TEKTRONIX

Inter-Office Communication

To: JACK DAY

Date: OCTOBER 2, 1961

From: TONY H. BRYAN

LAFAYETTE

Subject: HICKOK 180A

Dear Jack,

Investigation of the ceramic strip mounting structure in the Hickok version of our 180A reveals they are not using a plastic yoke mounting like the Tek made item. The manual with the instrument does shown the yoke mounting, however. This obviously was copied from our manual. Instead of a yoke mounting, they use a threaded hole in the ceramic strip. The plastic mounting post is threaded on one end and tapered on the other end for a 6-32 screw. In order to remove a spacer it is necessary to unscrew the nylon post from the chassis and then unscrew the post from the ceramic strip.

I hope our patent application may have covered other possible mounting arrangements. Sort of sorry in a way this couldn't have been an outright violation.

Best regards,

Tony /et

Tony

THB: ldt
nr

cc: Ed Bauder
Lee Cooper
George Edens

000-641

MEMO

To Jack Day Department Administration Date September 6, 1961

Subject Hickok Manual

file

Thought you'd be interested in a copy of this Hickok manual. Tony Bryan got the loan of one and our scofflaw little group went and violated Hickok's copyright to the extent of making four Xerox's. Tony has to give back the original next week, but we'll hold it a few more days in case you or Bill would like to eyeball it.

Geoff

Geoff Gass
Field Information Staff

GG:jf

encl.

RD INSTRUMENTS

FOR RESEARCH AND DEVELOPMENT

INSTRUCTION MANUAL

for

MODEL 1817
TIME-MARK GENERATO

THE HICKOK ELECTRICAL INSTRUMENT COMPANY • 10514 Dupont Avenue, Cleveland 8, Ohio

MODEL 1817
TIME-MARK GENERATOR

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THE HICKOK ELECTRICAL INSTRUMENT COMPANY
10514 Dupont Avenue - Cleveland 8, Ohio

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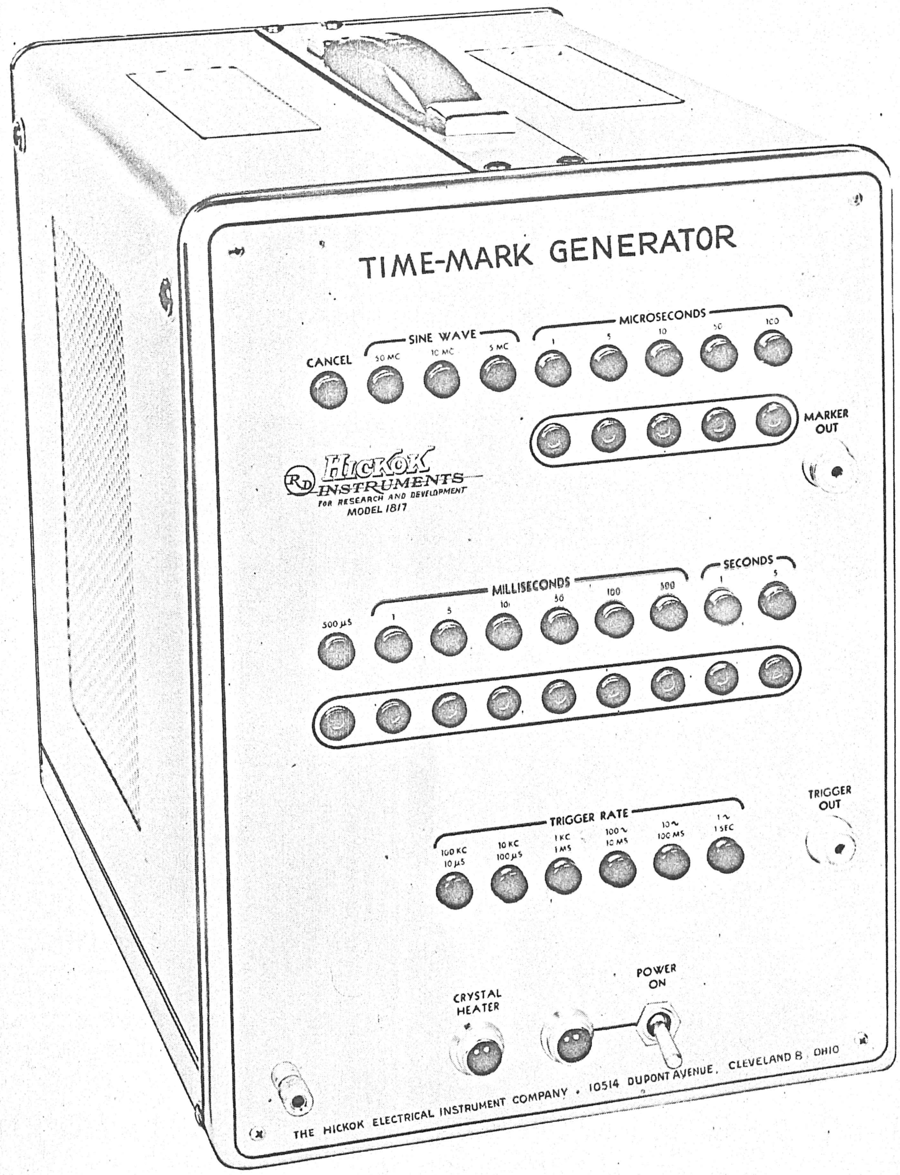


Figure 1-1. Identifying View of Time-Mark Generator, Model 1817

ERRATA SHEET

Corrections to Model 1817 Instruction Book:

I In Table III, Pg. 12, the column headed "Oscilloscope Time/CM" should be corrected to read as follows:

1 Microsec
5 Microsec
10 Microsec
50 Microsec
100 Microsec
500 Microsec
1 Millisec
5 Millisec
10 Millisec
50 Millisec
100 Millisec
500 Millisec
1 Sec

II The value of the -19 volt bias supply should be -16 volts. This change should be made in the following places in the manual:

Pg. 6	Para. 3 - 1a	
	Para. 3 - 6	(2) *
Pg. 11	Para. 4 - 12	
	Para. 4 - 12d	
Pg. 16	Fig. 5 - 1	
Pg. 17	Fig. 5 - 2	
Pg. 18	Fig. 5 - 3	(4)
Pg. 19	Fig. 5 - 4	(4)
Pg. 20	Fig. 5 - 5	(4)

* Note: Numbers in parenthesis refer to number of corrections to be made in that section.

III Capacitor C412 should be corrected to read 390 on Fig. 5 - 4, Pg. 19.

In the Parts List the description of C412 should be modified to read 390 UUF, rather than 250 UUF. The new part No. is 3095-138.

The description of C577 should read:

Part No. 3095-129 - Capacitor, Fixed, Silver Mica, 250 UUF, 5%, 500 volts.

The following accessories are supplied with the Model 1817 Time-Mark Generator:

Part No.	Description	Quantity
1050-141	Adapter, Coaxial - Connector to Alligator Clips.	1
3030-156	Cable Assembly, Coaxial	2

SECTION I
INTRODUCTION AND DESCRIPTION

INTRODUCTION

1-1. GENERAL. The Hickok Model 1817 Time-Mark Generator is a portable instrument which provides an accurate and stable source of sine waves, trigger pulses and time markers. The wide choice of outputs available permits the use of the generator in a variety of laboratory and production applications. It provides an excellent source of calibrating signals for oscilloscope sweep circuits, oscillators and counters. The 1817 can also be used as a source of trigger-rate pulses and as a time measuring device. Markers can be used either separately or in combination depending on the desired presentation or application.

DESCRIPTION

1-2. LEADING CHARACTERISTICS.

OUTPUT SIGNALS.

a. Sine waves of 5 mc, 10 mc, and 50 mc.

b. Microsecond markers at intervals of 1, 5, 10, 50, 100, and 500 microseconds.

c. Millisecond markers at intervals of 1, 5, 10, 50, 100 and 500 milliseconds.

d. One-second and five-second interval markers.

e. Trigger pulses at rates of 1 cps, 10 cps, 100 cps, 1 kc, 10 kc and 100 kc.

CRYSTAL OSCILLATOR.

a. Frequency: 1 mc ± 10 cps

b. Accuracy: APPROX. .001%

c. Stability: Within three parts per million per 24 hours

POWER REQUIREMENTS.

a. 105 to 125 volts ac, or 210 to 250 volts ac.

b. 50 to 60 cps.

c. 240 watts power consumption at 117 volts.

TABLE I. OUTPUT SIGNAL VALUES

OUTPUT SIGNAL	TERMINAL				
	MARKER OUT Connector			Jacks	
	Open Circuit Voltage	Impedance (at half-voltage)	*Risetime	Open Circuit Voltage	Impedance
Markers	1 volt minimum	470Ω at 1μ second to 3 kilohms at 5 seconds	0.05 μ sec at 1 μ sec Ω to 0.9 μ sec at 5 seconds	6 volts minimum	100Ω at 1μ sec to 180Ω at 5 seconds
Trigger Pulses	1.5 volt minimum	82Ω at 1 cps to 120Ω at 100 kc	0.07μ sec at 100 kc to 0.25 μ sec at 1 cps		
Sine Waves	1.5 volt minimum across 52-ohms				

*With output terminated in 93 ohms

PHYSICAL CHARACTERISTICS.

a. Ventilation: filtered forced air

b. Finish: anodized, etched front panel gray enamel case

c. Height: 14 inches

d. Width: 10 inches

e. Depth: 17 inches

f. Weight: 30-1/2 pounds

VOLTAGE, IMPEDANCE AND RISE-TIME VALUES

a. Nominal voltage, impedance and rise-time values for the various output signals are tabulated in Table I.

ELECTRON TUBE COMPLEMENT.

Table II includes all electron tubes used in the model 1817.

1-3. All output connections are to banana jacks or to the coaxial connector on the front panel. The MARKER OUT connector will supply any of the markers, depending upon which push-button or buttons are depressed. The banana jacks provide only the individual marker identified above the jack and are independent of the push button switches. The three sine wave outputs are available only at the MARKER OUT connector.

TABLE II. ELECTRON TUBE COMPLEMENT

TUBE TYPE	REF DESIG	QUANTITY	SECTION	FIGURE
12AU7	V273	13	Oscillator and Multiplier	5-2
	V303		Low Frequency Dividers	5-3
	V343		Low Frequency Dividers	5-3
	V353		Low Frequency Dividers	5-3
	V393		Low Voltage Power Supply	5-1
			Low Frequency Dividers	5-3
	V403		Intermediate Frequency Divider	5-4
	V443		Intermediate Frequency Divider	5-4
	V453		Intermediate Frequency Divider	5-4
	V493		Intermediate Frequency Divider	5-4
	V503		High Frequency Divider	5-5
	V543		High Frequency Divider	5-5
	V553		High Frequency Divider	5-5
	V593		High Frequency Divider	5-5
12B4	V157	2	Low Voltage Power Supply	5-1
	V167		Low Voltage Power Supply	5-1
5651	V149	1	Low Voltage Power Supply	5-1
5965	V150	14	Trigger C.F. and Switching	5-6
	V265		Oscillator and Multiplier	5-2
	V333		Low Frequency Dividers	5-3
	V335		Low Frequency Dividers	5-3
	V383		Low Frequency Dividers	5-3
	V385		Low Frequency Dividers	5-3
	V433		Intermediate Frequency Divider	5-4
	V435		Intermediate Frequency Divider	5-4
	V483		Intermediate Frequency Divider	5-4
	V485		Intermediate Frequency Divider	5-4
	V533		High Frequency Divider	5-5
	V535		High Frequency Divider	5-5
	V583		High Frequency Divider	5-5
	V585		High Frequency Divider	5-5
6AL5	V262	13	Oscillator and Multiplier	5-2
	V302		Low Frequency Divider	5-3
	V322		Low Frequency Divider	5-3
	V352		Low Frequency Divider	5-3
	V372		Low Frequency Divider	5-3
	V402		Intermediate Frequency Divider	5-4
	V422		Intermediate Frequency Divider	5-4

TABLE II. ELECTRON TUBE COMPLEMENT (Continued)

TUBE TYPE	REF DESIG	QUANTITY	SECTION	FIGURE
6AL5 (cont.)	V452	13 (cont.)	Intermediate Frequency Divider	5-4
	V472		Intermediate Frequency Divider	5-4
	V502		High Frequency Divider	5-5
	V522		High Frequency Divider	5-5
	V552		High Frequency Divider	5-5
	V572		High Frequency Divider	5-5
6AN8	V144	3	Low Voltage Power Supply	5-1
	V200		Oscillator and Multiplier	5-2
	V204		Oscillator and Multiplier	5-2
6AU6	V104	2	Low Voltage Power Supply	5-1
	V124		Low Voltage Power Supply	5-1
6DK6	V224	3	Oscillator and Multiplier	5-2
	V234		Oscillator and Multiplier	5-2
	V244		Oscillator and Multiplier	5-2
6080	V107	1	Low Voltage Power Supply	5-1

SECTION II
OPERATING INSTRUCTIONS

INSTALLATION

2-1. GENERAL. Since Model 1817 Time-Mark Generator is a portable-type instrument, it requires no special installation procedures. It is necessary only to connect it to an ac power source of correct voltage and frequency.

