WOR

BROADWAY

18, N.Y.

W O R
OPERATING MANUAL

BOOK 13.1

Instructions 23341

for

Type TMV-128-A Frequency Modulator

INTRODUCTION

The Type TMV-128-A Frequency Modulator is a device for use with a test oscillator (such as the TMV-97-C or similar) to "sweep" the oscillator frequency and at the same time provide a voltage for synchronizing the timing axis of a cathode-ray oscillograph (such as the TMV-122-B) with the position of the sweep condenser. It consists of a driving motor coupled to a sweep condenser and an impulse generator. Two ranges of sweep capacity are provided, as listed below, and a cable fitted with plugs at each end is furnished for connection to the test oscillator. The unit operates entirely from a 110/120 volt, 50/60 cycle a-c supply.

INSTALLATION

Figure 1 shows the interconnections of the Frequency Modulator with the TMV-97-C Test Oscillator and Cathode-Ray Oscillograph, Type TMV-122-B. This arrangement is commonly used for making r-f and i-f alignment of a radio receiver. For other applications, this set up may be modified according to the requirements of the particular case.

OPERATION

When the units are properly interconnected, select the "Hi" or "Lo" position of the range switch according to the percentage sweep desired (see the curve on the back of this sheet), and turn the motor "On." When through operating, turn the motor switch to the "Off" position.

MAINTENANCE AND SERVICE

Specifications

Power Supply Voltage and Freq.	110/120 Volts, 50/60 Cycles
Power Consumption	25 Watts
Drive Motor	Shaded Pole-Induction; 1/200 HP.
Drive Motor Speed	1550 R.P.M.
Sweep Condenser Capacitance	High Range—25 to 70 Mmfd. Low Range—15 to 37 Mmfd.
Connection Cable Capacitance	40 Mmfd.
Impulse Generator Output	1.5 Volts
Over All Dimensions	Height, 8½ Inches Width, 9¾ Inches Depth, 4½ Inches
Weight	5¼ Pounds

Bearing Lubrication

The small induction drive motor has oil holes at each of its waste-packed bearings. Light engine oil should be used at these points. A ball-bearing support is used at the impulse generator. It is packed with "vaseline," which should be replenished after every 100 hours of operation.

Sweep Condenser

This element of the assembly consists of two conventional type rotary condensers, each having a single rotor plate attached to a revolving shaft. The stators are wired so that one remains connected at all times and a switch is used to parallel the two in order to increase the range of sweep.

The rotor plates should be exactly centered between the stator plates when the mechanism is operating at its normal speed (1550 r.p.m.). If the plates change their relation, they should be re-centered by adjusting the drive shaft in the coupling, or shifting the rotor plates on the shaft. The line-up of the rotor plates in respect to the armature of the impulse generator is important in that it governs the synchronization of the system. The proper adjustment is obtained when the two rotor plates are either at maximum or minimum capacitance, and the armature sets horizontal (air gap minimum). A slight shift may be necessary to center the resonance curve on the screen of the TMV-122-B.

Impulse Generator

A small induction generator is used to furnish means of controlling the frequency of the "Saw Tooth Oscillator" of the Oscillograph. It is necessary to maintain a definite polarity on the output connec-

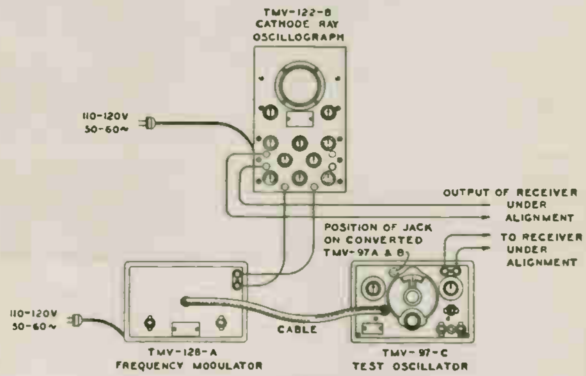

Figure 1

tions of this generator. The horse-shoe magnet should therefore be replaced as originally installed, if it has been removed for repair or service. It is also important to retain the original relation of the coils. Correct polarity exists when a positive swing is obtained on a 200 microampere d-c meter with its plus terminal connected to "high," and the mechanism rotated by hand in such a direction as to cause a decrease in air gap.

Mechanical Alignment

The drive motor, sweep condenser and impulse generator must be in correct physical relations to each other, inasmuch as they all rotate on the same shaft. The motor mounting screws are arranged to permit small lateral adjustments of the motor position. Both the stator and rotor plates of the sweep condenser may be adjusted to obtain the correct centering alignment. End-play of the shaft should be kept at a minimum without affecting the freedom of rotation.

Brush Connection

The point of contact between the revolving shaft and the brush of the sweep condenser circuit should be kept clean at all times. No oil or dirt should be allowed to accumulate. Poor contact is evidenced by ragged wave form on the oscillographic image.

REPLACEMENT PARTS

Insist on genuine factory tested parts, which are readily identified and may be purchased from authorized dealers

Stock No.	DESCRIPTION	List Price	Stock No.	DESCRIPTION	List Price
	FREQUENCY MODULATOR (TMV-128-A)		7899	Coupling—Motor coupling	$0.25
			7901	Escutcheon—Off-On switch escutcheon	.28
			7902	Escutcheon—High-Low switch escutcheon	.28
7905	Brush—Grounding brush—Package of 5	$0.85	7903	Jack (J1)	.45
7907	Cable—Connector cable with two plugs	1.50	7898	Motor—Motor complete (M1)	12.00
7909	Case—Case complete—Less binding posts, jack, switches and chassis	6.70	7908	Plug—Cable plug	.68
7904	Coil—Impulse coil (L1, L2)	1.25	7906	Post—Binding post engraved "High"—"Low"	.45
			7900	Switch—Toggle switch (S1, S2)—Off-On, High-Low—Less escutcheon	.75

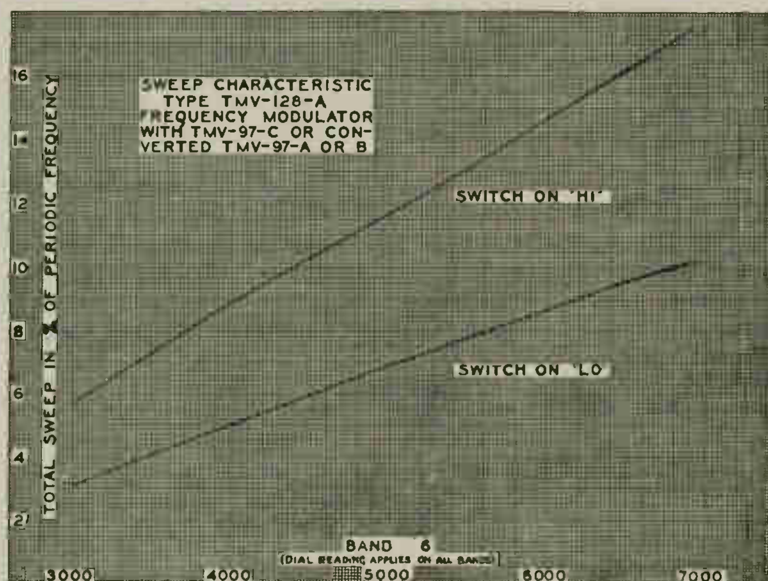

Figure 2—Sweep Characteristics of TMV-128-A with TMV-97-C

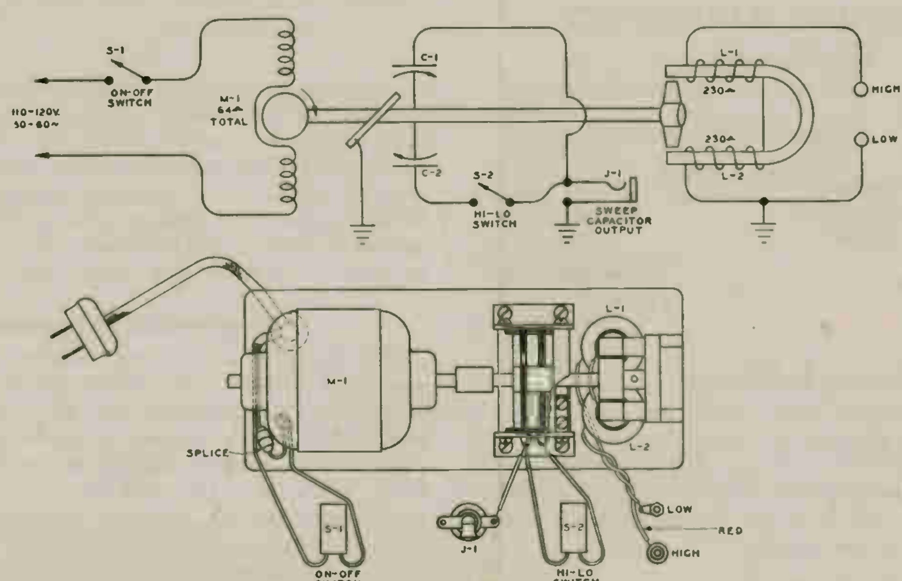

Figure 3—Schematic and Wiring Diagrams, Type TMV-128-A Frequency Modulator

RCA Parts Division **RCA Manufacturing Company, Inc.** Camden, N. J., U. S. A.

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CATHODE-RAY OSCILLOGRAPH

STOCK NO. 160-B

RADIO CORPORATION OF AMERICA

Camden, New Jersey, U. S. A.

IB-32010-3

Cathode-Ray Oscillograph

Stock No. 160-B

TECHNICAL SUMMARY

Power Supply:

Rating .... 105-125 volts, 50-60 cycles
(Specifications based on 117 volts, 60 cycles)
Power Consumption .... 55 watts
Fuse Protection .... 1 ampere

Operating Data (Gain Max.):

Deflection Sensitivity at Vertical Amplifier Input ...... 0.02 volts (rms) per inch*

Deflection Sensitivity at Cathode-Ray Input —RMS ..... 17.5 volts (rms) per inch*
DC .... 50 volts (d-c) per inch*

Frequency Response of Amplifiers:
Flat within .... 1 db. to 12 kc.*
Flat within .... –3 db. to 35 kc.*
Useful range .... 3 cycles to 100 kc.

