211A

HEWLETT-PACKARD COMPANY / OPERATING AND SERVICE MANUAL

211A

SQUARE WAVE GENERATOR

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OPERATING AND SERVICE MANUAL

MODEL 211A

SERIALS PREFIXED: 026 -

SQUARE WAVE GENERATOR

00093-3

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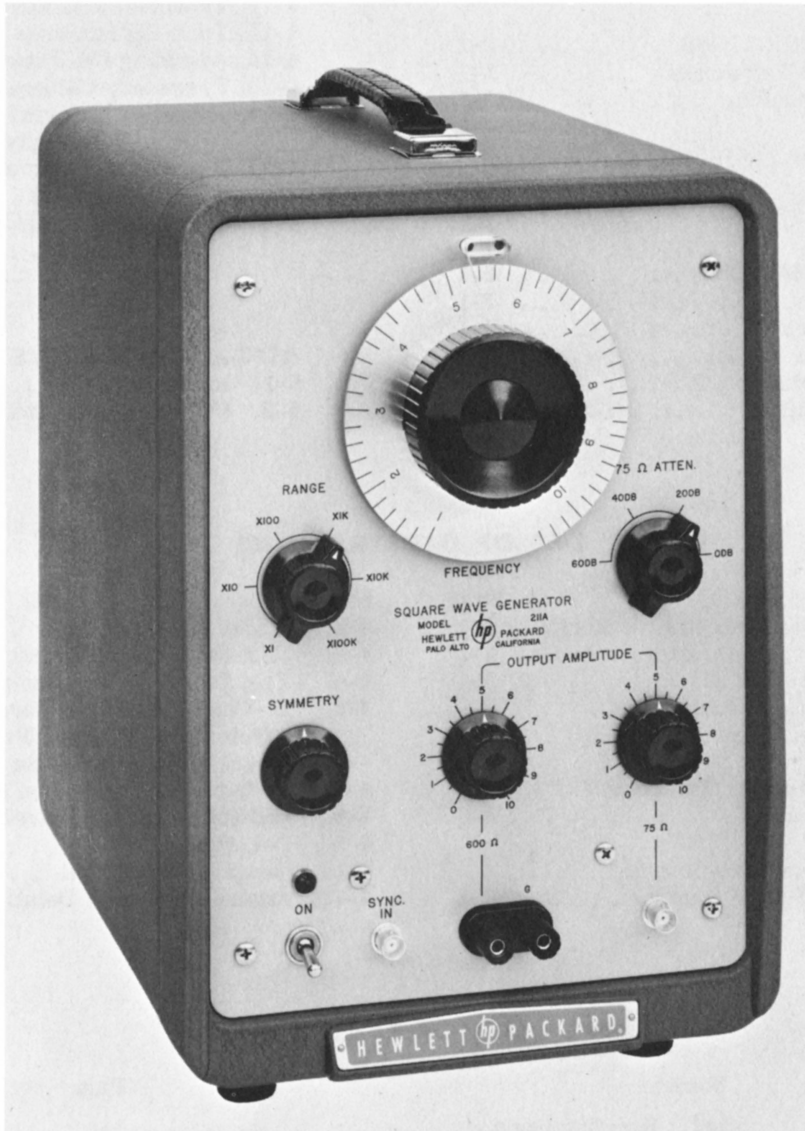


Figure 1-1. Model 211A **Square Wave Generator**

SECTION I
GENERAL INFORMATION

1-1. GENERAL DESCRIPTION.

1-2. The ⓗⓟ Model 211A Square Wave Generator is a precision wide range instrument particularly suited for use with a fast oscilloscope for video amplifier testing, permitting a rapid examination of amplifier frequency characteristics up to many megacycles. In computer, pulse code, telemetering, and similar applications it offers great convenience as a variable trigger source for switching purposes. In television work it can serve as a bar generator. In high frequency applications it is valuable as a modulator source. It also finds use in testing a variety of devices such as attenuators, filters, delay lines and audio systems.

1-3. The Model 211A has been designed with two outputs, one 75-ohm output and one 600-ohm output. The rise time of the signal from the 75-ohm output is only 20 millimicroseconds, which is sufficiently fast to test the response of video devices out to approximately 20 megacycles or to provide a high speed triggering voltage of variable rate. The peak-to-peak amplitude of the signal across the 75-ohm internal impedance is 7 volts, or 3.5 volts peak-to-peak into a 75-ohm external load. This output level may be adjusted with a 60-db step attenuator in combination with an amplitude control, a particularly desirable arrangement when low output levels are required.

1-4. The second output from the generator provides 55 volts peak-to-peak from a source impedance of 600 ohms. The rise time of this signal is less than 0.1 microsecond with the output level controlled separately from that of the 75-ohm output. Both outputs are used simultaneously.

1-5. The frequency range of the instrument, 1 cps to 1 mc, is covered in six 10/1 bands. The frequency

Table 1-1. Specifications

Frequency Range:
1 cps to 1 mc, continuous coverage.

Low Impedance Output:
-3.5 volt peak across 75-ohm load -7 volt open circuit, zero level clamped to chassis; rise time less than 0.02 μsec.

High Impedance Output:
-27 volt peak across 600-ohm load -55 volt open circuit, zero level clamped to chassis; rise time less than 0.1 μsec.

Relative Phase:
180° phase difference between high and low impedance output signals.

Amplitude Control:
Low Impedance Output - Potentiometer and 60 db attenuator, variable in 20 db steps.
High Impedance Output - Potentiometer.

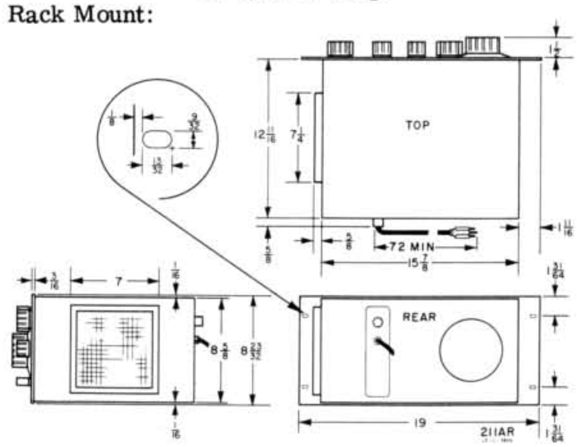
Frequency Control:
Dial calibrated "1 to 10" and decade multiplier switch. Six bands.

Symmetry Control:
Allows exact square-wave balance.

Sync Input:
Positive-going pulse or sine wave signal, min. amplitude 5 volts peak.

Power:
115/230 volts ±10%, 50-60 cps, 225 watts.

Dimensions:
Cabinet Mount: 9-3/4 in. wide, 15-1/4 in. high, 14-5/8 in. deep.
Rack Mount:



Cabinet Mount: Net 26 lbs, shipping 38 lbs.
Rack Mount: Net 25 lbs, shipping 34 lbs.

Accessories Available: (Cable Assemblies)
ⓗⓟ AC-16A. Four feet of RG-58C/U 50-ohm coaxial cable terminated with dual banana plugs.

ⓗⓟ AC-16B. Four feet of RG-58C/U calbe terminated by a dual banana plug on one end and a UG-88/U type BNC male connector on the other.

ⓗⓟ AC-16D. Four feet of RG-58C/U cable terminated on one end by a BNC male connector.

ⓗⓟ AC-16K. Four feet of RG-58C/U cable terminated by BNC male connectors on each end.

dial is linearly calibrated from 1 to 10. The six positions on the range switch multiply these calibrations in decade steps.

1-6. For purposes of synchronization a Schmitt trigger circuit is located ahead of the multivibrator and is set to trigger on a minimum input sync signal of 3 volts peak, but a 5-volt peak sine wave or a positive pulse signal is recommended for practical use. The sync trigger provides a fast trigger of uniform rise and amplitude which aids in obtaining accurate time switching of the frequency multivibrator, and at the same time isolates the multivibrator from the input waveform. If no sync signal is used the multivibrator free-runs at a frequency controlled by the range switch and the frequency control.

1-7. The multivibrator employs two type 6CL6 power pentodes with precision components in the rc timing networks. Residual variation in tubes or time constants may be compensated by a symmetry control which balances the relative plate voltage swing on the multivibrator tubes.

1-8. Two outputs are taken from the frequency multivibrator to drive a push-pull clipper amplifier consisting of two 6CL6's. The clipper serves as the driver for four 6CL6 power tubes arranged in push-pull parallel as the output power stage. Local feedback is used in the power stage to stabilize the system against variations in output level with a change in frequency or range. This local feedback together with a regulated power supply assures an output essentially free from amplitude variations over the entire frequency range from 1 cps to 1 mc once the output controls have been set.

1-9. DAMAGE IN TRANSIT.

1-10. After unpacking the instrument, should any shipping damage be discovered, follow the procedure described in the "Claim for Damage" sheet in this manual.

1-11. POWER TRANSFORMER CONVERSION.

1-12. Should it be desired to operate the Model 211A from a 210-250 volt source proceed as follows:

a. Remove the two bare wire jumpers from the terminal strip located beneath the power transformer. These jumpers connect the Black to the Black-Green lead and the Black-Red to the Black-Yellow lead of the power transformer primary.

b. Insert a new jumper on the terminal strip which will connect the Black-Yellow to the Black-Green lead.

c. Change line fuse F1 to one with a 1.25 ampere slow-blow rating. As shown in the schematic diagram, this alteration changes the primary windings of the power transformer from a parallel to a series arrangement.

SECTION II
OPERATING INSTRUCTIONS

2-1. CONTROLS AND TERMINALS.

2-2. ON. Applies line voltage to the instrument.

2-3. RANGE. Switches time constants in the multivibrator circuit to establish various frequency ranges.

2-4. FREQUENCY. Varies the multivibrator grid voltage to produce 1:10 frequency change on each RANGE switch position.

2-5. OUTPUT AMPLITUDE. The 600 Ω control varies the amplitude of the signal at the 600 Ω output terminals. The 75 Ω control varies the signal voltage applied to the 75 Ω output attenuator.

2-6. 75 Ω ATTEN. This control reduces the output jack in 20 db steps below the level set with the 75 Ω OUTPUT AMPLITUDE control.

2-7. SYMMETRY. A balance potentiometer in the multivibrator plate circuit which effectively balances the amplitudes of the signals to the multivibrator grids and equalizes each square wave half cycle.

2-8. 600 Ω OUTPUT. Two three-fourth inch spaced binding posts which serve as the 600 Ω output, or as a sync out connection when 75Ω output is in use.

2-9. 75 Ω OUTPUT. A female type BNC connector serves as the 75 Ω output connector, or as a sync out connector when the 600Ω output is in use.

2-10. SYNC IN. A female type BNC connector to the SYNC trigger which accepts sine waves or positive pulse synchronizing signals with a minimum amplitude of 5 volts peak. FREQUENCY control must be set at a slightly lower frequency than the desired synchronized frequency.

2-11. INSTRUMENT LOADING.

2-12. For low frequency applications involving high impedance devices under test the output from the 211A may be taken from either the 75-ohm terminal or the 600-ohm terminal with little effect on the square wave characteristic and the calibration of the 75-ohm attenuator.

2-13. Low impedance devices, however, require greater attention to impedance matching and line losses in order to preserve attenuator calibration and to prevent deterioration of square wave shape.

2-14. The Model 211A produces a square-wave current pulse with a peak value of 100 ma across its internal impedances. The use of the 75-ohm terminal permits a fast rise square wave to be developed across the 75-ohm internal impedance, and the 75-ohm attenuator allows these square waves to be reduced in amplitude without destroying their characteristics.

2-15. When it is desired to realize the 20 millimicrosecond rise time, 75-ohm output cable should be used (RG-59/U). When it is desired to drive low impedance systems other than 75 ohms, it is necessary to match both ends of the output cable to its characteristic impedance.

2-16. Physical arrangements for use in matching the instrument output to common impedances are shown in figure 2-1.

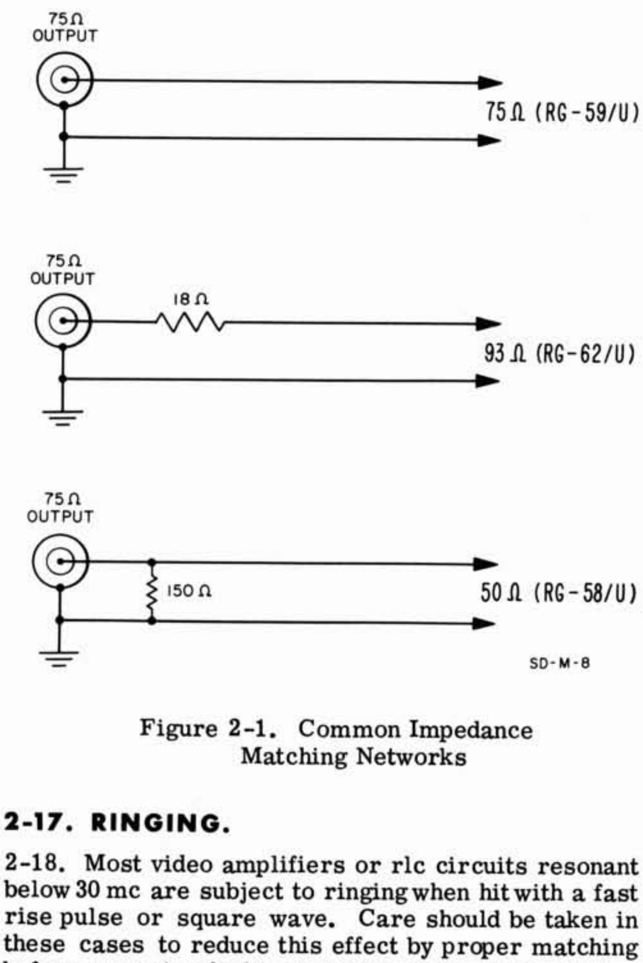


Figure 2-1. Common Impedance Matching Networks

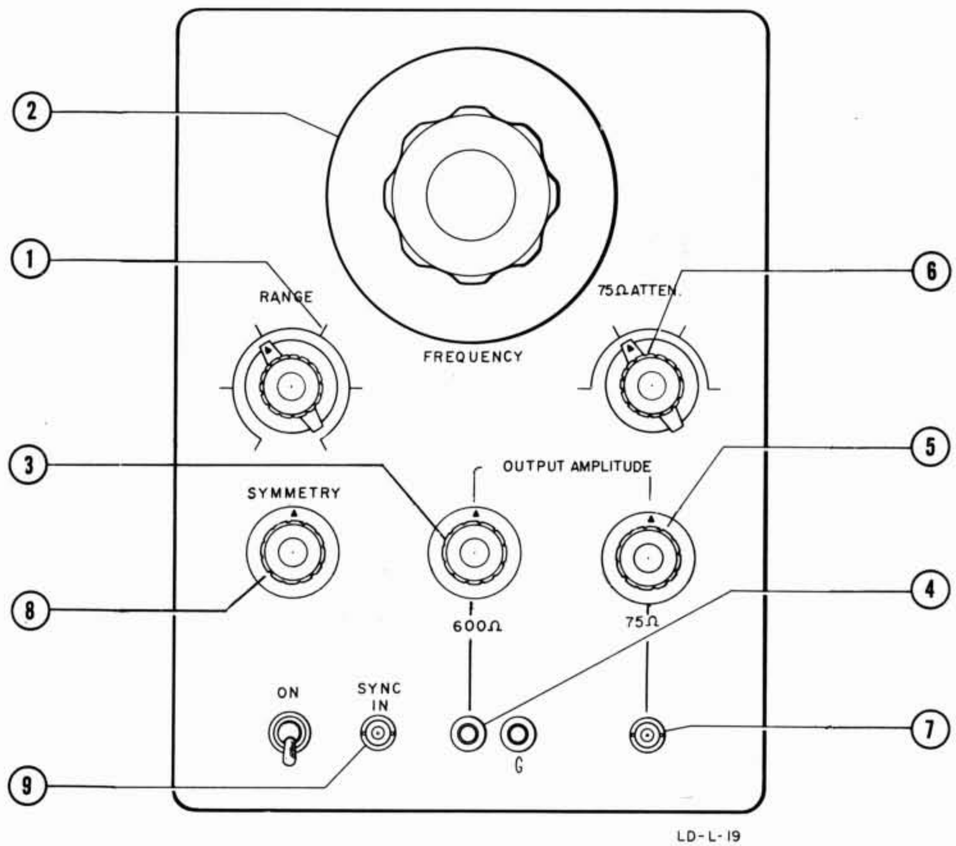
2-17. RINGING.

2-18. Most video amplifiers or rlc circuits resonant below 30 mc are subject to ringing when hit with a fast rise pulse or square wave. Care should be taken in these cases to reduce this effect by proper matching before assuming faulty operation of the Model 211A.