2-2. Control of ac power to the instrument for operation is provided by an ON-OFF Switch. This switch does not control the crystal oven which is in operation whenever the ac plug is inserted into the power receptacle. The pilot lamp indicates when the instrument is ON or OFF. The crystal oven indicator will show the cycling period of the crystal oven heater element.

2-3. POWER CONNECTIONS. Unless otherwise indicated by the metal plate on the back of the case, the equipment is wired for operation from an ac power source of 117 volts (range 105 to 125 volts) at a frequency of 50 to 60 cycles. If operation from a 234 volt source (range 210 to 250 volts) is required, follow the procedures in paragraph 2-4.

2-4. Remove the left side panel of the instrument. (Refer to figure 2-1).

a. Remove jumpers between terminals 1 and 2 and terminals 3 and 4 of T101. Connect jumper across terminals 2 and 3. This arrangement places the two primary windings of the power transformer T101 in series for operation on 234 volts input.

b. Remove jumpers (1 and 2) at terminal strip for crystal oven transformer T102. Connect jumper (3) as shown. This arrangement equips transformer T102 for operation on 234 volts.

CAUTION

Always change the connections on the crystal oven transformer when changing connections on the power transformer.

OUTPUT SIGNALS

2-5. MARKER SIGNAL OPERATION. The time-mark signals labeled MICROSECONDS, MILLISECONDS and SECONDS are obtainable at the MARKER OUT connector by pressing the desired push button switch. Banana plug jacks mounted below each switch provide individual markers and are independent of the push button operation.

2-6. SINE WAVE OUTPUTS. Sine wave outputs are available only at the MARKEROUT connector. Pressing any one of the three sine wave push buttons automatically cancels all other time-mark signals at the MARKER OUT connector, leaving only the desired sine wave as the time-mark signal. Pressing the CANCEL switch automatically disconnects all marker signals from the MARKER OUT connector.

2-7. TRIGGERING PULSES. Six individual push button switches provide the selected output at the TRIGGER OUT connector. Depressing any button automatically cancels a previous trigger pulse selection.

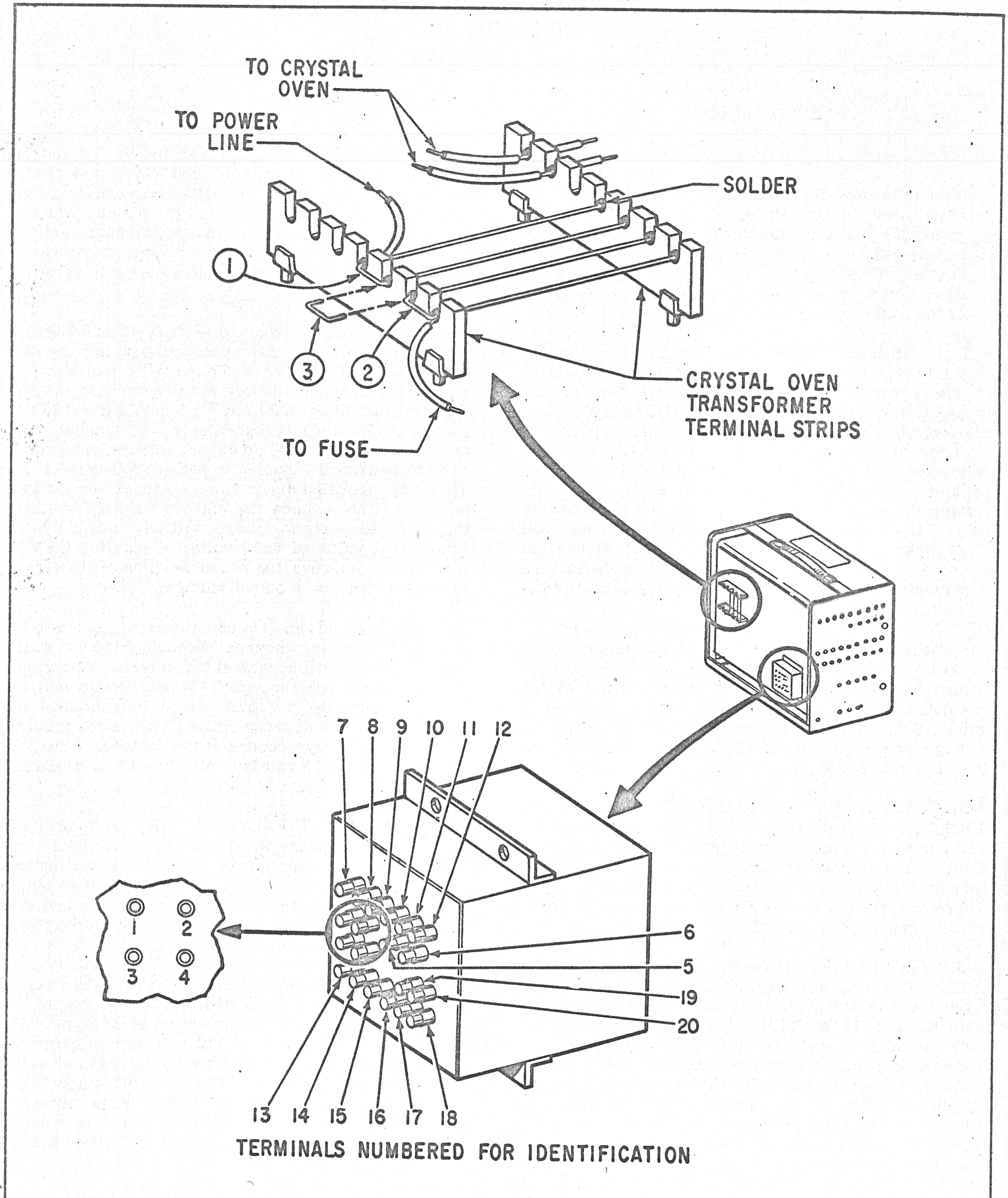


Figure 2-1. Connection of Primary Terminals of Transformers T101 and T102 when Converting from 117 Volt to 234 Volt Operation

SECTION III
CIRCUIT DESCRIPTION

POWER SUPPLY

NOTE

The following description of the various circuits used in the Model 1817 is made with reference to the functional block diagram, figure 3-1, and to the schematic diagrams in Section V, figures 5-1 through 5-6. The description presupposes a thorough knowledge of the basic principles of electronics.

3-1. POWER TRANSFORMER. The primary winding of power transformer T101 (see figure 5-1) consists of two separate windings. One of the windings is tapped to furnish voltage to the ventilating fan. Thermal switch K101 is a safety switch connected in series with the primary winding of the power transformer. In instances of fan failure or high ambient room temperature (above 128°F) K101 will open, thus protecting the instrument from damage due to excessive heat. The crystal oven will continue to operate when K101 opens. When the unit cools, K101 closes and power is restored to the unit. Fuse F101 is used as a protective device against electrical overload in the circuit.

a. The secondary winding of T101 consists of seven separate windings. Three of these windings are connected to selenium rectifier bridges which feed the regulated voltage supplies. Regulated voltages of +350, +225, and -150 are furnished by the supplies. Voltage sources of -8 and -19 volts are derived from the -150 volt supply.

3-2. CRYSTAL OVEN TRANSFORMER. Transformer T102 is a separate transformer which supplies 6.3 volts ac to a thermostatically-controlled crystal oven. Lamp B201 indicates when the oven is on. Transformer T102 is directly fed from the ac power line. Therefore, the ON and OFF power switch has no effect on the crystal oven control.

3-3. -150 VOLT REGULATED REFERENCE VOLTAGE. The -150 volt regulated power supply is fed from the 185 volt secondary winding across terminals 11 and 12 of T101. The gas diode tube V149 acts as a reference voltage source for the -150 volts supply and maintains a fixed potential of -84 volts on the grid of V144B (one-half of a difference-amplifier). The triode section of V144 is connected across the voltage divider R141, R142 and R143. The potential on the grid of V144A depends upon the setting of potentiometer R143, the -150 volts adjust control. When this control is properly adjusted, the output voltage is exactly -150 volts. Capacitor C163 filters the output.

a. Variations in the load which tend to change the output voltage cause the potential on the grid of V144A to change proportionately. An error voltage thus exists between the grids of the difference amplifier. The error voltage is amplified by V144B and fed directly to the grids of V157 and V167. The change in potential at the grid of these tubes causes a corresponding change in voltage at the plates. The volt age at the plates is coupled, in turn, through rectifier CR141 in such a manner as to compensate for variations in the output voltage and to cause it to return to the -150 volt level.

3-4. +225 VOLT POWER SUPPLY. The -150 volt supply is used as a reference voltage for the +225 volt supply. Resistors R135 and R137 drop the -150 volt supply to approximately zero on the grid of V124. If the load should change, any tendency of the +225 volt supply to change correspondingly would cause V124 to amplify the change, or error voltage. The output of V124 is directly coupled to cathode follower V107A. Thus, the amplified error voltage appears on the grid of the V107A. Since the cathode of V107A follows the grid, the output voltage will be returned to its established value of +225 volts. Capacitor C136 is included to improve the response-time of the circuit to sudden changes in output voltage.

a. Since the screen grid of V124 is connected to the unregulated power source through R121, a small ripple voltage will appear at the screen. This ripple will be amplified through V124 and fed to both the grid and the plate of V107A. Since the grid and plate voltages are 180 degrees out of phase, a cancellation of the ripple voltage occurs at the cathode. Thus, the ripple on the +225 volt bus is reduced to a negligible value.

3-5. +350 VOLT SUPPLY. The +350 volt supply is fed from a secondary winding across terminals 7 and 8 of T101. This supply functions in the same manner as the +225 supply. The rectified, filtered output from the 115 volt ac secondary winding is added to the input of the +225 volt supply to furnish the power required for the +350 volt regulator.

3-6. BIAS VOLTAGES. Bias voltages for the electron tubes are derived from the -150 volt supply. A voltage-dividing network consisting of R174 and R176 across the output of the -150 volt supply drops the voltage at the junction of the two resistors to -8 volts. C174 filters this output. The -19 volt supply is set by the voltage divider R180, R181. This voltage is then fed through cathode-follower V393A in order to present a low impedance source. C170 filters the -19 volt output.

OSCILLATOR AND MULTIPLIERS

3-7. GENERAL. With reference to figure 5-2, it can be seen that the oscillator is a conventional electron-coupled, crystal-controlled oscillator. The oscillator is designed to generate a non-sinusoidal rf voltage at a frequency of one megacycle. The crystal is in-