Input Characteristics:
At amplifier inputs
0.5 megohms, 70 mmfd.
At deflector plates
0.47 megohms, 50 mmfd.

Timing Frequency Range .. 4 cycles to 18 kc.*

Tube Complement:

RCA-6C6	Horizontal Amplifier
RCA-6C6	1st Stage Vertical Amplifier
RCA-6C6	2nd Stage Vertical Amplifier
RCA-884	Timing Circuit Oscillator
RCA-5BP1/ 1802-P1	Cathode-Ray Tube (5 inch)
RCA-80	Low-Voltage Rectifier
RCA-879	High-Voltage Rectifier
RCA-VR-105-30 .	Voltage Regulator
RCA-VR-150-30 .	Voltage Regulator

Overall Dimensions:

Height (including carrying handle) .... 14⅜ inches
Width .... 8 inches
Depth .... 19½ inches
Weight (net) .... 30 pounds

* Guaranteed values. Factory standards exceed these values.

DESCRIPTION

The Stock No. 160-B Cathode-Ray Oscillograph is a reliable instrument for the observation of electrical circuit phenomena. Although practically unlimited in application, some of its more common uses include the study of wave shapes and transients, measurement of modulation, adjustment of radio receivers and transmitters, determination of peak voltages, and tracing of vacuum-tube characteristics. Its major but not only advantage over older types of visual devices is its freedom from inertia, allowing the observation of very rapid changes of current or voltage without appreciable distortion. The instrument is entirely portable, as shown by the cover illustration, and operates from an a-c source of 105 to 125 volts, 50 to 60 cycles. An integral power-supply unit furnishes all voltages required for operation.

Figure 1 shows the essential units of the instrument in block diagram form.

The primary purpose of these instructions is to give the fundamentals of operation. As the use of cathode-ray apparatus becomes more widespread, many new applications will be found and a thorough understanding of these fundamentals will enable the operator to readily adapt the equipment to his particular use.

For a comprehensive discussion of the fundamentals of cathode-ray tubes and an analysis of the figures which appear on the screen, see "A General Discussion of the Cathode-Ray Tube," RCA IB-26453.

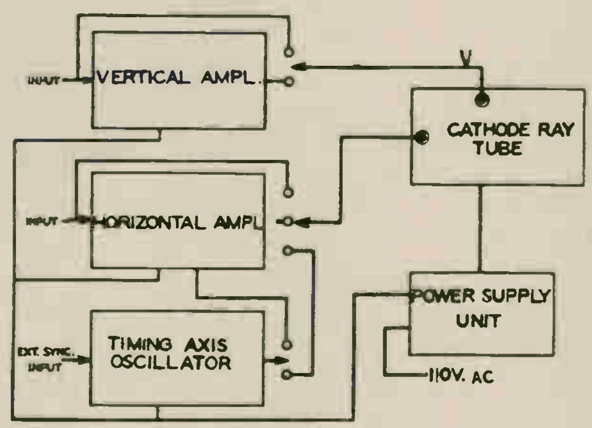


Figure 1—Block Diagram

WARNING—A POTENTIAL OF 1500 VOLTS IS PRESENT AT THE CATHODE-RAY TUBE SOCKET AND AT OTHER POINTS ON THE CHASSIS. ALWAYS DISCONNECT THE POWER CORD BEFORE REMOVING THE CHASSIS FROM THE CABINET.

INSTALLATION

Remove the screws at the rear of the case. Withdraw the chassis from the case, feeding the power cable through the hole in the back. Make certain that all tubes are firmly in their sockets and that all grid-cap connections are in place. Unpack the cathode ray tube and install it in its proper mounting and connect the socket, rotating the tube if necessary so that the socket key is located at the top. Replace the chassis in the case and replace the screws at the rear. With the "*Intensity*" control in the extreme counterclockwise ("*Off*") position, plug the power-supply cable into an electrical outlet supplying 105-125 volts at 50-60 cycles. The instrument is then ready for operation.

NOTE: AN INTERLOCK SWITCH, LOCATED AT THE REAR OF THE CHASSIS, OPENS THE POWER CIRCUIT WHEN THE CHASSIS IS REMOVED FROM THE CASE. DO NOT ATTEMPT TO OPERATE THE EQUIPMENT WHILE WITHDRAWN FROM THE CASE AS THE HIGH POTENTIALS USED ARE DANGEROUS.

OPERATION

Controls

Refer to the schematic and wiring diagrams for the location of circuit units designated by symbols.

1. "*Intensity*" control (R-38) consists of a potentiometer located in the high side of the high-voltage bleeder and controls the bias on the grid of the cathode-ray tube, which in turn determines the quantity of electrons emanating from the "gun," thus controlling the spot size. The power switch (S2) is attached to this potentiometer. Initial clockwise rotation of this control closes the switch and additional rotation increases the spot size.

2. "*Focus*" control (R-41) is a potentiometer located in the high-voltage bleeder. Its position controls the No. 1 anode voltage, which, with constant voltage on anode No. 2, determines the distance at which the electron beam focuses. In general, for a given "*Intensity*" setting, the "*Focus*" control should be set for maximum distinctness of spot or image.

3. "*Vertical Amplifier*" switch S-5 connects the "*Vertical*" pin jacks to the gain control through an amplifier to the vertical deflecting plates. A condenser is in the input circuit connected to the "*Cap*" jack and is omitted from the input circuit connected to the "*Grid*" jack.

4. "*Horizontal Amplifier*" switch (S-3) has five positions: The amplifier "*On*" and "*Off*" and three "*Timing*" positions. On all "*Timing*" positions the "saw-tooth" or timing-axis oscillator feeds through an amplifier to the horizontal deflecting plates of the cathode-ray tube. At "*On*," the "*Horizontal*" pin jacks are connected through an amplifier to these deflecting plates while at "*Off*," the pin jacks are connected straight through to the deflecting plates. In both of the latter two cases, there is a series condenser in the input circuit.

5. "*Vertical Gain*" control (R-19) is a potentiometer on the input circuit of the vertical amplifier. With "*Vertical Amplifier*" switch at "*High*" or "*Lo*" this potentiometer controls the vertical deflection. With the "*Vertical Amplifier*" switch on "*Lo.*" the sensitivity is cut approximately 75 times.

6. "*Horizontal Gain*" control (R-1) consists of a potentiometer located in the input circuit of the horizontal amplifier. With the "*Horizontal Amplifier*" switch set at "*Timing*" or "*On*," this potentiometer controls the horizontal deflection. Due to the capacity load on this input potentiometer, when operating on "*Timing*" at the higher audio frequencies, linear sweep will not be obtained at all settings of this control. For best results, the control should be set for maximum linearity.

7. "*Range*" switch (S-4) selects one of eight timing capacitor values. It thus changes the timing-axis oscillator frequency in steps, giving eight ranges approximately as shown on the front panel.

8. "*Freq.*" control (R-10) is a rheostat connected in series with the timing condenser. It changes the timing-axis oscillator frequency gradually as it is rotated, and in conjunction with the "*Range*" switch, gives a continuous range between the extremes of frequency.

9. "*Sync.*" control (R-5) is a potentiometer used to control the amount of synchronizing voltage fed to the grid of the RCA-884 tube. In general, it should be set as far counterclockwise as is consistent with a locked image, since over-synchronization results in a poor wave-form produced by the timing-axis oscillator.

10. "*Horizontal Amplifier*" switch (S-3) has three timing positions, "*Int*," "*60*," and "*Ext.*" for synchronization. At "*Int.*," the voltage drop across