2-19. EXTERNAL SYNC OPERATION.

2-20. With the instrument externally synchronized, the Schmitt trigger will control the switching of the multivibrator only when the period of the multivibrator is slightly greater than that of the external sync signal.

2-21. To permit the Schmitt-trigger output to fire the multivibrator, set the FREQUENCY control to a value slightly less than the frequency desired for sync use. This setting permits the trigger pulse to fire in a free-running recovery.



1. RANGE. Select range of output frequency desired.
2. FREQUENCY. Select output frequency.
3. OUTPUT AMPLITUDE 600Ω. Adjust output signal voltage at 600Ω output terminals.
4. OUTPUT SIGNAL. Source impedance 600Ω.
5. OUTPUT AMPLITUDE. Adjust output voltage at 75Ω output jack.
6. 75Ω ATTEN. Attenuate voltage at 75Ω output jack in 20 db steps.
7. OUTPUT SIGNAL. Source impedance 75Ω.
8. SYMMETRY. Adjust square-wave output voltage symmetry by viewing on cathode ray tube.
9. SYNC IN. Apply external signal to synchronize square-wave output signal.

Figure 2-2. Front Panel Showing Operating Controls

2-22. PULSES.

2-23. The clipper amplifier and output tubes in the Model 211A operate in a circuit designed for a 50% duty cycle. The balance of this circuit is maintained by the SYMMETRY control which balances the two outputs from the multivibrator. Any alteration of this circuit attempting to generate pulses, such as padding the SYMMETRY potentiometer to extend its range of control, would overdrive one side of the clipper amplifier and output tubes beyond the 50% duty cycle factor to the eventual damage of the instrument.

2-24. BALANCED OUTPUT.

2-25. The 211A can be converted to a balanced source without modifying the instrument in any way. Figure 2-3 shows the basic arrangement of the output circuit. The output tubes themselves are in push-pull but have unequal loads as shown. A balanced voltage can thus be obtained by equalizing the tube loads. This can be done directly at the terminals on the panel.

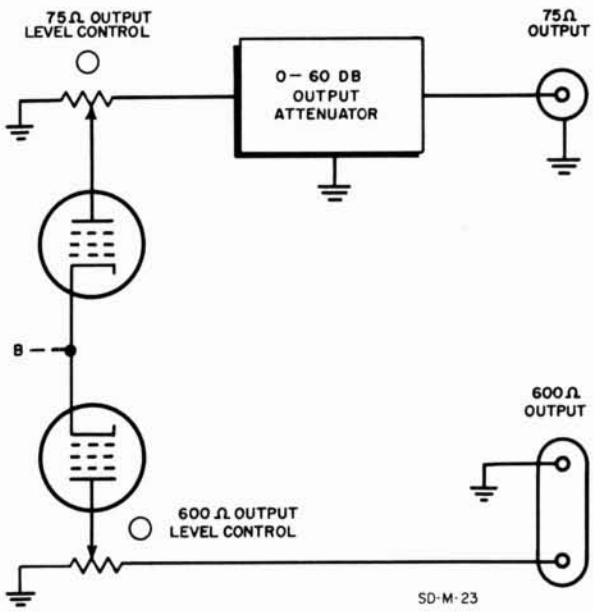


Figure 2-3. Basic Output Circuit of 211A.

2-26. In figure 2-4 the upper terminal represents the 75-ohm output and the lower terminals represent the 600-ohm output. To equalize the source impedance at the two outputs, a resistance of 86 ohms can be connected across the lower terminals as shown in figure 2-4. This additional resistance will reduce the source impedance at the lower terminals to about 75 ohms and will also reduce the voltage available from the lower terminals to approximately the same amount available at the upper terminal. At the same time the additional resistance will form a more favorable time constant with the stray capacity C_0 at the lower terminals and thus speed up the normally slower rise time at those terminals until it is comparable to that of the 75-ohm output.

2-27. Figure 2-4 suggests the use either of two 75-ohm cables or a balanced 150-ohm cable for connecting to the load. In either of these cases it is normally unnecessary to terminate the cables, so that they can be connected directly to the load. The arrangement has the advantage that it can be used with any load impedance. If cables of other impedances are used, they should be terminated in the characteristic impedance of the cable. This will involve a consideration of the load impedance in some cases.

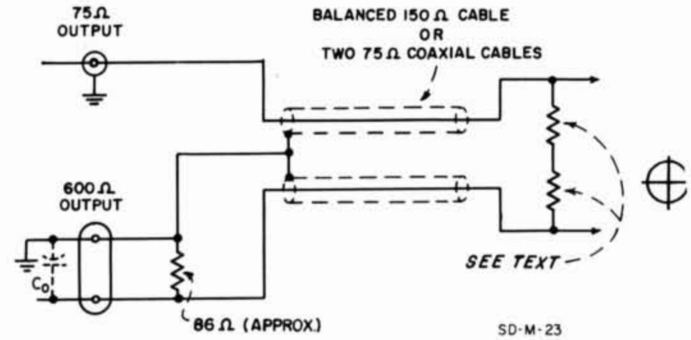


Figure 2-4. Method of Obtaining a Balanced Output from the 211A

2-28. The output voltage can be selected most conveniently if the 75 Ω ATTEN. output is first set to zero. The two OUTPUT AMPLITUDE controls will then have about the same voltage range and each should be set as necessary to obtain one-half of the desired output voltage. This will occur when both controls are at about the same angular position. If desired, both line-to-ground voltages can be measured with a voltmeter or an oscilloscope.

2-29. Output voltage will be as high as 14 volts peak-to-peak, open circuit, and 7 volts peak-to-peak terminated with 75 ohms.

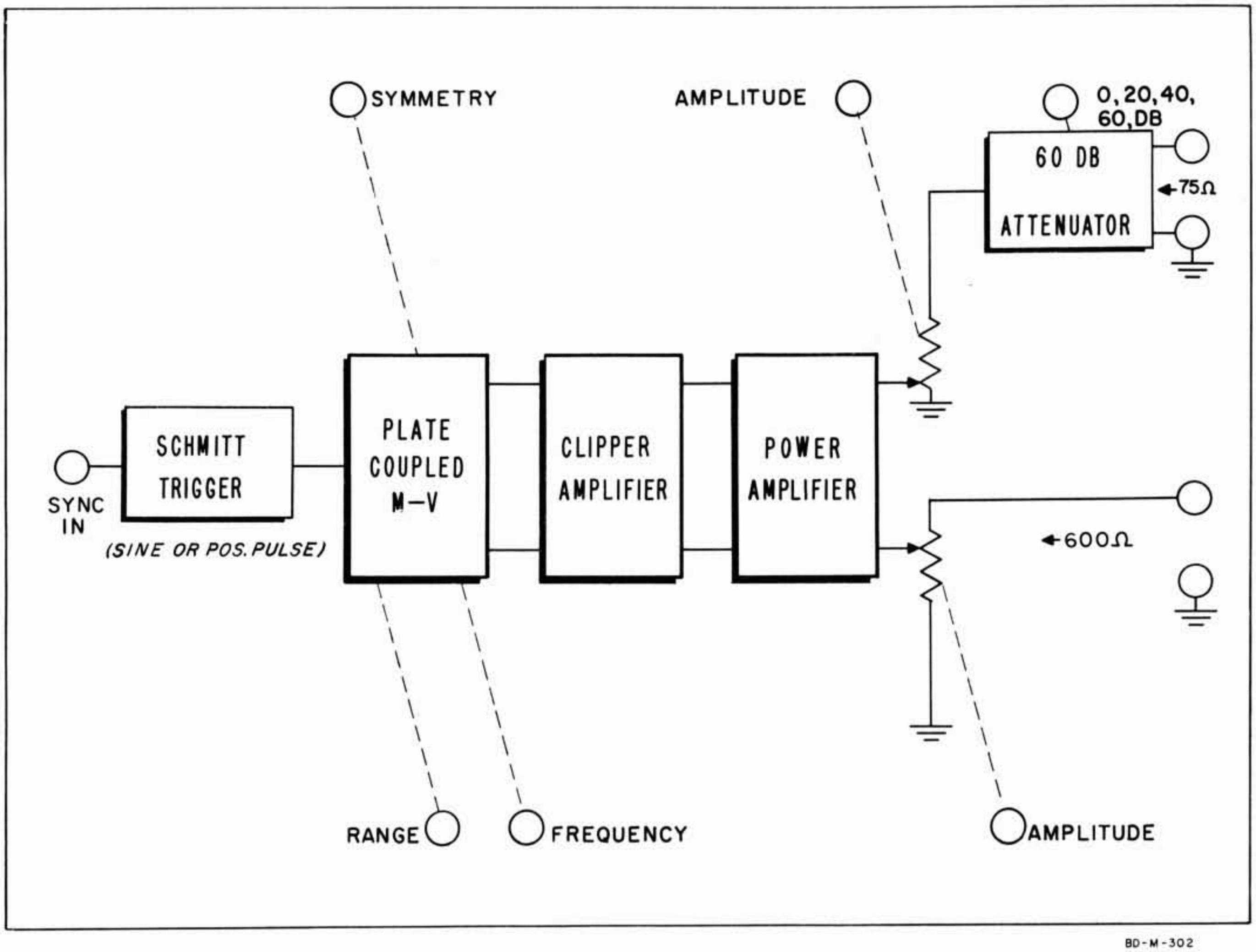


Figure 3-1. Block Diagram Showing Operating Controls of 211A

SECTION III
CIRCUIT DESCRIPTION

3-1. INTRODUCTION.

3-2. Major circuit elements are shown in the circuit block diagram figure 3-1. Special aspects of these circuit elements are discussed in subsequent paragraphs to supplement the general discussion in paragraph 1-1.

3-3. SYNC TRIGGER.

3-4. The sync trigger is a Schmitt trigger which switches with the application of a positive going signal on the input grid. The circuit configuration is conventional for a Schmitt trigger except the L1 and L2 are placed in the trigger-output circuit to produce spikes. Since the Schmitt trigger changes state once on the positive-going portion of an input signal and once on the negative-going portion, two spikes are developed across the L1, L2 differentiating circuit, one positive and the other negative.

3-5. The negative spike is coupled through CR1 to the grid of one multivibrator tube (V3) cutting off conduction. Conduction then starts in V2. For the sync trigger to effect a synchronized condition in the multivibrator, the negative cut-off pulse from the trigger must reach the grid of V3 before the tube reaches cut-off in a free-running condition. This is accomplished by the operator by setting the free-running rate (with the FREQUENCY dial) to a value slightly less than that of the incoming sync signals.

3-6. Output grid bias (effectively,sync sensitivity) in the Schmitt-trigger circuit is adjusted with R10, thus adjusting the cathode level. R10 is normally adjusted so that the triggering level is 3 volts above the level of the trigger input grid.

3-7. MULTIVIBRATOR.

3-8. The multivibrator (V2 and V3) is a conventional, free-running, plate-coupled multivibrator. The frequency of operation is varied by adjusting the grid return voltage with R37 (FREQUENCY control) over a 1:10 range.

3-9. The RANGE switch S2 inserts various rc time constants into the grid return circuit, and these time constants establish the rate of decay for the cut-off side of the multivibrator toward the voltage established by the FREQUENCY control R37.

3-10. The diode clamp controls the current of the conducting side of the circuit and thus controls the voltage drop across the plate load resistor of the conducting half. This voltage is established by adjusting R31 on the clamp control cathode follower V5. Since this adjustment determines the starting voltage level for decay in the section cutting off, it also exercises control over the frequency of operation, and it is used to calibrate the instrument initially at 1000 cps on the X100 range. The function of the clamps is to stabilize the frequency of operation against changes in the circuit such as tube aging, line voltage, and filiament fluctuations.

3-11. The output from the multivibrator furnishes a push-pull drive for the clipper amplifier V6 and V7.

3-12. CLIPPER AMPLIFIER.

3-13. Clipper amplifier tubes V6 and V7 alternately conduct and cut-off in opposition, and serve as the drivers for the output tubes. The outputs from the clipper amplifier are dc-coupled to the power amplifier stage through a broadband interstage network consisting of C19, and R52, C20 and R53, together with the associated plate load resistors including R55, R56, R57, R58, C21 and C22. This network is frequency sensitive to maintain a constant voltage on the grids of the output tubes. The clipper amplifier output voltages for low frequencies are developed across the normal plate load resistors (R56, R50, R51, R54).

3-14. At high frequencies, the effective plate loads are reduced to preserve fast rise time of the square waves. The high frequency path is defined by C19, C21 through C23 to B+ at chassis ground, and by C20, C22 through C23 to B+ at chassis ground. Through this path the high frequency plate loads become R55 and R58, since these are small compared to the normal plate loads which they parallel at high frequencies.

3-15. POWER AMPLIFIER.

3-16. The power amplifier consists of four type 6CL6 tubes arranged in push-pull parallel with a constant resistance network in the cathode circuit, R65, R66, R67, and L8. This network compensates for the effects of heater-cathode capacitance on the leading and trailing edges of square wave output during tube switching. The output tubes, like the clipper amplifier stage, alternately conduct and cut-off. The compensating network introduces a reactive transient into the circuit with a sign opposite to that produced by the tube elements during switching.

3-17. Each side of the power amplifier furnishes a separate output to the output stage of the instrument. The low impedance output passes through a 75-ohm potentiometer (OUTPUT AMPLITUDE control) to a 75-ohm three-section pi-filter. The 600-ohm output passes through a 600-ohm potentiometer (OUTPUT AMPLITUDE control) to the output terminals. The 600Ω OUTPUT AMPLITUDE control is a dual potentiometer and consists of two 1200-ohm sections in parallel to accommodate heat dissipation requirements.

3-18. Since the power supply is negative with respect to the chassis and the output is direct coupled, the square wave is actually negative with respect to the ground terminal. Thus the negative portion of the source wave is below ground potential and the positive portion is at ground potential.

Table 4-1. Tube Replacement Chart

TUBE	TYPE	FUNCTION	ADJUSTMENT REQUIRED
V1	6BQ7	Schmitt trigger	Adjust SYNC SENSITIVITY, paragraph 4-24
V2	6CL6	1/2 Multivibrator	Recalibrate FREQUENCY dial, para. 4-20
V3	6CL6	1/2 Multivibrator	Recalibrate FREQUENCY dial, para. 4-20
V4	6AL5	Diode Clamp	Recalibrate FREQUENCY dial, para. 4-20
V5	6C4	Clamp Control Cathode Follower	Recalibrate FREQUENCY dial, para. 4-20
V6	6CL6*	75Ω Output Clipper Amplifier	No adjustment
V7	6CL6*	600Ω Output Clipper Amplifier	No adjustment
V8	6CL6*	75Ω Output Tube	No adjustment
V9	6CL6*	75Ω Output Tube	No adjustment
V10	6CL6*	600Ω Output Tube	No adjustment
V11	6CL6*	600Ω Output Tube	No adjustment
V12	5V3	Full-Wave Rectifier	Check power supply output (paragraph 4-15)
V13	6AS7GA	Series Regulator	Check power supply output (paragraph 4-15)
V14	6BH6	Control Tube	Check power supply output (paragraph 4-15)
V15	5651	Reference Tube	Check power supply output (paragraph 4-15)

*Type 6197 tubes may be used in place of type 6CL6 if desired

SECTION IV
MAINTENANCE

4-1. INTRODUCTION.

4-2. This section contains instructions for maintaining, troubleshooting, replacing tubes, and internal adjustment of the Model 211A Square Wave Generator. A systematic troubleshooting chart will assist in localizing most troubles which may occur, and it is keyed to applicable paragraphs in the test to facilitate testing the instrument. Another chart includes instructions for tube replacement and subsequent adjustments. A table of important waveforms is given together with a discussion of techniques and equipment necessary to observe these fast rise waveforms.

4-3. CABINET REMOVAL.

4-4. To remove the instrument from the case, remove the two machine screws on the rear of the cabinet, and slide the instrument forward.

4-5. EQUIPMENT REQUIRED.

4-6. The test procedures in this section attempt to isolate as many probable difficulties as possible with a minimum of equipment. The nature and capabilities of the instrument, however, require that the following test equipment be available.

Table 4-2. Test Equipment Required

Application	Equipment
Power Supply Adjustment	Calibrated (±1%) voltmeter. ⓗⓟ Model 405 series or 412A.
Frequency Calibration	Electronic frequency counter (ⓗⓟ Model 523 or 524 series) or an oscillator and oscilloscope for Lissajous patterns.
Output Wave Characteristics	High frequency oscilloscope with dc input feature and a vertical amplifier rise time of at least 0.012μsec, to check squarewave leading edge output. (ⓗⓟ Model 170A/162F)

4-7. TROUBLE LOCALIZATION.

