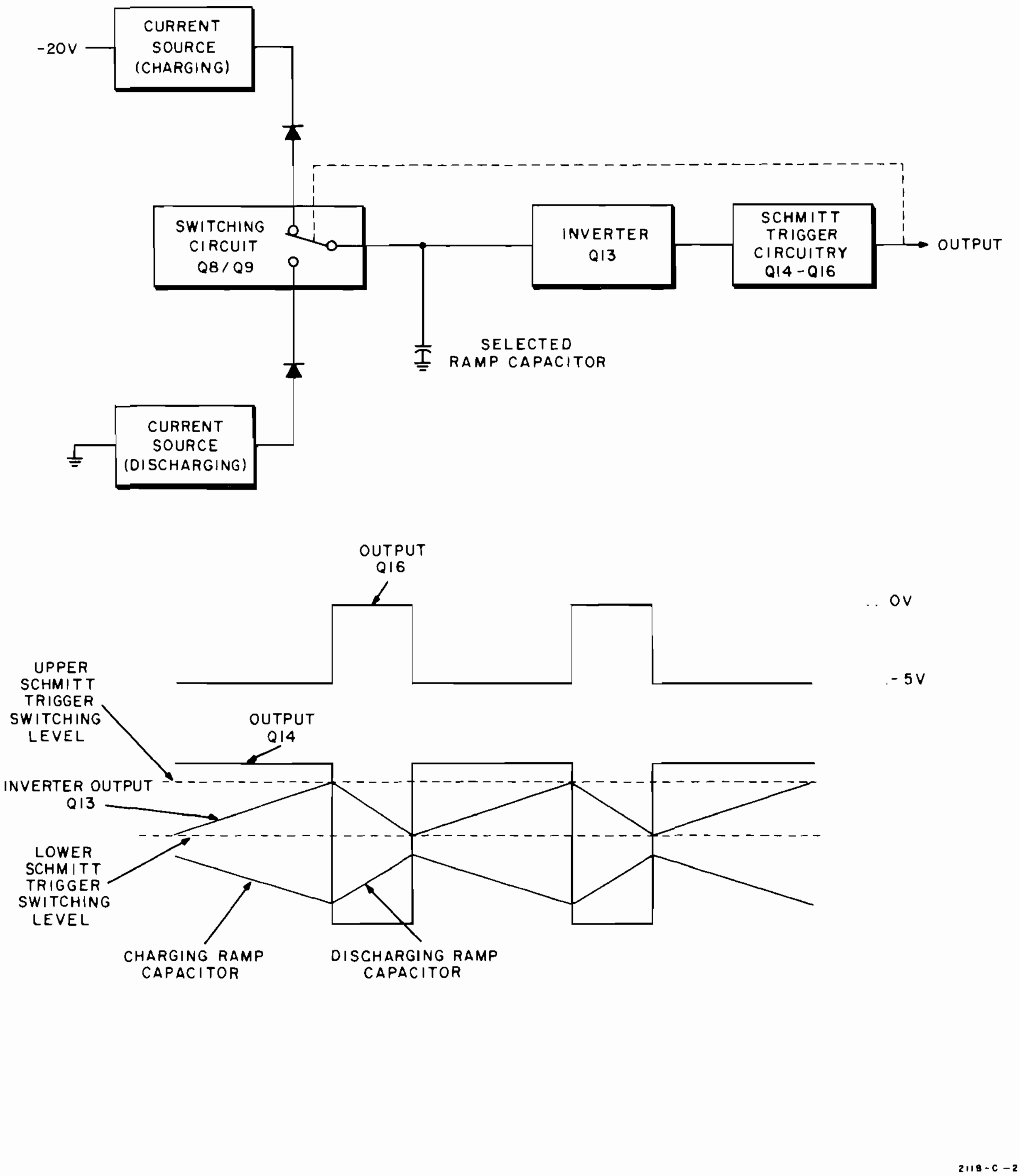


Figure 4-2. Schmitt Trigger Operation

4-24. Dual potentiometer R3 determines the duty cycle for each period of the pulse repetition rate. It controls the current in the emitter circuits of A2Q6 and A2Q7. Potentiometer R3 is adjusted by the SYMMETRY control knob on the front panel of the instrument. Varying the SYMMETRY control changes the rate at which the upper and lower hysteresis limits of the Schmitt trigger are crossed per repetition pulse. This establishes the duty cycle for each period.

4-25. FINE–FREQUENCY CONTROL.

4-26. The fine-frequency circuit of the Model 211B consists of potentiometer R2, A2R24, A2R25 and A2Q5. Potentiometer R2 is a 10:1 vernier controlled by the FREQUENCY (Hz) dial on the front panel of the instrument. The FREQUENCY (Hz) dial establishes the bias applied to current-control transistor A2Q5. The bias on A2Q5 controls the voltage developed across resistors A2R24 and A2R25. The voltages developed at A2R24 and A2R25 form the bias for charge and discharge transistors A2Q6 and A2Q7. The rate at which A2Q6 permits the ramp capacitor to charge and the rate at which A2Q7 permits it to discharge determine the repetition rate for the instrument.

4-27. On the three lower frequency ranges (controlled by A2C11, A2C12 and A2C13), a degenerative feedback network consisting of A2Q11 and A2Q12 is used to compensate for the slower charge and discharge rate required. Transistor A2Q12 inverts the emitter signal of A2Q13 and applies it to the base of A2Q11. The collector circuit of A2Q11 controls the bias on transistor A2Q10. Transistor A2Q10 forms a low-impedance ground circuit for the three lowest frequency capcitors. Variable resistors A2R33, A2R34 and A2R35 control the amplitude of the degenerative feedback signal. Refer to Section V of this manual for proper adjustments.

4-28. SCHMITT TRIGGER CIRCUIT.

4-29. Charging of the selected ramp capacitor produces the negative slope of the sawtooth waveform (Figure 4-2). This signal is applied to the base of transistor A2Q13. The inverted signal developed in the collector circuit of A2Q13 is applied to the base of transistor A2Q14. Transistors A2Q14 and A2Q15 function as a Schmitt trigger circuit. When the upper hysteresis limit of A2Q14 is reached, it conducts heavily and A2Q15 is cut off. When the lower hysteresis limit of A2Q14 is reached, it is biased off and A2Q15 conducts. The square-wave signal developed by A2Q15 is inverted by transistor A2Q16 and applied to the output circuits.

4-30. SWITCHING CIRCUIT.

4-31. Synchronization of the charge and discharge functions of the current sources is accomplished by transistors A2Q8 and A2Q9. The output signal from the Schmitt trigger is coupled through diode A2VR5 to the base circuits of A2Q8 and A2Q9. Transistors A2Q8 and A2Q9 are complementary (npn-pnp). Depending on the polarity of the output pulse, one transistor will conduct while the other is cut off. When A2Q8 is conducting (positive transition of the signal from A2Q16), diode A2CR11 is back biased and the charging circuit between A2Q6 and the ramp capacitor is blocked. During the same positive transition of the signal from A2Q16, transistor A2Q9 is cut off. The discharge path from the ramp capacitor through A2CR12 and A2Q7 to ground is operational. When A2Q8 is not conducting (negative transition of the signal from A2Q16) the charge path from the ramp capacitor through A2CR11 and A2Q6 to the −20-volt source is operational. During the same negative transition of the signal from A2Q16, transistor A2Q9 is conducting. With A2Q9 conducting, diode A2CR12 is back biased and the discharge path of the ramp capacitor is blocked.

4-32. OUTPUT CIRCUITS.

4-33. TRIGGER OUTPUT. The output signal from Impedance Converter A2Q16 is applied to a differentiating circuit A2C18 and A2R45 in the trigger output circuit. The positive spike developed by the differentiator is applied to trigger amplifier A2Q17. The signal is shaped into a negative pulse having a 10-nanosecond width and greater than 2 volts in amplitude (when terminated in a 50-ohm load). The output of A2Q17 is connected to one side of trigger-polarity switch S4 and transistor A2Q18. Transistor A2Q18 inverts the negative pulse and applies it to the other side of S4. The position of S4 determines the polarity of the trigger output pulse.

4-34. 50-OHM OUTPUT CIRCUIT. The signal from transistor A2Q16 is also applied to transistor A2Q23. Transistor A2Q23 and A2Q25 are used to amplify and shape the square-wave pulse. The output of A2Q25 is applied to a cascode amplifier stage consisting of A2Q29, A2Q30, A2Q32 and A2Q33. The output of the cascode amplifier is connected to attenuator A1.

4-35. The amplitude of the 50-ohm signal is controlled by AMPLITUDE switch A1S1 and the VERNIER control on the front panel of the instrument. The VERNIER control varies the bias on amplitude-control transitor A2Q27. An in-phase voltage at the emitter of A2Q27 is applied as bias to the output cascode transistors A2Q32 and A2Q33. By adjusting the bias on the output transistors, the amplitude of the output signal is varied from near zero to −5 volts. Diode A2CR20 functions as a protective device against any inductive overloads.

4-36. An attenuator network is used to limit the amplitude of the output signal to from −0.05 volt to −5 volts. Attenuator A1 has three pi-type resistance networks. These networks divide the signal from the cascode amplifiers by factors of two, five and ten. Amplitude switch A1S1 selects the desired voltage range by connecting the cascode amplifier output to selected combinations of the pi-networks. The output of the pi-networks is connected to the OUTPUT 50Ω connector on the front panel of the instrument.

4-37. 600-OHM OUTPUT. The signal from transistor A2Q16 is also applied to amplifier A2Q24 in the 600-ohm amplifier circuit. Transistors A2Q24 and A2Q26 amplify and shape the square-wave pulses before applying them to driver amplifier A2Q31. When the 1M frequency range is selected, A2Q24 is reverse biased by the addition of resistor R5 in its emitter circuit. There is no output from the 600-ohm circuit on the 1M frequency range. Variable resistor A2R88, is adjusted for a signal amplitude which results in no distortion of the output waveform.

4-38. The signal from A2Q26 is amplified by driver-amplifier A2Q31 and applied to transistors Q3 and Q4 operating in cascode. (Transistors Q3 and Q4 are located on the instrument chassis). Transistors Q3 and Q4 amplify and further shape the output signal. The amplitude of the output signal is continuously variable from zero to −30 volts by resistor R6 (AMPLITUDE). Diode A2CR21 functions as a protective device against any inductive overload.

4-39. SYNCHRONIZATION.

4-40. An external synchronization signal may be applied to the instrument at the SYNC INPUT connector J2. The synchronization signal must have an amplitude of at least +2 volts peak and a frequency of 105% to 140% of the frequency dial setting of the Model 211B. The synchronizing signal is applied to a divider bridge consisting of diodes A2CR13-A2CR16. The diode bridge configuration limits the amplitude of the input signal to +4 volts.

4-41. When the synchronizing signal produces a positive voltage at the junction of A2CR14 and A2CR16, transistor A2Q19 conducts. The negative voltage developed by A2Q19 is applied to A2Q20 through diode A2VR9. Normally, A2Q20 is forward biased and conducting. When the negative voltage from A2Q19 is applied, A2Q20 is cut off. The magnetic field produced by A2L1 when A2Q20 is conducting collapses and produces a 20-nanosecond positive pulse. Depending on the position of the SYMMETRY control, the 20-nanosecond pulse is applied to either A2Q21 or A2Q22 by switch S3. The synchronization pulses are applied to the Schmitt trigger circuit during the longer slope of the ramp waveform. When the duty cycle is below 50% of the pulse period, S3 connects the synchronizing pulses to A2Q22. When the duty cycle is greater than 50% of the pulse period, the synchronizing pulses are connected to A2Q21. Synchronization is not possible at exactly 50% of the duty cycle.

4-42. When either A2Q21 or A2Q22 conducts (with application of a synchronization pulse) a negative 20-nanosecond pulse is produced. The negative pulse is connected to the base of either A2Q14 or A2Q15 in the Schmitt trigger circuit. Since the pulse is applied to the Schmitt trigger transistor which is conducting, the Schmitt trigger switches operating states, thus synchronizing the sawtooth waveform from the frequency control circuit to the synchronization signal.

4-43. POWER SUPPLIES.

4-44. The regulated power supply operates from 115 or 230 volts ac. The voltage is rectified to provide the dc outputs of −20 volts, −70 volts, and +6.8 volts. The two primary windings of transformer T1 are connected either in series (230 volts ac operation) or in parallel (115 volts ac operation) by switch S2.

4-45. −20-VOLT POWER SUPPLY. Diodes A2CR1 and A2CR2 comprise a full-wave rectifer which furnishes the negative voltage for the −20-volt power supply. The unregulated voltage is filtered by capacitor C1 and applied to series regulator Q1. Resistor A2R7, A2R8, and A2R9 form a voltage-divider network between ground and the −20-volt output. The base of error-amplifier A2Q2 is connected to the voltage-divider network and senses any change in output voltage. The change in output voltage is amplified and inverted by A2Q2 and applied to regulator-driver A2Q1. Transistor A2Q1 functions as an emitter follower and is connected to the base circuit of series regulator Q1. This regulates the bias on Q1 and maintains the output of the power supply at −20 volts.

4-46. −70-VOLT POWER SUPPLY. The −70-volt power supply functions in the same manner as the −20-volt power supply with the exception of the rectifier circuit. The secondary winding of transformer T1 used by the −20-volt power supply is center-tapped to ground. This enables the use of the two-diode rectifier system. The two-diode rectifier arrangement cannot be employed for the −70-volt power supply. The secondary winding of transformer T1 used for the −70-volt power supply is not center-tapped. The bridge network consisting of A2CR5 through A2CR8 is used for full-wave rectification.

4-47. +6.8-VOLT POWER SUPPLY. Diodes A2CR3 and A2CR4 form a full-wave rectifier which supplies the +6.8-volt power for the instrument. Capacitor A2C5 filters the rectified voltage. Resistor A2R10 reduces the voltage to the proper level and breakdown diode A2VR1 regulates the output.

Table 5-1. Required Test Equipment

Recommended Instrument		Required Characteristics	Required for
Type	Model		
Sampling Oscilloscope	HP 140A with 1410A & 1425A	1 GHz Bandwidth	Performance Check
High-frequency Oscilloscope	HP 180A with 1801A & 1820A	50 MHz Bandwidth 50 mV/cm Sensitivity	Performance Check Adjustments
Frequency Counter	5245L	Period Meter Frequency Counter	Performance Check Adjustments
50-ohm Tee	HP 10221A	1 GHz Bandwidth	Performnace Check
20 dB-50-ohm Attenuator	Weinschel Model 50-20-S	Use Recommended Equipment	Performance Check
50-ohm Load	HP 11048B	Feed-through Load	Performance Check Adjustments
50-ohm Termination	GR 874-W50	1 GHz Bandwidth	Performance Check
600-ohm Load		600-ohm ±5% 2W	Performance Check
BNC Adapter	HP 10110A	BNC male to Binding Post	Performance Check
Test Oscillator	HP 651B	10 Hz to 10 MHz 3V Output Range	Performance Check
AC Voltmeter	HP 403B	0.003V to 0.03V Voltage Range	Adjustments Troubleshooting
DC Voltmeter	HP 412A	1 mV to 100V Voltage Range	Adjustments Troubleshooting
Digital Voltmeter	3440A 3441A Plug-in	±0.05% accuracy 4 digit display	Adjustments
Variable line Voltage Supply		100 - 128V 200 - 255V 25VA	Adjustments

SECTION V

PERFORMANCE CHECK AND ADJUSTMENTS

5-1. INTRODUCTION.

5-2. This section provides adjustment procedures and a performance check for the Model 211B. The performance check may be used as an incoming inspection, or after repairs or adjustments have been made to certify that the instrument meets the specifications listed in Table 1-1. When the initial performance check is made, record the indications on the Performance Check Record. These indications may be used for comparisons with equipment performance at a later date. Refer to paragraph 5-18 for adjustment procedures.

5-3. REQUIRED TEST EQUIPMENT.

5-4. Test equipment recommended for both the performance check and adjustments is listed in Table 5-1. Similar equipment may be substituted provided it has the required characteristics listed in the table.

5-5. PERFORMANCE CHECK.

5-6. PROCEDURE.

5-7. Connect the Model 211B to an external power source. Turn on the equipment and allow 10 minutes for warm-up. Perform the checks and adjustments in the same sequence as they are listed. Figure 5-1 is a typical waveform which illustrates points that are described in this section.