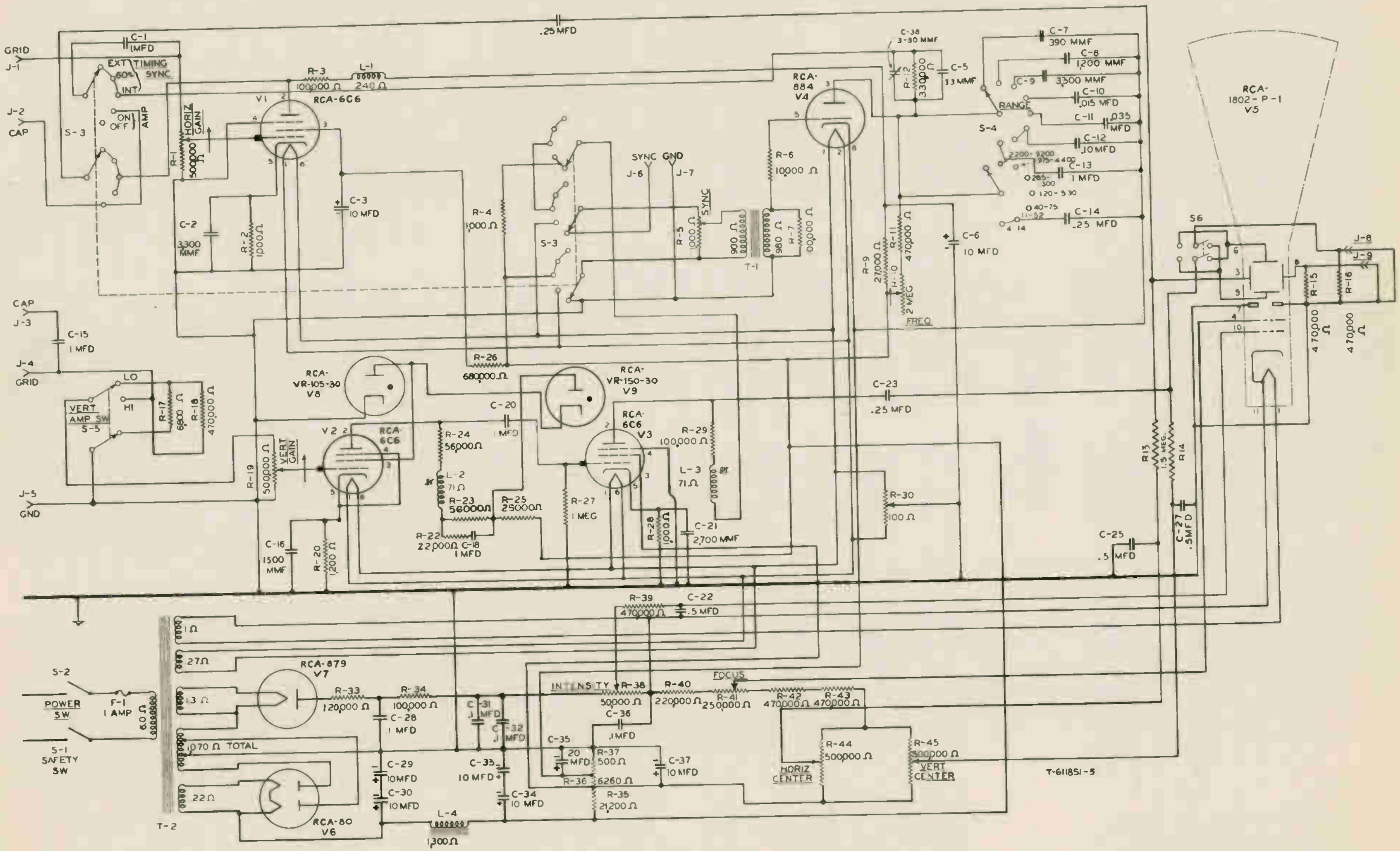


Figure 2—Schematic Circuit Diagram, Stock No. 160B

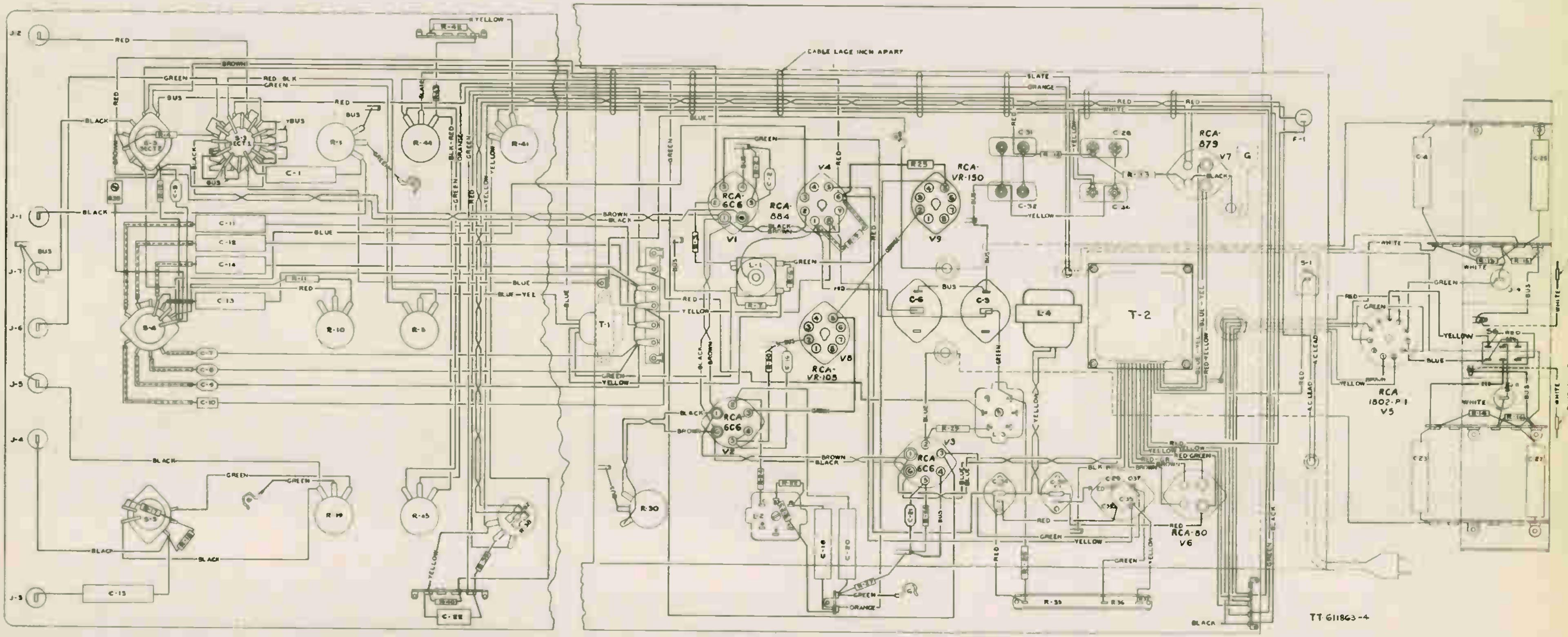


Figure 3 Chassis Wiring Diagram, Stock No. 165B

resistor R-4 in the plate circuit of the vertical amplifier is fed through the "*Sync.*" control and input transformer to the grid of the RCA-884 tube. Thus, the timing-axis oscillator can be synchronized with the signal on the vertical axis at the fundamental frequency or at any sub-multiple, such as ½, 1/3. . . . Synchronization is not effective if it is attempted to operate the timing-axis oscillator at a higher frequency than that of the synchronizing voltage. When set to "60" a portion of the 60 cycle filament voltage is used for synchronization. On "*Ext.*," the "*Sync.*" pin jack is connected to the "*Sync.*" control. This allows the use of an external source for synchronizing.

11. A vertical-deflection reversing switch (S6) is connected to the vertical deflecting plate so that the deflecting trace may be inverted. This is useful when observing resonance curves where deflecting impulses may reverse polarity. This is located at the left-hand side of the cathode-ray tube mounting bracket and can be reversed through the opening at the side.

12. The two "centering" controls regulate the amount of d-c potential between the two deflecting plates of each pair, and thereby allows adjustment of the position of the spot or image. There is sufficient voltage across these controls to move the spot approximately two inches on the screen. Start with both of these controls adjusted at about mid-position.

13. There are seven pin jacks on the unit. Voltage impressed across the "*Cap*" and "*Gnd.*" pin jacks is applied to the vertical (or horizontal) amplifier through a series capacitor. Voltage impressed across the "*Grid*" and "*Gnd.*" pin jacks is applied directly to the grid of the vertical (or horizontal) amplifier. The "Sync." pin jack may be used with an a-c source (not exceeding 15 volts) when it is desired to synchronize the timing-axis externally. (See 9 above.) The pin jacks marked "*Gnd.*" are common ground and the ones otherwise marked are insulated from ground.

Applications

The following procedures are included in order to familiarize the operator with the operations and connections involved in particular applications. All applications of the equipment are not described, but analysis of any other problem will show wherein it is similar to or differs from those given, enabling the operator to work out his own sequence of operations.

As has been pointed out previously, most applications of this instrument are performed with the output of the unit under test connected to the vertical plates of the cathode-ray tube, and the wave shape studied by application of known constants on the horizontal plates of the tube. Before any measurements are attempted, the operator is urged to go through the following procedure in order to familiarize himself with the controls and their location and to get the "feel" of their operation:

1. Connect the power plug to an a-c source of 105/125 volts, 50/60 cycles. Turn the "*Intensity*" control clockwise, causing a spot to appear on the screen, increasing in size as the "*Intensity*" control is advanced further clockwise. The "*Focus*" control should then be adjusted until maximum distinctness of the spot or image occurs. The centering controls should be set about mid-position.

CAUTION. DO NOT ALLOW A SMALL SPOT OF HIGH BRILLIANCY TO REMAIN STATIONARY ON THE SCREEN FOR ANY LENGTH OF TIME, AS DISCOLORATION OR BURNING OF THE SCREEN WILL RESULT.

With the spot on the screen and with the "*Intensity*" control retarded so that the spot is not too brilliant, adjust the position of the spot to the center of the screen by rotation of the two centering controls. After initial adjustment, these controls will rarely require re-adjustment, unless the cathode-ray tube is replaced.

To turn the equipment off, turn the "*Intensity*" control to its extreme counterclockwise position, until a distinct "snap" is heard.

2. Apply a source of 60-cycle current to the "*Vertical*" pin jacks. To adjust the length of the resultant line appearing on the screen, turn the "*Vertical Amplifier*" switch to "*Hi*" or "*Lo*" and adjust the "*Vertical Gain*" control until the length is as desired. Application of the same 60-cycle source to the "*Horizontal*" pin jacks with the "*Horizontal Amplifier*" switch "*On*" or "*Off*" will similarly show a horizontal line on the screen, the length of which may be varied (with the "*Horizontal Amplifier*" switch "*On*") by manipulation of "*Horizontal Gain*" control.

3. To expand (2) further, have 60 cycles available at both "*Horizontal*" and "*Vertical*" terminals.

CAUTION. Since all ground or "*Gnd*" pin jacks on the oscillograph are common, it is advisable to use an isolating transformer for one supply, so that there is no common connection between the two.

Apply the horizontal 60-cycle supply to the deflecting plates, preferably through the amplifier and its gain control, then apply the 60-cycle vertical supply through the other amplifier and its gain control. The result will be a diagonal line. (See "A General Discussion of the Cathode-Ray Tube," RCA IB-26453, Figure 5, and explanation.)

AC VOLTMETER WITHOUT AMPLIFIER—For this application make connections to the plates directly through the openings in the side of the cabinet, remove the grounded pin tip, and connect to the pin jack and ground. The approximate characteristics of the unit are as follows: Input resistance—470,000 ohms; input capacity—50 mmfs; voltage range—85 volts (higher with external attenuator); calibration—approximately 25 peak volts (or 50 peak-topeak) per inch or 17.5 rms volts per inch.

Procedure—Make connections to the Oscillograph and turn controls to the proper positions.

Measure or estimate the length of line appearing on the screen in inches (depending on accuracy desired) and multiply by 50. This gives the approximate peak-to-peak value of the unknown voltage. For approximate effective value, if voltage being measured is sinusoidal, divide peak-to-peak value by 2.8.