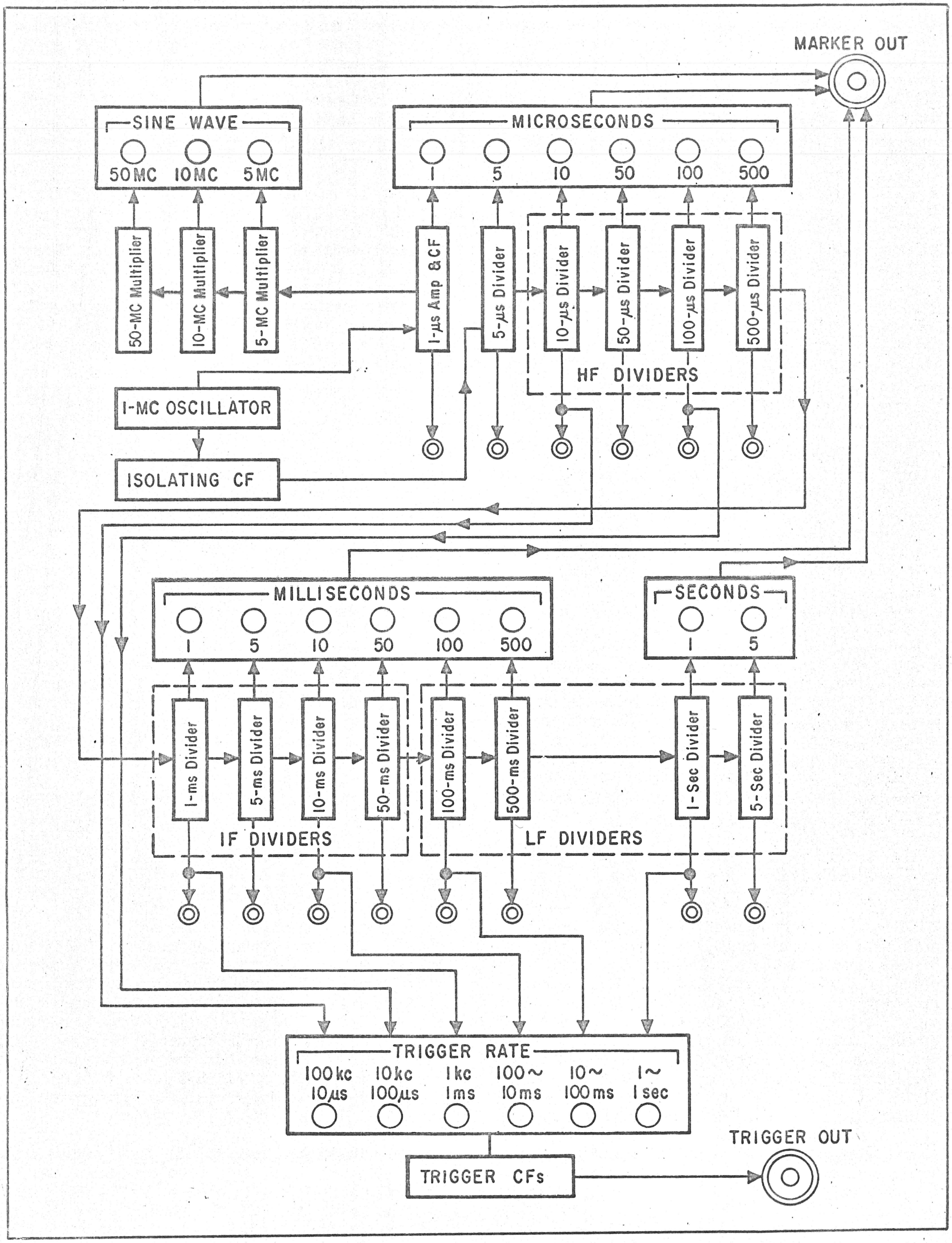


Figure 3-1. Functional Block Diagram of Model 1817

corporated in the oscillator circuit to maintain a constant frequency within a tolerance of ±10 cycles. The crystal is installed in a thermostatically controlled oven to minimize frequency drift. Adjustable capacitor C205 connected across the crystal permits slight adjustments to be made in oscillator frequency.

a. The output waveform from the plate of V200B is fed to the grid of V204B through C210 and to the grid of V200A through the RC network; R203, C203. The RC network is incorporated to increase the rise-time of the signal on the grid of the isolating cathode-follower V200A so that there is coincidence of pulses on the grid of V204B and V200A.

b. V204B is a conventional voltage amplifier that provides a voltage gain of about two and one-half times the input voltage. Inductor L207 is a peaking device incorporated to improve the rise-time of the otuput waveform.

3-8. OUTPUT CATHODE FOLLOWER: Triode V204A is biased at cutoff by the voltage divider R213 and R214. Coupling capacitor C216, in conjunction with L116, forms a differentiating circuit which shapes the output wave of V204B into sharp pulses on the grid of V204A. The positive pulses are taken from the cathode as one-microsecond markers. The output is then fed to SW710 and to the five megacycle sine-wave multiplier.

SINE WAVE MULTIPLIERS

3-9. 5 MC MULTIPLIER. Capacitor C222 and resistor R222 develop a gridleak bias of -4 volts. This is sufficient to operate V224 as a Class C amplifier. The plate tank circuit of V204B resonates at five megacycles. L224 and L227 are the primary and secondary, respectively, of an rf transformer. L227 resonates at a multiple of the primary frequency (ten megacycles) and is sustained by the primary excitation. The five megacycle sine wave developed across the tank circuit of V224 is link-coupled to output switch S710. The five megacycle multiplier operates when any one of the SINE WAVE push-button switches is actuated.

3-10. 10 MC MULTIPLIER. The grid circuit of V234 is inductively coupled to the plate tank circuit of the five megacycle multiplier through the rf transformer described above. The grid circuit is composed of L227, C227 and C229 and forms a series-resonant circuit tuned to ten megacycles. This signal is amplified by V234 and fed to the tuned plate circuit. L234 is the primary of an rf transformer and is tuned to ten megacycles. Like the five megacycle circuit described above, the secondary (L237) of the rf transformer is tuned to a multiple of the primary frequency (in this instance 50 megacycles) and is sustained by it. Like the five megacycle signal, the ten megacycle signal is link-coupled to the output switch. The ten megacycle multiplier operates only when the 10 MC or 50 MC push-button is actuated.

3-11. 50 MC MULTIPLIER. This multiplier, which is composed of 50 megacycle amplifier V244 and its associated circuit components, operates in the same manner as the five and ten megacycle multipliers. The plate tank circuit of this multiplier is tuned to 50 megacycles and is link-coupled to the 50 MC sine wave output switch. Plate voltage for V244 is applied only when the 50 MC push-button is actuated.

DIVIDER CIRCUITS

3-12. GENERAL. There are 13 divider circuits employed in the Model 1817, each containing a triggered multivibrator circuit. (See figures 3-2 and 5-2.) The fourteenth marker receives its signal directly from the crystal-controlled oscillator. The 10, 50, 100 and 500 microsecond markers are the high-frequency dividers. The 1, 5, 10 and 50 millisecond markers are the intermediate dividers. The 100 and 500 millisecond and the 1 and 5 second markers are the low-frequency dividers.

a. Operation of each divider circuit is essentially the same. Each circuit consists of a bi-stable multivibrator with diode coupling for triggering pulses. Operation of these circuits is described in the paragraphs that follow. Figure 3-2 is a simplified schematic diagram of a multivibrator circuit and should be referred to during the following description.

3-13. MULTIVIBRATOR. Oscillations of the multivibrator are maintained by the alternate shifting of conduction from V265A to V265B. Once started, each tube would tend to conduct indefinitely if the potential on the tube elements were not changed periodically by the trigger pulses from V200A. The cycle starts in this example with tube V265B at zero bias and V265A at cutoff. V265B is held in conduction by the grid-clamping action of diode V262B, while V265A does not conduct because of the fixed grid bias of -8 volts.

a. The trigger pulse which shifts the multivibrator from a quiescent to an unstable state is a negative-going pulse of approximately 50 volts fed to the cathode of V262A. This pulse drives the cathode more negative than the plate causing V262A to conduct. Since the plate of V262A is coupled to the grid of V265B through C267, the negative pulse breaks the clamping action of V262B and drives the grid of V265B negative. This, in turn, causes the cathode current to decrease. The decreasing cathode current through R265 causes the potential on the cathode of V265A to decrease. When the voltage on the cathode decreases to -8 volts, V265A conducts, causing a further drop in voltage at the plate. This negative-going voltage like the trigger pulse, is coupled to the grid of V265B through C267 and aids the negative-going trigger pulse in driving V265B to cutoff.

b. As tube V265A conducts, the plate voltage continues to drop until it reaches the same potential as that which is on the plate of V262A (175 volts). At this point, the plate of V262A is more negative than the cathode and subsequent trigger pulses cannot reach the grid of V265B. As the charge across C267 equalizes, the grid of V265B becomes more and more

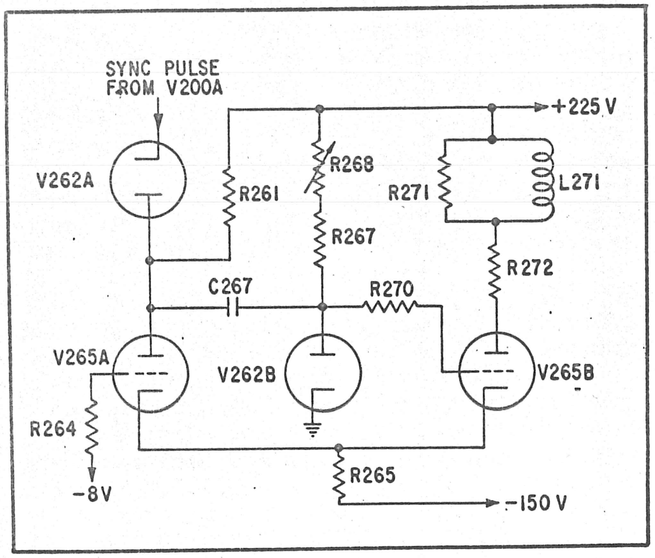


Figure 3-2. Simplified Diagram of Multivibrator Circuit

positive until the clamping action of V262B is restored.

c. At this point, the multivibrator begins to revert to its initial state, for as V265B begins to conduct the voltage on the cathode of V265A raises again to cutoff potential. The subsequent drop in current through R261 causes the plate voltage of V265A to increase. As the plate voltage of V265A increases C267 takes on a charge. The multivibrator is now restored to its quiescent state and, in the absence of further trigger pulses would remain so. But since more trigger pulses do follow the initial trigger, the multivibrator continues indefinitely to shift conduction from one tube to another in the manner described above. The value of the components in the five microsecond divider are selected to provide an elapsed time of five microseconds for each complete cycle.

3-14. CATHODE FOLLOWER. Cathode follower V200A, which couples the one megacycle oscillator to the five microsecond divider, isolates the divider stage from the oscillator. It also prevents any variations in the divider from affecting the stability of the oscillator.

3-15. 10 USEC DIVIDER. This circuit operates in the same manner as the five microsecond circuit, with the exception that the time constant components are of such value that the input diode will pass one pulse for every two pulses at the cathode.

3-16. OTHER DIVIDERS. The other multivibrator circuits operate in a manner similar to the 5 usec and 10 usec dividers previously described. With the exception of the five second divider, each divider contains a cathode follower in its output circuit.

EXTERNAL TRIGGERING

3-17. PUSH-BUTTON SWITCHES. The banana jacks, which are independent of the switches, receive signals directly from the dividers and multipliers. The MARKER OUT connector receives signals selected by the push-button switches, through a series isolation resistor for each divider circuit.

3-18. TRIGGER OUT CONNECTOR. (See figure 5-6.) The TRIGGER OUT connector receives the individual signals of 10 usec, 100 usec, 1 msec, 10 msec, 100 msec. These signals are fed to cathode follower V750A and are capacitive-coupled to V750B through C752. The dc level of the signal is a function of the signal repetition rate due to capacitor C752. To overcome a wide range in the dc level of the signal, diode V760 is incorporated in the grid circuit of V750B.

a. Resistors R756 and R755, along with diode V760, hold the grid of V750B at -7 volts when no signal is present. When a positive-going signal appears, diode V760 ceases conduction, thus allowing the grid and cathode to follow the signal excursion. When the signal passes, diode V760 and its associated circuitry clamps the grid to -7 volts. The pulses at the TRIGGER OUT connector will always start at about +6.5 volts. The amplitude of the pulses will depend upon the input signal at the grid of V750A.

SECTION IV
MAINTENANCE AND CALIBRATION

PREVENTIVE MAINTENANCE

4-1. AIR FILTER. The air filter in the Model 1817 Time-Mark Generator should be inspected and cleaned every three months. An air filter with a heavy deposit of dust obstructs the air drawn in by the cooling fan. This causes the temperature of the instrument to rise to a degree that can be injurious to the unit. The air filter should be tapped gently against a flat surface to remove all loose particles of dust and then washed in hot soapy water. After drying "Handi-Koter" or "Filtercoat" coatings should be applied.

4-2. FAN MOTOR. The fan motor should be lubricated by applying two drops of a good grade of light oil every three months.

4-3. SOLDERING HINTS. If any soldering is required use a rosin-core solder which contains approximately three percent silver. This can be purchased from any electronic parts distributor.

REPLACEMENT PARTS

4-4. The majority of the component parts, such as resistors, tubes, and capacitors, can be obtained readily from local radio or electronic parts stores. Components, such as transformers, crystals, etc. should be obtained from the Hickok Electrical Instrument Company.

4-5. When ordering parts from the factory please furnish the correct information to avoid delay. Include a full description of each part as given in Section VI. Always include the instrument Serial and Model number in correspondence relating to your instrument.

NOTE

Upon the receipt of the new equipment fill out the accompanying Warrenty Card and mail as directed.

TROUBLE SHOOTING

4-6. GENERAL. The task of locating the source of troubles which may develop in the time-mark generator may be simplified if the technician will familiarize himself with the basic sections in the instrument. Review Section III with special emphasis given to figures 3-1 and 3-2 before removing any components. The following paragraphs describe methods by which troubles may be traced to particular sections. If the technician is observant and employs analytical and logical effect-to-cause reasoning, oftentimes the individual part causing the trouble may be quickly singled out. Obvious troubles, such as open filaments and fuses, shorted resistors, loose connections and arcing can be caught by visual inspection or by the distinctive odor emanating from defective components.

CAUTION

This is a precision electronic test instrument. As such, it includes factory adjusted controls and specially processed vacuum tubes. Unnecessary tube replacement may degrade the performance of the unit. When testing vacuum tubes, replace all good tubes in their original sockets.