5-8. FREQUENCY CHECK.

a. See Figure 5-2. Connect the required equipment as indicated.

b. Set the controls of the Model 211B as follows:

MULTIPLIER	1
FREQUENCY (Hz)	1
SYMMETRY	approximately 50%
AMPLITUDE (switch)	5
VERNIER	cw

c. Set the Electronic Counter controls as follows:

SIGNAL INPUT	AC
SENSITIVITY (VOLTS RMS)	1V
TIME BASE	.1 us
FUNCTION	1 PERIOD AVERAGE

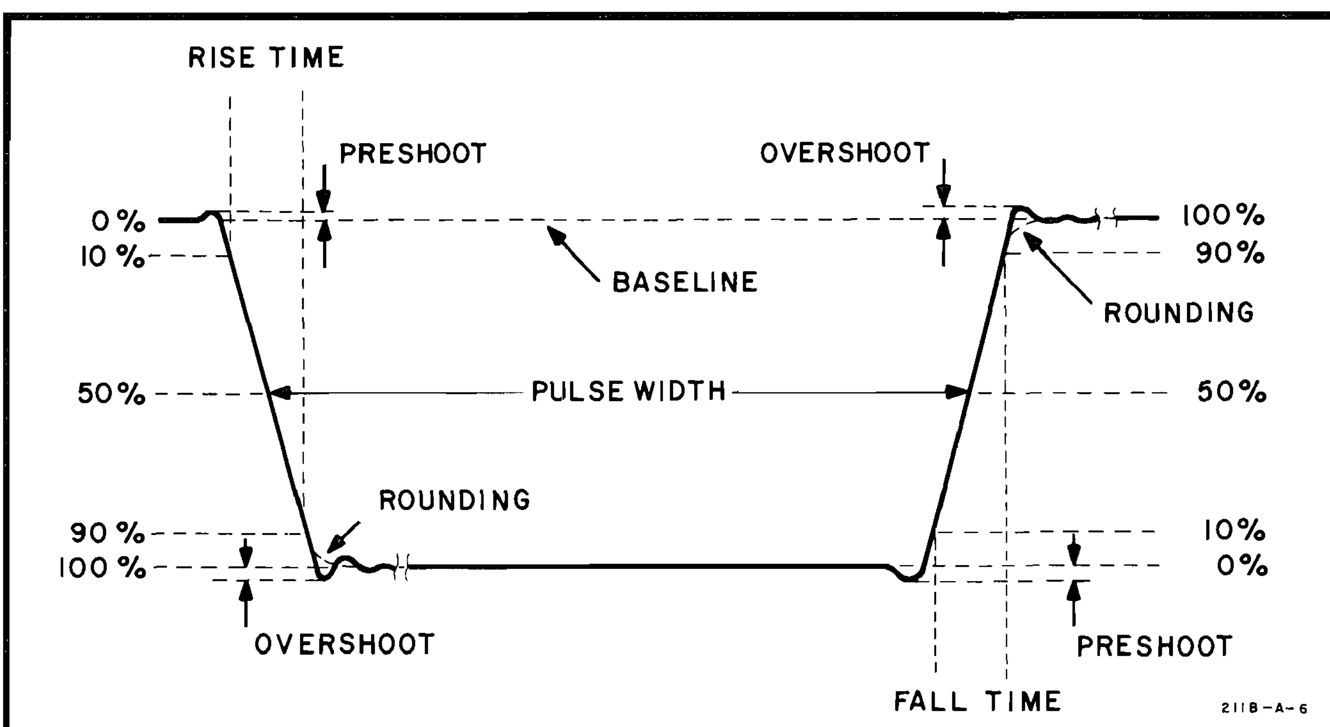


Figure 5-1. Typical Waveform Characteristics

Table 5-2. Frequency Check

Set MULTIPLIER switch to	Set FREQUENCY (Hz) dial to	Electronic Counter indication
		microseconds
1	1	850 000 – 1 150 000
1	5	186 000 – 214 000
1	10	94 000 – 106 000
10	1	85 000 – 115 000
10	5	18 600 – 21 000
10	10	9 400 – 10 600
100	1	8 500 – 11 500
100	5	1 860 – 2 140
100	10	940 – 1 060
Set Electronic Counter FUNCTION to FREQUENCY and TIME BASE to 1 sec		
		hertz
1K	1	850 – 1 150
1K	5	4 650 – 5 350
1K	10	9.4K – 10.6K
10K	1	8.5K – 11.5K
10K	5	46.5K – 53.5K
10K	10	94K – 106K
100K	1	85K – 115K
100K	5	465K – 535K
100K	10	0.95M – 1.06M
1M	1	0.85M – 1.15M
1M	5	4.65M – 5.35M
1M	10	9.4M – 10.6M

d. Accomplish the check by setting the Model 211B MULTIPLIER switch and FREQUENCY (Hz) dial as shown in Table 5-2, columns one and two. The Electronic Counter indication should be as shown in column three.

Note

When the MULTIPLIER switch is advanced from 100 to 1K, the Electronic Counter control settings must be changed.

5-9. SYMMETRY CONTROL CHECK.

a. With the Model 211B connected as shown in Figure 5-2, set the controls as follows:

MULTIPLIER 10K
FREQUENCY (Hz) 1
SYMMETRY .... cw
AMPLITUDE (switch) 5
VERNIER .... cw

b. Set the high-frequency oscilloscope as follows:

TIME/DIV 10
TRIGGER .... INT
MODE .... NORM
VOLTS/DIV 2

c. Adjust the high-frequency oscilloscope for a stable display.

d. The pulse width should be greater than 75% of the period.

e. Turn the SYMMETRY control of the Model 211B fully ccw. The pulse width should be less than 25% of the period.

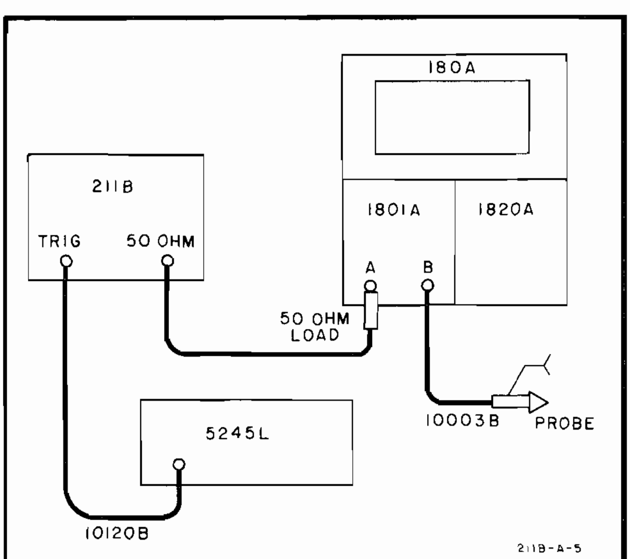


Figure 5-2. Frequency Check Test Setup

5-10. SYNCHRONIZATION CHECK.

a. This procedure checks the ability of the Model 211B to synchronize on an external trigger source.

b. Connect the equipment as indicated in Figure 5-3.

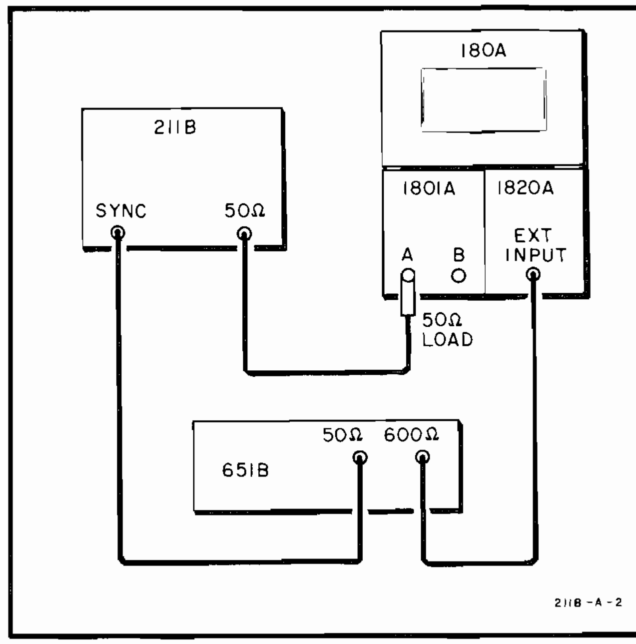


Figure 5-3. Synchronization Test Setup

c. Set the controls of the Model 211B as follows:

MULTIPLIER 100K
FREQUENCY (Hz) 10
SYMMETRY .... ccw
AMPLITUDE (Switch) 5
VERNIER .... cw

d. Set the high-frequency oscilloscope as follows:

TIME/DIV .... .5 usec
TRIGGER .... EXT
MODE .... NORM
VOLTS/DIV 2

e. Set the test oscillator controls as follows:

FREQUENCY 110K
AMPLITUDE .... 4V pk-to-pk

f. Adjust the high-frequency oscilloscope until one pulse period occupies 8 divisions on the CRT.

g. Turn the FREQUENCY dial of the test oscillator slowly until one pulse period occupies 4 divisions on the oscilloscope CRT.

h. Turn the Model 211B SYMMETRY control slowly cw. Observe the phase shift reversal at 50% duty-cycle point.

i. Repeat the procedure with the SYMMETRY control in the cw position.

5-11. 600-OHM OUTPUT CHECK.

a. See Figure 5-l for definition of pulse characteristics.

b. Connect the equipment as shown in Figure 5-4.

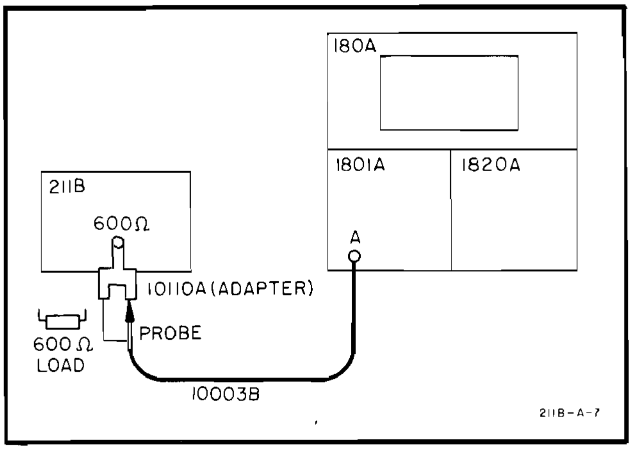


Figure 5-4. 600-Ohm Output Test Setup

c. Set the Model 211B controls as follows:

MULTIPLIER	10K
FREQUENCY (Hz)	10
SYMMETRY	approximately 50%
AMPLITUDE. (600-Ohm control)	cw

d. Set the high-frequency oscilloscope controls as follows:

TIME/DIV	2 usec
TRIGGER	+,INT
MODE	NORM
SLOPE	(-)
VOLTS/DIV	10

e. Adjust the AMPLITUDE control of the Model 211B for a pulse amplitude of 60 volts (6 divisions). The overshoot should be less than 3 minor divisions (5%).

f. Connect a 600-ohm load across the 600-ohm output connector of the Model 211B. The pulse amplitude should be 30 volts (3 divisions) ±5%.

g. Turn the AMPLITUDE (600-ohm) control of the Model 211B fully ccw.

h. Set the oscilloscope VOLTS/DIV dial to .1 and adjust the AMPLITUDE control of the Model 211B for 0.3 volt (3 divisions) as indicated on the oscilloscope. The overshoot should be less than 1.5 minor divisions. Disconnect the 600-ohm load.

5-12. RISETIME AND FALLTIME

a. Set the high-frequency oscilloscope TIME/DIV dial to .2 USEC and the VOLT/DIV dial to 1. Adjust the 600-ohm AMPLITUDE control on the Model 211B for 6 divisions deflection.

b. Move the leading edge of the pulse to the center of the CRT. Set the oscilloscope MAGNIFIER to X10. Check the risetime between 10% and 90% amplitude points. It should be less than 7 divisions (140 ns).

c. Change the oscilloscope SLOPE to (+) and move the trailing edge of the pulse to the center of the CRT. Check fall time between the 10% and 90% amplitude points. It should be less than 7 divisions (140 ns).

d. Connect the Model 211B output to a 600-ohm load.

e. Set the oscilloscope VOLT/DIV dial to .5. Check the fall time between 10% and 90% amplitude points. It should be less than 3.5 divisions (70 ns).

f. Change the oscilloscope SLOPE to (-) and move the leading edge of the pulse to the center of the CRT. Check risetime between 10% and 90% amplitude points. It should be less than 3.5 divisions (70 ns). Remove the 600-ohm load.

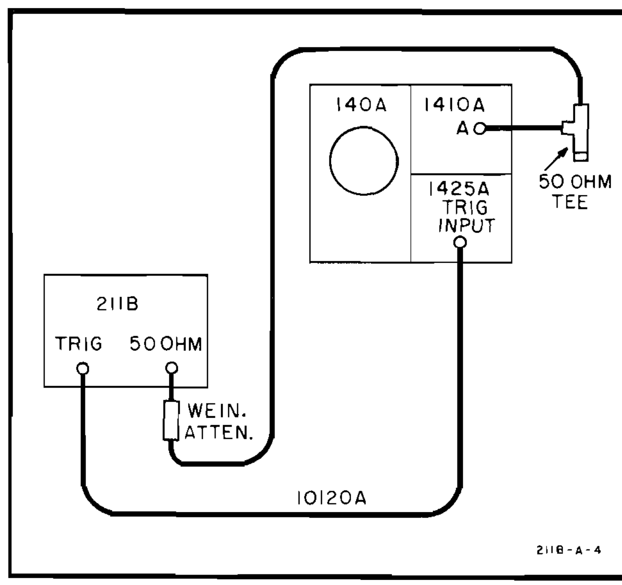


Figure 5-5. 50-Ohm Output Test Setup

5-13. 50-OHM OUTPUT CHECK.

a. Connect the equipment as shown in Figure 5-5.

b. Set the controls of the Model 211B as follows:

MULTIPLIER	1M
FREQUENCY (Hz)	5
SYMMETRY	50% duty cycle
AMPLITUDE (Switch)	5
VERNIER	cw
TRIGGER POLARITY	(-)

c. Set the sampling oscilloscope controls as follows:

TIME/DIV .... 20 nSEC
MAIN SWEEP MAGNIFIER 20
MAIN SWEEP TRIGGER .... NORM
MAIN SWEEP TRIGGER SLOPE .... (-)
MILLIVOLTS/DIV 50
SMOOTHING .... NORM

d. Adjust the pulse amplitude to 5 volts (10 divisions) with the Model 211B VERNIER.

e. Move the leading edge of the pulse to the center of the CRT. The risetime shall be less than 5 ns.

f. Move the trailing edge of the pulse to the center of the CRT. The falltime shall be less than 5 ns.

5-14. With the Model 211B controls set as in paragraph 5-13b, set the sampling oscilloscope controls and plug-in units as follows:

TIME/DIV .... 50 nSEC
MAIN SWEEP MAGNIFIER 2
MAIN SWEEP TRIGGER .... NORM
MAIN SWEEP TRIGGER SLOPE .... (-)
MILLIVOLTS/DIV 50
SMOOTHING .... NORM

a. Adjust the pulse amplitude to 5 volts (10 divisions) with the Model 211B amplitude VERNIER.

b. Move the leading edge of the pulse to the center of the CRT. The preshoot and the overshoot of the leading edge shall be no more than 5 minor divisions (5%).

c. Move the trailing edge of the pulse to the center of the CRT. The preshoot and the overshoot of the trailing edge of the pulse shall be no more than 5 minor divisions (5%).

5-15. SYMMETRY (10 MHz).

a. Set the FREQUENCY (Hz) dial of the Model 211B to 10 and the SYMMETRY control fully ccw. All other control settings to remain as in paragraph 5-14.

b. The pulse width of the period displayed should be less than 30%.

c. Turn the SYMMETRY control of the Model 211B fully cw. The pulse width of the period shall be more than 70%.

5-16. TRIGGER OUTPUT CHECK.

5-17. This procedure verifies the trigger output characteristics of the Model 211B. Connect the equipment as shown in Figure 5-6.

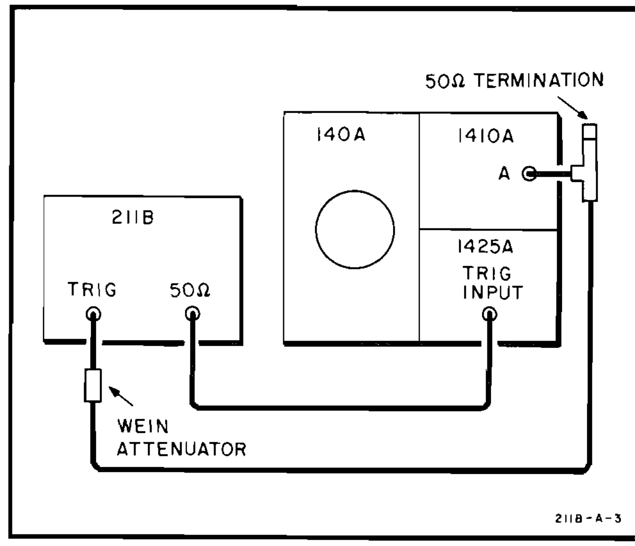


Figure 5-6. Trigger Output Test Setup

a. Set the Model 211B controls as follows:

MULTIPLIER 1M
FREQUENCY (Hz) 5
AMPLITUDE (Switch) 5
VERNIER .... cw
TRIGGER POLARITY .... (-)

b. Set the sampling oscilloscope controls as follows:

TIME/DIV .... 20 nSEC
MAIN SWEEP MAGNIFIER 2
MILLIVOLTS/DIV 50

c. Move the trigger pulse to the center of the CRT. The pulse amplitude should be 2 volts or more (4 divisions).

d. Adjust the sampling oscilloscope plug-in unit VERNIER for full-screen display (10 divisions). Observe the pulse width at 50% amplitude points. The pulse width should be approximately 10 ns (1 division).

e. Change the Model 211B TRIGGER POLARITY switch to (+). The pulse should be positive with the same specifications as in steps c and d above.

5-18. ADJUSTMENTS.

5-19. The Model 211B Square Wave Generator contains a number of selected components which are factory installed. Selected components are indicated in the Parts List (refer to Section VI) and on the schematics by (*). Table 5-3 lists the selected components, description, ranges and the reason and method of selection. If a unit cannot be adjusted to meet the performance tests after repair and/or component replacement, check Table 5-3 for possible replacement of a select component.