4-8. The Model 211A Square Wave Generator is a precision instrument designed conservatively for long component life. Tube replacement and adjustments will repair a majority of difficulties which develop. Isolation of a circuit failure is frequently possible by considering the basic sections of the instrument as shown in the block diagram, figure 3-1.

4-9. The troubleshooting chart (see table 4-3) describes checks to be performed which locate specific symptoms, together with possible causes and remedies. In the chart (table 4-3) only the tubes are referenced, but it should be remembered that components associated with the referenced tubes are also failure possibilities. The maintenance steps in the chart should be performed in the order given since the chart assumes that the section ahead of the one under investigation is operating correctly.

4-10. A voltage and resistance diagram has been included (figure 4-7) which gives values measured on a normally operating instrument. In addition, a chart of important waveforms observed on a typical instrument is given, together with a discussion of the equipment and techniques needed to successfully observe these fast rise waveforms (paragraph 4-27).

4-11. For all testing of the Model 211A the use of a variable transformer to adjust the line voltage between 105 and 125 volts is recommended. An instrument in satisfactory condition should operate over this range. An instrument having marginal operation (from weak tubes) can be quickly detected at low line voltages, and weaknesses become easier to trace.

4-12. TUBE REPLACEMENT.

4-13. Tubes used in the Model 211A Square Wave Generator are listed in table 4-1. A tube may be replaced with any tube of its type having standard EIA characteristics. Those tubes which require adjustment when replaced are accompanied by a reference to the applicable paragraph in this section of the manual.

4-14. The type 6CL6 tubes may be replaced with their ruggedized equivalents, type 6197, to take advantage of the benefits of this premium type. All references to the 6CL6 apply equally to the 6197.

4-15. ADJUSTING THE POWER SUPPLY.

4-16. The power supply in the 211A must function correctly before the instrument will operate properly. Noise or variations in the regulated voltages may cause the instrument to drift out of calibration and other circuits to operate erratically.

4-17. To measure power supply voltage, connect a dc voltmeter with ±1% calibrated accuracy between the end terminal of R10 (shown in figure 4-2) and the chassis. The voltage should be between -192 and -200 volts. This voltage must be set to the point where regulation is obtained under high (115 volts +10%) and low (115 volts -10%) line conditions. A value of -195 volts is average for most instruments.

4-18. If the voltage is set too low, regulation will be lost under high-line conditions and excessive jitter will occur in the leading edge of the output square wave. If the voltage is set too high, loss of regulation and leading edge jitter will be noted under low-line conditions. Excessive jitter in the leading edge of the output square wave will indicate loss of regulation more quickly than a dc voltmeter connected directly across the output of the power supply. This check

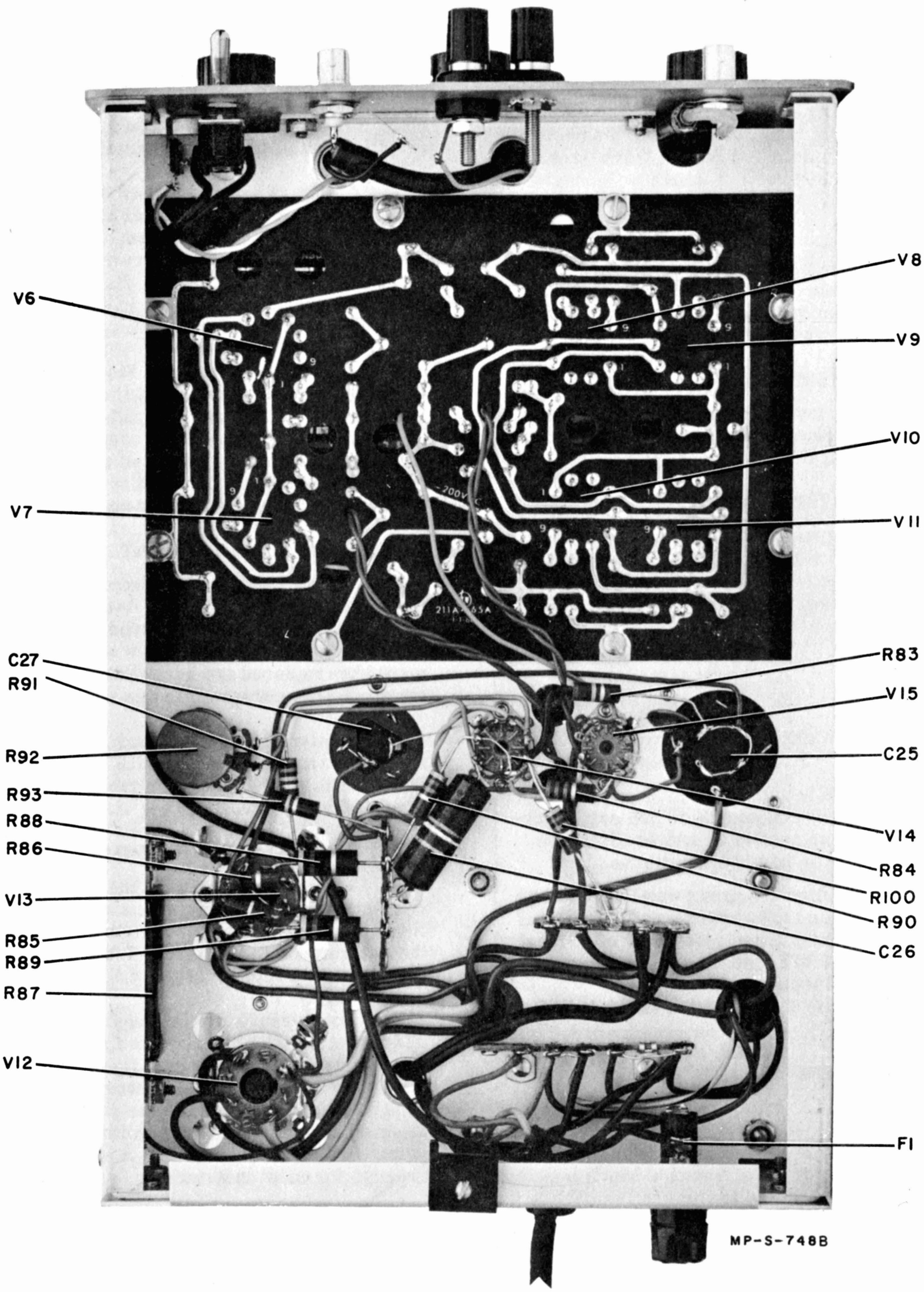


Figure 4-1. Model 211A Bottom View Showing Amplifier and Power Supply

Table 4-3. Troubleshooting Chart

CHECKS AND SYMPTOMS	POSSIBLE CAUSE	REMEDY
1. POWER SUPPLY		
With line voltage set at 115V, check that output of regulated supply is at correct value (see figure 4-2)		
Slowly vary supply voltage from 105 to 125 volts. The negative output of the supply should not vary.		
Excessive variation:	Replace V13, V14, V12 or V15 in this order. V13, V14 and V12 are most likely to cause trouble.	Readjust R92, if necessary, with 115V ac line. See paragraph 4 -15.
Low voltage:	Defective rectifier V12 or regulator V13.	Replace tubes; check supply; see paragraph 4-15.
High voltage:	Defective control tube V14.	Replace; check supply; see paragraph 4-15.
Erratic voltage:	Defective reference tube V15.	Replace; check supply; see paragraph 4-15.
2. OUTPUT WAVEFORMS 75 Ω OUTPUT		
Observe and measure output waveform at 75 output terminals with a high-speed (30 mc response) oscilloscope. See paragraph 4-27. Adjust SYMMETRY control to mechanical center.		
Waveform grossly out of symmetry. Cannot correct with control:	Defective V2 or V3.	Replace; recalibrate X100 range. See DIAL CALIBRATION, this chart.
Leading edge rounding:	Defective V6, V8, or V9.	Replace. No adjustment.
Low peak voltage (75 Ω out) (600 Ω output normal):	Defective V6, V8, or V9.	Replace. No adjustment.
	Power Supply.	Check paragraph 4-15 and POWER SUPPLY, this chart.
Weak output (both 75 Ω and 600 Ω outputs):	Defective V6 and/or V7.	Replace. No adjustment.
With dc input feature on scope, check 1 cps output (be sure dc amplifier in scope is balanced)		
Sloping top on waveform:	Defective V2 or V3.	Replace; recalibrate X100 range. See DIAL CALIBRATION, this chart.
	Defective V6 thru V11.	Replace as necessary. No adjustment.
Check leading edge of output at 1 mc Rise time slow:	Defective V6 thru V11.	Replace as necessary. No adjustment.
3. OUTPUT WAVEFORMS 600 Ω TERMINALS.		
Observe and measure output waveforms at 600 terminals with a high frequency oscilloscope with a rise time = 0.012μsec or less (30 mc response) if possible. See paragraph 4-27.		
Leading edge rounding:	Defective V7, V10 or V11.	Replace as necessary. No adjustment.
Low peak voltage (75 Ω normal):	Defective V10 or V11	Replace as necessary. No adjustment.
Check 600 Ω output at 1 cps and 1 mc as described above (step 2).		

Table 4-3. Troubleshooting Chart (cont'd)

CHECKS AND SYMPTOMS	POSSIBLE CAUSE	REMEDY
4. DIAL CALIBRATION		
Check calibration at 1000 cps on X100 range with setup shown in figure 4-3.		
Calibration tracking off more at one end than at other:	Power supply not properly set.	Check power supply.
Slight deviation:	Out of adjustment.	Adjust R31 for 1000∿. See paragraph 4-20.
Unable to adjust with R31:	Defective V2 and V3.	Replace; recalibrate X100 range. See paragraph 4-20.
Check	Defective V4.	Replace; recalibrate X100 range. See paragraph 4-20.
5. INPUT TRIGGER		
Drive sync in with 5-volt peak 1000∿ signal. Set 211A dial to 980 cps. Test setup shown in figure 4-4.		
No sync:	Defective V1	Replace; adjust sync sensitivity. See paragraph 4-24.
Check range of sync to 950 cps. Sync will not hold range:	Defective CR1 or V1.	Replace; adjust sync sensitivity. See paragraph 4-24.
Sync normal at 1 kc lack of sync at 1 mc:	L2 open	Replace; adjust sync sensitivity. See paragraph 4-24.

is valid only when all other tubes in the instrument are known to be good. Failure of the power supply to regulate properly is generally an indication of weak tubes. See table 4-3, Troubleshooting Chart.

4-19. If prevailing high or low line conditions occur at a location where a 211A is being used, the power supply can be adjusted to partially compensate for any adverse effects in instrument performance. The negative dc output of the power supply is referred to as -200 volts in the text and the schematic diagrams in this manual. The actual voltage in an instrument will vary from this figure as just described.

4-20. FREQUENCY CALIBRATION.

4-21. The output from the 211A is adjusted to the 1000 cps on the X100 range with the FREQUENCY dial set to 10. The operating frequency of the 211A on the X100 range is determined by the multivibrator operating current (bias) which can be adjusted by potentiometer R31 in the clamp circuit. All other ranges are calibrated by adjusting the rc time constants in the timing network after the X100 range is correctly set.

4-22. The test setup for frequency calibration is shown in figure 4-3. The procedure is as follows:

a. Set FREQUENCY dial on 211A to 10 and the RANGE switch to X100.

b. Connect instrument output to either a counter or to the horizontal sweep of an oscilloscope with a stable oscillator driving the vertical sweep at 1000 cps.

c. Adjust R31, shown in figure 4-2, to obtain 1000 cps from the Model 211A on the counter, or a zero beat Lissajous pattern on the scope.

d. Repeat steps a and b above using 100 cps, with FREQUENCY dial set to 1. Adjust R98 to obtain 100 cps on the counter or a zero beat Lissajous pattern on scope.

4-23. Calibration of all ranges should be done in the order shown in the Calibration Chart (table 4-4). If a frequency counter is used for calibration, use period measurement for steps 5 and 6, rather than frequency measurement. When using period measurement, measure a total square wave period, rather than a half-period, to eliminate SYMMETRY control effects.

Note

A 0.01 μf capacitor should be connected between the Model 211A output and the counter input when making period measurement.

Table 4-4. Calibration Chart

Perform Steps in Order	Set Range to:	Set Dial to:	Adjust Pot.	Measure Frequency
1.	X100	10	Paragraphs 4-20, steps a through d	
2.	X1K	10	R21	10,000 cps
3.	X10K	5	R20	50,000 cps
4.	X100K	5	R19	500 kc
5.	X10	1	R23	10 cps (100 ms)
6.	X1	1	R24	1 cps (1000 ms)