AC VOLTMETER WITH AMPLIFIER—For this application, the characteristics of the unit are as follows: Input resistance—500,000 ohms, input capacity—approximately 70 mmfs; frequency range—20-35,000 cycles; calibration—approximately 0.02 rms volts per inch.

Procedure—Make connections and adjust controls. With the "*Vertical Gain*" control in the extreme clockwise position, "*Vertical Amplifier*" switch on "*High*," a line one inch long is obtained on the screen for about 0.03 peak volts input. Intermediate positions of the gain control give different calibrations, of course, and if considerable use is made of this feature, it may be advisable to plot a curve of the inputs required to give a one-inch deflection at various intermediate positions of the gain control. If working at a frequency above 10,000 cycles, it must be remembered that retarding the gain control from maximum impairs the linearity of the amplifier.

A particular application of operation as an a-c voltmeter is in making hum measurements in a power supply unit. In this case, the "*Gnd.*" pin jack ("*Vertical*") is connected to the common lead of the filter circuit of the unit under test and the "*Cap*" pin jack is used to check the a-c ripple present at the various circuit component terminals.

AUDIO QUALITY MEASUREMENTS—Use of the "saw-tooth oscillator" feature of the oscillograph provides a check which cannot be made with an ordinary voltmeter. This is extremely helpful in determining the audio quality of a receiver or similar instrument and also in locating causes of audio distortion.

Procedure—Apply the output from a constant frequency record or audio oscillator to the "*Vertical*" pin jacks. Turn the "*Range*" switch to that tap giving a range including the frequency of the input signal and adjust the "*Freq.*" control until the saw-tooth oscillator frequency is near that of the input signal. If the two frequencies are identical, one cycle of the input signal will be observed on the screen; if the saw-tooth oscillator frequency is one-half that of the input signal, two cycles of the latter will appear; if one-third, three cycles; etc. Next, connect this constant frequency record or audio oscillator output to the audio input of the unit under test and connect the output of the unit under test to the "*Vertical*" pin jacks of the oscillograph. If the resultant wave does not correspond to that obtained when the input was direct to the oscillograph, audio distortion is present.

If it is desired to measure the overall audio fidelity of a receiver, for instance, the procedure is similar to that above except that the voltage modu-

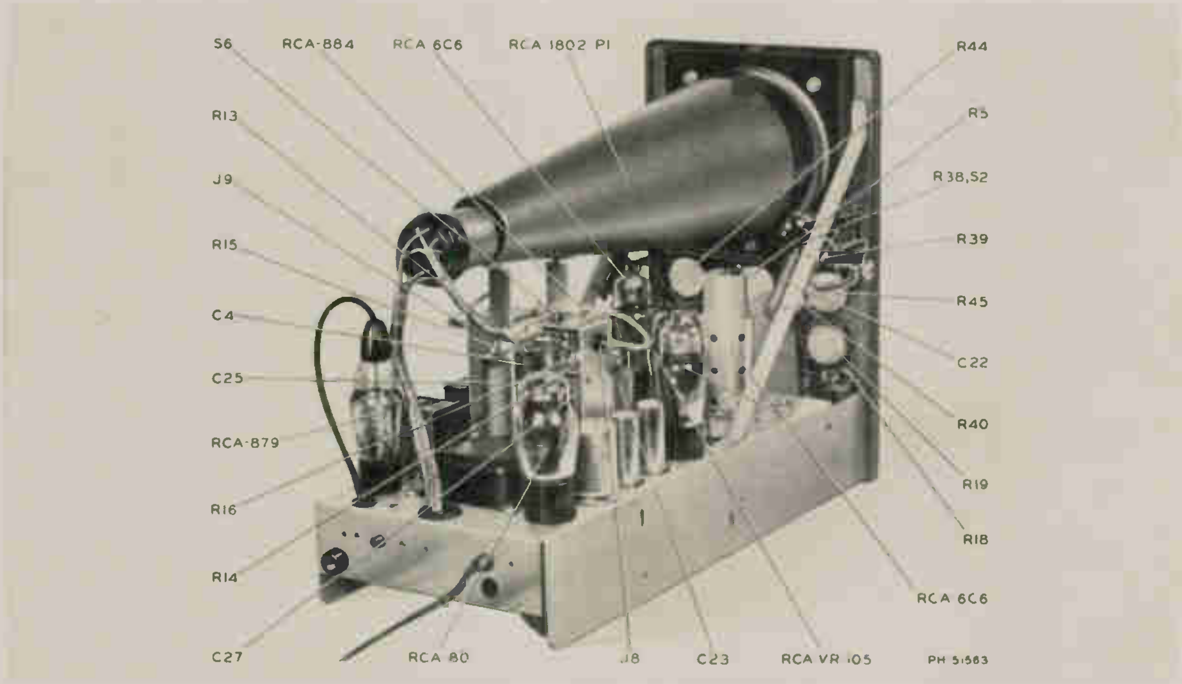


Figure 4—Top View of Chassis

lating an r-f oscillator is fed into the oscillograph, adjusted as above. Then the modulated oscillator is connected to the r-f input terminals of the receiver and the loudspeaker voice coil connected to the oscillograph. Comparison of the two resultant waves will indicate how much distortion occurs in the receiver under test. Observing the quality of the input to the receiver from the test oscillator will also show how much distortion is being fed into the receiver from the test oscillator. This is desirable since it may show that all the distortion present in the receiver output may not be due to the receiver characteristics, but to those of the test oscillator (assuming no distortion from modulation).

MODULATION INDICATOR—(1) One method of measuring the modulation of a transmitter is to place the modulated r-f output of the transmitter into the vertical plates of the cathode-ray tube and the audio input signal to the transmitter on the "*Sync.*" pin jack.

Procedure—Connect a constant-frequency input to the transmitter and connect a small pickup coil, located near the transmitter tank coil, to the "*Vertical*" pin jacks for direct deflection which are on the side of the cabinet. The pickup on this coil should be from 35-70 volts. Connect the "*Sync.*" binding post of the oscillograph to the transmitter audio amplifier at a point providing for a 2- to 4-volt signal. Set "*Horizontal Amplifier*" switch to "*Ext.*" position. Turn the "*Range*" switch to the tap which includes the frequency of the input signal and adjust "*Freq.*" control until the saw-tooth oscillator interlocks with the signal on the vertical plates. Adjustment of the "*Sync.*" control provides control of the voltage from the audio amplifier to the grid of the RCA-884 tube. Adjustment of "*Horizontal Gain*" control varies the horizontal deflection.

(2) Another and somewhat similar method of modulation measurement is to connect the pickup coil to the pin jacks located at the side of the cabinet as before, but connect the audio signal (from the transmitter audio amplifier) to the "*Horizontal*" pin jacks. Adjust "*Horizontal Gain*" control until desired horizontal deflection is obtained. The percentage modulation can then be readily determined. (See Figure 31, "A General Discussion of the Cathode-Ray Tube," RCA IB-26453.)

ALIGNMENT OF INTERMEDIATE-FREQUENCY STAGES—For alignment of the intermediate-frequency stages of a receiver, it is essential that an auxiliary apparatus, a frequency modulator, be available to sweep the intermediate frequency for which the receiver is designed. One type of frequency modulator consists of a sweep condenser and a synchronizing generator rotated in synchronism by a driving motor. The condenser is arranged to "sweep" the frequency of the r-f input to the receiver (or i-f stages) and the synchronizing generator connects to the "*Sync.*" pin jack of the oscillograph so as to synchronize the saw-tooth oscillator with the frequency variation of the test oscillator input to the receiver. Or an electronic sweep test oscillator may be used to provide both a frequency-modulated signal and a synchronizing signal, so that no other frequency modulator is required.

The test oscillator output should be coupled to the grid of the tube preceding the i-f stage under alignment. It is essential that this connection be made without altering any of the operating characteristics of this stage. If the grid of the tube to which connection is to be made is at zero d-c potential with respect to ground, connect the oscillator to the grid of the tube and disconnect the lead normally on the grid, the low side of the test oscillator output returning to chassis ground. If the grid is not at zero d-c potential with respect to ground, connect the high side of the oscillator to the grid (disconnecting the lead on the grid) and the other side to the "—C" lead for this grid. Or, in either case, couple the test oscillator to the grid through a small capacitor without disconnecting the lead normally on the grid, and connect the low side of the test oscillator to chassis ground.

The "*Vertical*" pin jacks of the oscillograph should be connected to the audio output of the second detector. For a diode detector, this connection may be across the volume control alone or across both the volume control and automatic volume control resistor, if this connection is convenient. When the second detector is a triode, tetrode or pentode, resistance-coupled to the first audio stage, the connection to the "*High*" pin jacks may be to the plate of the tube, the "*Gnd.*" pin jack being connected to ground. In the case of a triode, tetrode or pentode, transformer or impedance-coupled to the first audio stage, connect a resistor of approximately 20,000 ohms in series with the plate of the tube and by-pass the inductance in the plate circuit by a 1.0 mfd or larger capacitor. This changes the impedance of the plate circuit to resistance rather than inductive reactance; the "*High*" pin jack should be connected to the plate of the tube and the "*Gnd.*" pin jack to ground in order to take the audio voltage off this resistor. If the image or resonance curve appears inverted, correction may be made by reversing the position of switch S6.

ALIGNMENT OF RADIO-FREQUENCY STAGES—The equipment used for r-f alignment is identical to that for i-f alignment, except that the test oscillator output is connected to the antenna lead of the receiver, and different frequencies are employd.