5-20. The following are factory adjustments and do not normally need readjusting. After instrument repair and/or component replacement, accomplish the performance

Table 5-3. Factory Selected Components

Ref. Desig.	Description	Reason and Method of Selection
A2C29	C: fxd. 22pF C: fxd. 24pF C: fxd. 27pF C: fxd. 30pF C: fxd. 33pF C: fxd. 36pF C: fxd. 39pF	Typical 22 pF. Selected to optimize output pulse shape. Selected with A2R84 (see elsewhere in this Table).
A2R9	R: fxd. 1300 ohms	Typical 1300 ohms: –20 V adjust is critical because of high Temp coef of R8, and its resistance must be kept low. R9 is also selectable because of VR2.
A2R18 & A2R48	R: fxd. 2400 ohms R: fxd. 2700 ohms R: fxd. 3000 ohms R: fxd. 3300 ohms R: fxd. 3600 ohms	R18 typical 2400 ohms: –70 V adjust is critical because of high Temp coef of R17, and its resistance must be kept low. R18 is also selected because of VR4. R48 typical 3300 ohms: Selected for small freq. change with Symmetry. Set Freq to 10 MHz. Turn Symmetry control cw to ccw. Monitor freq with counter. Freq should change less than ±5%.
A2R19	R: fxd. 560 ohms	Typical 560 ohms: Adjusts the mechanical potentiometer path of R2 to correspond with frequency dial.
A2R31	R: fxd. 46 ohms R: fxd. 51 ohms R: fxd. 56 ohms R: fxd. 62 ohms	Typical 56 ohms: Adjust for correct freq. Set Mult. Sw. to 1 MHz. Set Freq dial to 1. Adjust C9 for 1 MHz. Set Freq dial to 10. Select R31 for 10 MHz. Recheck C9 setting.
A2R32	R: fxd. 12 ohms Range 6 ohms to 18 ohms	Typical 12 ohms: Selected to meet freq specs on the 100K range.
A2R41	R: fxd. 91 kilohms R: fxd. 120 kilohms R: fxd. 150 kilohms R: fxd. 180 kilohms R: fxd. 200 kilohms R: fxd. 220 kilohms	Typical 200 kilohms: Selected for small freq change with Symmetry. Set Mult. sw. to 10K. Set Freq dial to 1. Turn Symmetry control cw to ccw. Monitor freq with counter. Change should be less than ±3%.
A2R84	R: fxd. 22 ohms R: fxd. 27 ohms R: fxd. 30 ohms R: fxd. 39 ohms R: fxd. 47 ohms R: fxd. 82 ohms R: fxd. 160 ohms	Typical 82 ohms: Selected to optimize output pulse shape. Selected with A2C29.

checks as outlined in Paragraphs 5-5 through 5-17. If an instrument does not meet the performance checks, proceed with the following adjustments. These adjustments must be performed in the sequence given below. See Figure 5-7 for locations of adjustments.

5-21. POWER SUPPLY ADJUSTMENT.

a. Use a digital voltmeter to make the following measurements and adjustments.

b. −20V SUPPLY. Measure from test point TP-20V on board assembly A2 to chassis. Adjust potentiometer A2R8 to obtain −20 volts. Vary the line voltage ±10% about the nominal input voltage. The −20 volts should not change more than ±200 millivolts.

c. −70V SUPPLY. Measure from test point TP-70V on board assembly A2 to chassis. Adjust potentiometer A2R17 to obtain −70 volts. Vary the line voltage ±10% about the nominal input voltage. The −70 volts should not change more than ±700 millivolts.

5-22. FREQUENCY ADJUSTMENT.

a. Connect the equipment as shown in Figure 5-2.

b. Set the Model 211B controls as follows:

MULTIPLIER 10K
FREQUENCY (Hz) 1
SYMMETRY .... approximately 50%
AMPLITUDE (switch) 5
VERNIER .... cw

c. Set the high-frequency oscilloscope controls as follows:

TIME/DIV 1MSEC
TRIGGER .... INT
MODE .... NORM
VOLTS/DIV (channel A) 2
POLARITY .... (+) UP
COUPLING .... DC
VOLTS/DIV (channel B) .... .05
COUPLING .... AC

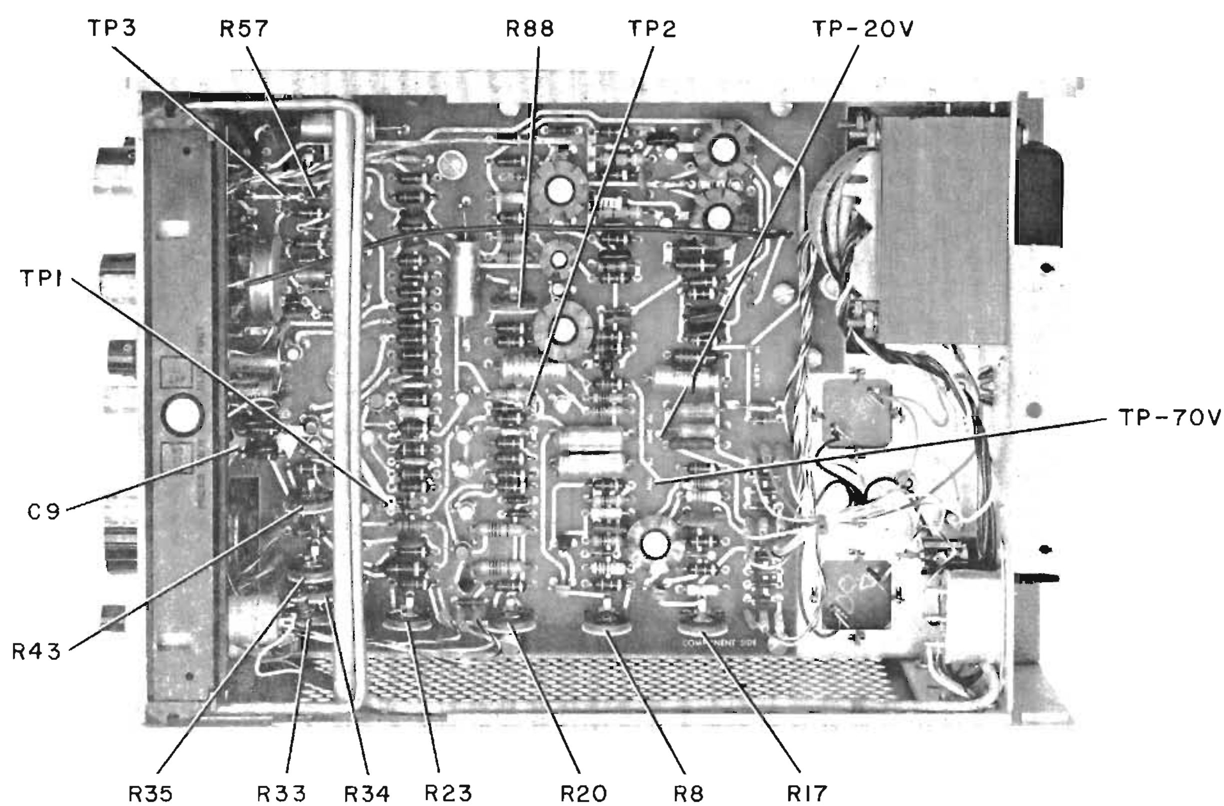


Figure 5-7. Component Adjustment Location

d. Measure the amplitude of the triangular waveform with the oscilloscope test probe at test point TP1 (located on board assembly A2). Adjust the amplitude of the waveform with A2R43 for 1.8 volts. Remove the probe.

e. Set the electronic counter controls as follows:

SIGNAL INPUT .... AC
SENSITIVITY (VOLTS RMS) 1V
TIME BASE .... .1 sec
FUNCTION .... FREQUENCY

f. Set the FREQUENCY (Hz) dial of the Model 211B to 10 and adjust A2R23 for 100 KHz ±1% as indicated on the electronic counter.

g. Set the FREQUENCY (Hz) dial of the Model 211B to 1 and adjust A2R20 for 10 KHz ±1% as indicated on the electronic counter.

h. Repeat steps (f) and (g) above if necessary, until both requirements are met.

i. Set FREQUENCY (Hz) dial of the Model 211B to 1 and the MULTIPLIER switch to 1M. Adjust capacitor A2C9 for 1 MHz ±1% as indicated on the electronic counter.

j. Set the FREQUENCY (Hz) dial of the Model 211B to 10 and check the frequency. The frequency should be 10 MHz ±4%. If difficulty is encountered, check A2R31 (refer to Table 5-3).

k. Set the electronic counter controls as indicated in Paragraph 5-8c. Set the Model 211B MULTIPLIER switch to 100 and the FREQUENCY (Hz) dial to 10.

WARNING

Potentiometers A2R33, A2R34, and A2R35 are directly beneath the AC Power Switch (S1). Extreme care should be taken when adjusting these resistors to avoid shock.

l. Adjust A2R35 for 983 usec as indicated on the electronic counter.

m. Set the Model 211B MULTIPLIER switch to 10 and adjust A2R34 for 9830 usec as indicated on the electronic counter.

n. Set the Model 211B MULTIPLIER switch to 1 and adjust A2R33 for 98300 usec as indicated on the electronic counter.

o. Set the Model 211B FREQUENCY (Hz) dial to 1 and check the 1, 10 and 100 MULTIPLIER ranges. The time change shall be less than ±5% on each range.

5-23. SYNCHRONIZATION ADJUSTMENT.

a. Measure the voltage at test point TP3 on the board assembly A2 with the dc voltmeter on the 0.1-volt range. Adjust A2R57 for an indication of 0 volt.

5-24. PULSE AMPLITUDE 600-OHM OUTPUT ADJUSTMENT.

a. Connect the equipment as shown in Figure 5-4.

b. Set the Model 211B MULTIPLIER switch to 10K, the FREQUENCY (Hz) dial to 10, the SYMMETRY control to 50% duty cycle, and the AMPLITUDE control (600-ohm) fully clockwise. Adjust A2R88 for greatest amplitude without distortion on the falltime.

CUT ALONG DOTTED LINE

PERFORMANCE CHECK RECORD

Serial Number ______________

Paragraph Reference	Check	Reference Standard	
		Required	Actual
5-8	Frequency Check	See Table 5-2	______
5-9	Symmetry Control Check		
	Duty Cycle Symmetry - CW	⩾75%	______
	Duty Cycle Symmetry - CCW	⩽25%	______
5-10	Synchronization Check		
	180° Phase shift - CW	50% duty cycle	______
	180° Phase shift - CCW	50% duty cycle	______
5-11	600-ohm Output		
	600-ohm output Voltage - no load	⩾ 60V	______
	600-ohm output Voltage - load	⩾ 30V	______
5-12	Risetime and Falltime 600-ohm output		
	Risetime (no load)	< 140 ns	______
	Falltime (no load)	< 140 ns	______
	Risetime (load)	< 70 ns	______
	Falltime (load)	< 70 ns	______
5-13	50-Ohm Output Check		
	Risetime (load)	< 5 ns	______
	Falltime (load)	< 5 ns	______
	Preshoot (leading edge)	⩽5%	______
	Overshoot (leading edge)	⩽5%	______
	Preshoot (trailing edge)	⩽5%	______
	Overshoot (trailing edge)	⩽5%	______

Paragraph Reference	Check	Reference Standard Required	Reference Standard Actual
5-14	Symmetry -10 MHz		
	Symmetry Control - ccw	Duty Cycle < 30%	________
	Symmetry Control - cw	Duty Cycle > 70%	________
5-15	Trigger Output Check		
	Amplitude (-) pulse	> 2 volts	________
	Pulse width -50% amplitude	10 ns	________
	Amplitude (+) pulse	> 2 volts	________
	Pulse width - 50% amplitude	10 ns Ref.	________

Comments:

CUT ALONG DOTTED LINE

SECTION VI

REPLACEABLE PARTS

6-1. INTRODUCTION.

6-2. This section contains information for ordering replacement parts. Table 6-2 lists the parts in alphanumeric order by reference designation. All chassis-mounted parts (assemblies and parts not mounted on assemblies) appear first, followed by each assembly with sub-assemblies (if any) and components mounted on that assembly. Reference designations for groups of identical items may be shown as TP1 - TP9 followed by a single part number and description indicating that TP1 through TP9 are separate but identical parts.

6-3. Parts consisting of several smaller, yet separately replaceable parts such as jacks or relays have all sub-parts listed so that partial replacement of these items can be accomplished. Miscellaneous parts which are not assigned reference designations appear at the end of the chassis parts listing and at the end of each assembly listing.

6-4. ORDERING INFORMATION.

6-5. Many parts used in Hewlett-Packard equipment are manufactured by HP or are selected by HP under specifications more rigid than the manufacturer's standard specifications. These parts must be ordered directly from Hewlett-Packard Company. Information concerning standard replaceable parts will be supplied upon request to allow procurement directly from the manufacturers. Contact the local HP Sales/Service Office for details.

6-6. To obtain replacement parts from HP, address order or inquiry to the nearest Hewlett-Packard Sales/Service Office (names and addresses in rear of manual), and supply the following information:

a. HP Part number of item(s).

b. Model number and nine-digit serial number of instrument.

c. Quantity of part(s) desired.

6-7. To order a part not listed in the table, provide the following information:

a. Model number and nine-digit serial number of the instrument.

b. Description of the part including function and location in the instrument.

Table 6-1. Reference Designators and Abbreviations

REFERENCE DESIGNATORS

A	= assembly	E	= misc. electronic part	M	= meter	TB	= terminal board
AT	= attenuator, resistive termination	F	= fuse	MP	= mechanical part	TP	= test point
		FL	= filter	P	= plug	U	= microcircuit(non-repairable)
B	= motor, fan	H	= hardware	PS	= power supply	V	= vacuum tube, neon bulb, photocell, etc.
C	= capacitor	IC	= integrated circuit	Q	= transistor		
CP	= coupling	J	= jack	R	= resistor	VR	= voltage regulator (diode)
CR	= diode	K	= relay	RT	= thermistor	W	= cable
DL	= delay line	L	= inductor	S	= switch	X	= socket
DS	= device signaling (lamp)	LS	= speaker	T	= transformer	Y	= crystal

ABBREVIATIONS

A	= ampere(s)	Ge	= germanium	minat	= miniature	s-b	= slow-blow
ampl	= amplifier(s)	G	= giga (10^9)	mom.	= momentary	Se	= selenium
assy	= assembly	gl	= glass	mtg	= mounting	sect	= section(s)
		grd	= ground(ed)	my.	= mylar	semicon	= semiconductor(s)
bd	= board(s)					Si	= silicon
bp	= bandpass	H	= henry(ies)	n	= nano (10^{-9})	sil	= silver
		Hg	= mercury	n/c	= normally closed	sl	= slide
c	= centi (10^{-2})	hr	= hour(s)	Ne	= neon	sp	= single pole
car.	= carbon	HP	= Hewlett-Packard	n/o	= normally open	spl	= special
ccw	= counterclockwise	Hz	= hertz	npo	= negative positive zero (zero temperature coefficient)	st	= single throw
cer	= ceramic					std	= standard
coax.	= coaxial	if.	= intermediate freq				
coef	= coefficient	impg	= impregnated	nsr	= not separately replaceable	Ta	= tantalum
com	= common	incd	= incandescent			td	= time delay
comp	= composition	incl	= include(s)			TD	= tunnel diode(s)
conn	= connector(s)	ins	= insulation(ed)	obd	= order by description	tgl	= toggle
CRT	= cathode-ray tube	int	= internal	ox	= oxide	Ti	= titanium
cw	= clockwise					tol	= tolerance
d	= deci (10^{-1})	k	= kilo (10^3)	p	= pico (10^{-12})	trim.	= trimmer
depc	= deposited carbon			pc	= printed (etched) circuit(s)		
dp	= double pole	lb	= pound(s)	PGM	= program	u	= micro (10^{-6})
dt	= double throw	lev	= lever	piv	= peak inverse voltage(s)		
		lin	= linear taper	p/o	= part of	V	= volt(s)
elect.	= electrolytic	log.	= logarithmic taper	poly	= polystyrene	var	= variable
encap	= encapsulated	lpf	= low-pass filter(s)	porc	= porcelain		
ext	= external			pos	= position(s)	W	= watt(s)
		m	= milli (10^{-3})	pot.	= potentiometer(s)	w/	= with
F	= farad(s)	M	= mega (10^6)	pk-pk	= peak-to-peak	w/o	= without
fet	= field-effect transistor(s)	metflm	= metal film	rect	= rectifier(s)	wVdc	= dc working volt(s)
fxd	= fixed	metox	= metal oxide	rf	= radio frequency	ww	= wirewound