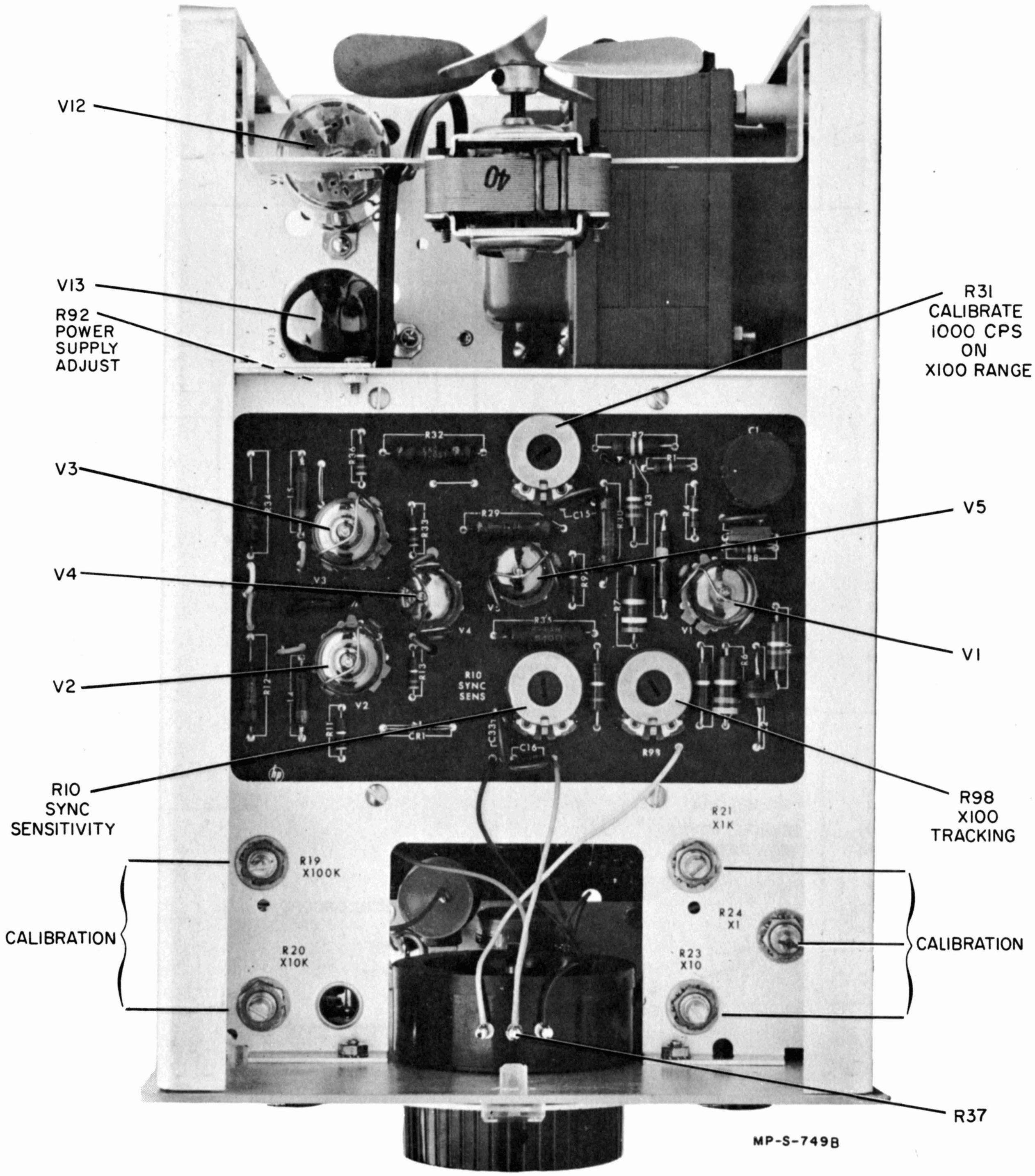


Figure 4-2. Model 211A Top View

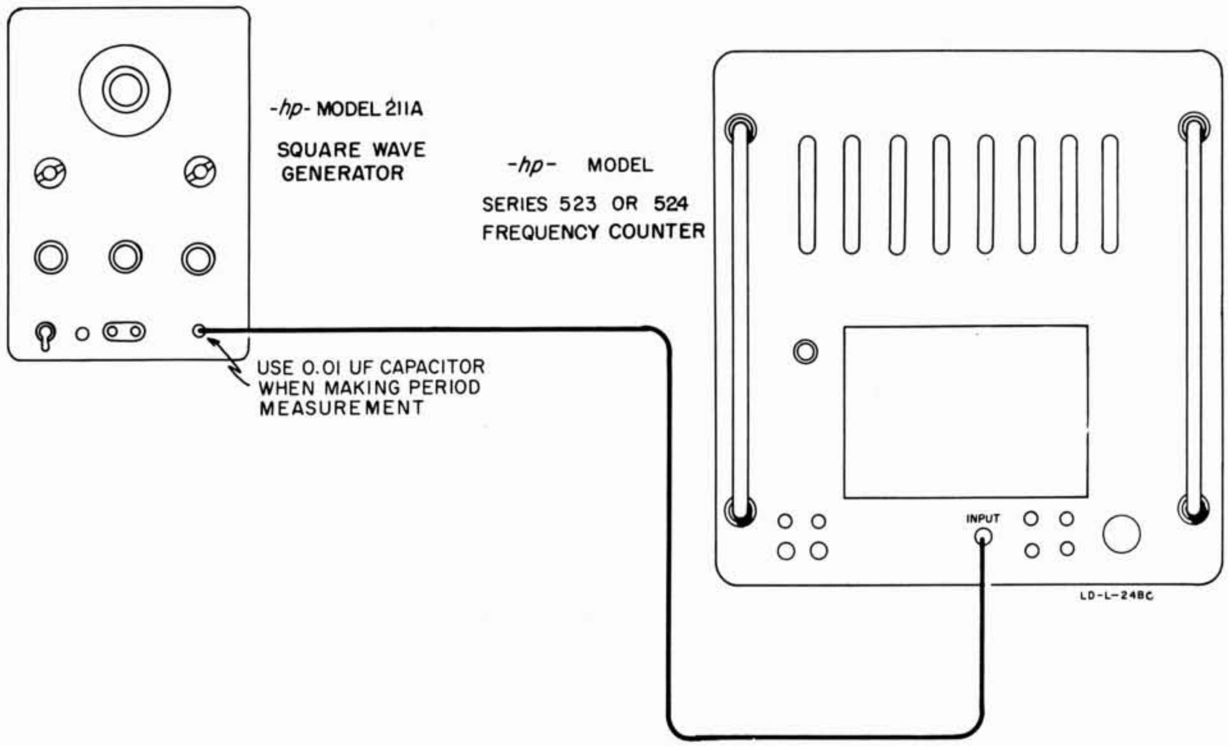


Figure 4-3. Test Setup for Frequency Calibration

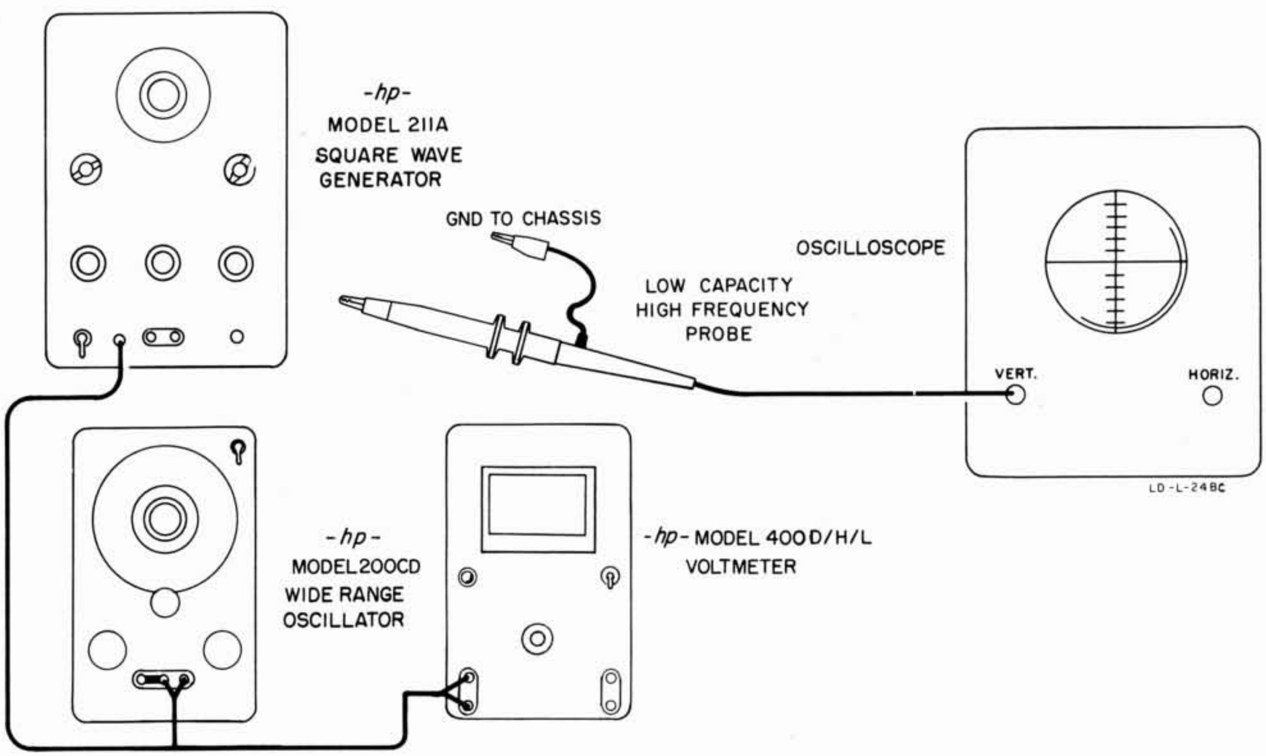


Figure 4-4. Test Setup for Sync Sensitivity Adjustment

4-24. ADJUSTING EXTERNAL SYNC SENSITIVITY.

4-25. In the no-signal condition the input section of the Schmitt-trigger tube V1 is biased approximately 3 volts below cut-off. Operation of the sync circuit therefore requires an input signal of at least 3 volts peak amplitude.

4-26. To adjust the sensitivity of the trigger:

a. Drive the SYNC IN connector with a 1000 cps sine wave of 2.1 volts rms (3.0 volts peak).

b. Connect oscilloscope through a low-capacity probe to pin 6 of V1. See figure 4-4.

c. Turn R10 to obtain a square-wave on oscilloscope.

d. Turn R10 to maximum cw and waveform on oscilloscope should disappear.

e. Adjust R10 counterclockwise until negative pulse just appears on oscilloscope.

f. This is correct adjustment of the SYNC sensitivity control for reliable external synchronization with a positive-going pulse or sine wave signal having a minimum amplitude of 5 volts peak.

4-27. WAVEFORM OBSERVATION AND MEASUREMENT.

4-28. The 211A is very reliable in that it is for the most part a "go" or "no go" type of circuit. If the unit is operating normally, there is very little chance that the rise time of the leading edge of the square wave is slower than rated. Generally slow rise time is due to weak tubes, however, it is possible that if a part has been damaged and has changed value, the rise time may be less than rated.

4-29. The rise time of the 600-ohm output is less than 0.1 microseconds with the OUTPUT AMPLITUDE set at maximum. Reducing the setting of the 600 Ω OUTPUT AMPLITUDE control to approximately a dial setting of "2" will give a voltage level approximately the same as that from the 75-ohm output jack. The rise time will be improved due to reduced shunting effect of circuit capacity. A rise time of essentially the same as that from the 75-ohm output jack is possible under these conditions.

4-30. A low capacity probe specifically designed for high frequencies should be used for observing waveforms. Certain probes may tend to ring at a high frequency when hit with very fast pulses.

4-31. To measure the rise time of the 600 Ω output, which is approximately 0.1 microsecond, an oscilloscope with a bandwidth of 10 megacycles is quite adequate. Excellent oscilloscopes for this purpose are the ⓗⓟ Model 160B or 150A.

4-32. TO ACCURATELY MEASURE THE RISE TIME OF THE 75 Ω OUTPUT REQUIRES AN EXTREMELY HIGH SPEED OSCILLOSCOPE. The oscilloscope vertical amplifier should have a bandwidth of at least 30 megacycles. This corresponds to a rise time of approximately 0.012 microseconds. Approximate rise time of an oscilloscope can be calculated by dividing bandwidth into 0.35. For example, if bandwidth is 30 mc, the rise time is approximately 0.012 microsecond.

4-33. When using an oscilloscope with a 30 mc response (rise time = 0.012 microsecond), an error will still be read in the rise time of the 75 Ω output. The true rise time of the 211A alone can be conveniently computed, however. The formula is as follows:

$$t_o = \sqrt{t_1^2 - t_2^2}$$

where t_o = actual rise time in microseconds

t_1 = observed rise time

t_2 = known rise time of oscilloscope vertical amplifier

4-34. As an example, the measured values taken from a production unit which are shown in the waveform charts figure 4-7A and 4-7B, indicate a rise time of 0.023 μsec. The actual rise time is computed below:

$$t_o = \sqrt{t_1^2 - t_2^2} = \sqrt{(0.023)^2 - (0.012)^2}$$

t_o = 0.0196 microseconds actual rise time of the 211A Square Wave Generator.

4-35. The typical waveforms shown in figure 4-7A, B can be observed with the following equipment:

a. Oscilloscope: ⓗⓟ Model 170A with 162F Preamplifier, or Tektronix Type 545A with type K Preamplifier (use either instrument).

b. Probe: ⓗⓟ Model AC-21A (10:1) or AC-21C (50:1).

4-36. Use of an oscilloscope which is not in good operating order as far as high frequency signals are concerned, may cause the 1 mc square wave to look slightly uneven across the top, even though it is perfectly square at low frequencies. A simple check to determine if the trouble is in the oscilloscope or in the 211A is to use d-c coupling when observing a 1 mc square wave from the 75-ohm output.

4-37. Since the 211A square wave is negative going with respect to ground, the highest part of the square wave must be in fact at zero volts. While on d-c coupling, ground the probe and note the position of the trace on the graticule, then note if the highest part of the square wave exceeds the point of zero volts. If it does, the oscilloscope is at fault.

4-38. If the oscilloscope is proven not to be at fault, one of the tubes in the 211A is weak and should be replaced. The two situations are shown in figure 4-6.

4-39. When observing a 1 mc square wave there may be a very small amount of overshoot or undershoot at the leading edge of the bottom of the negative portion of the square wave. This is normal. A shorted C24 will cause approximately 5-10 volts drop in amplitude of the 600 Ω output and a slightly slower rise time.

4-40. If C19, C20, C21, or C22 have too much capacity or if the associated resistors R52, R53, R56, and R57 have low resistance, there will be overshoot on the square wave. If the capacity of any of these capacitors is low or the associated resistors have for some reason increased in resistance, there will be undershoot or rounding of the corner of the leading edge of the square wave. Before any changes in these parts are made, however, every effort should be made to correct the trouble with good tubes as this is the normal reason for poor waveshape. Unless these parts have changed value, these circuits should not need adjustment. No adjustment should be attempted unless a 30 megacycle oscilloscope is available to determine when the compensation is correct.

CAUTION

To avoid accidental damage, always turn off power before removing or installing circuit board assemblies.

4-41. SERVICING ETCHED CIRCUIT BOARDS.

4-42. The Model 211A is supplied with single-sided etched circuit boards; i. e., conductive material is located only on one side of the boards. Funneled eyelets insure good electrical contact between component leads and conductor. When servicing these boards, the following general rules should be followed:

a. DO NOT APPLY EXCESSIVE HEAT to components or conductor.

b. To remove damaged components, clip leads near component; then apply heat and remove leads with a straight upward motion.

c. Use a toothpick or wooden splinter to clean component mounting holes before installing new components.

d. APPLY SOLDER FROM CONDUCTOR SIDE of board to insure good contact between eyelets, component lead, and conductor.

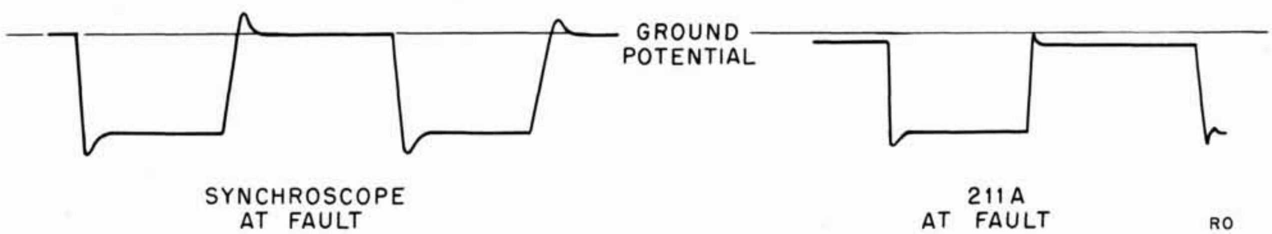
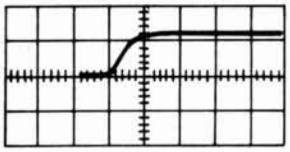


Figure 4-5. 75-ohm Output Waveform which has Defects on Positive Portion, as Observed with a DC Coupled Oscilloscope

1KC SQUARE WAVE

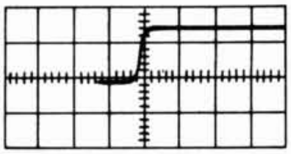


600-ohm output

Amplitude control set at "10"

0.1 μsec/cm

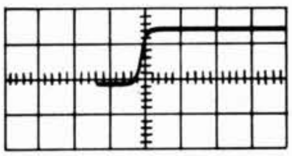
50 volts/cm



600-ohm output

Amplitude control set at approx. "2"

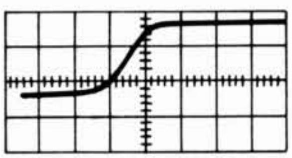
5 volts/cm



75-ohm output

Controls set for maximum output

5 volts/cm



75-ohm output

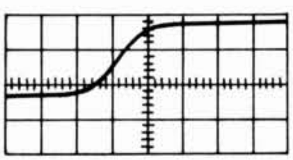
0.02 μsec/cm

X50 attenuation

10 megohm probe used

Gain adjusted to give 10 divisions vertical deflection for ease in measuring rise time of leading edge of square wave

1MC SQUARE WAVE



75-ohm output

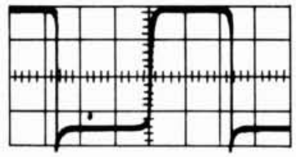
Same test conditions as for 1 kc

Note that rise time is the same at 1 mc as at 1 kc

Figure 4-6A

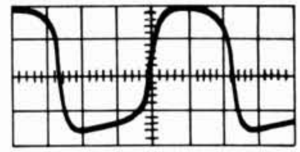
V6 PIN 2

1 KC



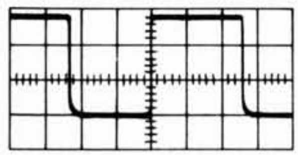
200 μS/CM
5 V/CM

1 MC

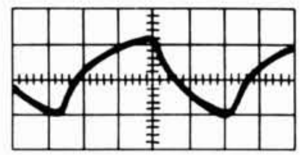


0.2 μS/CM
5 V/CM

V6 PIN 6

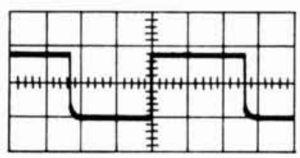


200 μS/CM
20 V/CM

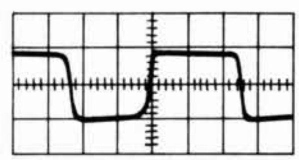


0.2 μS/CM
20 V/CM

V8 PIN 9



200 μS/CM
5 V/CM



0.2 μS/CM
5 V/CM

NOTE: Since the circuit is balanced, the waveforms on V7 and V10 are the same as those on V6 and V8.