4-7. POWER SUPPLY. All sections of the laboratory instrument depend upon the regulated power supply. Before checking any other section of the instrument it is advisable to check the regulated power supply.

a. If the regulated power supply is inoperative, check to see if the ac power is connected. The pilot lamp should be on and the cooling fan operating with the POWER SWITCH in the ON position. If this does not occur, check the power source and fuse F101.

b. Next, check the output of the three voltage supplies. Voltage measurement checks at the output of the power sources will determine whether they are producing the correct voltages. (See test points and voltages in figure 5-1.) If the voltages at the various test points are abnormal, check the tubes. If the tubes are not faulty check components, particularly the metallic rectifier, in the faulty circuit.

4-8. OSCILLATOR CHECK. If the oscillator is suspected as the source of trouble, remove V262 from its socket, thus disconnecting the divider stages from the oscillator and multiplier. Place an oscilloscope in the 1 usec banana jack and check for 1 mc output. If this output registers on the oscilloscope the oscillator and amplifier stages are functioning properly.

4-9. DIVIDER CHECK. If the oscillator and amplifier are found to be operating properly, check the divider stages. Check wave forms with the oscilloscope until the defective stage is found. Remove the diode which couples the defective stage to the following stages. If the defective stage then functions normally, the trouble is probably due to loading by the stages that follow. Before replacing any components isolate the trouble by checking the multivibrator with an oscilloscope and a vacuum tube voltmeter.

a. To check multivibrator, check the incoming signal at the grid on one-half of the tube and the output signal at the plate of the other half of the tube. An oscilloscope is used for this test. If the desired signals are present at these points, check for signals at the output cathode follower stage. If no signal appears on the cathode, check through switch S710 to the MARKER OUT connector.

b. If the input signal to the multivibrator registers on the oscilloscope but no signal appears at the output, measure the voltage at multivibrator plate which connects directly to the input diode plate. The voltage reading should be +225 volts. The plate voltage of the other half of the tube should read +100 volts. The grid voltage on the first half of the tube should read approximately -6 to -8 volts. If further checks are required, it is advisable to make component checks of the divider at fault.

4-10. MULTIPLIER CHECKS. The multiplier circuits may become faulty due to tube failure. These troubles may be corrected by replacing the faulty tube. Readjustments are sometimes necessary due to aging of components and to variations in characteristics of replacement parts. These adjustments are described in the "Recalibration Procedures".

RECALIBRATION PROCEDURES

4-11. EQUIPMENT REQUIRED. Hickok Oscilloscope Model 1805, Hickok Preamplifier Model 1832.

NOTE

Any oscilloscope having vertical deflection characteristics of 5 millivolts to 0.2 volts-per-centimeter, and calibrated sweep rates for 0.02 microseconds to 5 seconds-per-centimeter with a bandpass of 30 megacycles can be used if the recommended oscilloscope is not available.

a. The Hickok Probe, part number 16970-47 is a special probe with an input resistance of 10 megohms and an input capacitance of 11 micro-microfarads. The probe attenuation ratio is 10:1.

b. An ac voltmeter with a 0-150 volts range and an accuracy of ± 1%.

c. A variac that will vary the line voltage from 105 to 125 volts ac.

d. A dc voltmeter with a 300 volt scale and a sensitivity not less than 20,000 ohms-per-volt and an accuracy of ± 1%.

e. A terminating 52 ohm connector and a 93 ohm coaxial cable.

4-12. VOLTAGE ADJUSTMENTS. The -150 volt regulated supply can be varied and is used as a reference voltage for the +225 volt and +350 volt power supplies. The two bias supply voltages of -8 and -19 volts are developed from resistive networks connected across the output of the -150 volt reference supply.

a. THE -150 VOLT SUPPLY. The -150 volt regulated reference voltage should be the first adjustment. Remove the side panels from the instrument and connect the ac input of the instrument to the output of the variac. Set the variac to 117 volts. Connect the positive lead of a dc voltmeter to ground and the negative lead to cathode pins 3 and 9 of V144. Set the -150 ADJ control to read exactly -150 volts on meter.

b. THE +225 VOLTAGE SUPPLY. Connect the positive lead of dc voltmeter to pin 3 of V107A, and the negative lead to ground. The voltage should be +225 volts ±2%.

c. THE +350 VOLTAGE SUPPLY. The positive lead of meter should be placed on pin 6 of V107B and negative lead to ground. The reading should be +350 volts ±2%.

d. BIAS VOLTAGES. Place the positive connection of dc meter on ground. Apply the negative lead to cathode, pin 3 of V393A. The voltage should be -19 volts ±1 volt. To read the -8 volt bias, place the negative lead at the junction of R174 and R176. The meter should read -8 volts ±1 volt.

4-13. RIPPLE VOLTAGE MEASUREMENTS. The three regulated power supply circuits are so designed as to produce a very low ripple factor in the output voltages. Failure of a component part in any of the three power units can cause an increase in the ripple voltage. Measurement of the ripple is a good check on the operation of the regulated output. The method is described as follows:

a. OSCILLOSCOPE CONTROL SETTINGS. Set the following controls of the Hickok 1805 Oscilloscope as follows:

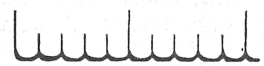
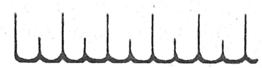
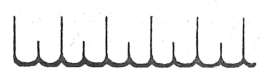
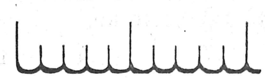
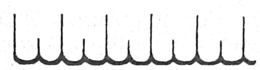
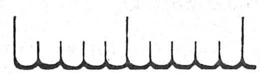
Control	Position
STABILITY	PRESET
TRIGGERING LEVEL	Not Used in AUTOMATIC Mode
TRIGGERING MODE	AUTOMATIC
TRIGGER SLOPE	+ LINE
TIME/CM	1 MILLISEC
MULTIPLIER	5
5X MAGNIFIER	OFF
HORIZONTAL DISPLAY	INTERNAL SWEEP
HORIZONTAL POSITION	Centered
POWER	ON
SQUARE-WAVE CALIBRATION	OFF
(Black Knob)	Any Position

b. PREAMPLIFIER CONTROL SETTINGS.

Control	Position
VERTICAL POSITION	Centered
VOLTS/CM	0.005
VARIABLE	CALIBRATED
INPUT SELECTOR	AC x 10

TABLE III

TIME-MARK DIVIDER ADJUSTMENTS

OSCILLISCOPE TIME/CM	TYPE 180A OUTPUT		TYPE ADJUSTMENT	DISPLAYED WAVE FORM
	TRIGGER	MARKERS		
1 MICROSEC	100 KC	1 and 5 MICROSECONDS	5 µS	
2 MICROSEC	100 KC	5 and 10 MICROSECONDS	10 µS	
10 MICROSEC	10 KC	10 and 50 MICROSECONDS	50 µS	
20 MICROSEC	10 KC	50 and 100 MICROSECONDS	100 µS	
100 MICROSEC	1 KC	100 and 500 MICROSECONDS	500 µS	
200 MICROSEC	1 KC	500 MICROSECONDS 1 MILLISECOND	1 MS	
1 MILLISEC	100 cycles	1 and 5 MILLISECONDS	5 MS	
2 MILLISEC	100 cycles	5 and 10 MILLISECONDS	10 MS	
10 MILLISEC	10 cycles	10 and 50 MILLISECONDS	50 MS	
20 MILLISEC	10 cycles	50 and 100 MILLISECONDS	100 MS	
100 MILLISEC	1 cycle	100 and 500 MILLISECONDS	500 MS	
200 MILLISEC	1 cycle	500 MILLISECONDS 1 SECOND	1 SEC	
1 SECOND	*	1 and 5 SECONDS	5 SEC	

*USE INTERNAL TRIGGERING

c. With the instruments side panels removed either remove the 1 MC crystal from its socket or place a jumper across crystal pins 4 and 6 to disable the oscillator.

d. With the variac adjusted to 117 volts, turn the POWER switch of the Model 1817 to the ON position. Allow the instrument to warm up for at least five minutes.

e. To measure ripple on the -150 volt supply, connect one terminal of oscilloscope to ground and the other terminal to the -150 volt regulated supply. Vary the output of the variac from 105 to 125 volts. The ripple viewed on the oscilloscope should not be greater than 5 millivolts.

f. Using the same equipment and same variac voltage outputs as above for the -150 voltage supply, connect the hot lead of the oscilloscope to pin 3 of V107A. Check the +225 regulated supply. The ripple factor should not exceed 30 millivolts.

g. The measurement procedure for the +350 volt supply is made in the same manner as the +225 volt supply with the exception of placing the hot lead of scope to pin 6 of V107B. The ripple factor should not exceed 30 millivolts.

4-14. ADJUSTMENTS OF THE DIVIDER CIRCUITS. Potentiometers are incorporated in the cathode-coupled multivibrator circuits to adjust the dividing rate of the stage under test. These are adjusted in the following manner:

a. OSCILLOSCOPE CONTROL SETTINGS. Set the controls of the oscilloscope as follows:

Control	Position
HORIZONTAL DISPLAY	INTERNAL SWEEP
TIME/CM	1 MICROSEC
MULTIPLIER	1
5X MAGNIFIER	OFF
STABILITY	PRESET
TRIGGERING SLOPE	+ EXT.
TRIGGERING LEVEL	Full clockwise rotation
TRIGGERING MODE	AC SLOW
HORIZONTAL POSITION	Centered
SQUARE-WAVE CALIBRATOR	OFF
POWER	ON

b. PREAMPLIFIER CONTROL SETTINGS.

Control	Position
VERTICAL POSITION	Centered
VOLTS/CM	0.1
VARIABLE	CALIBRATED
INPUT SELECTOR	AC

c. Connect Hickok Probe, part number 16970-47, to the INPUT A of preamplifier and to the MARKER OUT connector of Model 1817. Connect the TRIGGER OUT of Model 1817 to the TRIGGER INPUT of Model 1805 Oscilloscope.

d. After allowing sufficient warm-up time, depress the push-button labeled 1 MICROSECONDS of the time mark generator. Rotate the TRIGGERING LEVEL control of the oscilloscope in a counterclockwise direction until a stable trace appears on the screen.

NOTE

It might be necessary to make slight adjustments of the controls on the oscilloscope for different amplitudes of the signal.

e. When recalibrating the divider circuits, Table III should be followed. The first column gives the proper settings for the oscilloscope. Columns two and three give the correct settings of the Model 1817 Time-Mark Generator. Column four gives the potentiometer adjustment required. Column five illustrates the correct wave form which should appear on the oscilloscope for each adjustment. The amplitude of these waveforms on all ranges should be at least 1 volt.

f. The amplitude of any pulses at the TRIGGER OUT connector should be no less than 2 volts.

4-15. ADJUSTMENTS OF SINE WAVE OUTPUT CIRCUITS. Tuned circuits in the output circuits of the multipliers provide adjustments for the correct frequency and amplitude of the signal. These adjustments are accomplished as follows:

a. OSCILLOSCOPE CONTROL SETTINGS.

Control	Position
HORIZONTAL DISPLAY	INTERNAL SWEEP
HORIZONTAL POSITION	Centered
SQUARE WAVE CALIBRATOR	OFF
MULTIPLIER	1
5X MAGNIFIER	ON
TIME/CM	1 MICROSEC
STABILITY	PRESET
TRIGGERING SLOPE	TEXT
TRIGGERING MODE	AC FAST
TRIGGERING LEVEL	Full clockwise or counterclockwise
POWER	ON

b. PREAMPLIFIER CONTROL SETTINGS.

Control	Position
VERTICAL POSITION	Centered
VARIABLE	CALIBRATED
AC-DC	AC
VOLTS/CM	0.1

c. Connect the TRIGGER OUT of Model 1817 to the TRIGGER INPUT of oscilloscope Model 1805. Connect probe, part number 16970-47, to the INPUT of the preamplifier. Connect the Terminating Resistor adapter, to the MARKER OUT connector on the Model 1817. Insert the tip of the probe into the terminating resistor. The ground lead of probe connects to the ground side of terminating resistor.

d. Depress the 5 MC SINE WAVE push-button and display a five megacycle stable sine wave. Adjust capacitors C229 and C223 of the 5 mc output circuit for one cycle-per-centimeter with an amplitude of two volts or more.

e. Press the 10 MC SINE WAVE push-button on panel of Time-Mark Generator. Change the position of the TIME/CM control to .1 MICROSEC and turn the 5X MAGNIFIER to the OFF position. Adjust C233, and C239 for one cycle-per-centimeter with maximum amplitude.

f. Press the 50 MC SINE WAVE push-button switch. Set the 5X MAGNIFIER to the ON position. Adjust capacitors C243 and C247 for one-cycle-per-centimeter with an amplitude of approximately 1.2 centimeters.