FREQUENCY MEASUREMENTS—In using the oscillograph for frequency measurement, either Lissajou figures (sine waves on both axes) may be used, or the linear timing axis may be employed on the horizontal axis. The most flexible method for frequencies up to 100,000 cycles is the linear timing axis method. The frequency stability of the saw-tooth oscillator running free is not good enough to depend upon for accurate measurements, but when this oscillator is synchronized with a standard-frequency voltage, its frequency stability is the same as that of the standard, and it can be synchronized at any sub-multiple of the standard frequency down to about one-tenth. This allows convenient calibration of a device at many points between one-hundredth of—and ten times a single standard-frequency source, and every point is as accurate as the standard. If a 1000-cycle standard source is used, calibration points between 10 and 10,000 cycles are easily obtained. Using Lissajous figures, calibraton points between 100 and 10,000 cycles can be obtained. A frequency standard which is almost universally available is the 60-cycle a-c supply. Since the advent and rapid spread of electric clocks, the frequency of nearly all commercial power is held to a very close tolerance. This allows accurate calibration at frequencies up to about 600 cycles.

Checking Phase Shift—To check phase shift of electrical equipment with the oscillograph, observe the screen pattern with the input to the equipment connected to the "*Horizontal*" pin jacks and the output from the equipment connected to the "*Vertical*" pin jacks. If no phase shift exists, a sloping straight-line image will appear. The internal amplifiers in the oscillograph introduce some phase displacement which must be considered. If sufficient voltage is available, the internal amplifiers should not be employed.

CIRCUITS

The schematic arrangement of the entire circuit is shown in Figure 2.

An amplifier consisting of two stages constitutes the means of obtaining gain for the signal applied to the vertical deflecting system. The input to this stage is a two-step attenuator connected to provide stepped gain control. An isolation capacitor is made a part of the input circuit to exclude from the grid any direct current which may be associated with the circuit being observed. The plate circuit of the output tube (RCA-6C6) is composed of two elements in series, a resistor and an inductance whose values are so designed as to effect a broad and uniform frequency response in the amplifier stage. Coupling from the amplifier plate to the cathode-ray tube is made through a capacitor.

Connection direct to the vertical deflecting plates is made through an opening at the side of the cabinet. D-C potentials may be measured without affecting the beam centering functions even though one side is grounded. These deflection plates are normally grounded, but are ungrounded for deflecting purposes by the removal of a grounded pin tip. The amplifier for the signal applied to the horizontal deflecting plates is a single stage. A switch is provided to disconnect the Horizontal Amplifier, thereby applying the voltage to be studied directly to the deflecting plate. Extra contacts are used on the input switch to the horizontal amplifier for feeding in the timing or "saw-tooth" oscillator signal.

A synchronization system is included, as shown in the input circuit of the RCA-884. This is in-

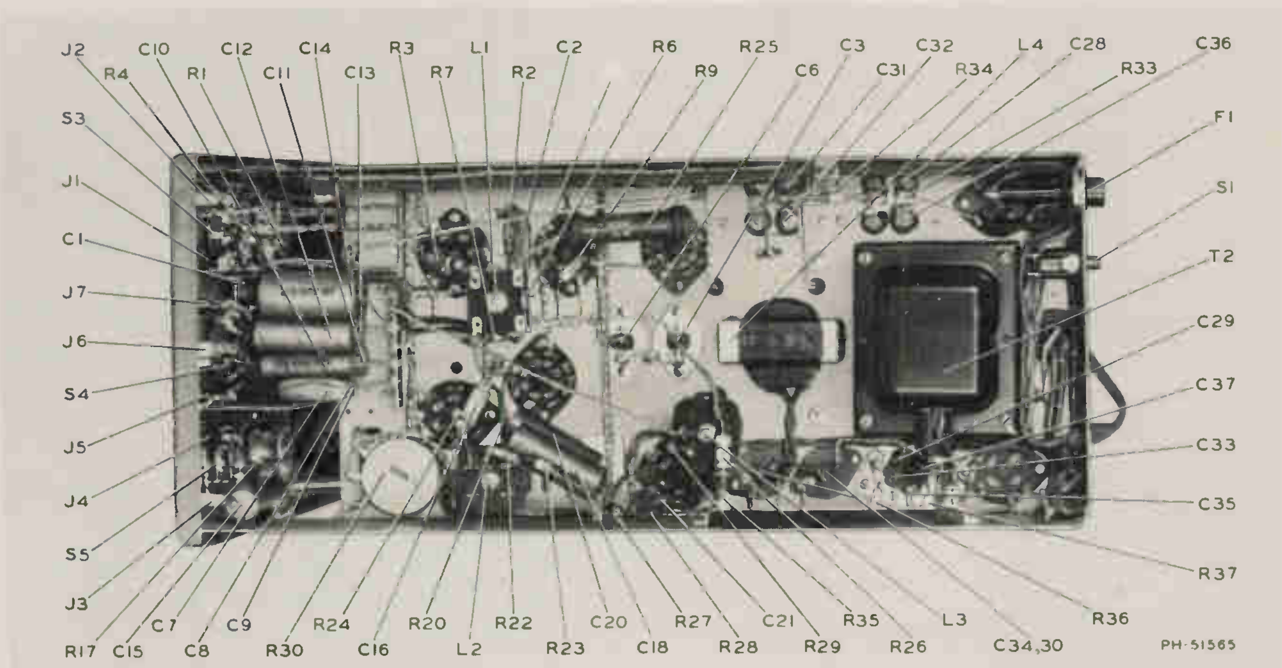


Figure 5—Bottom View of Chassis

cluded in the "*Horizontal Amplifier*" switch and is described under "Operation." The timing axis oscillator stage, using the RCA-884, is designed to have a frequency range of approximately 4-20,000 cycles, controlled through the "*Range*" switch and "*Frequency*" control. The signal from this oscillator has a "saw-tooth" wave shape, obtained as follows: A d-c potential is applied across a capacitor and resistor in series in the plate circuit of the RCA-884 tube. This voltage charges the capacitor until the ionization potential (plate voltage at which the gas in the tube ionizes) is reached. When the RCA-884 ionizes, the capacitor is short-circuited and the voltage across it drops nearly to zero. The tube immediately deionizes and allows the capacitor to start charging again. In this manner, the voltage across the capacitor has a "saw-tooth" characteristic. The capacitor referred to above is selected by the position of the "*Range*" switch as described in "Operation." With the "*Horizontal Amplifier*" switch on "*Timing*," the voltage across this capacitor passes through the horizontal amplifier to the plates of the cathode-ray tube. The operation of the "*Sync.*" control, in the grid circuit of the RCA-884 is described under "Operation."

The cathode-ray tube is described in "A General Discussion of the Cathode-Ray Tube," RCA IB-26453. Controls used to alter the intensity, focus and zero adjustments are described under "Operation."

Power required for operation of the instrument is obtained through the power unit from a 105- to 125-volt, 50- to 60-cycle supply. Voltage rectification is accomplished by one RCA-80 and one RCA-879 rectifier tube, one being used full-wave and the other half-wave. One of these tubes supplies plate voltages for the amplifier stages and sweep oscillator, filtered through a reactor-capacitor combination. The other supplies the high voltage to the cathode-ray tube for polarization purposes.

MAINTENANCE

Under ordinary circumstances no adjustments need be made on the instrument but if these are disturbed they can be readjusted only with the use of square wave inputs obtained from a reliable square generator. Normally this means returning the instrument to the factory.

The hum balance control R-30 can be adjusted as follows: Set vertical gain at minimum, adjust the sweep to approximately 59 cycles per second with synchronizing control at minimum. Adjust for minimum vertical deflection.

Radiotrons

Under ordinary usage within the ratings specified for voltage supply, tube life will be consistent with that obtained in other applications. The amplifier, oscillator and rectifier tubes will wear in accordance with loss of emission; whereas the determining factor in the life of the cathode-ray tube is the deterioration of the fluorescent screen. It is therefore advisable to avoid leaving a bright, concentrated "spot" on the screen. Also, the image of the phenomena under observation should be removed from the screen when not actually being studied or measured; this item of care will enable a long and useful life to be obtained from the tube.

It is ordinarily not possible to test the Radiotrons in their respective sockets, due to the likelihood of circuit effects causing error. However, through the use of the RCA Chanalyst, amplifier tubes may be checked while in their circuits and under operating conditions by the signal-tracing method.

The tubes may also be removed and checked with standard tube testing apparatus or the questionable tube may be replaced with one known to be in good condition.

On the cathode-ray tube, excessive wear and approach to its limit of life is indicated by inability to obtain a satisfactory focus, and also by the screen becoming streaked and spotted. When it becomes necessary to install a new cathode-ray tube, some rotational adjustment may be required to bring the axes of deflection into their proper horizontal and vertical planes. This is accomplished by loosening the wing nut on the cathode-ray tube shield clamp, rotating the socket as desired, and then tightening the wing nut.

Fuse Replacements

A small 1-ampere cartridge fuse is used in the primary circuit of the power transformer. This fuse is intended for protection of the entire power system of the oscillograph, and, therefore, should not be replaced by one having a higher rating, nor be shorted out. A fuse failure should be carefully investigated before making a replacement, since with fuses of accepted quality, there usually will be a definite cause for the breakdown. The cause may originate from a surge in the power-supply line, but the greater percentage of causes may be centered in the apparatus protected, such as shorted rectified elements, and so forth. Occasionally, a fuse may open from heat generated at one of its clip contacts. These points should therefore be kept clean and in secure contact with the fuse.

Resistance and Continuity Tests

The chassis wiring layout giving color code and physical relation of the parts is shown in Figure 3. All resistor and capacitor values are given to facilitate a rapid and sure test for continuity of circuit and the condition of same. Coils and transformer windings have their d-c resistances shown.