Figure 4-6B

Figure 4-6. Model 211A Waveforms

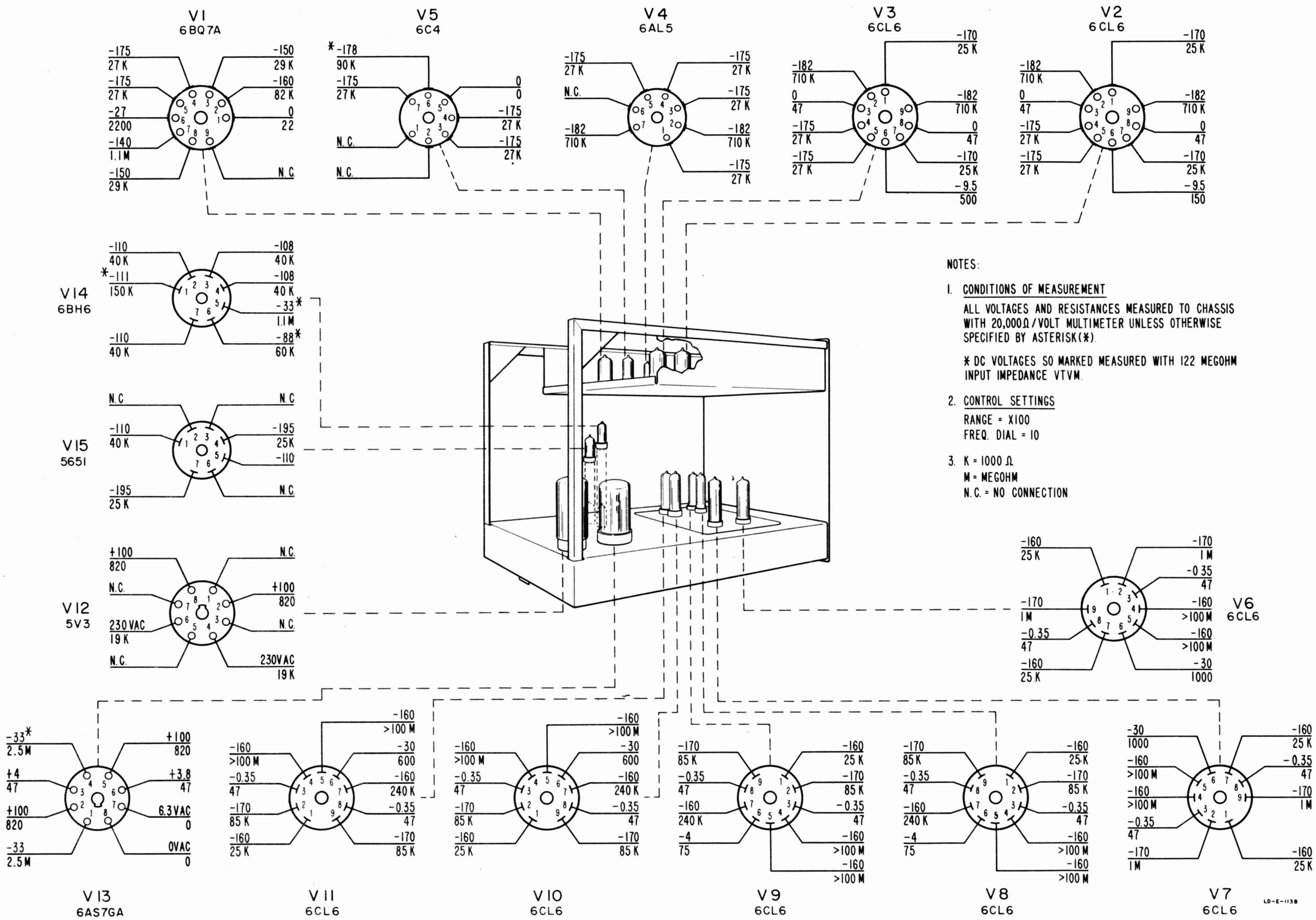


Figure 4-7. Voltage and Resistance Diagram

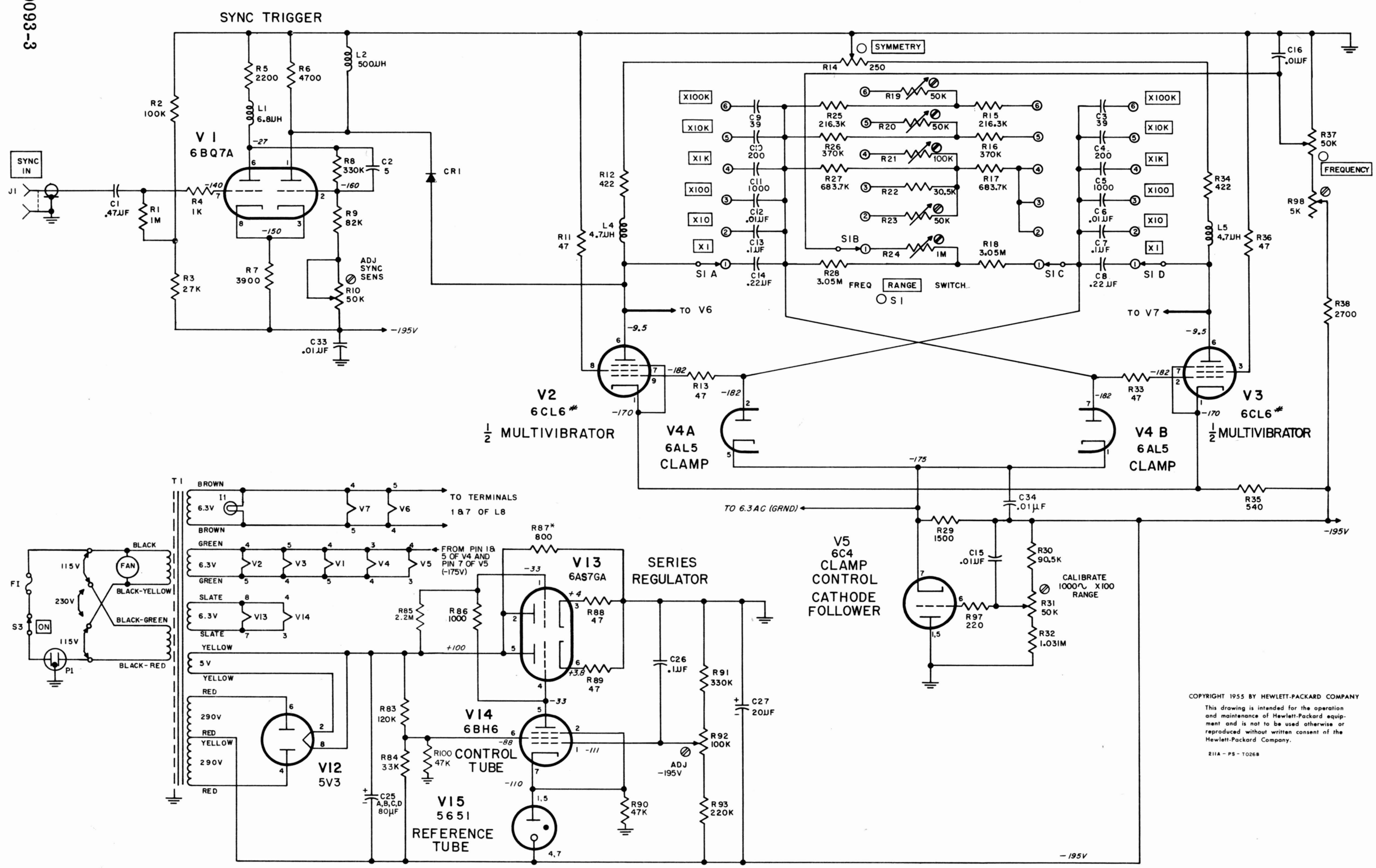
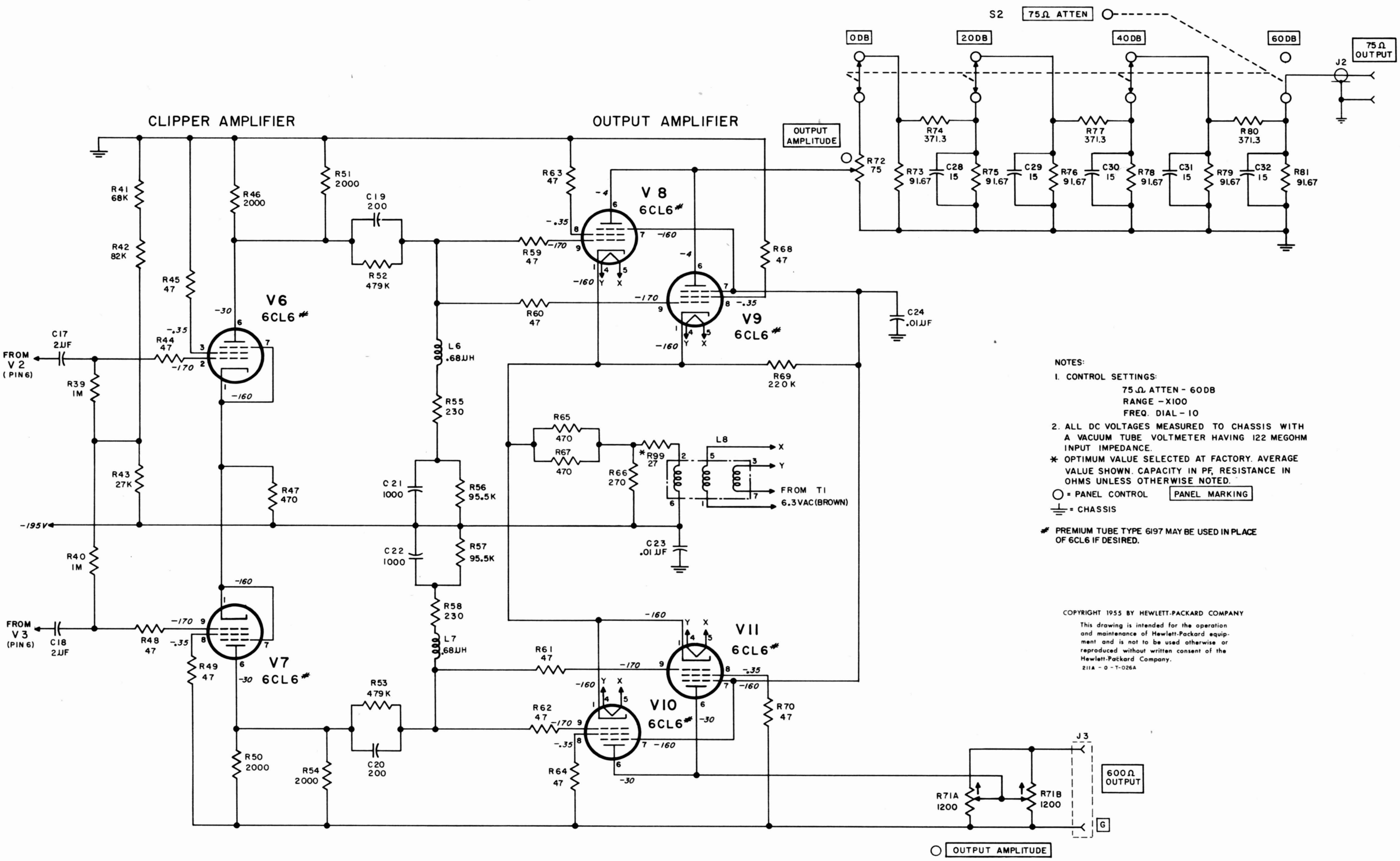


Figure 4-8. Multivibrator and Power Supply



NOTES:

1. CONTROL SETTINGS:
   75Ω ATTEN - 60DB
   RANGE - X100
   FREQ. DIAL - 10
2. ALL DC VOLTAGES MEASURED TO CHASSIS WITH A VACUUM TUBE VOLTMETER HAVING 122 MEGOHM INPUT IMPEDANCE.

* OPTIMUM VALUE SELECTED AT FACTORY. AVERAGE VALUE SHOWN. CAPACITY IN PF, RESISTANCE IN OHMS UNLESS OTHERWISE NOTED.

○ = PANEL CONTROL [PANEL MARKING]

⏚ = CHASSIS

PREMIUM TUBE TYPE 6197 MAY BE USED IN PLACE OF 6CL6 IF DESIRED.

Figure 4-9. Output Section

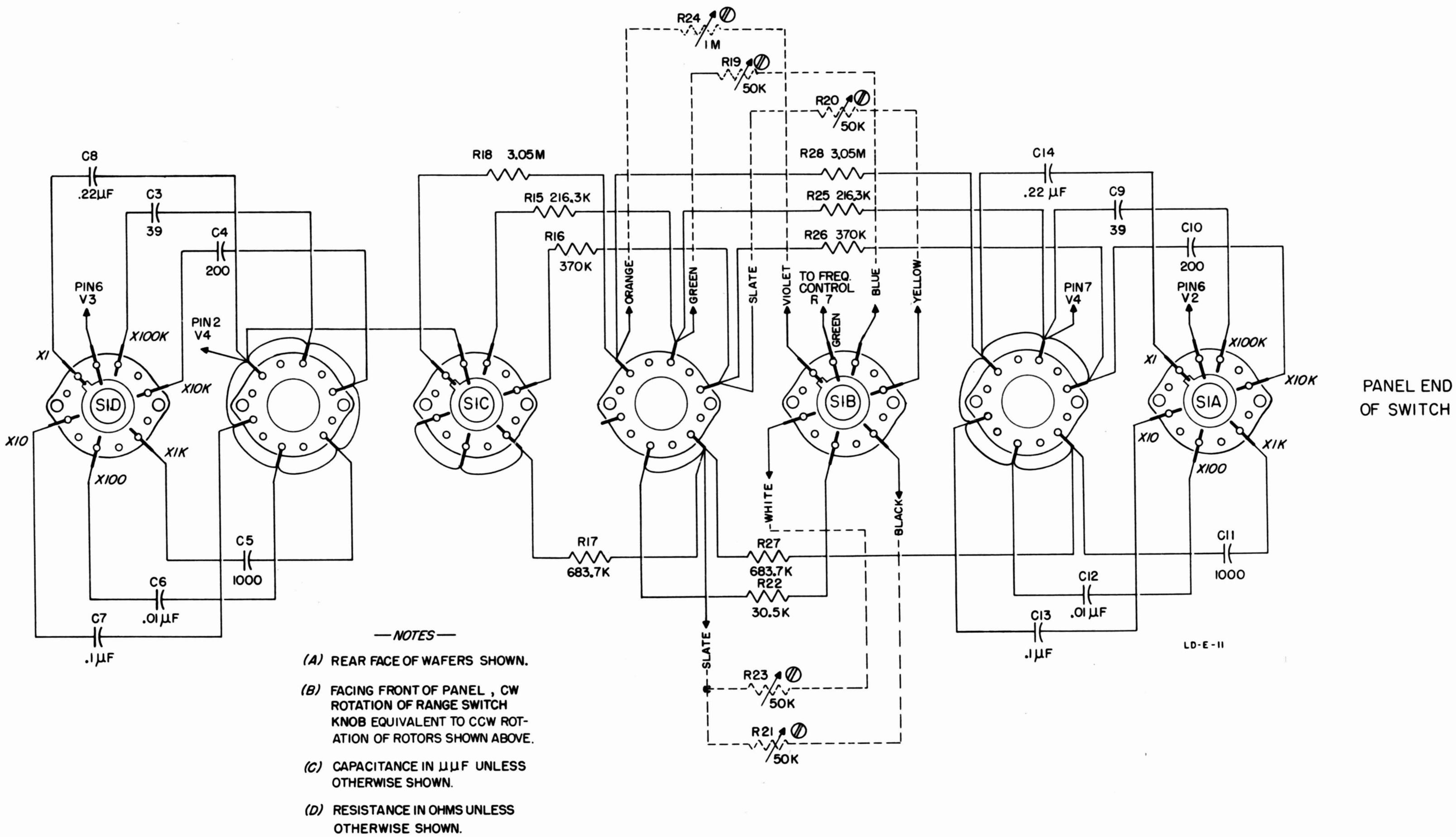


Figure 4-10. Range Switch Detail

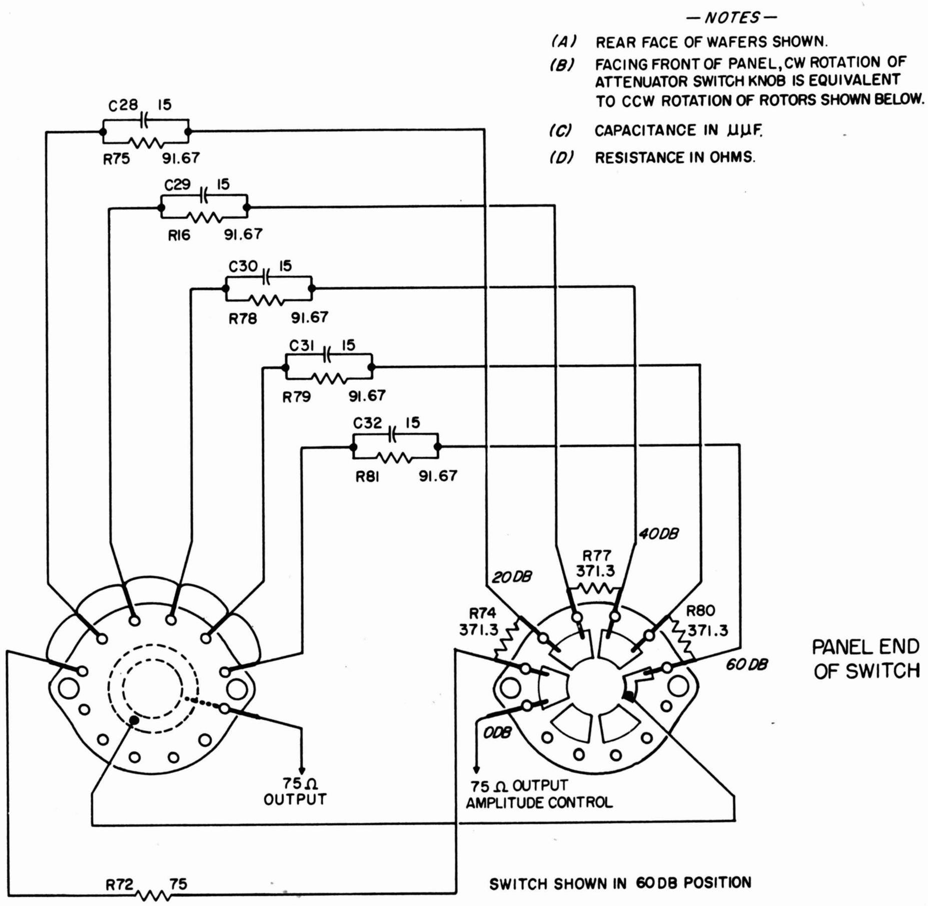


Figure 4-11. Attenuator Switch Detail

SECTION V
REPLACEABLE PARTS

5-1. INTRODUCTION.