4-16. WAVE FORM PULLING. When used to provide a source of external triggers the Time-Mark Generator may cause "pulling" of the wave form on the screen of the oscilloscope. As stated previously, the trigger pulses should be adjusted for two volts amplitude, but the adjustments may have to be changed slightly to prevent "pulling".

a. To make this adjustment, set the front panel controls as stated in paragraph 4-16f for the 50 mc output. Since each trigger push-button is labeled with respect to time as well as frequency, the oscilloscope should be triggered from each trigger rate in turn. The stage causing the pulling should then be slightly adjusted. If the 100 kc trigger rate is not evident on the test oscilloscope as a single cycle trace it can be reduced to produce a double trace.

4-17. ADJUSTMENT OF THE 1-MC CRYSTAL OSCILLATOR. Capacitor C205 is connected in parallel with the oscillator crystal and is used to adjust the oscillator frequency to exactly one megacycle. To adjust the frequency of the oscillator a one megacycle frequency from the Time-Mark Generator can be fed to the test oscilloscope along with a stable known frequency. The drift on the screen of the oscilloscope of the signal can be reduced to zero by adjusting capacitor C205.

a. A tuned circuit can be designed to receive the strongest standard broadcast station in your area. Since the carrier frequency of the broadcast station is a multiple of 10 kc with a frequency tolerance of ±20 cps it can be used as the stable known frequency. The output of the tuned circuit is fed to the INPUT A of the Hickok preamplifier, model number 1832.

b. Connect a lead from the 100 usec banana jack to the EXTERNAL TRIGGER of the oscilloscope. Set the oscilloscope controls as given in paragraph 4-14. Set the TRIGGER MODE to + EXT.

c. Adjust the oscilloscope STABILITY and TRIGGERING LEVEL controls until the station's modulation envelope slowly drifts across the screen of the cathode ray tube. Next, adjust C205 until the drift is the same in both directions as the temperature of the crystal goes up and down.

SECTION V

CIRCUIT SCHEMATICS

NOTE

All measurements shown on the schematics are from test point to ground. All voltages are dc unless otherwise stated. Voltage measurements were made with a dc vacuum tube voltmeter with an input resistance of 11 megohms.