In working on the chassis of the oscillograph, care must be observed to have the power supply completely disconnected. The high voltages associated with the circuits of the cathode-ray tube *make it especially dangerous to attempt to handle or work on the chassis while the power is "On."*

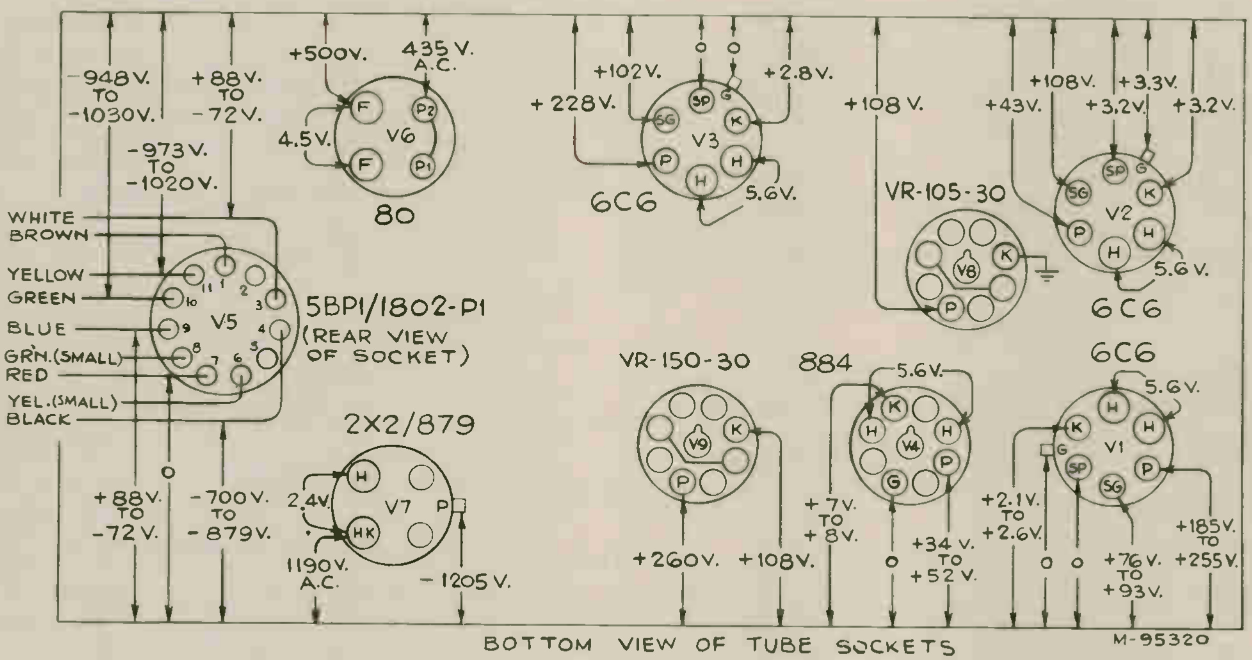
Care should be exercised in replacing any part that may be found faulty. All wiring associated with the part involved must be removed, and especial attention given to the possibility of damage to other wiring or parts. The relation of wiring and parts should be the same as in the original assembly. The insulation and spacing of the high-voltage leads is very necessary and an important item to be adhered to in servicing of the instrument.

Voltage Measurements

One means of learning the condition of operation and tracing the circuit faults of the oscillograph is by checking the values of the voltages and currents at the Radiotron sockets. The normal values, which can be expected to be found when the instrument is working properly under the specified power rating, are indicated by the Radiotron Socket Voltage Table. In general, the values shown are measured from the socket contacts to ground; however, the heater or filament voltages are a-c and appear between the F-F or H-H clips. All readings given are actual operating values, and do not allow for any errors likely to be caused by current drain of the measuring instrument.

TUBE SOCKET VOLTAGES

Voltages to ground: using RCA VoltOhmyst. 115 volts applied to primary.



Bottom View of Tube Sockets (M-95320)

REPLACEMENT PARTS

Insist on genuine factory-tested parts, which are readily identified and may be purchased from authorized dealers.

STOCK No.	DESCRIPTION
12948	Capacitor—33 mmfd. (C5)
13894	Capacitor—390 mmfd. (C7)
13054	Capacitor—1,200 mmfd. (C8)
13762	Capacitor—1,500 mmfd. (C16)
33858	Capacitor—2,700 mmfd. (C21)
4881	Capacitor—3,300 mmfd. (C2, C9)
30856	Capacitor—.015 mfd. (C10)
30857	Capacitor—.035 mfd. (C11)
30848	Capacitor—0.1 mfd. (C12)
18000	Capacitor—0.1 mfd., 1,250 volts (C28, C31, C32, C36)
30860	Capacitor—0.5 mfd. (C22, C27, C25)
30849	Capacitor—0.25 mfd. (C14, C4, C23)
18416	Capacitor—1 mfd. (C1, C13, C15, C20, C18)
33879	Capacitor—10 mfd. (C30, C34)
33880	Capacitor—10 mfd., 300 volts, 10 mfd., 300 volts, 10 mfd., 150 volts, 20 mfd., 25 volts (C29, C33, C37, C35)
18793	Capacitor—10 mfd., 450 volts (C6, C3)
12477	Choke—Filter choke (L4)
33881	Choke—Horizontal amplifier plate choke (L1)
33882	Choke—Vertical amplifier plate choke (L3)
33883	Choke—Vertical amplifier plate choke (L2)
11859	Condenser—3 to 30 mmfd., variable condenser (C-38)
33876	Control—100 ohms—Hum balance control (R30)
33874	Control—1,000 ohms — synchronizing control (R5)
33863	Control—50,000 ohms—intensity control with power switch (R38, S2)
33864	Control—250,000 ohms—Focus control (R41)
33875	Control—500,000 ohms—Vertical gain control (R19)
33859	Control — 500,000 ohms — Horizontal gain control or centering control (R1, R44, R45)
33860	Control—2 meg.—Frequency control (Fine) (R10)
14086	Cord—Power cord and plug
37315	Escutcheon—Front panel escutcheon
30926	Foot—Elastic foot for case
14133	Fuse—1 ampere line fuse (F1)
30925	Handle—Carrying handle for case
32059	Holder—Tubular type fuse holder with screw cap
33891	Jack—Black pin jack (J5, J7, J8, J9)
33889	Jack—Green pin jack (J1, J4)
33890	Jack—Red pin jack (J2, J3, J6)
32116	Knob—Control knob
33893	Plate—Cover plate for case
14720	Resistor—1,000 ohms, ¼ watt (R2, R4, R28)
12267	Resistor—1,200 ohms, ¼ watt (R20)
12265	Resistor—6,800 ohms, ¼ watt (R17)
14559	Resistor—10,000 ohms, ¼ watt (R6)
33877	Resistor—Voltage divider comprising one 21,600-ohm, one 6,260-ohm, and one 500-ohm section (R35, R36, R37)
30492	Resistor—22,000 ohms, ¼ watt (R22)
30409	Resistor—27,000 ohms, ½ watt (R9, R33)
	In some equipments R33 is #11366—Resistor—120,000 ohms, 1 watt.
30650	Resistor—56,000 ohms, ½ watt (R24) (R23)
14560	Resistor—100,000 ohms, ¼ watt (R7)
3252	Resistor—100,000 ohms, ½ watt (R34)
37316	Resistor—25,000 ohms, 10 watts (R25)
30154	Resistor—100,000 ohms, 1 watt (R3, R29)
14583	Resistor—220,000 ohms, ½ watt (R40)
30784	Resistor—330,000 ohms, ½ watt (R12)
12285	Resistor—470,000 ohms, ¼ watt (R11, R15, R16, R18, R39)
18020	Resistor—470,000 ohms, 1 watt (R42, R43)
32727	Resistor—680,000 ohms, 1 watt (R26)
13730	Resistor—1 meg., ¼ watt (R27)
12201	Resistor—1.5 meg., ¼ watt (R13, R14)
33871	Screen—Calibration screen for cathode-ray tube
4233	Shield—Tube shield (6C6)
31769	Socket—4-contact tube socket (V6, V7)
18351	Socket—6-contact tube socket (V1, V2, V3)
18467	Socket—8-contact octal tube socket (V4, V8, V9)
33001	Socket—11-contact magnal cathode-ray tube socket (V5)
33886	Switch—Horizontal amplifier switch (S3)
33887	Switch—Range switch (S4)
33885	Switch—Safety interlock switch (S1)
33888	Switch—Vertical amplifier switch (S5)
37314	Switch—Vertical deflection reversing switch (S6)
33884	Transformer—105-125-volt, 60-cycle power transformer (T2)
14119	Transformer—Synchronizing transformer (T1)

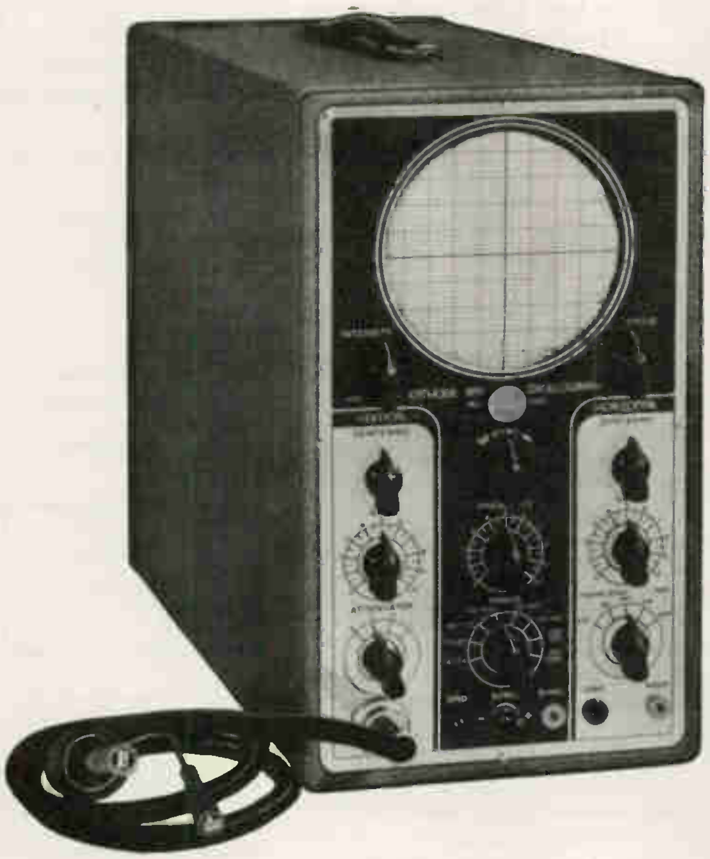
43-31-3

Replacement parts supplied are within Engineering Specification Tolerances.