5-2. This section contains information for ordering replacement parts. Table 5-1 lists parts in alpha-numerical order of their reference designators and indicates the description and hp stock number of each part, together with any applicable notes. Table 5-2 lists parts in alpha-numerical order of their hp stock numbers and provides the following information on each part:

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

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

c. Typical manufacturer's stock number.

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

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

5-3. Miscellaneous parts not indexed in table 5-1 are listed at the end of table 5-2.

5-4. ORDERING INFORMATION.

5-5. To order a replacement part, address order or inquiry either to your authorized Hewlett-Packard sales representative or to

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

or, in Western Europe, to

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

5-6. Specify the following information for each part:

a. Model and complete serial number of instrument.

b. Hewlett-Packard stock number.

c. Circuit reference designator.

d. Description.

5-7. To order a part not listed in table 5-1, give a complete description of the part and include its function and location.

REFERENCE DESIGNATORS

A = assembly
B = motor
C = capacitor
CR = diode
DL = delay line
DS = device signaling (lamp)
E = misc electronic part

F = fuse
FL = filter
J = jack
K = relay
L = inductor
M = meter
MP = mechanical part

P = plug
Q = transistor
R = resistor
RT = thermistor
S = switch
T = transformer

V = vacuum tube, neon bulb, photocell, etc.
W = cable
X = socket
XF = fuseholder
XDS = lampholder
Z = network

ABBREVIATIONS

a = amperes

bp = bandpass
bwo = backward wave oscillator

c = carbon
cer = ceramic
cmo = cabinet mount only
coef = coefficient
com = common
comp = composition
conn = connection
crt = cathode-ray tube

dep = deposited

EIA = Tubes or transistors meeting Electronic Industries' Association standards will normally result in instrument operating within specifications; tubes and transistors selected for best performance will be supplied if ordered by hp stock numbers.

elect = electrolytic
encap = encapsulated

f = farads
fxd = fixed

Ge = germanium
grd = ground (ed)

h = henries
Hg = mercury

impg = impregnated
incd = incandescent
ins = insulation (ed)

K = kilo = 1000

lin = linear taper
log = logarithmic taper

m = milli = 10^{-3}
M = megohms
ma = milliamperes
μ = micro = 10^{-6}
minat = miniature
mfgl = metal film on glass
mfr = manufacturer

mtg = mounting
my = mylar

NC = normally closed
Ne = neon
NO = normally open
NPO = negative positive zero (zero temperature coefficient)
nsr = not separately replaceable

obd = order by description

p = peak
pc = printed circuit board
pf = picofarads = 10^{-12} farads
pp = peak-to-peak
piv = peak inverse voltage
pos = position(s)
poly = polystyrene
pot = potentiometer

rect = rectifier

rot = rotary
rms = root-mean-square
rmo = rack mount only

s-b = slow-blow
Se = selenium
sect = section(s)
Si = silicon
sil = silver
sl = slide

td = time delay
TiO_2 = titanium dioxide

tog = toggle
tol = tolerance
trim = trimmer
twt = traveling wave tube

var = variable
w/ = with
W = watts
ww = wirewound
w/o = without

* = optimum value selected at factory, average value shown (part may be omitted)

01194-4

Table 5-1. Reference Designation Index

Circuit Reference	ⓗ Stock No.	Description #	Note
C1	0160-0051	C: fxd, my, 0.47 μf ±10%, 400 vdcw	
C2	0140-0033	C: fxd, mica, 5 pf ±20%, 500 vdcw	
C3	0140-0035	C: fxd, mica, 39 pf ±5%, 500 vdcw	
C4	0140-0090	C: fxd, mica, 200 pf ±5%, 500 vdcw	
C5	0140-0018	C: fxd, mica, 1000 pf ±5%, 500 vdcw	
C6	0140-0009	C: fxd, mica, 0.01 μf ±5%, 500 vdcw	
C7	0160-0022	C: fxd, my, 0.1 μf ±5%, 600 vdcw	
C8	0160-0018	C: fxd, my, 0.22 μf ±10%, 400 vdcw	
C9	0140-0035	C: fxd, mica, 39 pf ±5% , 500 vdcw	
C10	0140-0090	C: fxd, mica, 200 pf ±5%, 500 vdcw	
C11	0140-0018	C: fxd, mica, 1000 pf ±5%, 500 vdcw	
C12	0140-0009	C: fxd, mica, 0.01 μf ±5%, 500 vdcw	
C13	0160-0022	C: fxd, my, 0.1 μf ±5%, 600 vdcw	
C14	0160-0018	C: fxd, my, 0.22 μf ±10%, 400 vdcw	
C15, C16	0150-0012	C: fxd, cer, 0.01 μf ±20%, 1000 vdcw	
C17, C18	0170-0002	C: fxd, my, 2 μf ±20%, 400 vdcw	
C19, C20	0140-0098	C: fxd, mica, 200 pf ±1%, 500 vdcw	
C21, C22	0140-0099	C: fxd, mica, 1000 pf ±1%, 500 vdcw	
C23, C24	0150-0012	C: fxd, cer, 0.01 μf ±20%, 1000 vdcw	
C25	0180-0025	C: fxd, elect, 4 sect, 20 μf/sect., 450 vdcw	
C26	0160-0013	C: fxd, my, 0.1 μf ±10%, 400 vdcw	
C27	0180-0011	C: fxd, elect, 20 μf, 450 vdcw	
C28 thru C32	0140-0004	C: fxd, mica, 15 pf ±10%, 500 vdcw	
C33, C34	0150-0012	C: fxd, cer, 0.01 μf ±20%, 1000 vdcw	
CR1	1910-0009	Diode, Ge	
F1	2110-0015	Fuse, cartridge: 2.5 amp, s-b (for 115 V operation)	
	2110-0021	Fuse, cartridge: 1.25 amp, s-b (for 230 V operation)	
I1	2140-0012	Lamp, minat: 2 pin base, 6.3 V, 0.15 amp, #12	
J1, J2	1250-0118	Connector: BNC (rack model)	
	1250-0083	Connector: BNC (cabinet model)	

 # See introduction to this section

Table 5-1. Reference Designation Index (cont'd)

Circuit Reference	ⓗ Stock No.	Description #	Note
L1	9140-0026	Inductor: RF, 6.8 μh	
L2	9140-0022	Inductor: RF, 500 μh	
L3		Not assigned	
L4, L5	9140-0025	Inductor: RF, 4.7 μh	
L6, L7	9140-0024	Inductor: RF, 0.68 μh	
L8	211A-60A	Inductor: RF, (special)	
P1	8120-0050	Cord, power	
R1	0687-1051	R: fxd, comp, 1M ±10%, 1/2 W	
R2	0690-1041	R: fxd, comp, 100K ohms ±10%, 1 W	
R3	0690-2731	R: fxd, comp, 27K ohms ±10%, 1 W	
R4	0687-1021	R: fxd, comp, 1K ohms ±10%, 1/2 W	
R5	0690-2221	R: fxd, comp, 2.2K ohms ±10%, 1 W	
R6	0693-4721	R: fxd, comp, 4.7K ohms ±10%, 2 W	
R7	0693-3921	R: fxd, comp, 3.9K ohms ±10%, 2 W	
R8	0687-3341	R: fxd, comp, 330K ohms ±10%, 1/2 W	
R9	0690-8231	R: fxd, comp, 82K ohms ±10%, 1 W	
R10	2100-0084	R: var, comp, 50K ohms ±20%, 1/3 W	
R11	0687-4701	R: fxd, comp, 47 ohms ±10%, 1/2 W	
R12	0727-0073	R: fxd, dep c, 422 ohms ±1%, 1/2 W	
R13	0687-4701	R: fxd, comp, 47 ohms ±10%, 1/2 W	
R14	2100-0079	R: var, comp, 250 ohms ±10%	
R15	0730-0079	R: fxd, dep c, 216.3K ohms ±1%, 1 W	
R16	0730-0087	R: fxd, dep c, 370K ohms ±1%, 1 W	
R17	0730-0096	R: fxd, dep c, 683.7K ohms ±1%, 1 W	
R18	0730-0118	R: fxd, dep c, 3.05M ±1%, 1 W	
R19, R20	2100-0013	R: var, comp, lin, 50K ohms ±20%	
R21	2100-0063	R: var, comp, lin, 100K ohms	
R22	0730-0045	R: fxd, dep c, 30.5K ohms ±1%, 1 W	
R23	2100-0013	R: var, comp, lin, 50K ohms ±20%	
R24	2100-0074	R: var, comp, lin, 1M ±30%	
R25	0730-0079	R: fxd, dep c, 216.3K ohms ±1%, 1 W	
R26	0730-0087	R: fxd, dep c, 370K ohms ±1%, 1 W	
R27	0730-0096	R: fxd, dep c, 683.7K ohms ±1%, 1 W	

See introduction to this section

Table 5-1. Reference Designation Index (cont'd)

Circuit Reference	ⓗⓟ Stock No.	Description #	Note
R28	0730-0118	R: fxd, dep c, 3.05 M ±1%, 1 W	
R29	0730-0017	R: fxd, dep c, 1.5K ohms ±1%, 1 W	
R30	0730-0065	R: fxd, dep c, 90.5K ohms ±1%, 1 W	
R31	2100-0084	R: var, comp, 50K ohms ±20%, 1/3 W	
R32	0730-0106	R: fxd, dep c, 1.031M ±1%, 1 W	
R33	0687-4701	R: fxd, comp, 47 ohms ±10%, 1/2 W	
R34	0727-0073	R: fxd, dep c, 422 ohms ±1%, 1/2 W	
R35	0811-0004	R: fxd, ww, 540 ohms ±1%, 5 W	
R36	0687-4701	R: fxd, comp, 47 ohms ±10%, 1/2 W	
R37	2100-0130	R: var, ww, 50K ohms ±1%, 8 W	
R38	0690-2721	R: fxd, comp, 2.7K ohms ±10%, 1 W	
R39, R40	0687-1051	R: fxd, comp, 1M ±10%, 1/2 W	
R41	0687-6831	R: fxd, comp, 68K ohms ±10%, 1/2 W	
R42	0687-8231	R: fxd, comp, 82K ohms ±10%, 1/2 W	
R43	0687-2731	R: fxd, comp, 27K ohms ±10%, 1/2 W	
R44, R45	0687-4701	R: fxd, comp, 47 ohms ±10%, 1/2 W	
R46	0763-0001	R: fxd, mfgl, 2K ohms ±1%, 2 W	
R47	0771-0002	R: fxd, mfgl, 470 ohms ±10%, 4 W	
R48, R49	0687-4701	R: fxd, comp, 47 ohms ±10%, 1/2 W	
R50, R51	0763-0001	R: fxd, mfgl, 2K ohms ±1%, 2 W	
R52, R53	0730-0091	R: fxd, dep c, 479K ohms ±1%, 1 W	
R54	0763-0001	R: fxd, mfgl, 2K ohms ±1%, 2 W	
R55	0730-0007	R: fxd, dep c, 230 ohms ±1%, 1 W	
R56, R57	0730-0066	R: fxd, dep c, 95.5K ohms ±1%, 1 W	
R58	0730-0007	R: fxd, dep c, 230 ohms ±1%, 1 W	
R59 thru R64	0687-4701	R: fxd, comp, 47 ohms ±10%, 1/2 W	
R65	0771-0002	R: fxd, mfgl, 470 ohms ±10%, 4 W	
R66	0690-2711	R: fxd, comp, 270 ohms ±10%, 1 W	
R67	0771-0002	R: fxd, mfgl, 470 ohms ±10%, 4 W	
R68	0687-4701	R: fxd, comp, 47 ohms ±10% , 1/2 W	
R69	0687-2241	R: fxd, comp, 220K ohms ±10%, 1/2 W	
R70	0687-4701	R: fxd, comp, 47 ohms ±10%, 1/2 W	
R71	2100-0075	R: var, comp, dual,1.2K ohms ±10%	
R72	2100-0076	R: var, comp, 75 ohms ±10%	
R73	0727-0324	R: fxd, dep c, 91.67 ohms ±1%, 1/2 W	

See introduction to this section

Table 5-1. Reference Designation Index (cont'd)

Circuit Reference	ⓗ Stock No.	Description #	Note
R74	0727-0323	R: fxd, dep c, 371.3 ohms ±1%, 1/2 W	
R75, R76	0727-0324	R: fxd, dep c, 91.67 ohms ±1%, 1/2 W	
R77	0727-0323	R: fxd, dep c, 371.3 ohms ±1%, 1/2 W	
R78, R79	0727-0324	R: fxd, dep c, 91.67 ohms ±1%, 1/2 W	
R80	0727-0323	R: fxd, dep c, 371.3 ohms ±1% , 1/2 W	
R81	0727-0324	R: fxd, dep c, 91.67 ohms ±1%, 1/2 W	
R82		Not assigned	
R83	0690-1241	R: fxd, comp, 120K ohms ±10%, 1 W	
R84	0690-3331	R: fxd, comp, 33K ohms ±10%, 1 W	
R85	0690-2251	R: fxd, comp, 2.2M ±10%, 1 W	
R86	0690-1021	R: fxd, comp, 1000 ohms ±10%, 1 W	
R87	0818-0008	R: fxd, ww, 800 ohms ±5%, 40 W Optimum value selected at factory average value shown	
R88, R89	0693-4701	R: fxd, comp, 47 ohms ±10%, 2 W	
R90	0690-4731	R: fxd, comp, 47K ohms ±10%, 1 W	
R91	0690-3341	R: fxd, comp, 330Kohms ±10%, 1 W	
R92	2100-0063	R: var, comp, lin, 100K ohms	
R93	0690-2241	R: fxd, comp, 220K ohms ±10%, 1 W	
R94 thru R96		Not assigned	
R97	0687-2211	R: fxd, comp, 220 ohms ±10%, 1/2 W	
R98	2100-0082	R: var, comp, 5K ohms ±20%, 1/2 W	
R99	0690-2701	R: fxd, comp, 27 ohms ±10%, 1 W Optimum value selected at factory average value shown	
R100	0690-4731	R: fxd, comp, 47K ohms ±10%, 1 W	
S1	211A-19W	Assy, range switch	
S2	211A-19A	Assy, attenuator switch	
S3	3101-0001	Switch, tog: SPST	
T1	9100-0062	Transformer, power	
V1	1932-0021	Tube, electron: 6BQ7A	
V2, V3	1923-0030	Tube, electron: 6CL6 or 6197	
V4	1930-0013	Tube, electron: 6AL5	
V5	1921-0005	Tube, electron: 6C4	

See introduction to this section

Table 5-1. Reference Designation Index (cont'd)

Circuit Reference	ⓗ Stock No.	Description #	Note
V6 thru V11	1923-0030	Tube, electron: 6CL6 or 6197	
V12	1930-0020	Tube, electron: 5V3	
V13	1932-0019	Tube, electron: 6AS7GA	
V14	1923-0027	Tube, electron: 6BH6	
V15	1940-0001	Tube, electron: 5651	
XV1 thru XV3	1200-0062	Socket, tube: 9 pin minat (for pc)	
XV4, XV5	1200-0053	Socket, tube: 7 pin minat (for pc)	
XV6 thru XV11	1200-0062	Socket, tube: 9 pin minat (for pc)	
XV12, XV13	1200-0020	Socket, tube: octal	
XV14, XV15	1200-0009	Socket, tube: 7 Pin minat	