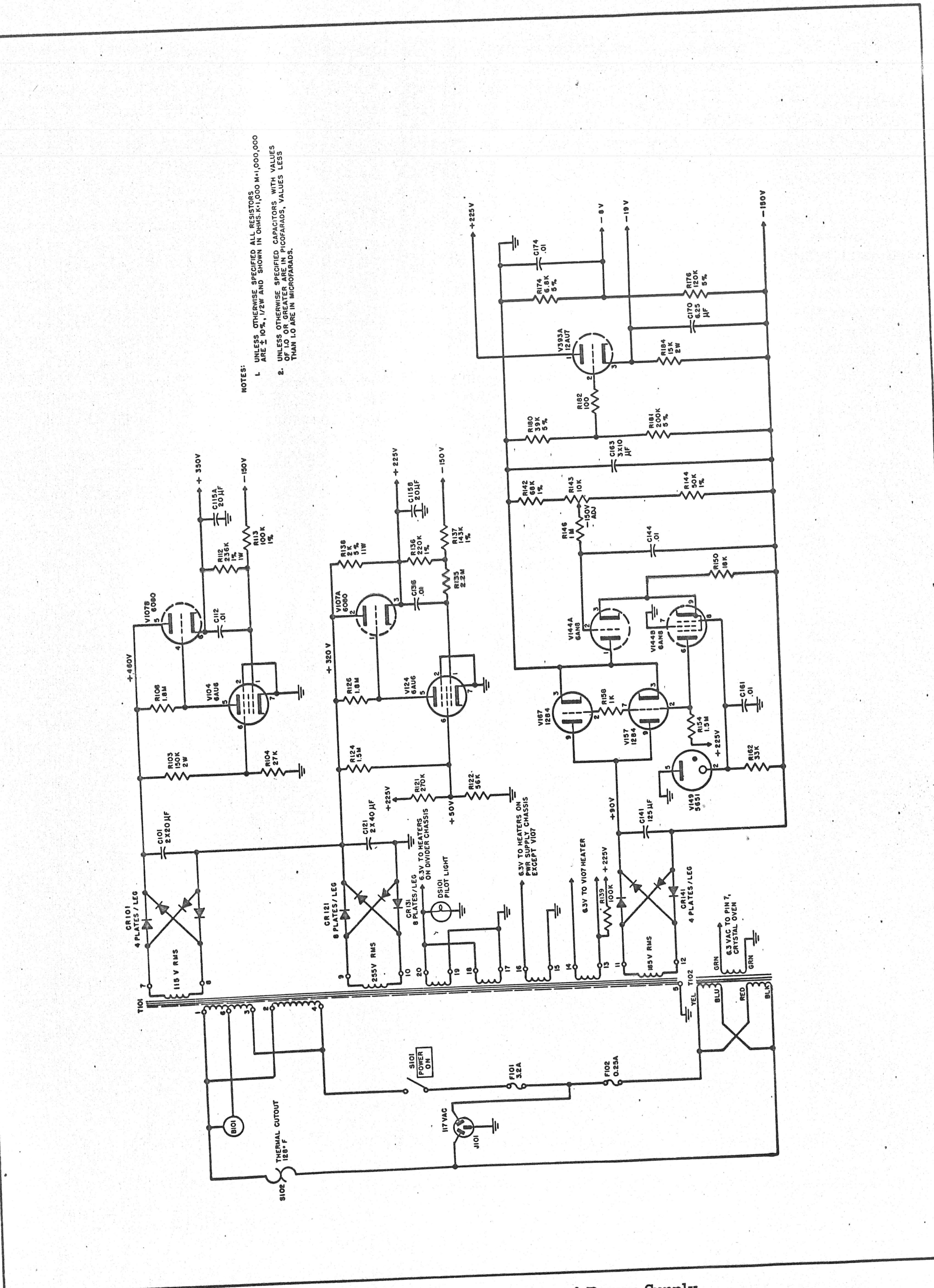


Figure 5-1. Schematic Diagram of Power Supply

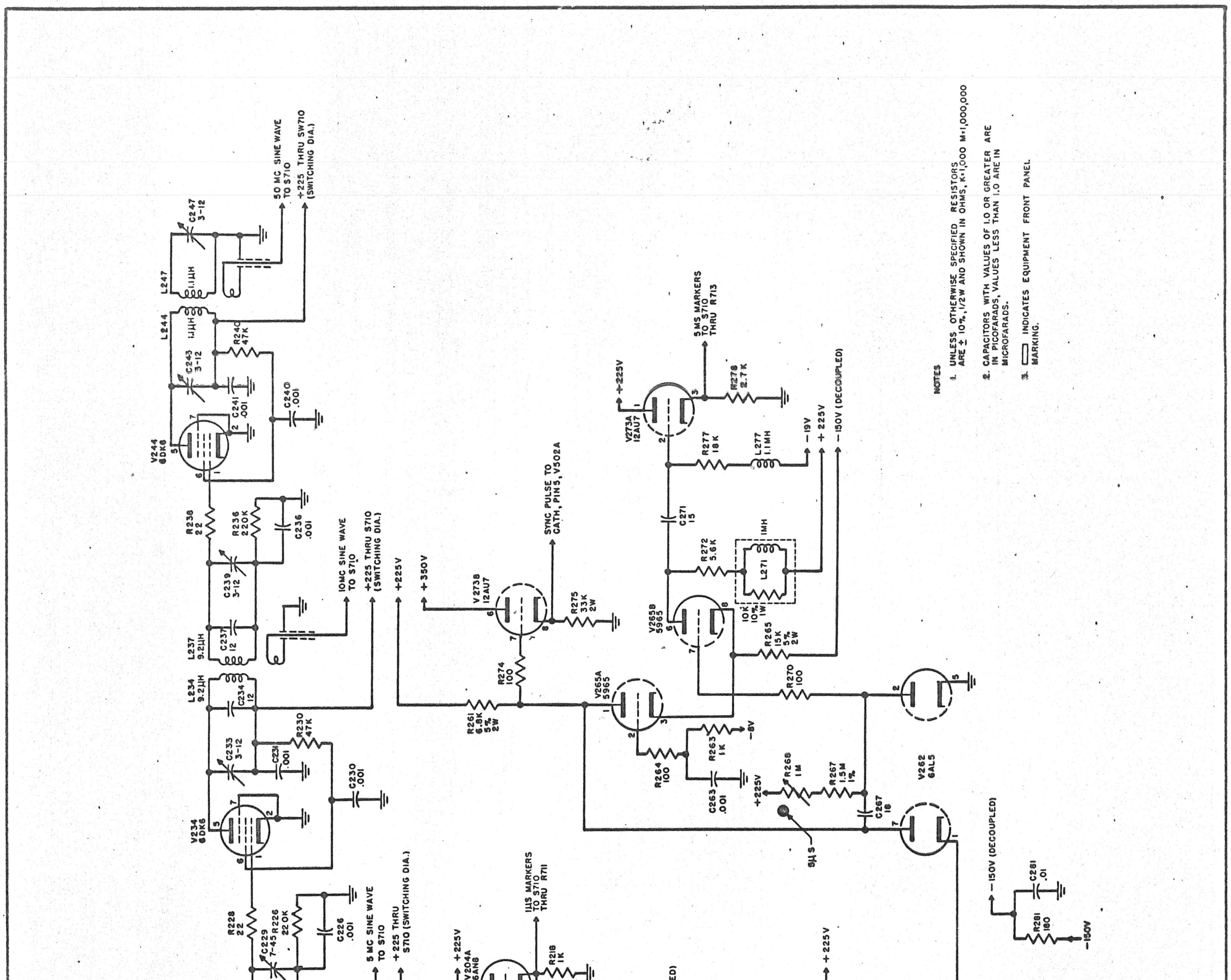


Figure 5-2. Schematic Diagram of Oscillator and Multiplier

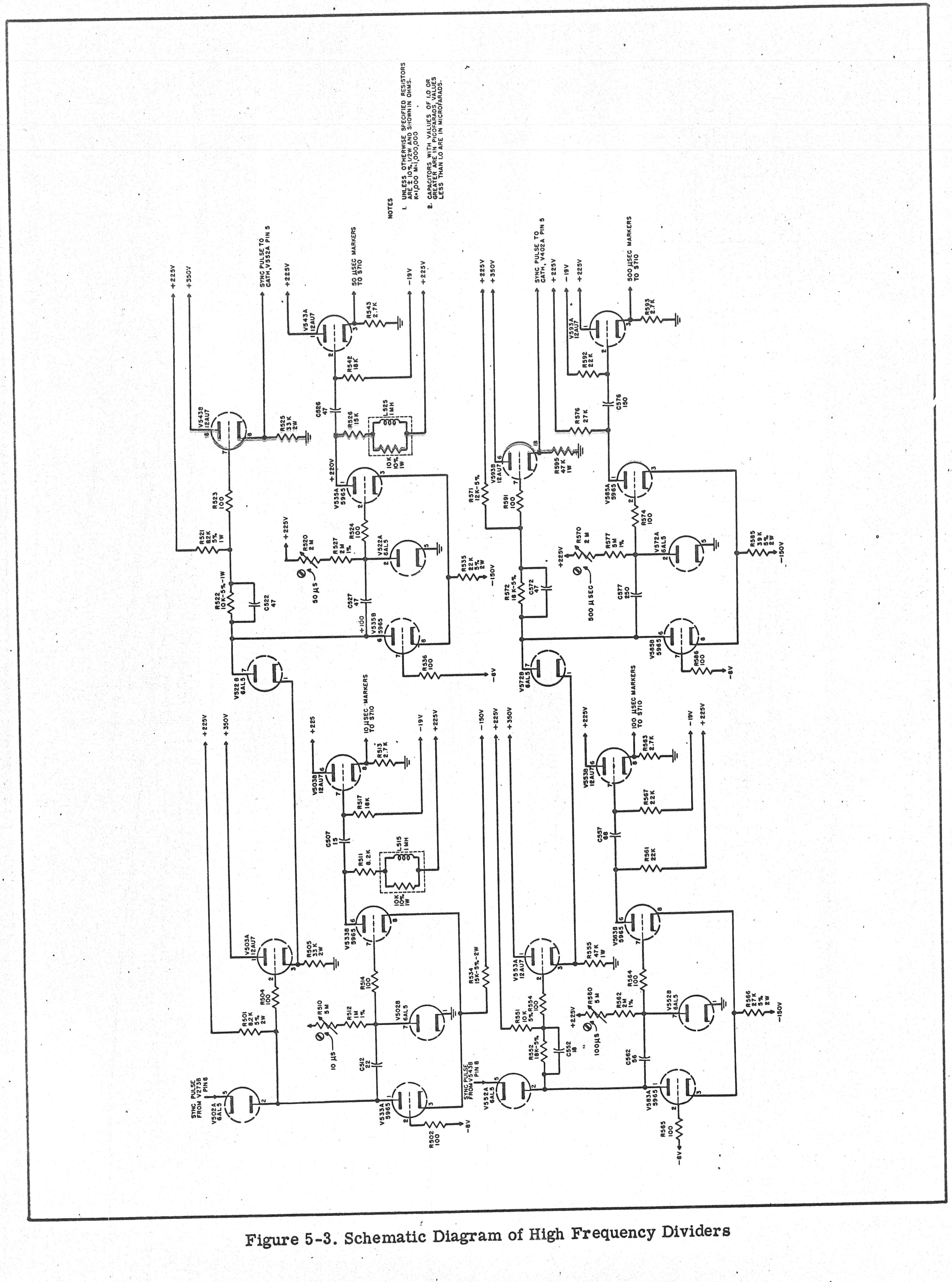


Figure 5-3. Schematic Diagram of High Frequency Dividers

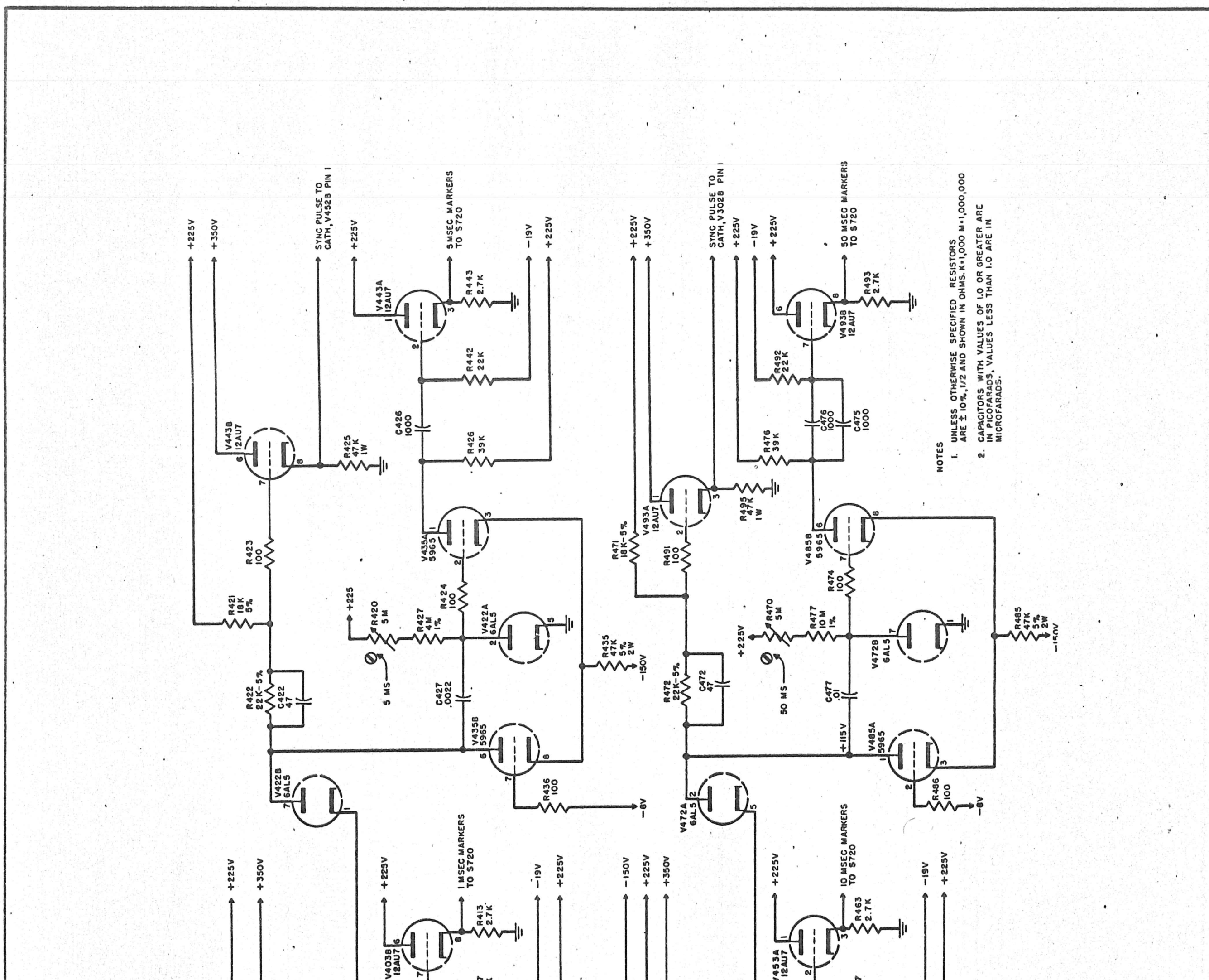


Figure 5-4. Schematic Diagram of Intermediate Frequency Dividers

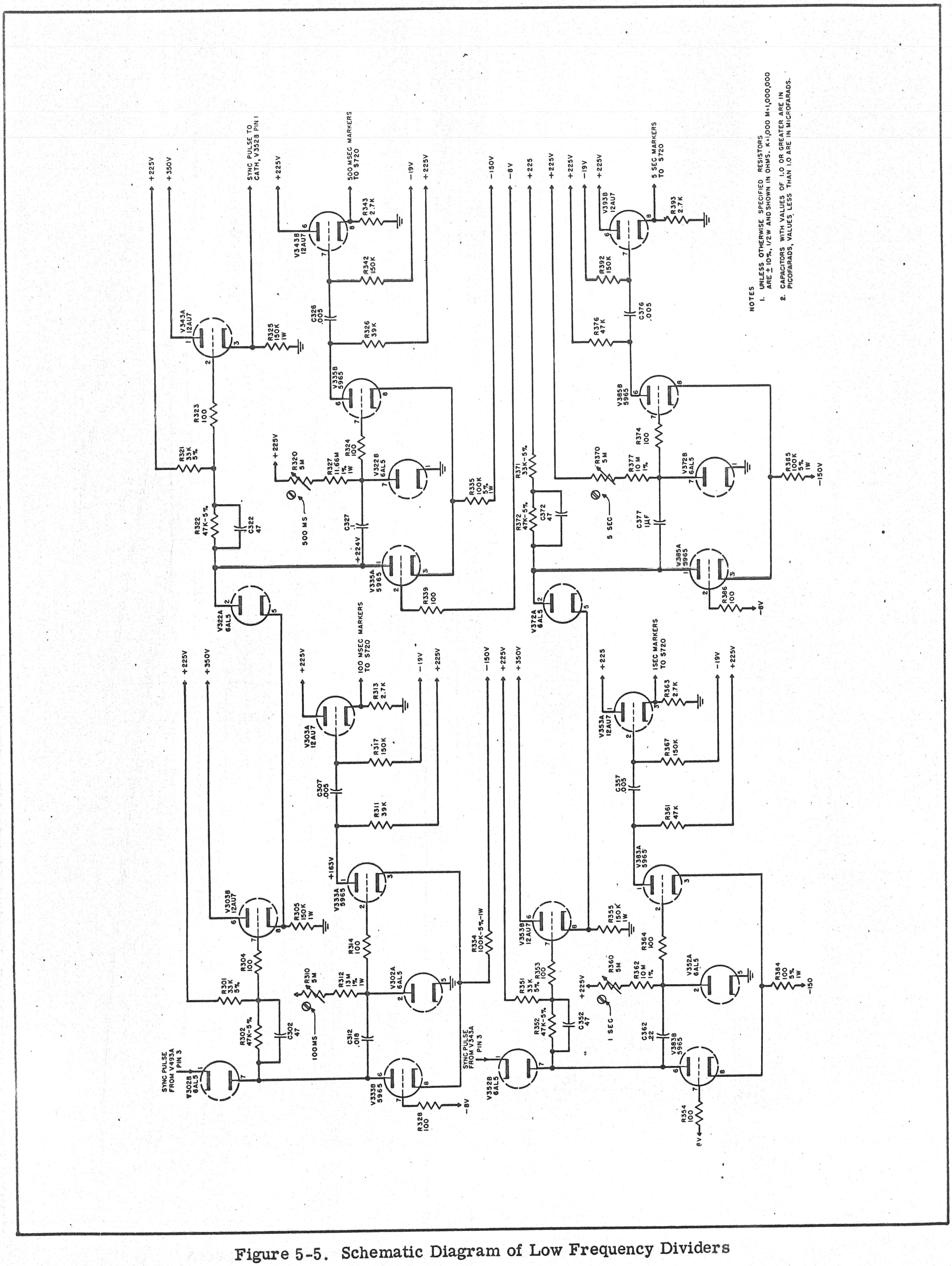


Figure 5-5. Schematic Diagram of Low Frequency Dividers

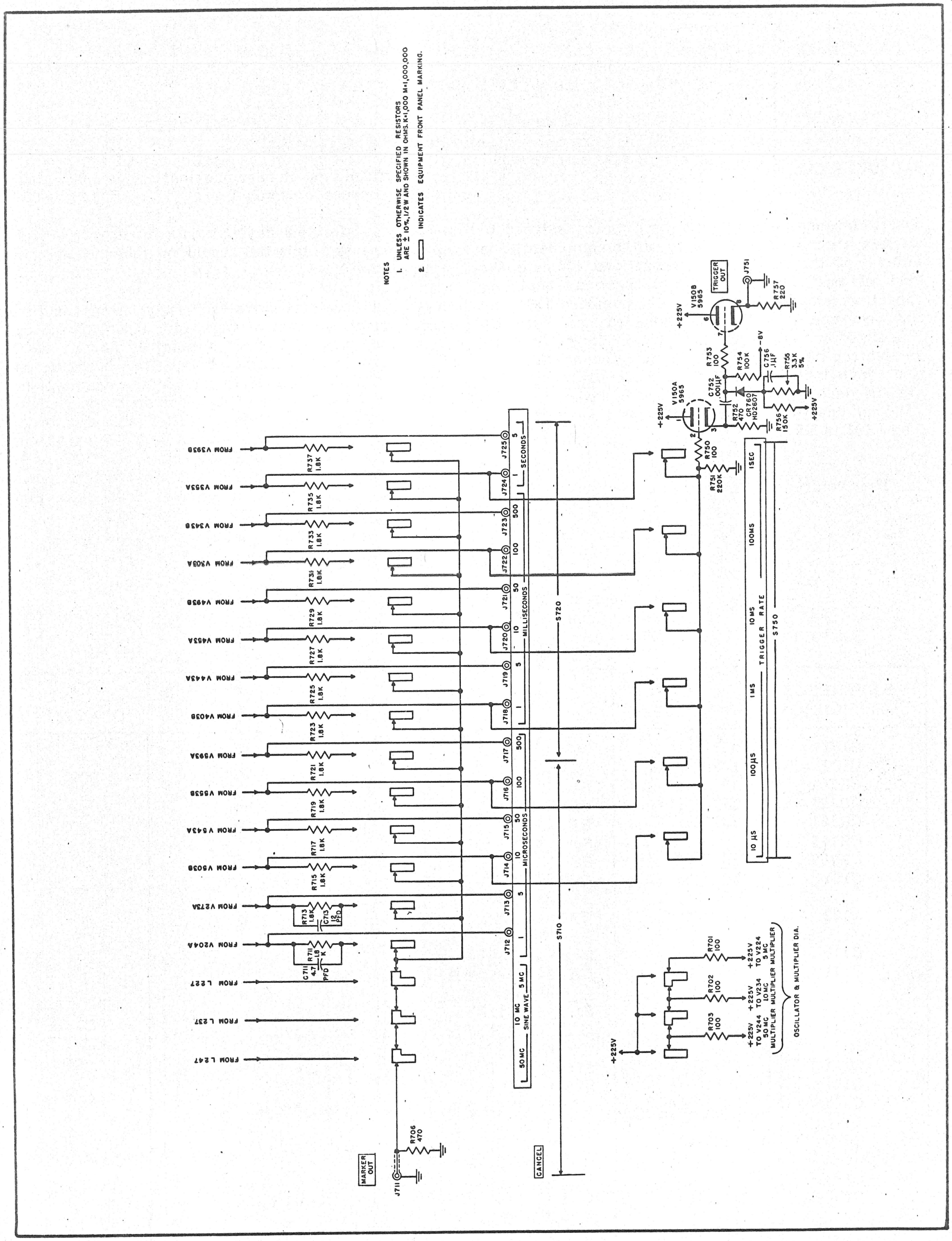


Figure 5-6. Schematic Diagram of Trigger Cathode Follower and Switching

SECTION VI

PARTS LIST

6-1. GENERAL.