Printed in U. S. A.

CATHODE-RAY OSCILLOGRAPH

STOCK No. 158



RADIO CORPORATION OF AMERICA
Camden, New Jersey, U. S. A.

IB-32012-4

Cathode-Ray Oscillograph

Stock No. 158

TECHNICAL SUMMARY

Power Supply:

Rating . . . . 105-125 volts, 50-60 cycles
(Specifications based on 117 volts, 60 cycles)
Power Consumption . . . . 55 watts
Fuse Protection . . . . 1 ampere

Tube Complement: R

RCA-6C6 . . . . Horizontal Amplifier
RCA-6SJ7 . . . . . . 1st Stage Vertical Amplifier
RCA-1852 . . . . . . 2nd Stage Vertical Amplifier
RCA-884 . . . . Timing Circuit Oscillator
RCA-5BP1/1802-P1 Cathode-Ray Tube (5 inch)
RCA-80 . . . . Low-voltage Rectifier
RCA-879 . . . . High-voltage Rectifier

Overall Dimensions:

Height (including carrying handle) . . . . 14⅜ inches
Width . . . . 8 inches
Depth . . . . 19½ inches
Weight (net) . . . . 30 pounds

Operating Data (Gain Max.):

Deflection Sensitivity at Vertical Amplifier Input:
With cable . . . . . 0.4 volts (r.m.s.) per inch*
Without Cable . 0.04 volts (r.m.s.) per inch*

Frequency Response of Vertical Amplifier:
Flat within . . . . 1 db to 200 kc.*
Flat within . . . . –3 db. to 500 kc.*
Useful range . . . . 5 cycles to 1 mc.

Frequency Response of Horizontal Amplifier:
Flat within . . . . 1 db. to 45 kc.*
Flat within . . . . –3 db. to 100 kc.*

Input Characteristics:
Vertical amplifier with cable 1.15 megohms, 16 mmfd.
Vertical amplifier without cable 0.15 megohms, 38 mmfd.

Timing Frequency Range . . 4 cycles to 18 kc.*

* Guaranteed values. Factory standards exceed these values.

DESCRIPTION

The Stock No. 158 Cathode-Ray Oscillograph is a reliable instrument for the observation of electrical circuit phenomena. Although specifically designed for use in servicing television receivers, it is practically unlimited in application, some of its more common uses include the study of wave shapes and transients, measurement of modulation, adjustment of radio receivers and transmitters, determination of peak voltages, and tracing of vacuum-tube characteristics. Its major but not only advantage over older types of visual devices is its freedom from inertia, allowing the observation of very rapid changes of current or voltage without appreciable distortion. The instrument is entirely portable, as shown by the cover illustration, and operates from an a-c source of 105 to 125 volts, 50 to 60 cycles An integral power-supply unit furnishes all voltages required for operation.

Figure 1 shows the essential units of the instrument in block diagram form.

The primary purpose of these instructions is to give the fundamentals of operation. As the use of cathode-ray apparatus becomes more widespread, many new applications will be found and a thorough understanding of these fundamentals will enable the operator to readily adapt the equipment to his particular use.

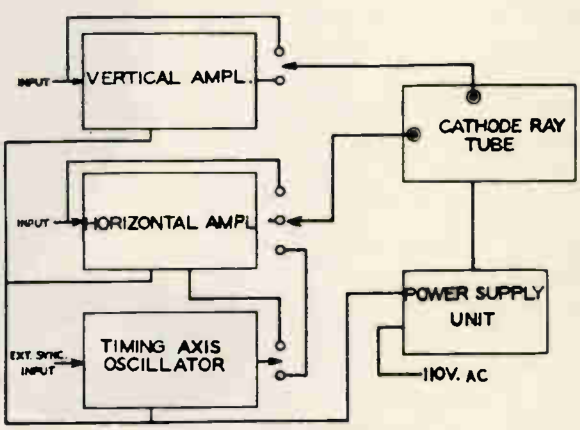


Figure 1—Block Diagram

For a comprehensive discussion of the fundamentals of cathode-ray tubes and an analysis of the figures which appear on the screen, see "A General Discussion of the Cathode-Ray Tube," RCA-IB-26453.

WARNING—A POTENTIAL OF 1500 VOLTS IS PRESENT AT THE CATHODE-RAY TUBE SOCKET AND AT OTHER POINTS ON THE CHASSIS. ALWAYS DISCONNECT THE POWER CORD BEFORE REMOVING THE CHASSIS FROM THE CABINET.

INSTALLATION

Remove the screws at the rear of the case. Withdraw the chassis from the case, feeding the power cable through the hole in the back. Make certain that all tubes are firmly in their sockets and that all grid-cap connections are in place. Unpack the cathode ray tube and install it in its proper mounting and connect the socket, rotating the tube if necessary so that the socket key is located at the top. Replace the chassis in the case and replace the screws at the rear. With the "*Intensity*" control in the extreme counterclockwise ("*Off*") position, plus the power-supply cable into an electrical outlet supplying 105-125 volts at 50-60 cycles. The instrument is then ready for operation.

NOTE: AN INTERLOCK SWITCH, LOCATED AT THE REAR OF THE CHASSIS, OPENS THE POWER CIRCUIT WHEN THE CHASSIS IS REMOVED FROM THE CASE. DO NOT ATTEMPT TO OPERATE THE EQUIPMENT WHILE WITHDRAWN FROM THE CASE AS THE HIGH POTENTIALS USED ARE DANGEROUS.

OPERATION

Controls

Refer to the schematic and wiring diagrams for the location of circuit units designated by symbols.

1. "*Intensity*" control (R-41) consists of a potentiometer located in the high side of the high-voltage bleeder and controls the bias on the grid of the cathode-ray tube, which in turn determines the quantity of electrons emanating from the "gun," thus controlling the spot size. The power switch (S2) is attached to this potentiometer. Initial clockwise rotation of this control closes the switch and additional rotation increases the spot size.

2. "*Focus*" control (R-43) is a potentiometer located in the high-voltage bleeder. Its position controls the No. 1 anode voltage, which, with constant voltage on anode No. 2, determines the distance at which the electron beam focuses. In general, for a given "*Intensity*" setting, the "*Focus*" control should be set for maximum distinctness of spot or image.

3. "*Vertical Amplifier*" switch (S-6) is an input attenuator in the grid circuit of the first amplifier stage. The attenuation steps are approximately 1:5. Connection to the input is made through a special cable which may be omitted if higher input capacity is permissible. An increase in sensitivity of approximately 10 to 1 is obtained without the cable. Input connection, in this case, is made to terminal #2 of the input jack.

4. "*Horizontal Amplifier*" switch (S-3) has five positions: The amplifier "*On*" and "*Off*" and three "*Timing*" positions. On all "*Timing*" positions the "saw-tooth" or timing-axis oscillator feeds through an amplifier to the horizontal deflecting plates of the cathode-ray tube. At "*On*," the "*Horizontal*" phone tip jacks are connected through an amplifier to these deflecting plates while at "*Off*," the phone tip jacks are connected straight through to the deflecting plates. In booth of the latter two cases, there is a series condenser in the input circuit.

5. "*Vertical Gain*" control (R-33) consists of a potentiometer located in the grid circuit of the 2nd stage of the vertical amplifier. With the "*Vertical Amplifier*" switch set for any given position this potentiometer controls the vertical deflection. By advancing the "*Vertical Amplifier*" switch from a lower to the next largest number the sensitivity is cut approximately 5 to 1.

6. "*Horizontal Gain*" control (R-2) consists of a potentiometer located in the input circuit of the horizontal amplifier. With the "*Horizontal Amplifier*" switch set at "*Timing*" or "*On*," this potentiometer controls the horizontal deflection. Due to the capacity load on this input potentiometer, when operating on "*Timing*" at the higher audio frequencies, linear sweep will not be obtained at all setting of this control. For best results, the control should be set for maximum linearity.

7. "*Range*" switch (S-5) selects one of eight timing capacitor values. It thus changes the timing-axis oscillator frequency in steps, giving eight ranges approximately as shown on the front panel.

8. "*Freq.*" control (R-12) is a rheostat connected in series with the timing condenser. It changes the timing-axis oscillator frequency gradually as it is rotated, and in conjunction with the "*Range*" switch gives a continuous range between the extremes of frequency.

9. "*Sync.*" control (R-6) is a potentiometer used to control the amount of synchronizing voltage fed to the grid of the RCA-884 tube. In general, it should be set as far counter-clockwise as is consistent with a locked image, since over-synchronization results in a poor wave-form produced by the timing-axis oscillator.