Table 6-2. Replaceable Parts

Ref Desig	HP Part No.	TQ	Description (See Table 6-1.)
			CHASSIS
C1	0180-0047	1	C: fxd elect. 500 uF 75 wVdc
C2	0180-0214	1	C: fxd elect. 275 uF -10% +50% 200 wVdc
C3	0150-0093	7	C: fxd cer 0.01 uF +80% -20% 100 wVdc
DS1		1	DS: p/o S1
E1	1200-0081	4	E: Bushing, transistor
E2	1200-0043	2	E: Insulator Q
E3	1200-0077	2	E: Insulator Q
F1	2110-0008	1	F: Cart, s-b 1/2A 125V
	2110-0018	1	F: Cart, s-b 1/2A (230V operation)
H1	5040-0700	2	H: Hinge
H2	0360-0037	2	H: lug, solder
J1	1251-0148	1	J: Conn ac pwr
J2	1250-0083	3	J: Conn BNC
J3	1250-0083		J: Conn BNC
J4	1250-0140	1	J: Conn BNC
J5	1250-0083		J: Conn BNC
MP1	1200-0063	2	MP: clip, transistor Q3 and Q4
MP2	5000-0717	1	MP: cover, bottom
MP3	5000-0567	2	MP: cover, side, perforated
MP4	5060-0718	1	MP: cover top
MP5	7100-0389	1	MP: cover, transformer T1
MP6	3130-0038	1	MP: coupler, switch, .045 diam
MP7	1205-0008	2	MP: Dissipator, Heat, Q3 and Q4
MP8	00211-64001	1	MP: Knob assy
MP9	0370-0077	1	MP: Knob, blk w/arrow (Ampl 50-ohm)
MP10	0370-0084	2	MP: Knob, blk w/arrow (Ampl 600-ohm; Vernier)
MP11	0370-0099	1	MP: Knob, round (Multiplier)
MP12	0370-0134	1	MP: Knob, red (Symmetry)
MP13	1205-0007	2	MP: Nut, dissipator, heat, Q3 and Q4
MP14	0900-0016	1	MP: O ring, rubber
MP15	1490-0032	1	MP: Stand, tilt
Q1	1850-0098	2	Q: Ge pnp
Q2	1850-0098		Q: Ge pnp
Q3	1854-0090	2	Q: Si npn
Q4	1854-0090		Q: Si npn
R1	0757-0092	1	R: fxd metox 33 kilohms 2% 1/2W
R2	2100-0535	1	R: var 10 kilohms 10% 2W
R3	2100-0519	1	R: var 2 x 1000 ohms 3%
R4	2100-0036	1	R: var 1000 ohms 20% 1/2W
R5	0683-2035	1	R: fxd comp 20 kilohms 5% 1/4W
R6	2100-0075	1	R: var 2 x 1200 ohms 10%

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

Ref Desig	HP Part No.	TQ	Description (See Table 6-1.)
			CHASSIS (CONT'D)
S1	3101-0100	1	S: push, SPDT 5A, 125V
S2	3100-0033	1	S: slide, DPDT, non-shocking, .5A, 125V
S3		1	S: p/o S5
S4	3101-0011	1	S: slide, non-shorting, .5A, 125V
S5	3100-0507	1	S: rotary
T1	9100-0517	1	T: transformer, power
W1	8120-0078	1	W: Cable assy, input power
XF1	1400-0084	1	XF: extractor, post-type
			A1
A1	00211-63401	1	A: Attenuator assy
A1R1	0757-0172	1	R: fxd metflm 37.4 ohms 1% 1/2W
A1R2	0757-0801	2	R: fxd metflm 150 ohms 1% 1/2W
A1R3	0757-0801		R: fxd metflm 150 ohms 1% 1/2W
A1R4	0757-0069	1	R: fxd metflm 121 ohms 1% 1/4W
A1R5	0757-0795	2	R: fxd metflm 75 ohms 1% 1/2W
A1R6	0757-0795		R: fxd metflm 75 ohms 1% 1/2W
A1R7	0757-0071	1	R: fxd metflm 247.5 ohms 1% 1/2W
A1R8	0757-1005	2	R: fxd metflm 61.11 ohms 1/4% 1/2W
A1R9	0757-1005		R: fxd metflm 61.11 ohms 1/4% 1/2W
A1S1		1	S: Switch NSR Part of A1 assembly
A1W1	00211-61606	1	W: Cable assembly input
A1W2	00211-61607	1	W: Cable assembly output
			A2
A2	00211-66501	1	A: Printed Circuit Board
A2C1	0180-0049	3	C: fxd Alum 20 uF -10+75% 50 wVdc
A2C2	0180-0049		C: fxd Alum 20 uF -10+75% 50 wVdc
A2C3	0180-0291	9	C: fxd Ta 1 uF 10% 35 wVdc
A2C4	0150-0121	1	C: fxd cer 0.1 uF -20% +80% 50 wVdc
A2C5	0180-0049		C: fxd Alum 20 uF -10+75% 50 wVdc
A2C6	0150-0096	1	C: fxd cer 0.05 uF 20% 100 wVdc
A2C7	0180-0291		C: fxd Ta 1 uF 10% 35 wVdc
A2C8	0140-0194	1	C: fxd mica 110 pF 5% 300 wVdc
A2C9	0121-0046	1	C: var cer 9-35 pF
A2C10	0140-0147	1	C: fxd mica 180 pF 5% 500 wVdc

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

Ref Desig	HP Part No.	TQ	Description (See Table 6-1.)
			A2 (CONT'D)
			NOTE: (*) indicates selected value.
A2C11	0180-0137	1	C: fxd Ta 100 uF 20% 10 wVdc
A2C12	0180-0374	1	C: fxd Ta 10 uF 10% 20 wVdc
A2C13	0180-0291		C: fxd Ta 1 uF 10% 35 wVdc
A2C14	0160-0503	1	C: fxd polycarb 0.22 uF 2% 160 wVdc
A2C15	0160-0504	1	C: fxd polycarb 22 nF 1% 400 wVdc
A2C16	0140-0180	1	C: fxd mica 2000 pF 2% 300 wVdc
A2C17	0150-0093		C: fxd cer 0.01 uF -20% +80% 100 wVdc
A2C18	0180-0094	3	C: fxd Alum. 100 uF -10+75% 25 wVdc
A2C19	0150-0071	1	C: fxd cer 400 pF 5% 500 wVdc
A2C20	0180-0291		C: fxd Ta 1 uF 10% 35 wVdc
A2C21	0180-0291		C: fxd Ta 1 uF 10% 35 wVdc
A2C22	0180-0094		C: fxd Alum 100 uF -10+75% 25 wVdc
A2C23	0180-0094		C: fxd Alum 100 uF -10+75% 25 wVdc
A2C24	0150-0093		C: fxd cer 0.01 uF -20% +80% 100 wVdc
A2C25	0180-0291		C: fxd Ta 1 uF 10% 35 wVdc
A2C26	0140-0201	1	C: fxd mica 12 pF 5% 500 wVdc
A2C27	0150-0064	1	C: fxd cer 15 pF 5% 500 wVdc
A2C28	0150-0093		C: fxd cer 0.01 uF -20% +80% 100 wVdc
A2C29*	0140-0145	1	C: fxd mica 22 pF 5% 500 wVdc
A2C30	0180-0291		C: fxd Ta 1 uF 10% 35 wVdc
A2C31	0180-0291		C: fxd Ta 1 uF 10% 35 wVdc
A2C32	0180-0291		C: fxd Ta 1 uF 10% 35 wVdc
A2C33	0150-0093		C: fxd cer 0.01 uF -20% +80% 100 wVdc
A2C34	0150-0093		C: fxd cer 0.01 uF -20% +80% 100 wVdc
A2C35	0180-0091	1	C: fxd Alum 10 uF -10+50% 100 wVdc
A2C36	0150-0079	2	C: fxd cer 3.3 nF 10% 500 wVdc
A2C37	0150-0079		C: fxd cer 3.3 nF 10% 500 wVdc
A2C38	0150-0093		C: fxd cer 0.01 uF -20% +80% 100 wVdc
A2CR1	1901-0158	4	CR: Si
A2CR2	1901-0158		CR: Si
A2CR3	1901-0158		CR: Si
A2CR4	1901-0158		CR: Si
A2CR5	1901-0029	4	CR: Si
A2CR6	1901-0029		CR: Si
A2CR7	1901-0029		CR: Si
A2CR8	1901-0029		CR: Si
A2CR9	1901-0025	2	CR: Si
A2CR10	1901-0025		CR: Si
A2CR11	1901-0040	6	CR: Si
A2CR12	1901-0040		CR: Si
A2CR13	1910-0016	4	CR: Ge
A2CR14	1910-0016		CR: Ge
A2CR15	1910-0016		CR: Ge

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

Ref Desig	HP Part No.	TQ	Description (See Table 6-1.)
			A2 (CONT'D)
A2CR16	1910-0016		CR: Ge
A2CR17	1901-0040		CR: Si
A2CR18	1901-0040		CR: Si
A2CR19	1901-0040		CR: Si
A2CR20	1901-0040		CR: Si
A2CR21	1901-0050	1	CR: Si
A2L1	9140-0111	1	L: fxd rf 3.3 uH
A2L2	9170-0016	7	L: Bead, ferrite
A2L3	9140-0096	1	L: fxd rf 1 uH
A2L4	9170-0016		L: Bead, ferrite
A2L5	9170-0016		L: Bead, ferrite
A2L6	9170-0016		L: Bead, ferrite
A2L7	9170-0016		L: Bead, ferrite
A2L8	9170-0016		L: Bead, ferrite
A2L9	9170-0016		L: Bead, ferrite
A2Q1	1853-0029	4	Q: Si pnp
A2Q2	1853-0029		Q: Si pnp
A2Q3	1853-0001	2	Q: Si pnp
A2Q4	1853-0029		Q: Si pnp
A2Q5	1854-0071	3	Q: Si npn
A2Q6	1854-0019	8	Q: Si npn
A2Q7	1853-0009	5	Q: Si pnp
A2Q8	1854-0019		Q: Si npn
A2Q9	1853-0009		Q: Si pnp
A2Q10	1853-0029		Q: Si pnp
A2Q11	1854-0071		Q: Si npn
A2Q12	1854-0019		Q: Si npn
A2Q13	1854-0019		Q: Si npn
A2Q14	1854-0009	2	Q: Si npn 2N709
A2Q15	1854-0009		Q: Si npn 2N709
A2Q16	1854-0005	4	Q: Si npn 2N708
A2Q17	1854-0005		Q: Si npn 2N708
A2Q18	1853-0009		Q: Si pnp
A2Q19	1854-0005		Q: Si npn 2N708
A2Q20	1854-0005		Q: Si npn 2N708
A2Q21	1854-0019		Q: Si npn
A2Q22	1854-0019		Q: Si npn
A2Q23	1853-0009		Q: Si pnp
A2Q24	1853-0009		Q: Si pnp
A2Q25	1854-0019		Q: Si npn

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

Ref Desig	HP Part No.	TQ	Description (See Table 6-1.)
			A2 (CONT'D)
			NOTE: (*) indicates selected value.
A2Q26	1853-0012	1	Q: Si pnp 2N2904A
A2Q27	1854-0071		Q: Si npn
A2Q28	1853-0001		Q: Si pnp
A2Q29	1854-0267	2	Q: Si npn
A2Q30	1854-0267		Q: Si npn
A2Q31	1854-0019		Q: Si npn
A2Q32	1854-0091	2	Q: Si npn
A2Q33	1854-0091		Q: Si npn
A2R1	0758-0003	8	R: fxd metox 1000 ohms 5% 1/2W
A2R2	0757-0080	3	R: fxd metox 4700 ohms 5% 1/2W
A2R3	0758-0003		R: fxd metox 1000 ohms 5% 1/2W
A2R4	0813-0050	2	R: fxd ww 100 ohms 5% 3W
A2R5	0813-0050		R: fxd ww 100 ohms 5% 3W
A2R6	0758-0004	1	R: fxd metox 2700 ohms 5% 1/2w
A2R7	0758-0034	2	R: fxd metox 2400 ohms 5% 1/2W
A2R8	2100-0520	5	R: var 250 ohms 20% 1/8W
A2R9*	0758-0042	1	R: fxd metox 1300 ohms 5% 1/2W
A2R10	0761-0005	1	R: fxd metox 2200 ohms 5% 1W
A2R11	0812-0012	1	R: fxd ww 18 ohms 5% 3W
A2R12	0758-0048	1	R: fxd metox 8200 ohms 5% 1/2W
A2R13	0758-0008	3	R: fxd metox 390 ohms 5% 1/2W
A2R14	0758-0028	6	R: fxd metox 270 ohms 5% 1/2W
A2R15	0758-0006	3	R: fxd metox 10 kilohms 5% 1/2W
A2R16	0757-0080		R: fxd metox 4700 ohms 5% 1/2W
A2R17	2100-0520		R: var 250 ohms 20% 1/8W
A2R18*	0758-0034		R: fxd metox 2400 ohms 5% 1/2W
A2R19*	0758-0028		R: fxd metox 270 ohms 5% 1/2W
A2R20	2100-0520		R: var 250 ohms 20% 1/8W
A2R21	0683-1025	2	R: fxd metox 1000 ohms 5% 1/4W
A2R22	0758-0018	1	R: fxd metox 15 kilohms 5% 1/2W
A2R23	2100-0521	5	R: var 5000 ohms 30% 1/8W
A2R24	0757-0159	2	R: fxd metox 1000 ohms 1% 1/2W
A2R25	0757-0159		R: fxd metox 1000 ohms 1% 1/2W
A2R26	0758-0028		R: fxd metox 270 ohms 5% 1/2W
A2R27	0758-0028		R: fxd metox 270 ohms 5% 1/2W
A2R28	0758-0028		R: fxd metox 270 ohms 5% 1/2W
A2R29	0758-0028		R: fxd metox 270 ohms 5% 1/2W
A2R30	0758-0035	2	R: fxd metox 3000 ohms 5% 1/2W
A2R31*	0758-0093	1	R: fxd metox 56 ohms 5% 1/2W
A2R32	0683-1205	1	R: fxd comp 12 ohms 5% 1/4W
A2R33	2100-0521		R: var 5000 ohms 30% 1/8W
A2R34	2100-0521		R: var 5000 ohms 30% 1/8W
A2R35	2100-0521		R: var 5000 ohms 30% 1/8W

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

Ref Desig	HP Part No.	TQ	Description (See Table 6-1.)
			A2 (CONT'D)
			NOTE: (*) indicates selected value.
A2R36	0758-0007		R: fxd metox 150 ohms 5% 1/2W
A2R37	0758-0044	3	R: fxd metox 2200 ohms 5% 1/2W
A2R38	0761-0057	1	R: fxd metox 560 ohm 5% 1W
A2R39	0758-0071	1	R: fxd metox 4300 ohms 5% 1/2W
A2R40	0758-0057	1	R: fxd metox 5600 ohms 5% 1/2W
A2R41*	0758-0129	1	R: fxd metox 200 kilohms 5% 1/2W
A2R42	0758-0008		R: fxd metox 390 ohms 5% 1/2W
A2R43	2100-0520		R: var 250 ohms 20% 1/8W
A2R44	0757-0074	1	R: fxd metox 430 ohms 5% 1/2W
A2R45	0758-0082	1	R: fxd metox 130 ohms 5% 1/2W
A2R46	0698-5886	1	R: fxd metox 27 ohms 5% 1/2W
A2R47	0758-0041	1	R: fxd metox 91 ohms 5% 1/2W
A2R48*	0758-0010	2	R: fxd metox 3300 ohms 5% 1/2W
A2R49	0757-0076	2	R: fxd metox 560 ohms 2% 1/2W
A2R50	0758-0007	3	R: fxd metox 150 ohms 5% 1/2W
A2R51	0757-0080		R: fxd metox 4700 ohms 5% 1/2W
A2R52	0698-5887		R: fxd metox 30 ohms 5% 1/2W
A2R53	0757-0086	2	R: fxd metox 51 ohms 5% 1/2W
A2R54	0757-0086		R: fxd metox 51 ohms 5% 1/2W
A2R55	0758-0032	1	R: fxd metox 820 ohms 5% 1/2W
A2R56	0758-0006		R: fxd metox 10 kilohms 5% 1/2W
A2R57	2100-0521		R: var 5000 ohms 30% 1/8W
A2R58	0758-0010		R: fxd metox 3300 ohms 5% 1/2W
A2R59	0758-0078	1	R: fxd metox 13 kilohms 5% 1/2W
A2R60	0758-0043	2	R: fxd metox 1800 ohms 5% 1/2W
A2R61	0758-0045	1	R: fxd metox 3900 ohms 5% 1/2W
A2R62	0698-5884	2	R: fxd metox 22 ohms 5% 1/2W
A2R63	0757-0076		R: fxd metox 560 ohms 2% 1/2W
A2R64	0758-0003		R: fxd metox 1000 ohms 5% 1/2W
A2R65	0683-2225	1	R: fxd metox 2200 ohms 5% 1/4W
A2R66	0758-0003		R: fxd metox 1000 ohms 5% 1/2W
A2R67	0698-5887	3	R: fxd metox 30 ohms 5% 1/2W
A2R68	0758-0003		R: fxd metox 1000 ohms 5% 1/2W
A2R69	0698-5887		R: fxd metox 30 ohms 5% 1/2W
A2R70	0758-0024	1	R: fxd metox 100 ohms 5% 1/2W
A2R71	0758-0035		R: fxd metox 3000 ohms 5% 1/2W
A2R72	0758-0008		R: fxd metox 390 ohms 5% 1/2W
A2R73	0758-0043		R: fxd metox 1800 ohms 5% 1/2W
A2R74	0758-0003		R: fxd metox 1000 ohms 5% 1/2W
A2R75*	0758-0029	1	R: fxd metox 470 ohms 5% 1/2W
A2R76	0758-0044		R: fxd metox 2200 ohms 5% 1/2W
A2R77	0758-0003		R: fxd metox 1000 ohms 5% 1/2W
A2R78	0683-1025		R: fxd metox 1000 ohms 5% 1/4W