6-2. Reference designations have been assigned to identify all maintenance parts of the equipment. The letters of the reference designations indicate the kind of parts (generic group), such as resistor, capacitor, electron tube, etc. The numbers differentiate between parts in the same group. A socket associated with a particular plug-in device, such as an electron tube, is identified by a reference designation which includes the reference designation of the plug-in device. For example, the socket for tube V104 is designated XV104 and the fuse holder for fuse F101 is XF101.

a. The reference designations in this parts list are given in alpha-numerical sequence; that is, letters precede numerals.

b. All reference designation symbols of electronics components in this list appear on schematic diagrams in Section V.

6-3. Replacement parts can be purchased from Hickok Electrical Instrument Company. Most of the components, however, can be obtained locally as they are standard electronic parts. When ordering parts from Hickok, be sure to include the description, as well as the reference designation and the part number. For example, a certain capacitor should be ordered as follows: reference designation C512; part number 3110-92; ceramic fixed capacitor, 22 UUF, ± 10%, 500 volts for model 1817 Time-Mark Generator, Serial Number (fill in number from data plate).

NOTE

Only the symbols appearing in the reference designation column are used in connection with the Model 1817.

REFERENCE DESIGNATION	PART NUMBER	DESCRIPTION	QUANTITY
B101	13750-5	MOTOR, Fan	1
B102	2380-3	IMPELLER, Fan, axial	1
CR101	18150-59	RECTIFIER, Metallic, selenium type	2
CR121	18150-60	RECTIFIER, Metallic, selenium type	1
CR131	18150-60	RECTIFIER, Metallic, selenium type	1
CR141		Same as CR101	
CR760	3870-58	SEMICONDUCTOR, Diode	1
C101	3085-96	CAPACITOR, Fixed, electrolytic, 2 x 20 UF, . . 450 volts	2
C112	3105-252	CAPACITOR, Fixed, paper, 0.01 UF, 20% . . . . 400 volts	6
C115A-B		Same as C101	
C121	3085-88	CAPACITOR, Fixed, electrolytic, 2 x 40 UF, . . 450 volts	1
C136		Same as C112	
C141	3085-89	CAPACITOR, Fixed, electrolytic, 125 UF, ... 350 volts	1
C144		Same as C112	
C161		Same as C112	
C163	3085-104	CAPACITOR, Fixed, electrolytic, 3 x 10 UF, . . 350 volts	1
C170	3085-93	CAPACITOR, Fixed, electrolytic, 6.25 UF, ... 300 volts	1
C174		Same as C112	
C200	3110-64	CAPACITOR, Fixed, ceramic, 0.01 UF, ... +100 -20%, 500 volts	2

REFERENCE DESIGNATION	PART NUMBER	DESCRIPTION	QUANTITY
C201	3110-107	CAPACITOR, Fixed, ceramic, 0.001 UF, ... 500 volts	11
C203	3110-98	CAPACITOR, Fixed, ceramic, 47 UUF, ... 10%, 500 volts	15
C204	3110-87	CAPACITOR, Fixed, ceramic, 4.7 UUF ± ..... 1 UUF, 500 volts	2
C205	3115-20	CAPACITOR, Variable, 4.5-25 UUF, 20% ..... 500 volts	1
C210		Same as C203	
C214		Same as C201	
C216	3115-14	CAPACITOR, Variable, 3-12, UUF, 350 volts ..	1
C220		Same as C201	
C221		Same as C201	
C222		Same as C203	
C223	3115-21	CAPACITOR, Variable, 7-45 UUF, 20%, ... 500 volts	2
C224	3110-124	CAPACITOR, Fixed, ceramic, 12 UUF, 10%, .. 500 volts	4
C226		Same as C201	
C227	3110-92	CAPACITOR, Fixed, ceramic, 22 UUF, ± 10%, . 500 volts	2
C229		Same as C223	
C230		Same as C201	
C231		Same as C201	
C233	3115-23	CAPACITOR, Variable, 3-12 UUF, 20%, ... 500 volts	4
C234		Same as C224	
C236		Same as C201	
C237		Same as C224	
C239		Same as C233	
C240		Same as C201	
C241		Same as C201	
C243		Same as C233	
C247		Same as C233	
C263		Same as C201	
C267	3110-121	CAPACITOR, Fixed, ceramic, 18 UUF, 10%, .. 500 volts	2
C271	3110-120	CAPACITOR, Fixed, ceramic, 15 UUF, ... 10%, 500 volts	2
C281		Same as C200	
C302		Same as C203	
C307	3110-119	CAPACITOR, Fixed, ceramic, 0.005 UF, ... 500 volts	4
C312	3105-281	CAPACITOR, Fixed, paper, 0.018 UF, 10%, ... 600 volts	1
C322		Same as C203	
C326		Same as C307	
C327	3105-266	CAPACITOR, Fixed, paper, 0.1 UF, 20%, ... 400 volts	1
C352		Same as C203	
C357		Same as C307	
C362	3105-246	CAPACITOR, Fixed, paper, 0.22 UF, 20%, ... 400 volts	1
C372		Same as C203	
C376		Same as C307	
C377	3105-279	CAPACITOR, Fixed, paper, 1 UF, 600 volts ...	1
C402		Same as C203	
C407	3110-101	CAPACITOR, Fixed, ceramic, 470 UUF, 20%, .. 500 volts	1
C412	3095-129	CAPACITOR, Fixed, silver mica, 250 UUF, 5%, 500 volts	2
C422		Same as C203	

REFERENCE DESIGNATION	PART NUMBER	DESCRIPTION	QUANTITY
C426	3110-118	CAPACITOR, Fixed, ceramic, 1000 UUF, ... 10%, 500 volts	5
C427	3105-253	CAPACITOR, Fixed, paper, 0.0022 UF, 20%, .. 400 volts	1
C452		Same as C203	
C457		Same as C426	
C462	3105-280	CAPACITOR, Fixed, paper, 0.0033 UF, 20%, .. 400 volts	1
C472		Same as C203	
C475		Same as C426	
C476		Same as C426	
C477		Same as C112	
C507		Same as C271	
C512		Same as C227	
C522		Same as C203	
C526		Same as C203	
C527		Same as C203	
C552		Same as C267	
C557	3110-123	CAPACITOR, Fixed, ceramic, 68 UUF, ... 10%, 500 volts	1
C562	3095-128	CAPACITOR, Fixed, silver mica, 56 UUF, ... 10%, 500 volts	1
C572		Same as C203	
C576	3110-100	CAPACITOR, Fixed, ceramic, 150 UUF, 10%, .. 500 volts	1
C577		Same as C412	
C711		Same as C204	
C713		Same as C224	
C752		Same as C426	
C756	3110-115	CAPACITOR, Fixed, ceramic, disc-type...... 0.1 UF, +80 -30%, 75 volts	1
DS101	12270-12	LAMP, No. 47 G.E., 6 to 8 volts, 0.15 amp	2
DS201		Same as DS101	
*E100	2360-85	POST, Binding	1
FL100	6265-15	FILTER, Air, 7 inch x 7 inch x 1 inch	1
F101	6900-32	FUSE, Cartridge, 3.2 amp, 125 volts	1
F102	6900-20	FUSE, Cartridge, 0.25 amp, 125 volts	1
H100	8330-87	HANDLE, Leather	1
H101 thru H124	2920-7	KNOB, Push button type, black.............	23
H125	2920-8	KNOB, Push button type, red..............	1
J101	18075-69	CONNECTOR, Receptacle.................	1
J711	3475-112	CONNECTOR, Receptacle, UHF single ...... contact type	2
J712	10300-52	JACK, Tip, single contact banana type	14
J713		Same as J712	
J714		Same as J712	
J715		Same as J712	
J716		Same as J712	
J717		Same as J712	
J718		Same as J712	
J719		Same as J712	
J720		Same as J712	
J721		Same as J712	
J722		Same as J712	
J723		Same as J712	
J724		Same as J712	
J725		Same as J712	
J751		Same as J711	
L201	3320-218	COIL, Radio frequency, 1.1 mh	3
L207		Same as L201	

REFERENCE DESIGNATION	PART NUMBER	DESCRIPTION	QUANTITY
L216	3320-217	COIL, Radio frequency, 300 uh	1
L224	3320-222	COIL, Radio frequency, 18 uh	1
L227	3320-221	COIL, Radio frequency, 16 uh	1
L234	3320-220	COIL, Radio frequency, 9.2 uh.	2
L237		Same as L234	
L244	3320-219	COIL, Radio frequency, 1.1 uh.	2
L247		Same as L244	
L271	3320-216	COIL, Radio frequency, 1 mh	3
L277		Same as L201	
L515		Same as L271	
L525		Same as L271	
MP100 thru MP102	19200-13	MOUNT, Shock	3
R103	18434-152	RESISTOR, Fixed, composition, 150K ohms, . . 10%, 2 watt	1
R104	18413-272	RESISTOR, Fixed, composition, 27K ohms, . . . 10%, 1/2 watt	2
R108	18415-182	RESISTOR, Fixed, composition, 1.8 megohms, . 10%, 1/2 watt	2
R112	18550-169	RESISTOR, Fixed, wire-wound, 236K ohms, . . . 1%, 1 watt	1
R113	18525-790	RESISTOR, Fixed, wire-wound, 100K ohms, . . . 1%, 1/2 watt	1
R121	18414-272	RESISTOR, Fixed, composition, 270K ohms, . . . 10%, 1/2 watt	1
R122	18413-562	RESISTOR, Fixed, composition, 56K ohms, . . . 10%, 1/2 watt	2
R124	18415-152	RESISTOR, Fixed, composition, 1.5 megohms, . 10%, 1/2 watt	2
R126		Same as R108	
R135	18415-222	RESISTOR, Fixed, composition, 2.2 megohms, . 10%, 1/2 watt	1
R136	18530-90	RESISTOR, Fixed, film 220K ohms, ... 1%, 1/2 watt	1
R137	18530-176	RESISTOR, Fixed, film, 143K ohms, ... 1%, 1/2 watt	1
R138	18575-221	RESISTOR, Fixed, wire-wound, 2,000 ohms, . . . 5%, 11 watt	1
R139	18414-102	RESISTOR, Fixed, composition, 100K ohms, . . . 10%, 1/2 watt	2
R142	18530-175	RESISTOR, Fixed, film, 68K ohms, 1%, ... 1/2 watt	1
R143	16925-357	RESISTOR, Variable, wire-wound, 10K ohms, . . 10%, 2 watt	1
R144	18530-25	RESISTOR, Fixed, film, 50K ohms, 1%, ... 1/2 watt	1
R146	18415-102	RESISTOR, Fixed, composition, 1 megohm, . . . 10%, 1/2 watt	1
R150	18413-182	RESISTOR, Fixed, composition, 18K ohms, . . . 10%, 1/2 watt	4
R154		Same as R124	
R158	18412-102	RESISTOR, Fixed, composition, 1,000 ohms, . . . 10%, 1/2 watt	1
R162	18413-332	RESISTOR, Fixed, composition, 33K ohms, ... 10%, 1/2 watt	1
R174	18412-681	RESISTOR, Fixed, composition, 6,800 ohms . . . 5%, 1/2 watt	1
R176	18414-121	RESISTOR, Fixed, composition, 120K ohms, . . . 5%, 1/2 watt	1
R180	18413-391	RESISTOR, Fixed, composition, 38K ohms, . . . 5%, 1/2 watt	1

REFERENCE DESIGNATION	PART NUMBER	DESCRIPTION	QUANTITY
R181	18414-201	RESISTOR, Fixed, composition, 200K ohms, . . . 5%, 1/2 watt	1
R182	18411-102	RESISTOR, Fixed, composition, 100 ohms, ... 10%, 1/2 watt	46
R184	18433-152	RESISTOR, Fixed, composition, 15K ohms, ... 10%, 2 watt	1
R202	18412-182	RESISTOR, Fixed, composition, 1,800 ohms, . . 10%, 1/2 watt	15
R203	18412-392	RESISTOR, Fixed, composition, 3,900 ohms, . . 10%, 1/2 watt	1
R205		Same as R122	
R208	18412-332	RESISTOR, Fixed, composition, 3,300 ohms, . . 10%, 1/2 watt	1
R210	18414-222	RESISTOR, Fixed, composition, 220K ohms, . . . 10%, 1/2 watt	4
R211	18413-102	RESISTOR, Fixed, composition, 10K ohms, . . . 10%, 1/2 watt	1
R212	18413-472	RESISTOR, Fixed, composition, 47K ohms, . . . 10%, 1/2 watt	6
R213	18414-101	RESISTOR, Fixed, composition, 100K ohms, . . . 5%, 1/2 watt	1
R214	18413-392	RESISTOR, Fixed, composition, 39K ohms, . . . 10%, 1/2 watt	7
R218		Same as R158	
R219		Same as R182	
R220		Same as R212	
R222	18412-822	RESISTOR, Fixed, composition, 8,200 ohms, . . 10%, 1/2 watt	2
R226		Same as R210	
R228	18410-222	RESISTOR, Fixed, composition, 22 ohms . . . . . 10%, 1/2 watt	2
R230		Same as R212	
R236		Same as R210	
R238		Same as R228	
R240		Same as R212	
R254		Same as R182	
R255	18433-272	RESISTOR, Fixed, composition, 27K ohms, . . . 10%, 2 watt	1
R261	18432-681	RESISTOR, Fixed, composition, 6,800 ohms, . . 5%, 2 watt	1
R263		Same as R158	
R264		Same as R158	
R265	18433-151	RESISTOR, Fixed, composition, 15K ohms, . . . 5%, 2 watt	2
R267	18530-28	RESISTOR, Fixed, film, 1.5 megohms, 1%, . . . 1/2 watt	1
R268	16925-329	RESISTOR, Variable, composition, 1 megohm, . 10%, 2 watt	1
R270		Same as R182	
R272	18412-562	RESISTOR, Fixed, composition, 5,600 ohms, . . 10%, 1/2 watt	1
R274		Same as R182	
R275	18433-332	RESISTOR, Fixed, composition, 33K ohms, . . . 10%, 2 watt	3
R277		Same as R150	
R278	18412-272	RESISTOR, Fixed, composition, 2,700 ohms, . . 10%, 1/2 watt	13
R281	18411-182	RESISTOR, Fixed, composition, 180 ohms, ... 10%, 1/2 watt	1
R301	18413-331	RESISTOR, Fixed, composition, 33K ohms, . . . 5%, 1/2 watt	4
R302	18413-471	RESISTOR, Fixed, composition, 47K ohms, . . . 5%, 1/2 watt	4