See introduction to this section

Table 5-2. Replaceable Parts

ⓗ Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS		
211A-19A	Assy, attenuator switch	28480	211A-19A	1	1		
211A-19W	Assy, range switch	28480	211A-19W	1	1		
211A-60A	Inductor: RF, (special)	28480	211A-60A	1	1		
0140-0004	C: fxd, mica, 15 pf ±10%, 500 vdcw	76433	RCM15B150K	5	2		
0140-0009	C: fxd, mica, 0.01 μf ±5%, 500 vdcw	04062	CM35B103J	2	1		
0140-0018	C: fxd, mica, 1000 pf ±5%, 500 vdcw	76433	RCM20E102J	2	1		
0140-0033	C: fxd, mica, 5 pf ±20%, 500 vdcw	76433	RCM15E050M	1	1		
0140-0035	C: fxd, mica, 39 pf ±5%, 500 vdcw	76433	RCM15E390J	2	1		
0140-0090	C: fxd, mica, 200 pf ±5%, 500 vdcw	04062	CM15E201J	2	1		
0140-0098	C: fxd, mica, 200 pf ±1%, 500 vdcw	04062	CM15E201F	2	1		
0140-0099	C: fxd mica, 1000 pf ±1%, 500 vdcw	04062	CM20E102F	2	1		
0150-0012	C: fxd, cer, 0.01 μf ±20%, 1000 vdcw	56289	29C214A3-H-1038	6	2		
0160-0013	C: fxd, my, 0.1 μf ±10%, 400 vdcw	56289	160P10494	1	1		
0160-0018	C: fxd, my, 0.22 μf ±10%, 400 vdcw	56289	160P22494	2	1		
0160-0022	C: fxd, my, 0.1 μf ±5%, 600 vdcw	56289	160P10456	2	1		
0160-0051	C: fxd, my, 0.47 μf ±10%, 400 vdcw	00656	V161D	1	1		
0170-0002	C: fxd, my, 2 μf ±20%, 400 vdcw	84411	663UW20504	2	1		
0180-0011	C: fxd, elect, 20 μf, 450 vdcw	56289	D32550	1	1		
0180-0025	C: fxd, elect, 4 sect, 20 μf/sect, 450 vdcw	56289	D32452	1	1		
0687-1021	R: fxd, comp, 1K ohms ±10%, 1/2 W	01121	EB1021	1	1		
0687-1051	R: fxd, comp, 1M ±10%, 1/2 W	01121	EB1051	3	1		
0687-2211	R: fxd, comp, 220 ohms ±10%, 1/2 W	01121	EB2211	1	1		
0687-2241	R: fxd, comp, 220K ohms ±10%, 1/2 W	01121	EB2241	1	1		
0687-2731	R: fxd, comp, 27K ohms ±10%, 1/2 W	01121	EB2731	1	1		
0687-3341	R: fxd, comp, 330K ohms ±10%, 1/2 W	01121	EB3341	1	1		
0687-4701	R: fxd, comp, 47 ohms ±10%, 1/2 W	01121	EB4701	16	4		
0687-6831	R: fxd, comp, 68K ohms ±10%, 1/2 W	01121	EB6831	1	1		
0687-8231	R: fxd, comp, 82K ohms ±10%, 1/2 W	01121	EB8231	1	1		
0690-1021	R: fxd, comp, 1K ohms ±10%, 1 W	01121	GB1021	1	1		
0690-1041	R: fxd, comp, 100K ohms ±10%, 1 W	01121	GB1041	1	1		
0690-1241	R: fxd, comp, 120K ohms ±10%, 1 W	01121	GB1241	1	1		
0690-2221	R: fxd, comp, 2.2K ohms ±10%, 1 W	01121	GB2221	1	1		
0690-2241	R: fxd, comp, 220K ohms ±10%, 1 W	01121	GB2241	1	1		

#See introduction to this section

Table 5-2. Replacable Parts (cont'd)

Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS		
0690-2251	R: fxd, comp, 2.2M ohms ±10%, 1 W	01121	GB2251	1	1		
0690-2701	R: fxd, comp, 27*ohms ±10%, 1 W	01121	GB2701	1	1		
0690-2711	R fxd, comp, 270 ohms ±10%, 1 W	01121	GB2711	1	1		
0690-2721	R: fxd, comp, 2.7K ohms ±10%, 1 W	01121	GB2721	1	1		
0690-2731	R: fxd, comp, 27K ohms ±10%, 1 W	01121	GB2731	1	1		
0690-3331	R: fxd, comp, 33K ohms ±10%, 1 W	01121	GB3331	1	1		
0690-3341	R: fxd, comp, 330K ohms ±10%, 1 W	01121	GB3341	1	1		
0690-4731	R: fxd, comp, 47K ohms ±10%, 1 W	01121	GB4731	2	1		
0690-8231	R: fxd, comp, 82K ohms ±10%, 1 W	01121	GB8231	1	1		
0693-3921	R: fxd, comp, 3.9K ohms ±10%, 2 W	01121	HB3921	1	1		
0693-4701	R: fxd, comp, 47 ohms ±10%, 2 W	01121.	HB4701	2	1		
0693-4721	R: fxd, comp, 4.7K ohms ±10%, 2 W	01121	HB4701	1	1		
0727-0073	R: fxd, dep c, 422 ohms ±1%, 1/2 W	19701	DC1/2BR5 obd#	2	1		
0727-0323	R: fxd, dep c, 371.3 ohms ±1%, 1/2 W	19701	DC1/2CR5 obd#	3	1		
0727-0324	R: fxd, dep c, 91.67 ohms ±1%, 1/2 W	19701	DC1/2CR5 obd#	6	2		
0730-0007	R: fxd, dep c, 230 ohms ±1%, 1 W	19701	DC1R5 obd#	2	1		
0730-0017	R: fxd, dep c, 1.5K ohms ±1%, 1 W	19701	DC1R5 obd#	1	1		
0730-0045	R: fxd, dep c, 30.5K ohms ±1%, 1 W	19701	DC1R5 obd#	1	1		
0730-0065	R: fxd, dep c, 90.5K ohms ±1%, 1 W	19701	DC1R5 obd#	1	1		
0730-0066	R; fxd, dep c, 95.5 ohms ±1%, 1 W	19701	DC1R5 obd#	2	1		
0730-0079	R; fxd, dep c, 216.3K ohms ±1%, 1 W	19701	DC1R5 obd#	2	1		
0730-0087	R: fxd, dep c, 370K ohms ±1%, 1 W	19701	DC1R5 obd#	2	1		
0730-0091	R: fxd, dep c, 479K ohms ±1%, 1 W	19701	DC1R5 obd#	2	1		
0730-0096	R: fxd, dep c, 683.7 ohms ±1%, 1 W	19701	DC1R5 obd#	2	1		
0730-0106	R: fxd, dep c, 1.031M±1%, 1 W	19701	DC1R5 obd#	1	1		
0730-0118	R: fxd, dep c, 3.05M ±1%, 1 W	19701	DC1R5 obd#	2	1		
0763-0001	R: fxd, mfgl, 2K ohms ±1%, 2 W	07115	Type N30	4	1		
0771-0002	R: fxd, mfgl, 470 ohms ±10%, 4 W	07115	LP1-4	3	1		
0811-0004	R: fxd, ww, 540 ohms ±1%, 5 W	71468	obd#	1	1		
0818-0008	R: fxd, ww, 800*ohms ±5%, 40 W	91431	OR-40	1	1		
1200-0009	Socket, tube: 7 pin minat	91662	316PH-3702	2	1		

#See introduction to this section

Table 5-2. Replacable Parts (cont'd)

Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS		
1200-0020	Socket, tube: octal	71785	51A12272	2	1		
1200-0053	Socket, tube, 7 pin minat, (for pc)	91662	3708-2-4	2	1		
1200-0062	Socket, tube, 9 pin minat, (for pc)	91662	3908-2-4	9	1		
1250-0083	Connector: BNC (cabinet model)	91737	UG-1094/U	0	0		
1250-0118	Connector: BNC (rack model)	91737	8427	2	1		
1910-0009	Diode, Ge	98925	CTP-439	1	1		
1921-0005	Tube, electron: 6C4	80131	6C4	1	1		
1923-0027	Tube, electron: 6BH6	80131	6BH6	1	1		
1923-0030	Tube, electron: 6CL6 or 6197	80131	6CL6	8	8		
1930-0013	Tube, electron: 6AL5	80131	6AL5	1	1		
1930-0020	Tube, electron: 5V3	80131	5V3	1	1		
1932-0019	Tube, electron: 6AS7GA	80131	6AS7GA	1	1		
1932-0021	Tube, electron: 6BQ7A	80131	6BQ7A	1	1		
1940-0001	Tube, electron: 5651	80131	5651	1	1		
2100-0013	R: var, comp, lin, 50K ohms	71590	obd#	4	1		
2100-0063	R: var, comp, lin, 100K ohms	11237	Type 45 obd#	2	1		
2100-0074	R: var, comp, lin, 1M ±30%	11237	Type 45 obd#	1	1		
2100-0075	R: var, comp, 1.2K ohms ±10%,	01121	JD1N056P122UA	1	1		
2100-0076	R: var, comp, 75 ohms ±10%	01121	JA1N056S750UA	1	1		
2100-0079	R: var, comp, 250 ohms ±10%	01121	JA1N056S251UA	1	1		
2100-0082	R: var, comp, 5K ohms ±20%, 1/2 W	11237	UPM-45 obd#	1	1		
2100-0084	R: var, comp, 50K ohms ±20%, 1/3 W	11237	CPM-45 obd#	2	1		
2100-0130	R: var, ww, lin, 50K ohms ±1%, 8 W	98734	obd#	1	1		
2110-0015	Fuse cartridge: 2.5 amp, s-b (for 115 V operation)	71400	MDL-2-1/2	1	10		
2110-0021	Fuse cartridge: 1.25 amp s-b (for 230 V operation)	71400	MDL-1.25	0	0		
2140-0012	Lamp, minat, 2 pin base 6.3 V, 0.15 amp, # 12	24455	GE-12	1	1		
3101-0001	Switch, tog: SPST	04009	80994-H	1	1		
8120-0050	Cord, power	70903	obd#	1	1		

#See introduction to this section

Table 5-2. Replacable Parts (cont'd)

ⓗⓟ Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	RS		
9100-0062	Transformer, power	98734	4113	1	1		
9140-0022	Inductor: RF, 500 μh	99848	1500-15-501	1	1		
9140-0024	Inductor: RF, 0.68 μh	99848	203-11	2	1		
9140-0025	Inductor: RF, 4.7 μh	99848	213-11	2	1		
9140-0026	Inductor: RF, 6.8 μh	99848	215-11-68	1	1		
	MISCELLANEOUS						
AC-10C	Assy: binding post, black	28480	AC-10C	1	1		
AC-10D	Assy: binding post, red	28480	AC-10D	1	1		
G-74K	Knob: SYMMETRY OUTPUT AMPLITUDE	28480	G-74K	3	0		
G-74N	Knob: RANGE, 75 ohms ATTEN	28480	G-74N	2	0		
G-74Z	Knob: ATTEN	28480	G-74Z	1	0		
G-99K	Window, dial	28480	G-99K	1	0		
211A-40A	Dial, frequency	28480	211A-40A	1	0		
1400-0084	Fuseholder	75915	342014	1	1		
1450-0020	Pilot light, jewel	72765	14L15	1	0		
1450-0022	Lampholder	72765	2020AE	1	0		
3140-0010	Fan motor	73793	G5-CW-ER-6667	1	1		
3150-0004	Filter, air, rack mount only	82866	807390	1	1		
3150-0006	Filter, air, cabinet mount only	82866	obd#	1	1		
3160-0013	Fan blade	06812	0-04-27-4	1	1		

#See introduction to this section

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 1 of 2)

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

CODE NO.	MANUFACTURER	ADDRESS
00334	Humidial Co.	Colton, Calif.
00335	Westrex Corp.	New York, N.Y.
00373	Garlock Packing Co., Electronic Products Div.	Camden, N.J.
00656	Aerovox Corp.	New Bedford, Mass.
00779	Amp, Inc.	Harrisburg, Pa.
00781	Aircraft Radio Corp.	Boonton, N.J.
00853	Sangamo Electric Company, Ordill Division (Capacitors)	Marion, Ill.
00866	Goe Engineering Co.	Los Angeles, Calif.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	Pacific Semiconductors, Inc.	Culver City, Calif.
01295	Texas Instruments, Inc. Transistor Products Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
01561	Chassi-Trak Corp.	Indianapolis, Ind.
01589	Pacific Relays, Inc.	Van Nuys, Calif.
01930	Amerock Corp.	Rockford, Ill.
01961	Pulse Engineering Co.	Santa Clara, Calif.
02114	Ferroxcube Corp. of America	Saugerties, N.Y.
02286	Cole Mfg. Co.	Palo Alto, Calif.
02660	Amphenol-Borg Electronics Corp.	Chicago, Ill.
02735	Radio Corp. of America Semiconductor and Materials Div.	Somerville, N.J.
02771	Vocaline Co. of America, Inc.	Old Saybrook, Conn.
02777	Hopkins Engineering Co.	San Fernando, Calif.
03508	G.E. Semiconductor Products Dept.	Syracuse, N.Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp.	El Monte, Calif.
03877	Transitron Electronic Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co.	Morristown, N.J.
03954	Air Marine Motors, Inc.	Los Angeles, Calif.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04062	Elmenco Products Co.	New York, N.Y.
04222	Hi-Q Division of Aerovox	Myrtle Beach, S.C.
04298	Elgin National Watch Co., Electronics Division	Burbank, Calif.
04404	Dymec Division of Hewlett-Packard Co.	Palo Alto, Calif.
04651	Sylvania Electric Prods., Inc. Electronic Tube Div.	Mountain View, Calif.
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Arizona
04732	Filtron Co., Inc. Western Division	Culver City, Calif.
04773	Automatic Electric Co.	Northlake, Ill.
04796	Sequoia Wire & Cable Company	Redwood City, Calif.
04870	P M Motor Co.	Chicago, Ill.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Calif.
05277	Westinghouse Electric Corp., Semi-Conductor Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	San Mateo, Calif.
05593	Illumitronic Engineering Co.	Sunnyvale, Calif.
05624	Barber Colman Co.	Rockford, Ill.
05729	Metropolitan Telecommunications Corp., Metro Cap. Div.	Brooklyn, N.Y.
05783	Stewart Engineering Co.	Santa Cruz, Calif.
06004	The Bassick Co.	Bridgeport, Conn.
06555	Beede Electrical Instrument Co., Inc.	Penacook, N.H.
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.
07115	Corning Glass Works Electronic Components Dept.	Bradford, Pa.
07126	Digitran Co.	Pasadena, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07261	Avnet Corp.	Los Angeles, Calif.
07263	Fairchild Semiconductor Corp.	Mountain View, Calif.
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Rheem Semiconductor Corp.	Mountain View, Calif.
07966	Shockley Semi-Conductor Laboratories	Palo Alto, Calif.
07980	Boonton Radio Corp.	Boonton, N.J.
08145	U.S. Engineering Co.	Los Angeles, Calif.
08358	Burgess Battery Co.	Niagara Falls, Ontario, Canada
08717	Sloan Company	Burbank, Calif.
08718	Cannon Electric Co. Phoenix Div.	Phoenix, Ariz.
08792	CBS Electronics Semiconductor Operations, Div. of C.B.S. Inc.	Lowell, Mass.
08984	Mel-Rain	Indianapolis, Ind.
09026	Babcock Relays, Inc.	Costa Mesa, Calif.
09134	Texas Capacitor Co.	Houston, Texas
09250	Electro Assemblies, Inc.	Chicago, Ill.
09569	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Canada
10214	General Transistor Western Corp.	Los Angeles, Calif.
10411	Ti-Tal, Inc.	Berkeley, Calif.
10646	Carborundum Co.	Niagara Falls, N.Y.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of California, Inc.	So. Pasadena, Calif.
11312	Microwave Electronics Corp.	Palo Alto, Calif.
11534	Duncan Electronics, Inc.	Santa Ana, Calif.
11711	General Instrument Corporation Semiconductor Division	Newark, N.J.
11717	Imperial Electronics, Inc.	Buena Park, Calif.
11870	Melabs, Inc.	Palo Alto, Calif.
12697	Clarostat Mfg. Co.	Dover, N.H.
14655	Cornell Dubilier Elec. Corp.	So. Plainfield, N.J.
15909	The Daven Co.	Livingston, N.J.
16688	De Jur-Amsco Corporation	Long Island City 1, N.Y.
16758	Delco Radio Div. of G. M. Corp.	Kokomo, Ind.
18873	E. I. DuPont and Co., Inc.	Wilmington, Del.
19315	Eclipse Pioneer, Div. of Bendix Aviation Corp.	Teterboro, N.J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N.J.
19701	Electra Manufacturing Co.	Kansas City, Mo.
20183	Electronic Tube Corp.	Philadelphia, Pa.
21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.
21335	The Fafnir Bearing Co.	New Britain, Conn.
21964	Fed. Telephone and Radio Corp.	Clifton, N.J.
24446	General Electric Co.	Schenectady, N.Y.
24455	G.E., Lamp Division	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
26462	Grobet File Co. of America, Inc.	Carlstadt, N.J.
26992	Hamilton Watch Co.	Lancaster, Pa.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
33173	G.E. Receiving Tube Dept.	Owensboro, Ky.
35434	Lectrohm Inc.	Chicago, Ill.
37942	P. R. Mallory & Co., Inc.	Indianapolis, Ind.
39543	Mechanical Industries Prod. Co.	Akron, Ohio
40920	Miniature Precision Bearings, Inc.	Keene, N.H.
42190	Muter Co.	Chicago, Ill.
43990	C. A. Norgren Co.	Englewood, Colo.
44655	Ohmite Mfg. Co.	Skokie, Ill.
47904	Polaroid Corp.	Cambridge, Mass.
48620	Precision Thermometer and Inst. Co.	Philadelphia, Pa.
49956	Raytheon Company	Lexington, Mass.
54294	Shallcross Mfg. Co.	Selma, N.C.
55026	Simpson Electric Co.	Chicago, Ill.
55933	Sonotone Corp.	Elmsford, N.Y.
55938	Sorenson & Co., Inc.	So. Norwalk, Conn.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
59446	Telex, Inc.	St. Paul, Minn.
61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Swissvale, Pa.
62119	Universal Electric Co.	Owosso, Mich.
64959	Western Electric Co., Inc.	New York, N.Y.
65092	Weston Inst. Div. of Daystrom, Inc.	Newark, N.J.
66346	Wollensak Optical Co.	Rochester, N.Y.
70276	Allen Mfg. Co.	Hartford, Conn.
70309	Allied Control Co., Inc.	New York, N.Y.
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
70563	Amperite Co., Inc.	New York, N.Y.
70903	Belden Mfg. Co.	Chicago, Ill.
70998	Bird Electronic Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71041	Boston Gear Works Div. of Murray Co. of Texas	Quincy, Mass.
71218	Bud Radio Inc.	Cleveland, Ohio
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Allen D. Cardwell Electronic Prod. Corp.	Plainville, Conn.
71400	Bussmann Fuse Div. of McGraw-Edison Co.	St. Louis, Mo.
71450	CTS Corp.	Elkhart, Ind.
71468	Cannon Electric Co.	Los Angeles, Calif.
71471	Cinema Engineering Co.	Burbank, Calif.
71482	C. P. Clare & Co.	Chicago, Ill.
71528	Standard-Thomson Corp., Clifford Mfg. Co. Div.	Waltham, Mass.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.
71700	The Cornish Wire Co.	New York, N.Y.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71753	A. O. Smith Corp., Crowley Div.	West Orange, N.J.
71785	Cinch Mfg. Corp.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
72354	John E. Fast & Co.	Chicago, Ill.
72619	Dialight Corp.	Brooklyn, N.Y.
72656	General Ceramics Corp.	Keasbey, N.J.
72758	Girard-Hopkins	Oakland, Calif.
72765	Drake Mfg. Co.	Chicago, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Gudeman Co.	Chicago, Ill.
72982	Erie Resistor Corp.	Erie, Pa.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73138	Helipot Div. of Beckman Instruments, Inc.	Fullerton, Calif.
73293	Hughes Products Division of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Electronic Co., Div. of North American Phillips Co., Inc.	Hicksville, N.Y.
73506	Bradley Semiconductor Corp.	Hamden, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73682	George K. Garrett Co., Inc.	Philadelphia, Pa.
73734	Federal Screw Products Co.	Chicago, Ill.
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	The General Industries Co.	Elyria, Ohio