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

Ref Desig	HP Part No.	TQ	Description (See Table 6-1.)
			A2 (CONT'D)
			NOTE: (*) indicates selected value.
A2R79	0758-0096	1	R: fxd metox 110 ohms 5% 1/2W
A2R80	0757-0171	1	R: fxd metox 120 ohms 5% 1/2W
A2R81	0758-0044		R: fxd metox 2200 ohms 5% 1/2W
A2R82	0761-0041	2	R: fxd metox 56 ohms 5% 1W
A2R83	0761-0041		R: fxd metox 56 ohms 5% 1W
A2R84*	0758-0026	1	R: fxd metox 82 ohms 5% 1/2W
A2R85	0757-0198	2	R: fxd metox 100 ohms 1% 1/2W
A2R86	0757-0198		R: fxd metox 100 ohms 1% 1/2W
A2R87	0758-0015	1	R: fxd metox 220 ohms 5% 1/2W
A2R88	2100-0520		R: var 250 ohms 20% 1/8W
A2R89	0758-0003		R: fxd metox 1000 ohms 5% 1/2W
A2R90	0758-0073	1	R: fxd metox 24 kilohms 5% 1/2W
A2R91	0758-0006		R: fxd metox 10 kilohms 5% 1/2W
A2R92	0758-0031	1	R: fxd metox 680 ohms 5% 1/2W
A2R93	0698-5137	1	R: fxd metox 47 ohms 5% 1/2W
A2R94	0698-5890	2	R: fxd metox 39 ohms 5% 1/2W
A2R95	0698-5890		R: fxd metox 39 ohms 5% 1/2W
A2R96	0758-0007		R: fxd metox 150 ohms 5% 1/2W
A2R97	0758-0012	1	R: fxd metox 12 kilohms 5% 1/2W
A2RT1	0837-0502	1	RT: Thermistor 130 ohms 20% 1/2W
A2RT2	0837-0501	1	RT: Thermistor 50 ohms 20% 1W
A2VR1	1902-0048	3	CR: Brkdwn 6.81V 5% 400 mW
A2VR2	1902-0048		CR: Brkdwn 6.81V 5% 400 mW
A2VR3	1902-3256	2	CR: Brkdwn 23.7V 5% 400 mW
A2VR4	1902-3256		CR: Brkdwn 23.7V 5% 400 mW
A2VR5	1902-0074	1	CR: Brkdwn 7.15V 5% 400 mW
A2VR6	1902-0048		CR: Brkdwn 6.81V 5% 400 mW
A2VR7	1902-0188	1	CR: Brkdwn 4.12V 5% 400 mW
A2VR8	1902-3125	1	CR: Brkdwn 6.98V 2% 400 mW
A2VR9	1902-3105	1	CR: Brkdwn 5.62V 2% 400 mW
A2VR10	1902-0173	1	CR: Brkdwn 9.53V 5% 400 mW

SECTION VII

MANUAL CHANGES AND OPTIONS

7-1. MANUAL CHANGES.

7-2. This manual applies directly to the standard Model 211B having a serial prefix as listed on the title page of this manual. The following paragraphs provide instructions for modifying the manual to cover older instruments. Refer to the separate MANUAL CHANGES sheet supplied with this manual for newer instruments and errata.

7-3. OLDER INSTRUMENTS.

7-4. Table 7-1 lists the changes required to adapt this manual to an older instrument. Check Table 7-1 for the proper instrument serial prefix and make the changes indicated. Note that these changes adapt the manual to cover a particular instrument as manufactured and do not apply to an instrument subsequently modified in the field.

7-5. OPTIONS.

7-6. Options for an HP instrument are standard modifications installed at the factory. At the present time, no options are offered for the Model 211B.

7-7. SPECIAL INSTRUMENTS.

7-8. Modified versions (per customer's specifications) of any HP instrument are available on special order. The manual for these special instruments (having electrical modifications) will include a separate insert sheet that describes the modification and any special manual changes in addition to the MANUAL CHANGES sheet (if applicable). Contact the nearest HP Sales/Service Office if either of these sheets is missing from the manual of a special instrument by its full specification name and number.

Table 7-1 Manual Changes

Serial Prefix	Make Changes
No backdating changes are required at this time.	

Table 8-1. Schematic Notes

Refer to MIL-STD-15-1A for schematic symbols not listed in this table.

= Etched circuit board

= Front panel marking

= Rear panel marking

= Front panel control

= Screwdriver adjustment

P/O = Part of

CW = Clockwise end of variable resistor

N C = No connection

= Waveform test point (with number)

= Common electrical point (with letter) not necessarily ground

= Single pin connector on board

= Pin of a plug-in board (with letter or number)

= Main signal path

= Primary feedback path

= Secondary feedback path

* = Optimum value selected at factory, average value shown; part may have been omitted.

= Field effect transistor (N-channel)

= Breakdown diode

= Tunnel diode

= Step recovery diode

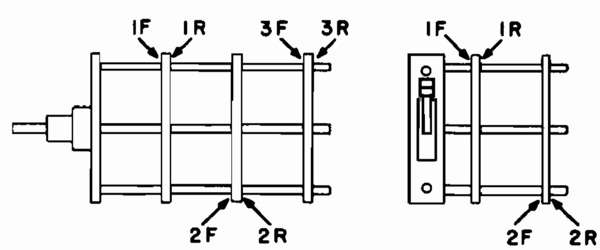
= Circuits or components drawn with dashed lines (phantom) show function only and are not intended to be complete. The circuit or component is shown in detail on another schematic.

Unless otherwise indicated:
resistance in ohms
capacitance in picofarads
inductance in microhenries

Wire colors are given by numbers in parentheses using the resistor color code [(925) is wht-red-grn].

0 - Black	5 - Green
1 - Brown	6 - Blue
2 - Red	7 - Violet
3 - Orange	8 - Gray
4 - Yellow	9 - White

Switch wafers are identified as follows:



SECTION VIII

SCHEMATICS AND TROUBLESHOOTING

8-1. INTRODUCTION.

8-2. This section contains schematics, repair and replacement information, component identification illustrations and troubleshooting tips. Figures 8-1 through 8-4 provide a guide to locating common problems. Table 8-1 defines symbols and conventions used on the schematics.

8-3. REFERENCE DESIGNATIONS.

8-4. The unit system of reference designations used in this manual is in accordance with the provisions of the USA Standard document USAS Y32.16, dated March, 1968. Minor variations due to design and manufacturing practices not specifically covered by the standard may be noted.

8-5. Each electrical component is identified by a class letter and number. This letter-number combination is the basic designation for each component. Components which are separately replaceable and are part of an assembly have, in addition to the basic designation, a prefix designation indicating the assembly on which the component is physically located. Components not located on an assembly will have only the basic designation and are listed in the replaceable parts list (Section VI) under Chassis Parts.

8-6. All components within the shaded areas on the schematics are physically located on etched circuit boards and should be prefixed with the assembly number assigned to the particular board (e.g., resistor R23 on assembly A2 is referred to as A2R23). There may also be an R23 on several other assemblies but the assembly designation will always be different (A3R23, A9R23, etc).

8-7. COMPONENT IDENTIFICATION.

8-8. Locations of components on etched circuit boards are illustrated in photographs adjacent to the schematics. Since the schematics are drawn to show function, a particular etched circuit board assembly may be shown on several schematics. The component-identification photograph is located next to the schematic that shows most of the circuitry. Components located on the chassis are identified in Figure 8-5 and Figure 8-6.

8-9. REPAIR AND REPLACEMENT.

8-10. Most electrical components are accessible from the component side of the etched circuit board. Section VI provides a detailed parts list for use in ordering replacement parts. If satisfactory repair cannot be made, contact the nearest Hewlett-Packard Sales/Service Office (address at rear of manual). If shipment for repair is recommended, refer to Section II for repackaging and shipping instructions.

8-11. SERVICING ETCHED CIRCUIT BOARDS.

8-12. The Model 211B has the plated-through type etched circuit boards. When servicing this type of board, components may be removed or replaced by unsoldering from either side of the board. When removing large components such as potentiometers, rotate the soldering iron tip from lead to lead while applying pressure to the part to lift it from the board. HP Service Note M-20D contains additional information on the repair of etched circuit boards. The important considerations are as follows:

a. Do not apply excessive heat.

b. Apply heat to component lead and remove lead with a straight pull away from the board.

c. Use a toothpick or wooden splinter to clean hole.

d. Do not force leads of replacement components into holes.

8-13. If the plated metal surface (conductor) lifts from the board, it may be cemented back with a quick-drying acetate-base cement (used sparingly) having good insulating properties. An alternate method of repair is to solder a good conducting wire along the damaged area.

8-14. TROUBLESHOOTING.

8-15. The most important prerequisite for successful troubleshooting is an understanding of how the instrument is designed to operate and correct usage of front-panel controls. Often suspected malfunctions are caused by improper control settings. Operation Section III which provides an explanation of controls and connectors and general operating considerations, and Principles of Operation Section IV which explains circuit theory are intended to satisfy this information requirement.

8-16. After ensuring that the malfunction is not the result of improper control settings,proceed as follows:

a. Visually inspect the instrument for loose or broken wires, charred or discolored components and any other indications of physical damage.

b. Use the troubleshooting trees and waveform chart in conjunction with schematics to isolate the malfunctioning component.

8-17. FREQUENCY CONTROL NETWORK. When the frequency control network fails to free-run, there are no waveforms to monitor, and the oscilloscope cannot be used as a troubleshooting instrument. The most effective method of troubleshooting the frequency control network in this condition is to determine which of the two states the Schmitt trigger is in and measure the dc voltages around the circuits. Table 8-2 lists the voltages of the frequency control circuits with the Schmitt trigger locked in one condition (either Q14 or Q15 emitter opened). When an erroneous voltage is located, basic troubleshooting procedures should be used to determine the exact cause.

8-18. D.C. VOLTAGES. DC voltages are indicated on some of the schematics for active components (transistors, etc). Control test conditions for making the voltage measurements are listed adjacent to each schematic. Since the conditions for making these measurements may differ from one circuit to another, always check the specific conditions listed adjacent to the schematic.

8-19. WAVEFORMS. Typical waveform measurement points (▽ with a number enclosed) are placed on the schematics along main signal paths. The numbers inside the measurement point symbols (▽) are keyed to corresponding waveforms adjacent to each schematic.

Note

Test points are also shown on the schematics with this symbol (TP ◎). Test points correspond to pins protruding from the etched circuit board and do not necessarily correspond to waveform measurement points.

8-20. Conditions for making the waveform measurements are also listed adjacent to each schematic and like the dc voltage measurement conditions may vary slightly from one circuit to another.