REFERENCE DESIGNATION	PART NUMBER	DESCRIPTION	QUANTITY
R304		Same as R182	
R305	18424-152	RESISTOR, Fixed, composition, 150K ohms, . . . 10%, 1 watt	3
R310	40101-505	RESISTOR, Variable, composition, 5 megohms, . . 20%, 2 watt	10
R311		Same as R214	
R312	18531-17	RESISTOR, Fixed, film, 13 megohms, 2%, ... 1 watt	1
R313		Same as R278	
R314		Same as R182	
R317	18414-152	RESISTOR, Fixed, composition, 150K ohms, . . . 10%, 1/2 watt	5
R320		Same as R310	
R321		Same as R301	
R322		Same as R302	
R323		Same as R182	
R324		Same as R182	
R325		Same as R305	
R326		Same as R214	
R327	18531-16	RESISTOR, Fixed, film, 11.66 megohms, ... 1%, 1 watt	1
R328		Same as R182	
R334	18424-101	RESISTOR, Fixed, composition, 100K ohms, . . . 5%, 1 watt	4
R335		Same as R334	
R339		Same as R182	
R342		Same as R317	
R343		Same as R278	
R351		Same as R301	
R352		Same as R302	
R353		Same as R182	
R354		Same as R182	
R355		Same as R305	
R360		Same as R310	
R361		Same as R212	
R362	18530-178	RESISTOR, Fixed, film, 10 megohms, ... 1%, 1/2 watt	3
R363		Same as R278	
R364		Same as R182	
R367		Same as R317	
R370		Same as R310	
R371		Same as R301	
R372		Same as R302	
R374		Same as R182	
R376		Same as R212	
R377		Same as R362	
R384		Same as R334	
R385		Same as R334	
R386		Same as R182	
R392		Same as R317	
R393		Same as R278	
R401	18413-181	RESISTOR, Fixed, composition, 18K ohms, . . . 5%, 1/2 watt	6
R402	18413-221	RESISTOR, Fixed, composition, 22K ohms, ... 5%, 1/2 watt	4
R403		Same as R182	
R404		Same as R182	
R405	18423-472	RESISTOR, Fixed, composition, 47K ohms, ... 10%, 1 watt	6
R410		Same as R310	
R411		Same as R214	
R412	18530-173	RESISTOR, Fixed, film, 5 megohms, ... 1%, 1/2 watt	3

REFERENCE DESIGNATION	PART NUMBER	DESCRIPTION	QUANTITY
R413		Same as R278	
R414		Same as R182	
R417	18413-222	RESISTOR, Fixed, composition, 22K ohms, ... 10%, 1/2 watt	7
R420		Same as R310	
R421		Same as R401	
R422		Same as R402	
R423		Same as R182	
R424		Same as R182	
R425		Same as R405	
R426		Same as R214	
R427	18530-177	RESISTOR, Fixed, film, 4 megohms, 1%, ... 1/2 watt	1
R434	18433-471	RESISTOR, Fixed, composition, 47K ohms, ... 5%, 2 watt	4
R435		Same as R434	
R436		Same as R182	
R442		Same as R417	
R443		Same as R278	
R451		Same as R401	
R452		Same as R402	
R454		Same as R182	
R455		Same as R405	
R460		Same as R310	
R461		Same as R214	
R462		Same as R412	
R463		Same as R278	
R464		Same as R182	
R465		Same as R182	
R466		Same as R434	
R467		Same as R417	
R470		Same as R310	
R471		Same as R401	
R472		Same as R402	
R474		Same as R182	
R476		Same as R214	
R477		Same as R362	
R485		Same as R434	
R486		Same as R182	
R491		Same as R182	
R492		Same as R417	
R493		Same as R278	
R495		Same as R405	
R501	18432-821	RESISTOR, Fixed, composition, 8,200 ohms, .. 5%, 2 watt	1
R502		Same as R182	
R504		Same as R182	
R505		Same as R275	
R510		Same as R310	
R511		Same as R222	
R512	18530-95	RESISTOR, Fixed, film, 1 megohm, 1%, ... 1/2 watt	1
R513		Same as R278	
R514		Same as R182	
R517		Same as R150	
R520	40101-205	RESISTOR, Variable, composition, 2 megohms, 20%, 2 watt	2
R521	18422-821	RESISTOR, Fixed, composition, 8,200 ohms, .. 5%, 1 watt	1
R522	18423-101	RESISTOR, Fixed, composition, 10K ohms, ... 5%, 1 watt	1

REFERENCE DESIGNATION	PART NUMBER	DESCRIPTION	QUANTITY
R523		Same as R182	
R524		Same as R182	
R525		Same as R275	
R526	18413-152	RESISTOR, Fixed, composition, 15K ohms, ... 10%, 1/2 watt	1
R527	18530-24	RESISTOR, Fixed, film, 2 megohms, 1%, ... 1/2 watt	2
R534		Same as R265	
R535	18433-221	RESISTOR, Fixed, composition, 22K ohms, ... 5%, 2 watt	1
R536		Same as R182	
R542		Same as R150	
R543		Same as R278	
R551	18413-101	RESISTOR, Fixed, composition, 10K ohms, ... 5%, 1/2 watt	1
R552		Same as R401	
R554		Same as R182	
R555		Same as R405	
R560		Same as R310	
R561		Same as R417	
R562		Same as R527	
R563		Same as R278	
R564		Same as R182	
R565		Same as R182	
R566	18433-271	RESISTOR, Fixed, composition, 27K ohms, ... 5%, 2 watt	1
R567		Same as R417	
R570		Same as R520	
R571	18413-121	RESISTOR, Fixed, composition, 12K ohms, ... 5%, 1/2 watt	1
R572		Same as R401	
R574		Same as R182	
R576		Same as R104	
R577		Same as R412	
R585	18433-391	RESISTOR, Fixed, composition, 39K ohms, ... 5%, 2 watt	1
R586		Same as R182	
R591		Same as R182	
R592		Same as R417	
R593		Same as R278	
R595		Same as R405	
R701		Same as R182	
R702		Same as R182	
R703		Same as R182	
R706	18411-472	RESISTOR, Fixed, composition, 470 ohms, ... 10%, 1/2 watt	2
R711		Same as R202	
R713		Same as R202	
R715		Same as R202	
R717		Same as R202	
R719		Same as R202	
R721		Same as R202	
R723		Same as R202	
R725		Same as R202	
R727		Same as R202	
R729		Same as R202	
R731		Same as R202	
R733		Same as R202	
R735		Same as R202	
R737		Same as R202	
R750		Same as R182	
R751		Same as R210	
R752		Same as R706	

REFERENCE DESIGNATION	PART NUMBER	DESCRIPTION	QUANTITY
R753		Same as R182	
R754		Same as R139	
R755	18412-331	RESISTOR, Fixed, composition, 3,300 ohms, 5%, 1/2 watt	1
R756		Same as R317	
R757	18411-222	RESISTOR, Fixed, composition, 220 ohms, 10%, 1/2 watt	1
S101	19911-14	SWITCH, Toggle, SPST	1
S102	19913-3	SWITCH, Thermo cut-out	1
S710	19910-146	SWITCH, Push, high frequency	1
S720	19910-147	SWITCH, Push, low frequency	1
S750	19910-148	SWITCH, Push, trigger selector	1
TB101 thru TB112	20352-201	TERMINAL STRIP, Ceramic, 1 notch	12
TB113 thru TB115	20352-501	TERMINAL STRIP, Ceramic, 1 notch	3
TB116	20352-202	TERMINAL STRIP, Ceramic, 2 notch	1
TB117 and TB118	20352-207	TERMINAL STRIP, Ceramic, 7 notch	2
TB119 and TB120	20352-209	TERMINAL STRIP, Ceramic, 9 notch	2
TB121 thru TB146	20352-209	TERMINAL STRIP, Ceramic, 11 notch	26
T101	20800-243	TRANSFORMER, Power	1
T102	20800-244	TRANSFORMER, Filament	1
V104	20875-75	ELECTRON TUBE, Type 6AU6	2
V107	20875-157	ELECTRON TUBE, Type 6080/6AS7GA	1
V124		Same as V104	
V144	20875-129	ELECTRON TUBE, Type 6AN8	3
V149	20875-158	ELECTRON TUBE, Type 5651	1
V150	20875-189	ELECTRON TUBE, Type 5965	14
V157	20875-172	ELECTRON TUBE, Type 12B4	2
V167		Same as V157	
V200		Same as V144	
V204		Same as V144	
V224	20875-181	ELECTRON TUBE, Type 6DK6	3
V234		Same as V224	
V244		Same as V224	
V262	20875-51	ELECTRON TUBE, Type 6AL5	13
V265		Same as V150	
V273	20875-69	ELECTRON TUBE, Type 12AU7	13
V302		Same as V262	
V303		Same as V273	
V322		Same as V262	
V333		Same as V150	
V335		Same as V150	
V343		Same as V273	
V352		Same as V262	
V353		Same as V273	
V372		Same as V262	
V383		Same as V150	
V385		Same as V150	
V393		Same as V273	
V402		Same as V262	
V403		Same as V273	
V422		Same as V262	
V433		Same as V150	
V435		Same as V150	

REFERENCE DESIGNATION	PART NUMBER	DESCRIPTION	QUANTITY
V443		Same as V273	
V452		Same as V262	
V453		Same as V273	
V472		Same as V262	
V483		Same as V150	
V485		Same as V150	
V493		Same as V273	
V502		Same as V262	
V503		Same as V273	
V522		Same as V262	
V533		Same as V150	
V535		Same as V150	
V543		Same as V273	
V552		Same as V262	
V553		Same as V273	
V572		Same as V262	
V583		Same as V150	
V585		Same as V150	
V593		Same as V273	
W101	3030-142	CABLE ASSEMBLY, Power	
W102	3475-109	CONNECTOR (Part of W101)	
W103	16525-138	PLUG, Contacts, male, ground-type, 3-wire, bladed (part of W101)	
XDS101	19350-296	LIGHT, Indicator	1
XDS201	19350-344	LIGHT, Indicator	1
XF101	8825-14	FUSEHOLDER, For type 3AG fuse	2
XF102		Same as XF101	
XV104	19350-299	SOCKET, Electron tube, for 7-pin miniature . . . tubes	19
XV107	19350-168	SOCKET, Electron tube, for octal base-type . . . tubes	2
XV124		Same as XV104	
XV144	19350-298	SOCKET, Electron tube, for novel type tubes . . .	32
XV149		Same as XV104	
XV150		Same as XV144	
XV157		Same as XV144	
XV167		Same as XV144	
XV200		Same as XV144	
XV204		Same as XV144	
XV224		Same as XV104	
XV234		Same as XV104	
XV244		Same as XV104	
XV262		Same as XV104	
XV265		Same as XV144	
XV273		Same as XV144	
XV302		Same as XV104	
XV303		Same as XV144	
XV322		Same as XV104	
XV333		Same as XV144	
XV335		Same as XV144	
XV343		Same as XV144	
XV352		Same as XV104	
XV353		Same as XV144	
XV372		Same as XV104	
XV383		Same as XV144	
XV385		Same as XV144	
XV393		Same as XV144	
XV402		Same as XV104	
XV403		Same as XV144	
XV422		Same as XV104	
XV433		Same as XV144	
XV435		Same as XV144	
XV443		Same as XV144	