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H4-1 Dated January 1962
H4-2 Dated January 1962

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Revised: 3 March 1962

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 2 of 2)

CODE NO.	MANUFACTURER	ADDRESS
73905	Jennings Radio Mfg. Co.	San Jose, Calif.
74455	J. H. Winns, and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Ill.
74868	R.F. Products Division of Amphenol-Borg Electronics Corp.	Danbury, Conn.
74970	E. F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75173	Jones, Howard B., Division of Cinch Mfg. Corp.	Chicago, Ill.
75378	James Knights Co.	Sandwich, Ill.
75382	Kulka Electric Corporation	Mt. Vernon, N.Y.
75818	Lenz Electric Mfg. Co.	Chicago, Ill.
75915	Littelfuse Inc.	Des Plaines, Ill.
76005	Lord Mfg Co.	Erie, Pa.
76210	C. W. Marwedel	San Francisco, Calif.
76433	Micamold Electronic Mfg. Corp.	Brooklyn, N.Y.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76493	J. W. Miller Co.	Los Angeles, Calif.
76530	Monadnock Mills	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio
76854	Oak Manufacturing Co.	Chicago, Ill.
77068	Bendix Pacific Division of Bendix Corp.	No. Hollywood, Calif.
77221	Phaostron Instrument and Electronic Co.	South Pasadena, Calif.
77342	Potter and Brumfield, Div. of American Machine and Foundry	Princeton, Ind.
77630	Radio Condenser Co.	Camden, N.J.
77638	Radio Receptor Co., Inc.	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
78189	Shakeproof Division of Illinois Tool Works	Elgin, Ill.
78283	Signal Indicator Corp.	New York, N.Y.
78471	Tilley Mfg. Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78790	Transformer Engineers	Pasadena, Calif.
78947	Ucinite Co.	Newtonville, Mass.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Ill.
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80031	Mepco Division of Sessions Clock Co.	Morristown, N.J.
80120	Schnitzer Alloy Products	Elizabeth, N.J.
80130	Times Facsimile Corp.	New York, N.Y.
80131	Electronic Industries Association Any brand tube meeting EIA standards	Washington, D.C.
80207	Unimax Switch, Div. of W. L. Maxson Corp.	Wallingford, Conn.
80248	Oxford Electric Corp.	Chicago, Ill.
80294	Bourns Laboratories, Inc.	Riverside, Calif.
80411	Acro Div. of Robertshaw Fulton Controls Co.	Columbus 16, Ohio
80486	All Star Products Inc.	Defiance, Ohio
80583	Hammerlund Co., Inc.	New York, N.Y.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
81030	International Instruments, Inc.	New Haven, Conn.
81415	Wilkor Products, Inc.	Cleveland, Ohio
81453	Raytheon Mfg. Co., Industrial Components Div., Industr. Tube Operations	Newton, Mass.
81483	International Rectifier Corp.	El Segundo, Calif.
81860	Barry Controls, Inc.	Watertown, Mass.
82042	Carter Parts Co.	Skokie, Ill.
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.
82170	Allen B. DuMont Labs., Inc.	Clifton, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod. Inc., Electronic Tube Div.	Emporium, Pa.
82376	Astron Co.	East Newark, N.J.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals and Controls, Inc., Div. of Texas Instruments, Inc., Spencer Prods.	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Manufacturing Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83053	Western Washer Mfr. Co.	Los Angeles, Calif.
83058	Carr Fastener Co.	Cambridge, Mass.
83086	New Hampshire Ball Bearing, Inc.	Peterborough, N.H.
83125	Pyramid Electric Co.	Darlington, S.C.
83148	Electro Cords Co.	Los Angeles, Calif.
83186	Victory Engineering Corp.	Union, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83330	Smith, Herman H., Inc.	Brooklyn, N.Y.
83501	Gavitt Wire and Cable Co., Div. of Amerace Corp.	Brookfield, Mass.
83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N.J.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
84171	Arco Electronics, Inc.	New York, N.Y.
84396	A. J. Glesener Co., Inc.	San Francisco, Calif.
84411	Good All Electric Mfg. Co.	Ogallala, Neb.
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.
85454	Boonton Molding Company	Boonton, N.J.
85474	R. M. Bracamonte & Co.	San Francisco, Calif.
85660	Koiled Kords, Inc.	New Haven, Conn.
85911	Seamless Rubber Co.	Chicago, Ill.
86197	Clifton Precision Products	Clifton Heights, Pa.
86684	Radio Corp. of America, RCA Electron Tube Div.	Harrison, N.J.
87216	Philco Corp. (Lansdale Division)	Lansdale, Pa.
87473	Western Fibrous Glass Products Co.	San Francisco, Calif.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
88220	Gould-National Batteries, Inc.	St. Paul, Minn.
89473	General Electric Distributing Corp.	Schenectady, N.Y.
89636	Carter Parts Div. of Economy Baler Co.	Chicago, Ill.
89665	United Transformer Co.	Chicago, Ill.
90179	U.S. Rubber Co., Mechanical Goods Div.	Passaic, N.J.
90970	Bearing Engineering Co.	San Francisco, Calif.
91260	Connor Spring Mfg. Co.	San Francisco, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat Brothers, Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Nebr.
91662	Elco Corp.	Philadelphia, Pa.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91827	K F Development Co.	Redwood City, Calif.
91921	Minneapolis-Honeywell Regulator Co., Micro-Switch Division	Freeport, Ill.
92196	Universal Metal Products, Inc.	Bassett Puente, Calif.
93332	Sylvania Electric Prod. Inc., Semiconductor Div.	Woburn, Mass.
93369	Robbins and Myers, Inc.	New York, N.Y.
93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio
93983	Insuline-Van Norman Ind., Inc. Electronic Division	Manchester, N.H.
94144	Raytheon Mfg. Co., Industrial Components Div., Receiving Tube Operation	Quincy, Mass.
94145	Raytheon Mfg. Co., Semiconductor Div., California Street Plant	Newton, Mass.
94148	Scientific Radio Products, Inc.	Loveland, Colo.
94154	Tung-Sol Electric, Inc.	Newark, N.J.
94197	Curtiss-Wright Corp., Electronics Div.	East Paterson, N.J.
94310	Tru Ohm Prod. Div. of Model Engineering and Mfg. Co.	Chicago, Ill.
94682	Worcester Pressed Aluminum Corp.	Worcester, Mass.
95236	Allies Products Corp.	Miami, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	New York, N.Y.
95264	Lerco Electronics, Inc.	Burbank, Calif.
95265	National Coil Co.	Sheridan, Wyo.
95275	Vitramon, Inc.	Bridgeport, Conn.
95354	Methode Mfg. Co.	Chicago, Ill.
95987	Weckesser Co.	Chicago, Ill.
96067	Huggins Laboratories	Sunnyvale, Calif.
96095	Hi-Q Division of Aerovox	Olean, N.Y.
96256	Thordarson-Meissner Div. of Maguire Industries, Inc.	Mt. Carmel, Ill.
96296	Solar Manufacturing Co.	Los Angeles, Calif.
96330	Carlton Screw Co.	Chicago, Ill.
96341	Microwave Associates, Inc.	Burlington, Mass.
96501	Excel Transformer Co.	Oakland, Calif.
97464	Industrial Retaining Ring Co.	Irvington, N.J.
97539	Automatic and Precision Mfg. Co.	Yonkers, N.Y.
97966	CBS Electronics, Div. of C.B.S., Inc.	Danvers, Mass.
98141	Axel Brothers Inc.	Jamaica, N.Y.
98220	Francis L. Mosley	Pasadena, Calif.
98278	Microdot, Inc.	So. Pasadena, Calif.
98291	Sealectro Corp.	Mamaroneck, N.Y.
98405	Carad Corp.	Redwood City, Calif.
98734	Palo Alto Engineering Co., Inc.	Palo Alto, Calif.
98821	North Hills Electric Co.	Mineola, N.Y.
98925	Clevite Transistor Prod. Div. of Clevite Corp.	Waltham, Mass.
98978	International Electronic Research Corp.	Burbank, Calif.
99109	Columbia Technical Corp.	New York, N.Y.
99313	Varian Associates	Palo Alto, Calif.
99515	Marshall Industries, Electron Products Division	Pasadena, Calif.
99707	Control Switch Division, Controls Co. of America	El Segundo, Calif.
99800	Delevan Electronics Corp.	East Aurora, N.Y.
99848	Wilco Corporation	Indianapolis, Ind.
99934	Renbrandt, Inc.	Boston, Mass.
99942	Hoffman Semiconductor Div. of Hoffman Electronics Corp.	Evanston, Ill.
99957	Technology Instrument Corp. of Calif.	Newbury Park, Calif.

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

CODE NO.	MANUFACTURER	ADDRESS
0000F	Malco Tool and Die	Los Angeles, Calif.
0000I	Telefunken (c/o American Elite)	New York, N.Y.
0000L	Winchester Electronics, Inc.	Santa Monica, Calif.
0000M	Western Coil Div. of Automatic Ind., Inc.	Redwood City, Calif.
0000N	Nahm-Bros. Spring Co.	San Leandro, Calif.
0000P	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
0000T	Texas Instruments, Inc. Metals and Controls Div.	Versailles, Ky.
0000U	Tower Mfg. Corp.	Providence, R.I.
0000W	Webster Electronics Co. Inc.	New York, N.Y.
0000X	Spruce Pine Mica Co.	Spruce Pine, N.C.
0000Y	Midland Mfg. Co. Inc.	Kansas City, Kans.
0000Z	Willow Leather Products Corp.	Newark, N.J.
000AA	British Radio Electronics Ltd.	Washington, D.C.
000BB	Precision Instrument Components Co.	Van Nuys, Calif.
000CC	Computer Diode Corp.	Lodi, N.J.
000EE	A. Williams Manufacturing Co.	San Jose, Calif.
000FF	Carmichael Corrugated Specialties	Richmond, Calif.
000GG	Goshen Die Cutting Service	Goshen, Ind.
000HH	Rubbercraft Corp.	Torrance, Calif.
000II	Birtcher Corporation, Industrial Division	Monterey Park, Calif.
000KK	Amatom	New Rochelle, N.Y.
000LL	Avery Label	Monrovia, Calif.
000MM	Rubber Eng. & Development	Hayward, Calif.

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MANUAL CHANGES

MODEL 211A

SQUARE WAVE GENERATOR

Manual Serial Prefixed: 026-
Manual Printed: 4/62

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

Instrument Serial Prefix	Make Manual Changes	Instrument Serial Prefix	Make Manual Changes
Applies to all serial prefixes	ERRATA		

ERRATA:

Figure 4-8, Multivibrator and Power Supply,
F1 and S3: Reverse positions to show F1 connected between S3 and P1.
R30: Add asterisk beside R30 and change value to 75K.

Figure 4-9, Output Section,
S2: Add arrowhead on switch contact which connects 60 DB section of S2 to 75Ω OUTPUT connector J2.

Table 5-1, Reference Designation Index,
CR1: Change to Diode, Ge, hp Stock No. 1910-0016.
R30: Change to Resistor, fixed, deposited carbon, 75K ohms ±1%, 1W. Optimum value selected at factory; average value shown. hp Stock No. 0730-0058.
V2, V3: Change hp Stock No. to 1923-0066.
V5: Change hp Stock No. to 1921-0030.
V6 thru V11: Change hp Stock No. to 1923-0067.

Table 5-2, Replaceable Parts,
0730-0065: Change to 0730-0058; R: fxd, dep c, 75K* ohms ±1%, 1W.
1910-0009: Change to 1910-0016; Diode, Ge; Mfr. 28480; Mfr. Part No. 1910-0016.
1921-0005: Change to 1921-0030; Tube, electron: 6C4; Mfr. 86684.
1923-0030: Change to 1923-0066; Tube, electron: 6CL6; Mfr. 86684; TQ=2; RS=2.
Add 1923-0067; Tube, electron: 6CL6; Mfr. 82219; Mfr. Part No. 6CL6; TQ=6; RS=6.
Under MISCELLANEOUS,

Change:	AC-10C	to	5060-0632
	AC-10D	to	5060-0633
	G-74K	to	0370-0032
	G-74N	to	0370-0035
	G-74Z	to	0370-0045
	G-99K	to	5040-0600

Section IV: Add paragraphs 4-43 and 4-44 on page 4-8,

4-43. AIR FILTER

4-44. Inspect air-filter element periodically. Clean element before air flow is restricted and instrument overheats. Proceed as follows:

a. Remove element and wash in detergent and water.

b. Dry element thoroughly.

c. Coat element with light film of filter oil (adhesive) before installing filter in instrument. Research Products Company No. 3 Filter Coat is recommended. This adhesive is available in "Handi-Koter" sprayer cans at most heating supply stores or from your local Hewlett-Packard sales office.

d. Install cleaned and coated air-filter element in instrument.

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