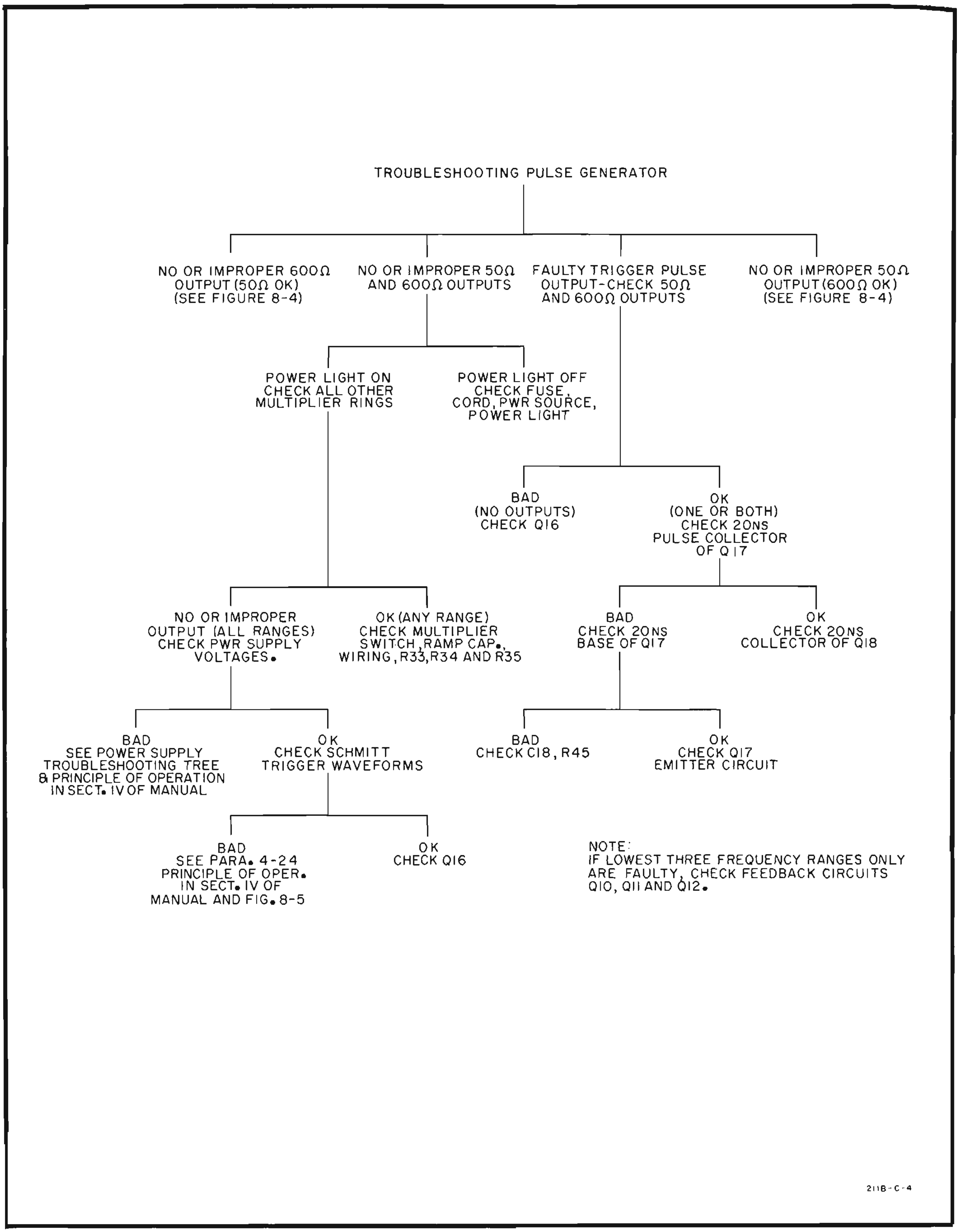


Figure 8-1. Pulse Generator Troubleshooting Tree

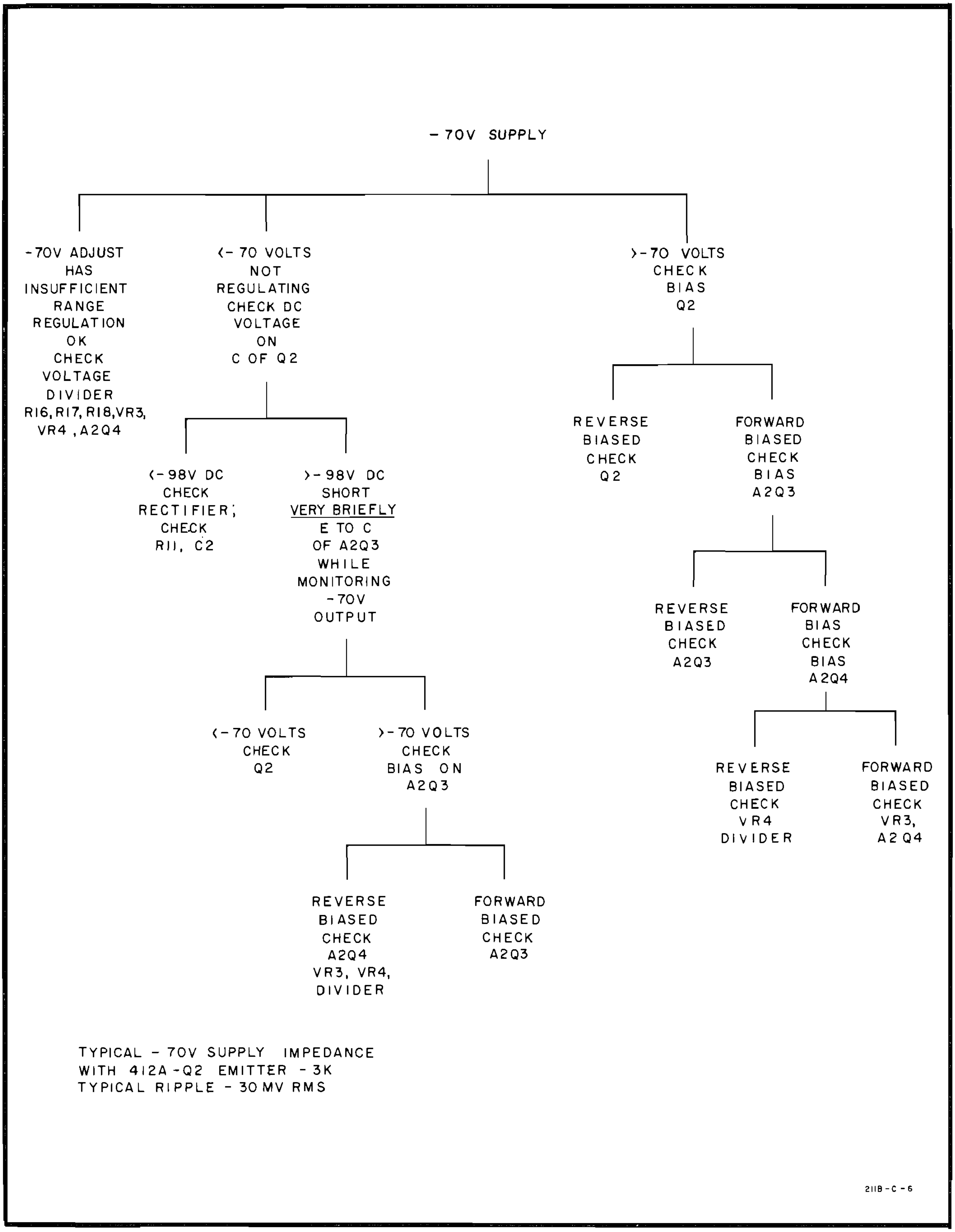


Figure 8-2. —70—Volts Supply Troubleshooting Tree

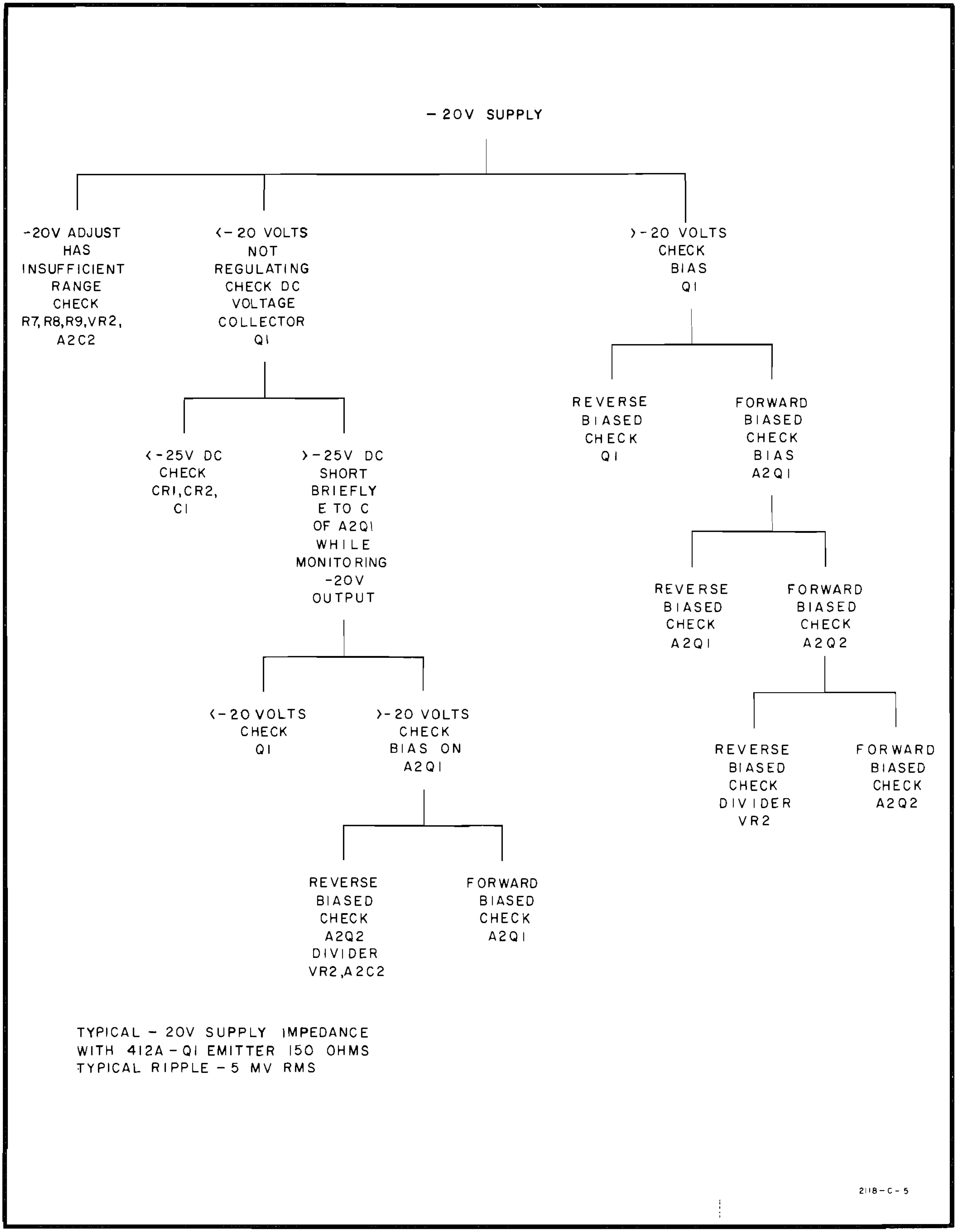


Figure 8-3. –20– Volts Supply Troubleshooting Tree

IMPROPER 50 OHM OUTPUT
(600 OHM OUTPUT OK)

- CHECK FOR DEFECTIVE RANGE ON AMPLIFIER SWITCH S6
  - NO OR IMPROPER OUTPUT (ALL RANGES) CHECK DC VOLTS SWING ON BASES OF Q32 & Q33 WHEN GAIN VERNIER IS ROTATED -12V TO -17V
    - WRONG VOLTAGE CHECK Q27,Q28
    - OK CHECK WAVEFORM ON C OF Q25
      - BAD CHECK WAVEFORM ON C OF Q23
        - BAD CHECK Q23,CR19
        - OK CHECK Q25
      - OK CHECK WAVEFORM ON C'S OF Q29 & Q30
        - BAD CHECK Q29 & Q30
        - OK CHECK Q32 & Q33
  - HAVE OUTPUT (ANY RANGE) CHECK FOR BROKEN WIRES, BAD CONTACTS, BAD RESISTORS ON S6

NO OR IMPROPER 600 OHM OUTPUT
(50 OHM OUTPUT OK)

- CHECK WAVEFORM ON C OF Q26
  - BAD CHECK WAVEFORM ON C OF Q24 AMPLIFIER APPROXIMETLY 1.6V P TO P
    - BAD CHECK Q24,R88 MULTIPLIER SWITCH S5
    - OK CHECK Q26,VR10,RT2
  - OK CHECK WAVEFORM ON C OF Q31
    - BAD CHECK Q31
    - OK CHECK Q3,Q4,R6A & B

2118-C-3

Figure 8-4. 50 Ohms—600 Ohms Output Troubleshooting Tree

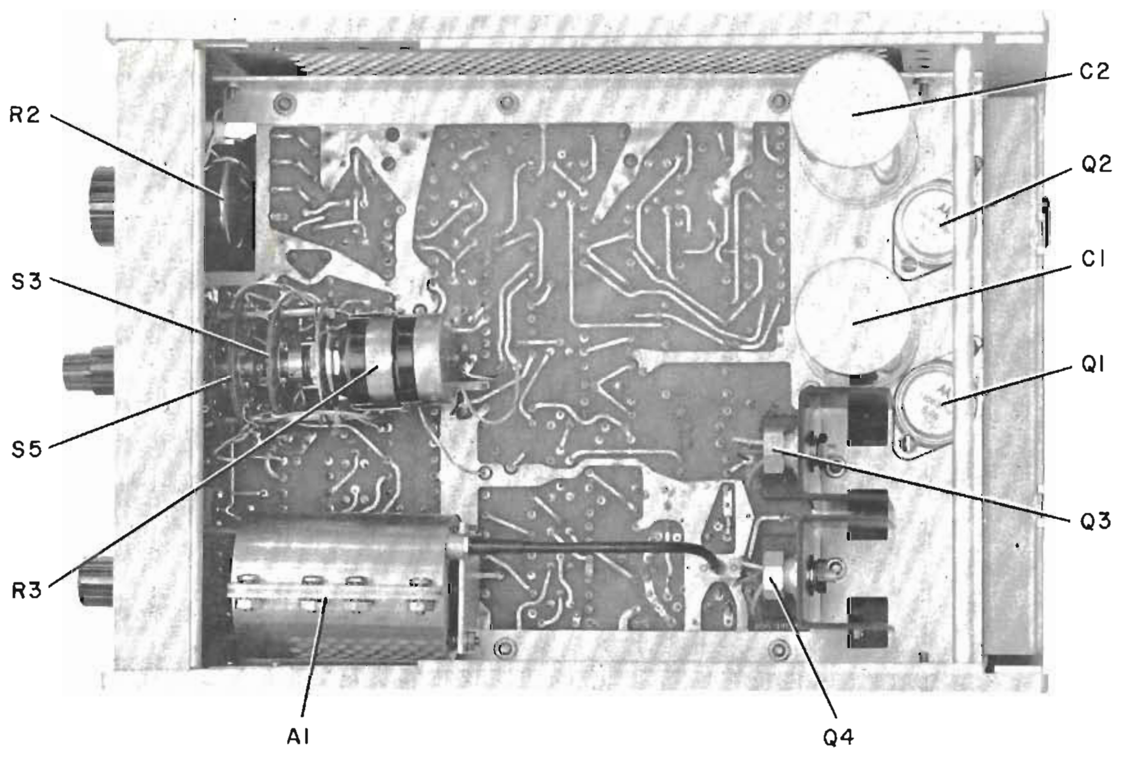


Figure 8-5. Chassis Component Identification - Top View

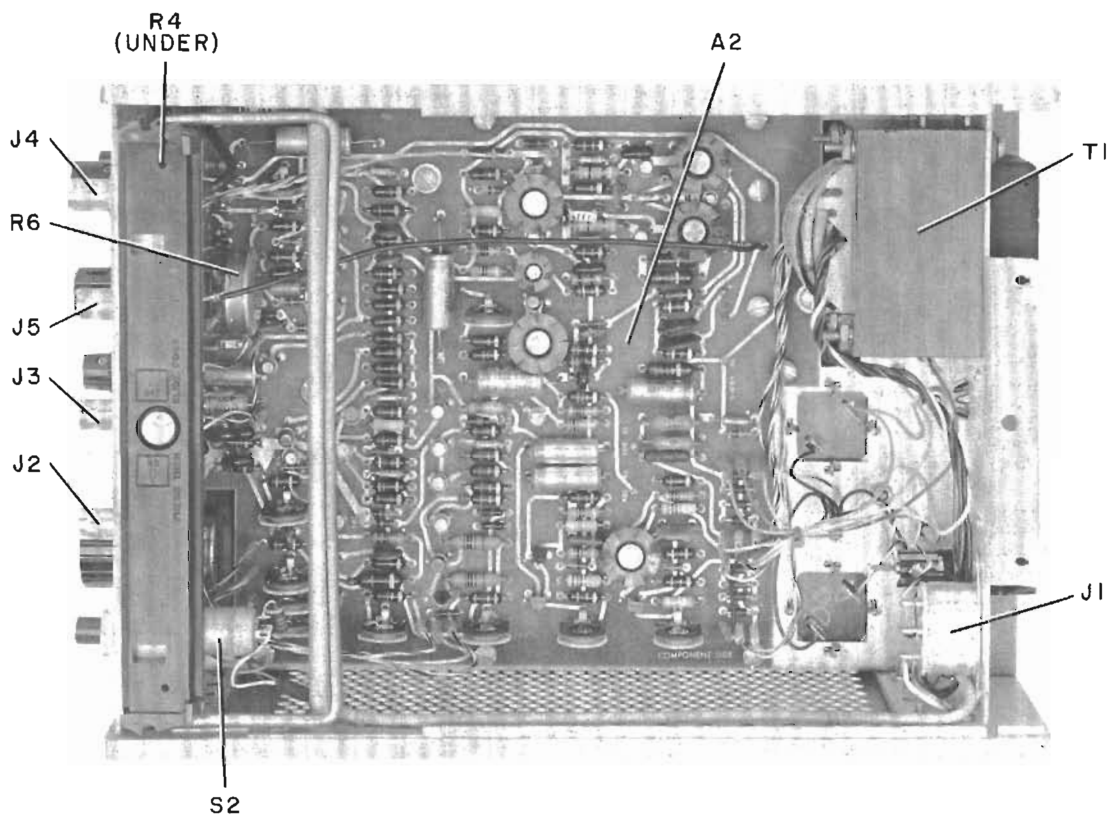
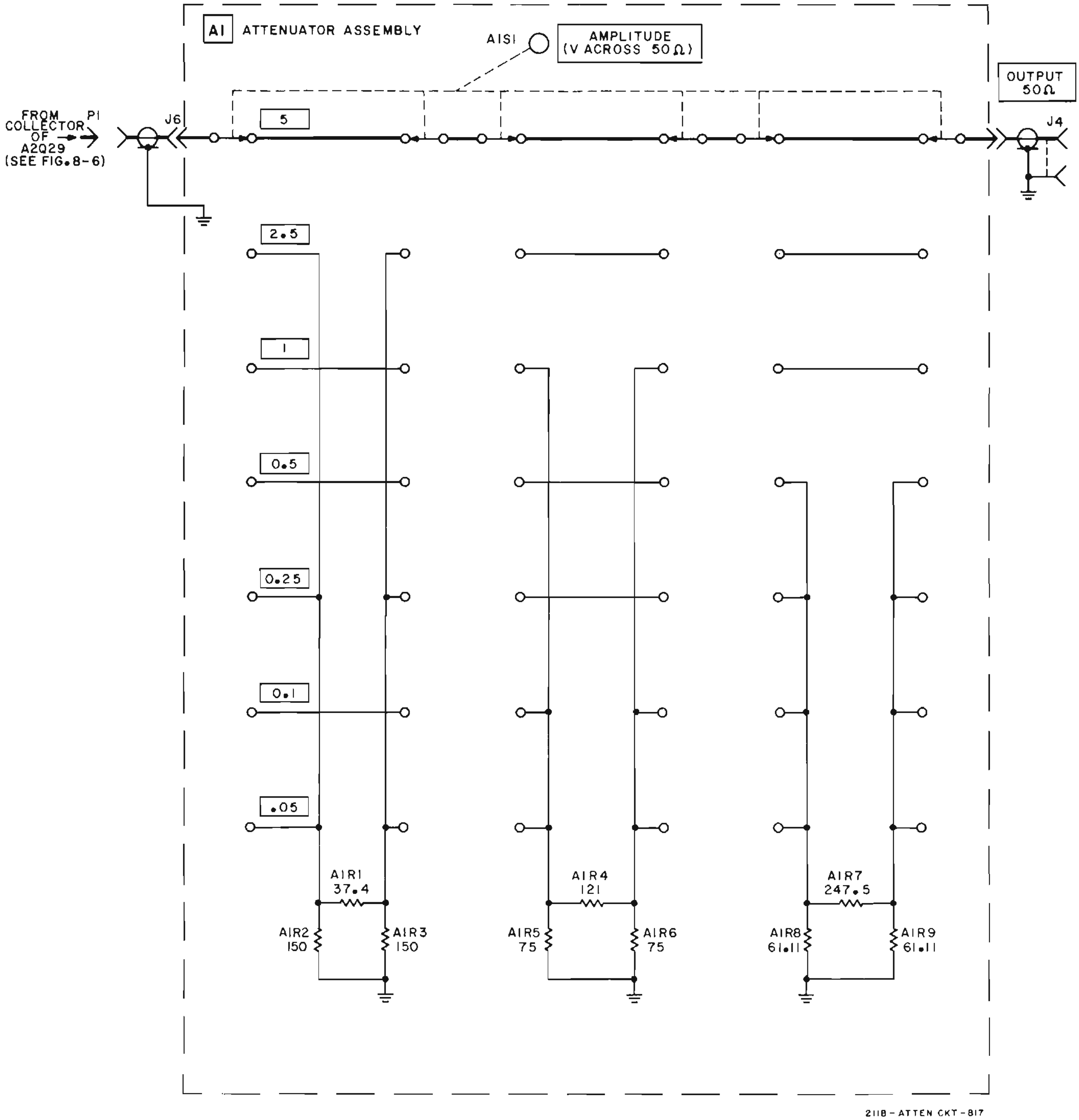


Figure 8-6. Chassis Component Identification - Bottom View



REFERENCE DESIGNATIONS

A1	CHASSIS
R1-9 S1	J4,6 P1

DELETED:

Reference designations within assemblies are abbreviated. Add assembly designation as prefix to form complete designation (e.g., R1 on assemby A2 is A2R1).

SEE TABLE 8-1 FOR SYMBOLS AND CONVENTIONS

Figure 8-7. Attenuator Assembly A1 Schematic

Table 8-2. Voltages with Schmitt Trigger Locked in One State

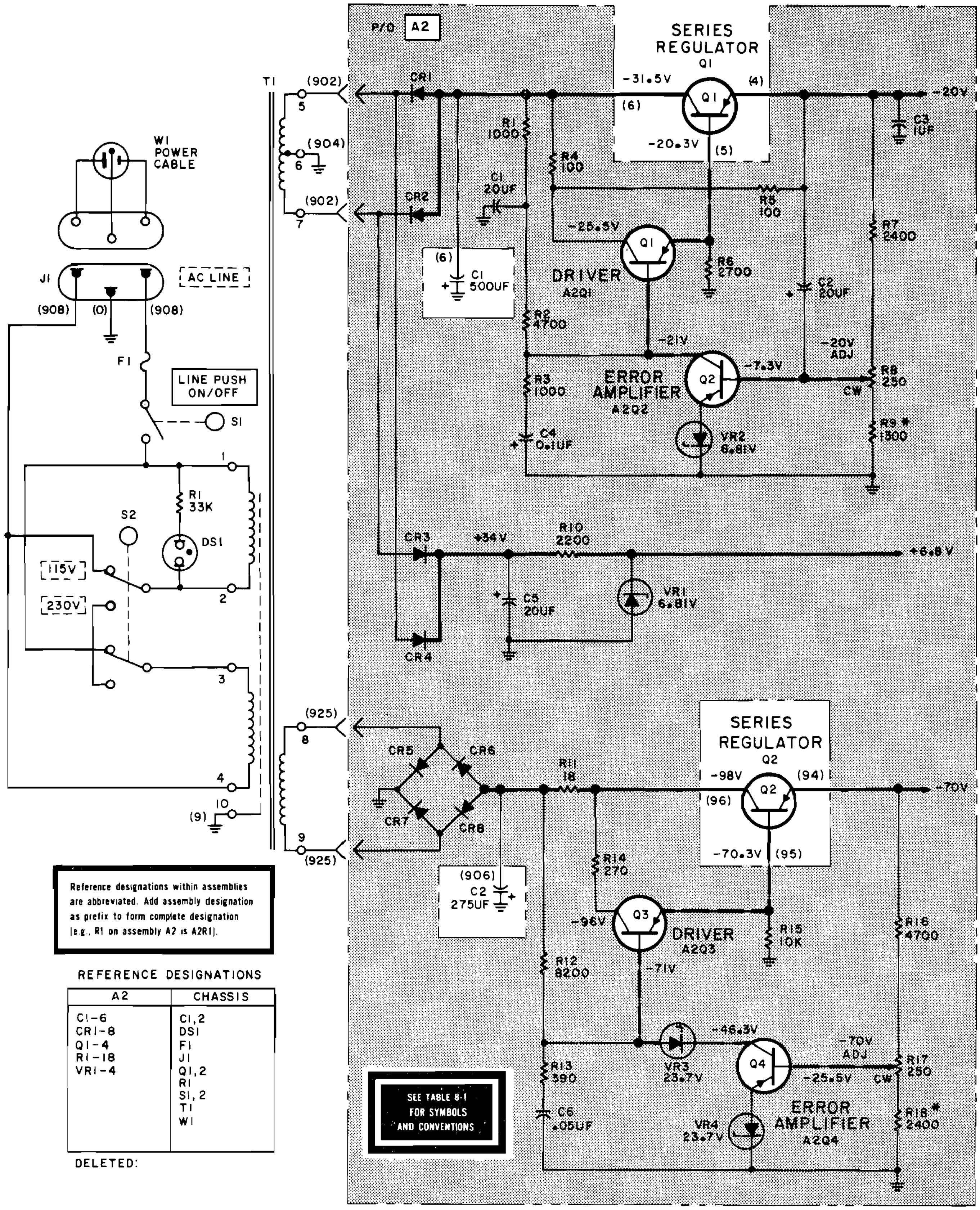
Transistor	Emitter of Q14 opened	Emitter of Q15 opened
Q14	Emitter . . . open Base . . . −3.1V Collector . . . −0.3V	Emitter . . . −7.1V Base . . . −6.3V Collector . . . −2.3V
Q15	Emitter . . . −4.6V Base . . . −3.8V Collector . . . −4.0V	Emitter . . . open Base . . . −5.6V Collector . . . 0V
Q16	Emitter . . . −4.6V Base . . . −4.0V Collector . . . 0V	Emitter . . . −0.7V Base . . . 0V Collector . . . 0V
Q13	Emitter . . . −12.7V Base . . . −12.1V Collector . . . −3.1V	Emitter . . . −8.6V Base . . . −7.9V Collector . . . −6.3V
Q5	Emitter . . . −19.2V Base . . . −18.6V Collector . . . −0.8V	Emitter . . . −19.2V Base . . . −18.6V Collector . . . −0.8V
Q6	Emitter . . . −20.0V Base . . . −19.2V Collector . . . −12.5V	Emitter . . . −20.0V Base . . . −19.2V Collector . . . −8.4V
Q7	Emitter . . . −0.1V Base . . . −0.8V Collector . . . −11.5V	Emitter . . . −0.1V Base . . . −0.8V Collector . . . −7.4V
Q8	Emitter . . . −12.5V Base . . . −12.0V Collector . . . 0V	Emitter . . . −8.4V Base . . . −7.8V Collector . . . 0V
Q9	Emitter . . . −11.7V Base . . . −12.0V Collector . . . −20.0V	Emitter . . . −7.4V Base . . . −7.8V Collector . . . −20.0V
Q12	Emitter . . . −19.8V Base . . . −19.2V Collector . . . −0.2V	Emitter . . . −16.3V Base . . . −15.6V Collector . . . −4.8V
Q11	Emitter . . . −0.8V Base . . . −0.2V Collector . . . −0.7V	Emitter . . . −5.3V Base . . . −4.8V Collector . . . −0.6V
Q10	Emitter . . . 0V Base . . . 0.7V Collector . . . 0.8V	Emitter . . . 0V Base . . . 0.6V Collector . . . −5.3V

Table 8-3. DC Voltage and Waveform Test Conditions

1. Set the model 211B controls as follows:

MULTIPLIER	1K
SYMMETRY	Approx 50%
FREQUENCY (Hz)	10
AMPLITUDE (sw)	5
VERNIER	cw
AMPLITUDE (dial)	cw

2. Voltages and waveforms may vary slightly from one instrument to another. Unless otherwise indicated, all voltages are dc, taken with a 20,000 ohm-per-volt meter and measured to chassis ground.



Reference designations within assemblies are abbreviated. Add assembly designation as prefix to form complete designation (e.g., R1 on assembly A2 is A2R1).

REFERENCE DESIGNATIONS

A2	CHASSIS
C1-6 CR1-8 Q1-4 R1-18 VR1-4	C1,2 DS1 F1 J1 Q1,2 R1 S1,2 T1 W1

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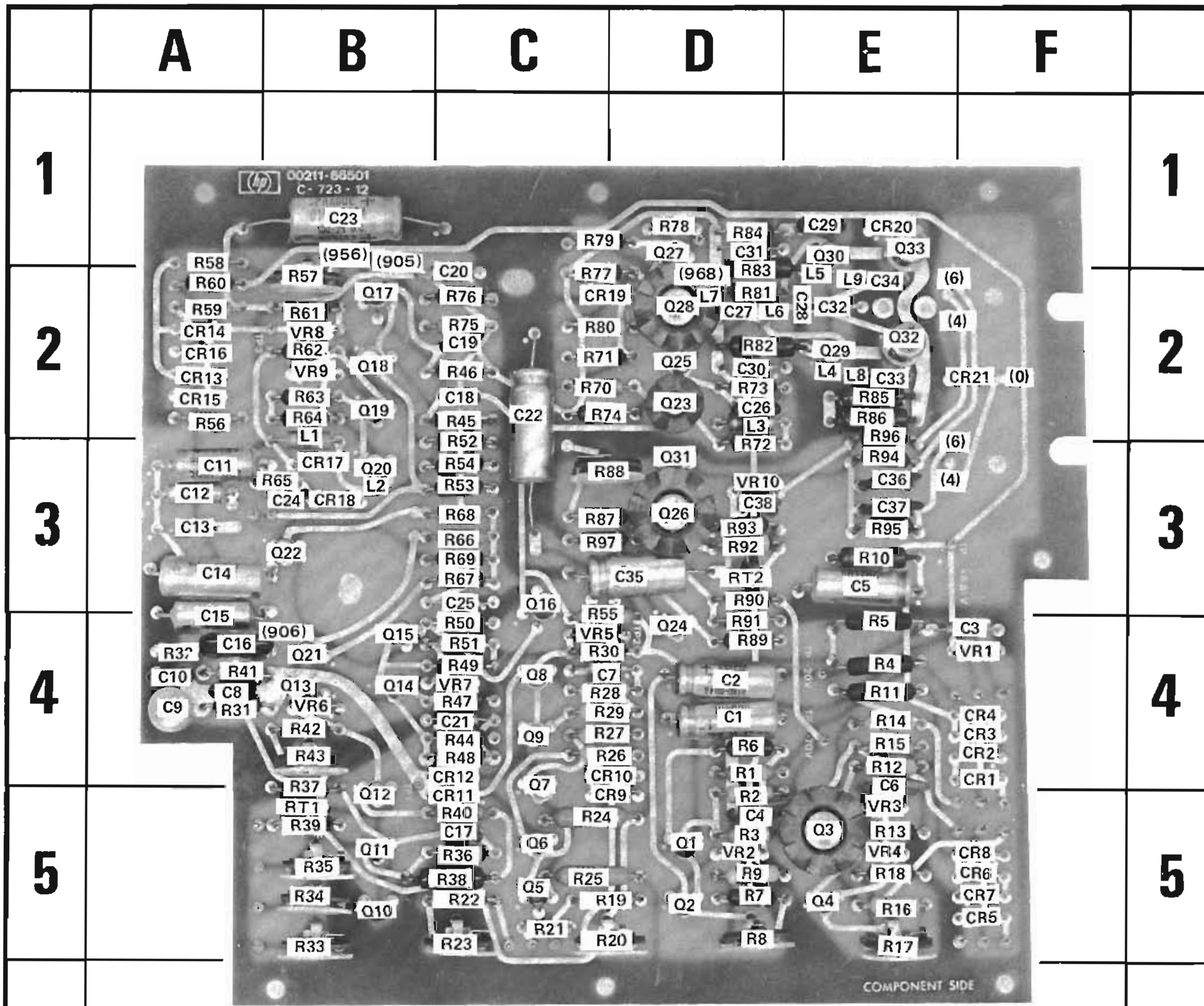
Figure 8-8. Power Supply Schematic

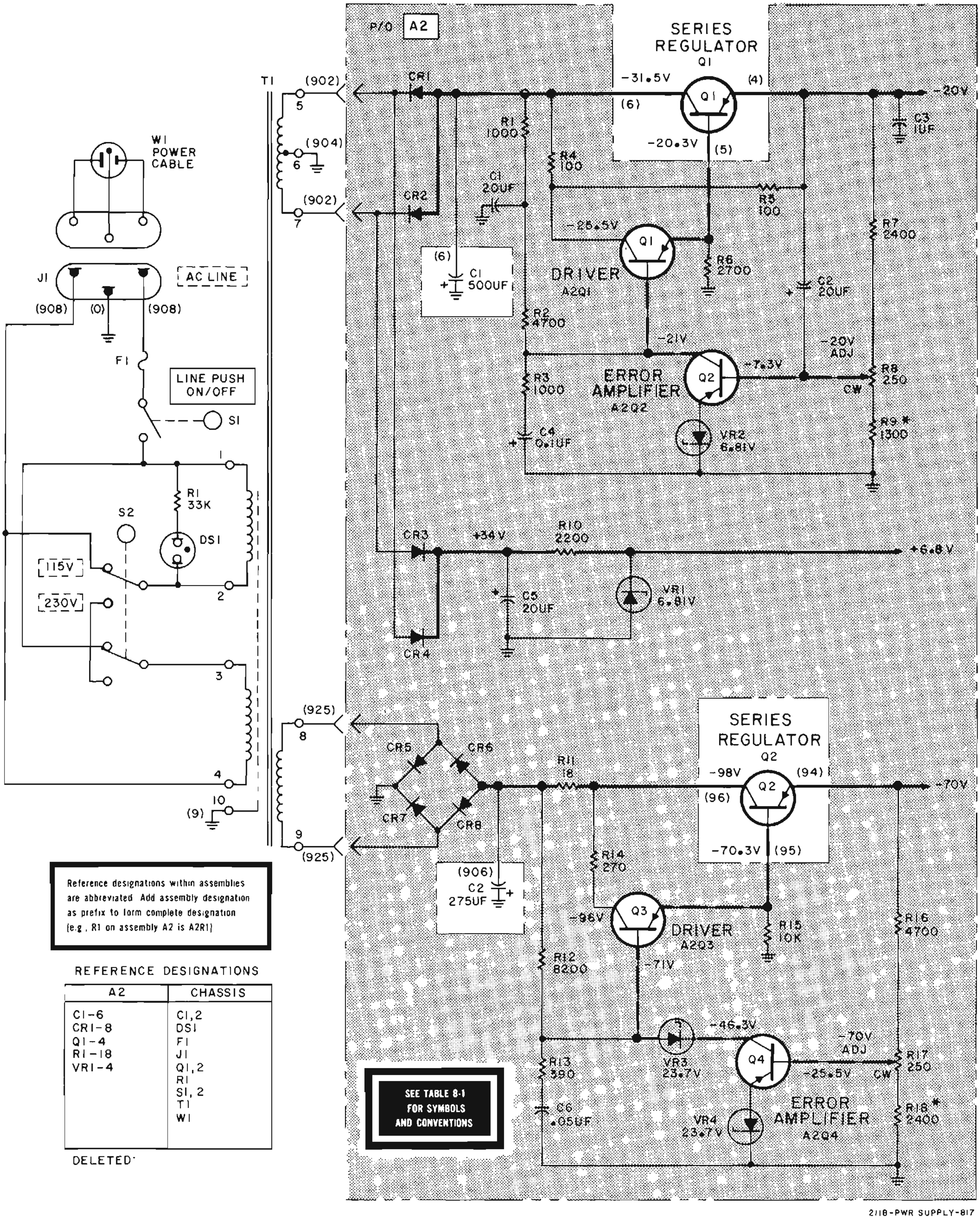


REF DESIG	GRID LOC	REF DESIG	GRID LOC	REF DESIG	GRID LOC	REF DESIG	GRID LOC	REF DESIG	GRID LOC	REF DESIG	GRID LOC	REF DESIG	GRID LOC	REF DESIG	GRID LOC
C1	D-4	C27	D-2	CR15	A-2	Q11	B-5	R4	E-4	R30	C-4	R56	A-2	R83	D-2
C2	D-4	C28	E-2	CR16	A-2	Q12	B-5	R5	E-4	R31	A-4	R57	B-2	R84	D-1
C3	F-4	C29	E-1	CR17	B-3	Q13	B-4	R6	D-4	R32	A-4	R58	A-1	R85	E-2
C4	D-5	C30	D-2	CR18	B-3	Q14	B-4	R7	D-5	R33	B-5	R59	A-2	R86	E-2
C5	E-3	C31	D-1	CR19	C-2	Q15	B-4	R8	D-5	R34	B-5	R60	A-2	R87	C-3
C6	E-4	C32	E-2	CR20	E-1	Q16	C-3	R9	D-5	R35	B-5	R61	B-2	R88	C-3
C7	C-4	C33	E-2	CR21	F-2	Q17	B-2	R10	E-3	R36	C-5	R62	B-2	R89	D-4
C8	A-4	C34	E-2	L1	B-2	Q18	B-2	R11	E-4	R37	B-4	R63	B-2	R90	D-3
C9	A-4	C35	D-3	L2	B-3	Q19	B-2	R12	E-4	R38	C-5	R64	B-2	R91	D-4
C10	A-4	C36	E-3	L3	D-2	Q20	B-3	R13	E-5	R39	B-5	R65	B-3	R92	D-3
C11	A-3	C37	E-3	L4	E-2	Q21	B-4	R14	E-4	R40	C-5	R66	C-3	R93	D-3
C12	A-3	C38	D-3	L5	E-2	Q22	B-3	R15	E-4	R41	A-4	R67	C-3	R94	E-3
C13	A-3	CR1	F-4	L6	D-2	Q23	D-2	R16	E-5	R42	B-4	R68	C-3	R95	E-3
C14	A-3	CR2	F-4	L7	D-2	Q24	D-4	R17	E-5	R43	B-4	R69	C-3	R96	E-2
C15	A-4	CR3	F-4	L8	E-2	Q25	D-2	R18	E-5	R44	C-4	R70	C-2	R97	D-3
C16	A-4	CR4	F-4	L9	E-2	Q26	D-3	R19	D-5	R45	C-2	R71	C-2	VR1	F-4
C17	C-5	CR5	F-5	Q1	D-5	Q27	D-1	R20	D-5	R46	C-2	R72	D-2	VR2	D-5
C18	C-2	CR6	F-5	Q2	D-5	Q28	D-2	R21	C-5	R47	C-4	R73	D-2	VR3	E-5
C19	C-2	CR7	F-5	Q3	E-5	Q29	E-2	R22	C-5	R48	C-4	R74	C-2	VR4	E-5
C20	C-2	CR8	F-5	Q4	E-5	Q30	E-1	R23	C-5	R49	C-4	R75	C-2	VR5	C-4
C21	C-4	CR9	D-5	Q5	C-5	Q31	D-3	R24	C-5	R50	C-4	R76	C-2	VR6	B-4
C22	C-2	CR10	C-4	Q6	C-5	Q32	E-2	R25	C-5	R51	C-4	R77	C-2	VR7	C-4
C23	B-1	CR11	C-5	Q7	C-4	Q33	E-1	R26	C-4	R52	C-3	R78	D-1	VR8	B-2
C24	B-3	CR12	C-4	Q8	C-4	R1	D-4	R27	C-4	R53	C-3	R79	C-1	VR9	B-2
C25	C-3	CR13	A-2	Q9	C-4	R2	D-5	R28	C-4	R54	C-3	R80	C-2	VR10	D-3
C26	D-2	CR14	A-2	Q10	B-5	R3	D-5	R29	C-4	R55	C-4	R81	D-2	RT1	B-5
												R82	D-2	RT2	D-3

211B-A-13

Figure 8-9. Assembly A2 Component Identification

REPLACEMENT PAGE



Reference designations within assemblies are abbreviated Add assembly designation as prefix to form complete designation (e.g., R1 on assembly A2 is A2R1)

REFERENCE DESIGNATIONS

A2	CHASSIS
C1-6 CR1-8 Q1-4 R1-18 VR1-4	C1,2 DS1 F1 J1 Q1,2 R1 S1, 2 T1 W1

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Figure 8-8. Power Supply Schematic

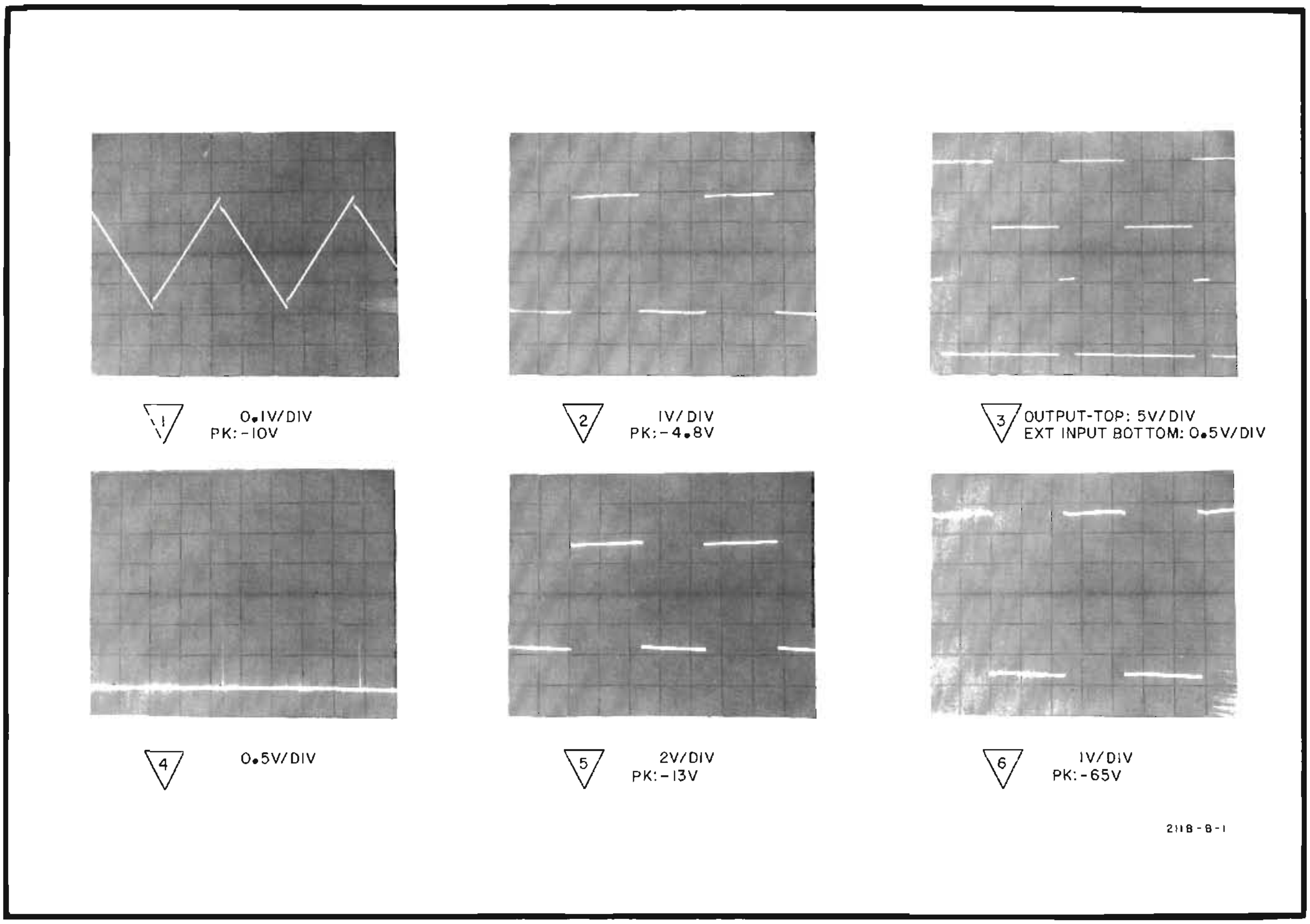
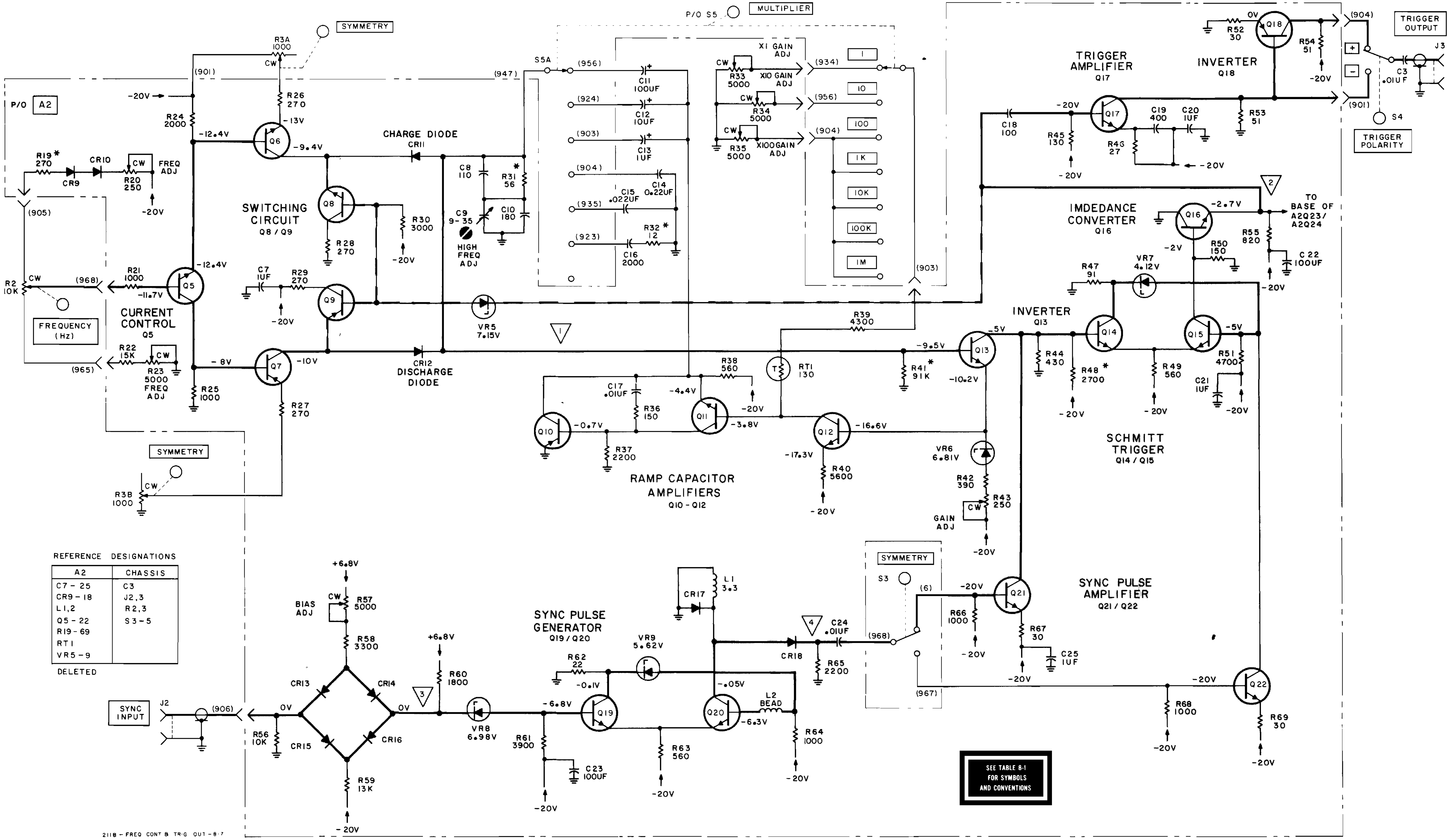


Figure 8-10. Test Point Waveforms



REFERENCE DESIGNATIONS

A2	CHASSIS
C7 - 25	C3
CR9 - 18	J2,3
L1,2	R2,3
Q5 - 22	S3 - 5
R19 - 69	
RT1	
VR5 - 9	

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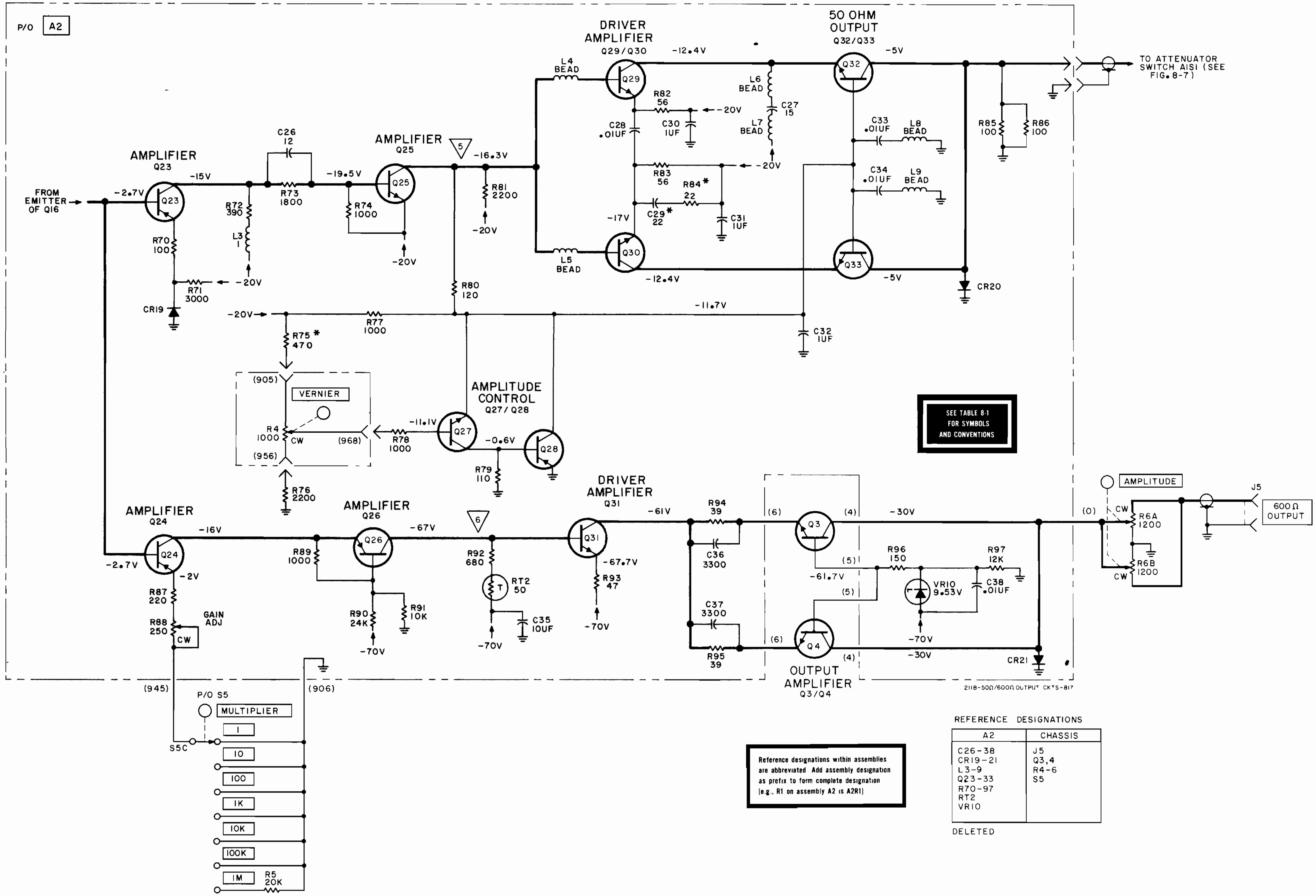
Figure 8-11. Frequency Control Schematic



SEE TABLE 8-1 FOR SYMBOLS AND CONVENTIONS

Reference designations within assemblies are abbreviated. Add assembly designation as prefix to form complete designation (e.g., R1 on assembly A2 is A2R1)

REFERENCE DESIGNATIONS

A2	CHASSIS
C26-38 CR19-21 L3-9 Q23-33 R70-97 RT2 VR10	J5 Q3,4 R4-6 S5

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Figure 8-12. Output Circuitry Schematic

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MANUAL CHANGES

MODEL 211B

SQUARE WAVE GENERATOR

Manual Serials Prefixed: 0817A
Manual Printed: March 1971

Make all changes listed below as Errata. Check the following table for your instrument serial prefix and/or serial number and make listed change(s) to the manual:

Serial Prefix or Number	Make Changes	Serial Prefix or Number	Make Changes
1210A	1		
1218A	1, 2		

ERRATA

Page 5-1,
Delete Paragraph 5-8.

Page 5-2,
Delete Table 5-2,

Page 5-3, Paragraph 5-9 step b,
Change TIME/DIV setting to 10 usec.
Add: TRIGGER SLOPE .... (–)

Page 5-3, Paragraph 5-10,
Change c to read as follows:
c. Set controls for Model 211B as follows:
MULTIPLIER 100K
FREQUENCY (Hz) 1
SYMMETRY .... ccw
AMPLITUDE (switch) 5
VERNIER .... cw

Change f to read as follows:
f. Adjust the high-frequency oscilloscope SWEEP VERNIER until one pulse period occupies 8 divisions on the CRT.

Delete step g.

Page 5-4, Figure 5-5.
Reverse the position of the 1410A and 1425A.

Page 5-5, Figure 5-6.
Reverse the position of the 1410A and 1425A.

Page 5-8a, Performance Check Record,
Delete the following items from Paragraph 5-13:

Preshoot (leading edge) ⩽ 5%
Overshoot (leading edge) ⩽ 5%
Preshoot (trailing edge) ⩽ 5%
Overshoot (trailing edge) ⩽ 5%

Table 6-2,
A2C18: Change to HP Part No. 0150-0073; TQ 1; C: fxd cer 100 pF 10% 1000 wVdc.
A2C27: Change to HP Part No. 0160-2261; TQ 1; C: fxd 15 pF 5% 500 wVdc.

Table 6-2 (Cont'd),
A2R19: Change to HP Part No. 0758-0076; TQ 1; R: fxd flm 560 ohm 2% 1/4W.
A2R31: Change to HP Part No. 0758-0094; TQ 1; R: fxd metox 62 ohm 5% 1/2W.
A2R32: Add asterisk (*) to indicate factory selected value.
A2R41: Change to HP Part No. 0758-0101; TQ 1; R: fxd metox 150K ohm 5% 1/2W.
A2R48: Change to HP Part No. 0758-0035; TQ 1; R: fxd metox 3K ohm 5% 1/2W.
A2R75: Change to HP Part No. 0758-0066; TQ 1; R: fxd metox 620 ohm 5% 1/4.
DS1: Change to HP Part No. 2140-0244; TQ 1; DS: neon p/o S1.
A2R84: Change to HP Part No. 0698-5884; TQ 1; R: fxd flm 22 ohm, 5% 1/2W.
MP5: Change to HP Part No. 01701-04109; TQ 1; MP: Cover, transformer T1.
Add: MP16; HP Part No. 00211-00207; TQ 1; MP: Panel, rear.
S2: Change to HP Part No. 3101-1234; TQ 1; S: slide DPDT.

Page 8-6, Figure 8-9,
Replace Figure 8-9 with the attached Figure 8-9.

Page 8-7/8-8, Figure 8-11,
A2R19: Change value to 560 ohms.
A2R24: Change value to 1000 ohms.
A2R31: Change value to 62 ohms.
A2R41: Change value to 151k ohms.
A2R48: Change value to 3000 ohms.
VR6: Move Q12 base connection from cathode of VR6 to anode of VR6.

Page 8-9, Figure 8-12,
A2R75: Change value to 620 ohms.

7 June 1972

Δ = Latest additions to this change sheet.
This change sheet supersedes all prior change sheets for this manual.

Supplement A for
00211-90901

CHANGE 1

Table 6-2,
MP2: Change to HP Part No. 5000-8583; TQ 1; MP: Cover, bottom, olive-gray.
MP3: Change to HP Part No. 5000-8479; TQ 2; MP: Cover, side, olive-gray.

Table 6-2 (Cont'd),
MP4: Change to HP Part No. 5060-8573; TQ 1; MP: Cover top, olive-gray.
MP16: Change to HP Part No. 00211-10202; TQ 1; MP: Panel, rear, mint-gray.
Add: MP17; HP Part No. 00211-10201; TQ 1; MP: Panel, front, mint-gray.

Δ CHANGE 2

Table 6-2,
S1: Change to HP Part No. 3101-1248; TQ1; S: push, SPDT, *illuminated.*

OPTIONS

Page 7-1, Paragraph 7-6,

Change paragraph 7-6 to read as follows:

Page 7-1 (Cont'd),

7-6. Options for an HP instrument are standard modification installed at the factory, and are available on request.

OPTION X95

Table 7-2. Replacement Parts for Option X95 Modification

Ref Desig	HP Part No.	TQ	Description
MP2	5000-0717	1	MP: Cover, bottom, blue-gray
MP3	5000-0567	2	MP: Cover, side, blue-gray
MP4	5060-0718	1	MP: Cover, top, blue-gray
MP16	00211-00207	1	MP: Panel, rear, light gray
MP17	00211-00201	1	MP: Panel, front, light gray

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