10. The "*Sync.*" switch provides for a 180-degree phase shift of the image on the screen.

11. "*Horizontal Amplifier*" switch (S-3) has three timing positions, "*Int.*," "*60*," and "*Ext.*" for synchronization. At "*Int.*,' the voltage drop across resistor R-5 in the plate circuit of the vertical amplifier is fed through the "*Sync.*" control and input transformer to the grid of the RCA-884 tube. Thus, the timing-axis oscillator can be synchronized with the signal on the vertical axis at the fundamental frequency or at any sub-multiple, such as ½, 1/3 . . . Synchronization is not effective if it is attempted to operate the timing-axis oscillator at

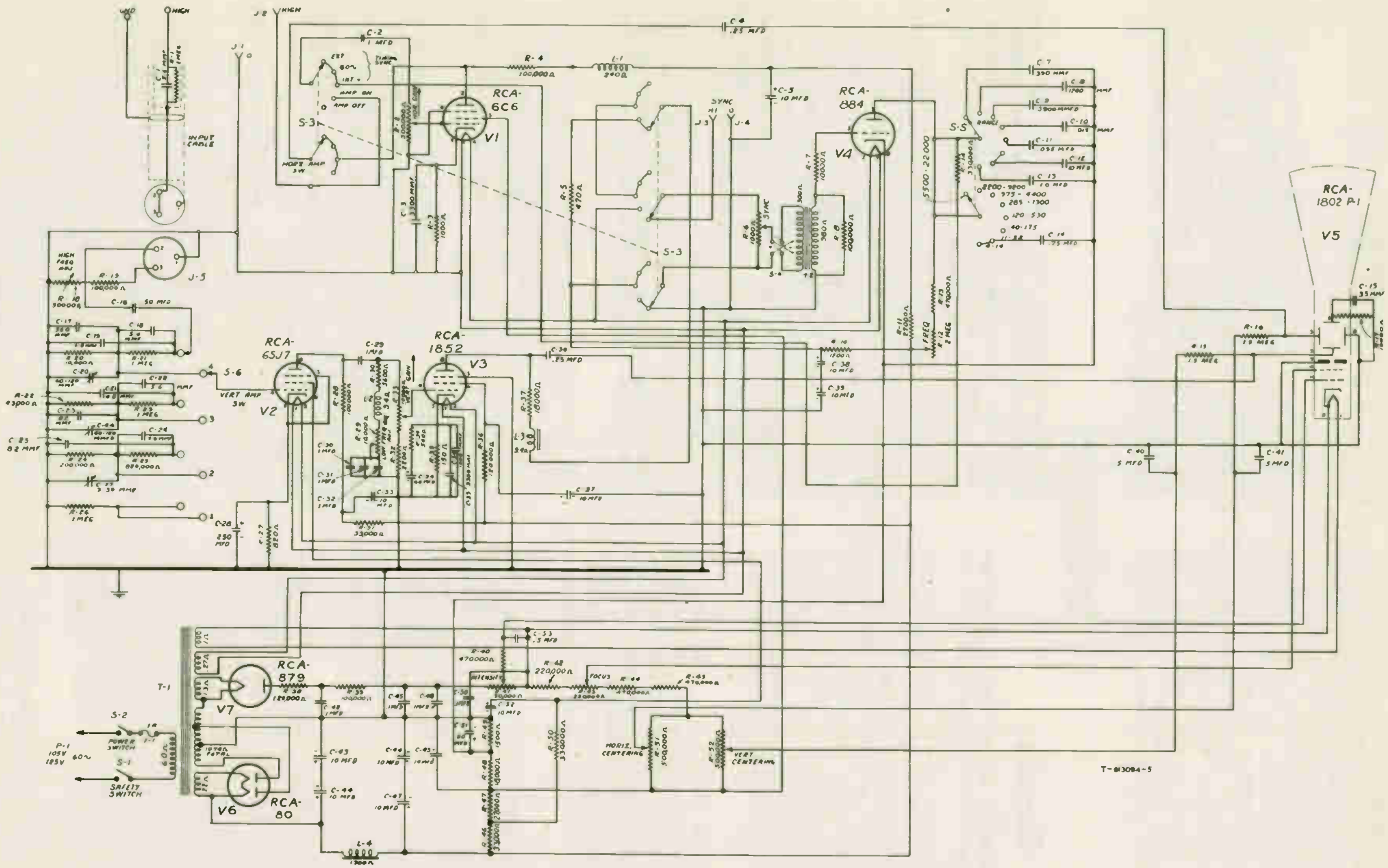


Figure 2—Schematic Circuit Diagram, Stock No. 158

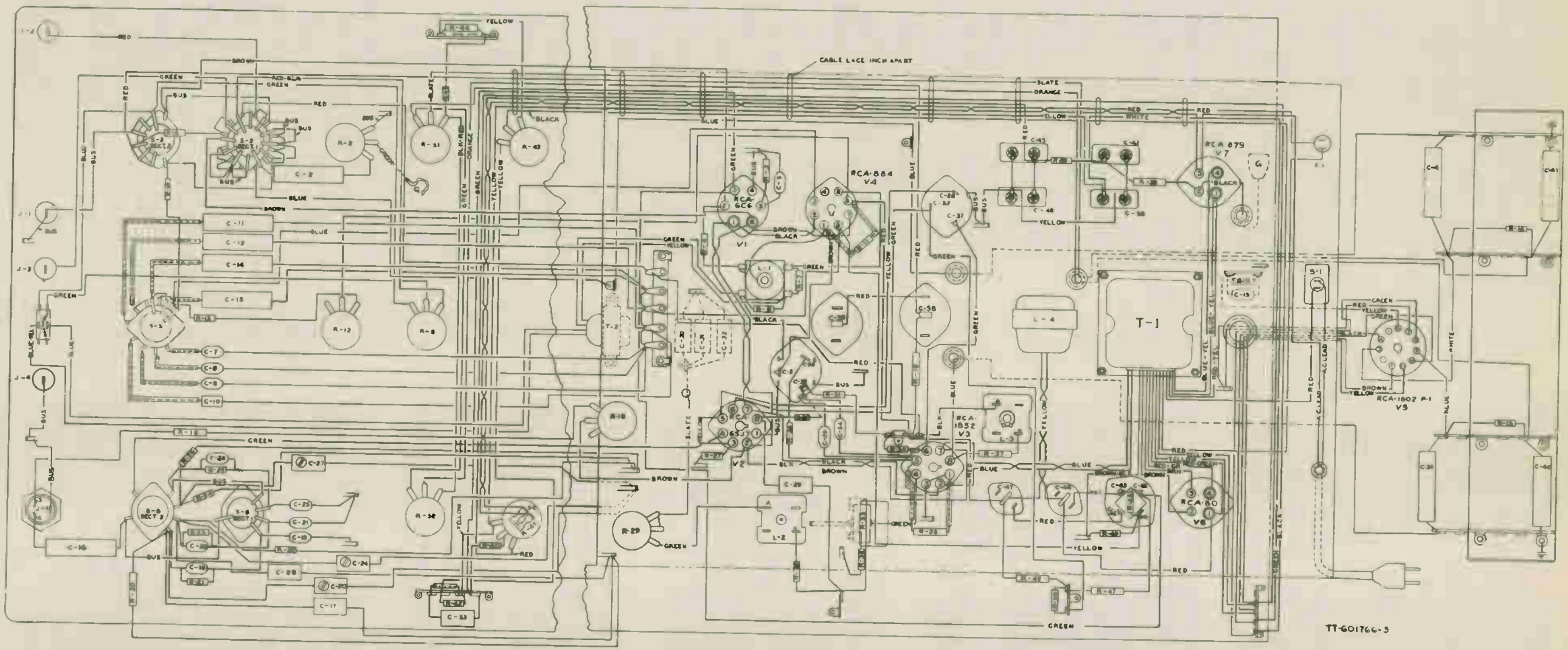


Figure 3—Chassis Wiring Diagram, Stock No. 158

a higher frequency than that of the synchronizing voltage. When set to "60" a portion of the 60 cycle filament voltage is used for synchronization. On "*Ext.*," the "*Sync.*" phone tip jack is connected to the "*Sync.*" control. This allows the use of an external source for synchronizing.

12. The two "centering" controls regulate the amount of d-c potential between the two deflecting plates of each pair, and thereby allows adjustment of the position of the spot or image. There is sufficient voltage across these controls to move the spot approximately two inches on the screen. Start with both of these controls adjusted at about mid-position.

13. There are four phone tip jacks provided on the panel. A voltage applied to the "*Horizontal*" jacks, with the horizontal amplifier switch S-3 in the "*On*" position, will result in a horizontal deflection of the spot. The "*Sync.*" phone tip jack is used for external synchronization of the saw tooth oscillator. Caution: Do not apply more than 15 (r.m.s.) volts to "*Ext. Sync.*" jack or damage to input components may result. The "*Gnd.*" jacks are connected to the chassis. A switch labeled "*Sync.*" controls the synchronization of the saw tooth oscillator with the source on either positive or negative impulses.

Applications

The following procedures are included in order to familiarize the operator with the operations and connections involved in particular applications. All applications of the equipment are not described, but analysis of any other problem will show wherein it is similar to or differs from those given, enabling the operator to work out his own sequence of operation.

As has been pointed out previously, most applications of this instrument are performed with the output of the unit under test connected to the vertical plates of the cathode-ray tube, and the wave shape studied by application of known constants on the horizontal plates of the tube. Before any measurements are attempted, the operator is urged to go through the following procedure in order to familiarize himself with the controls and their location and to get the "feel" of their operation:

1. Connect the power plug to an a-c source of 110/120 volts, 50/60 cycles. Turn the "*Intensity*" control clockwise, causing a spot to appear on the screen, increasing in size as the "*Intensity*" control is advanced further clockwise. The "*Focus*" control should then be adjusted until maximum distinctness of the spot or image occurs. The centering controls should be set about mid-position.

CAUTION. DO NOT ALLOW A SMALL SPOT OF HIGH BRILLIANCY TO REMAIN STATIONARY ON THE SCREEN FOR ANY LENGTH OF TIME, AS DISCOLORATION OR BURNING OF THE SCREEN WILL RESULT.

With the spot on the screen and with the "*Intensity*" control retarded so that the spot is not too brilliant, adjust the position of the spot to the center of the screen by rotation of the two centering controls. After initial adjustment, these controls will rarely require re-adjustment, unless the cathode-ray tube is replaced.

To turn the equipment off, turn the "*Intensity*" control to its extreme counterclockwise position, until a distinct "snap" is heard.

2. Apply a source of 60-cycle current to the input cable. To adjust the length of the resultant line appearing on the screen, turn the "*Attenuator*" switch to one of its four positions and adjust the "*Gain*" control until the length is as desired. Application of the same 60-cycle source to the "*Horizontal*" pin jacks with the "*Horizontal Amplifier*" switch '*On*" or "*Off*" will similarly show a horizontal line on the screen, the length of which may be varied (with the "*Horizontal Amplifier*" switch "*On*") by manipulation of "*Horizontal Gain*" control.

3. To expand (2) further, have 60 cycles available at both "*Horizontal*" and "*Vertical*" terminals.

CAUTION. Since all ground or "*Gnd*" pin jacks on the oscillograph are common, it is advisable to use an isolating transformer for one supply, so that there is no common connection between the two.

Apply the horizontal 60-cycle supply to the deflecting plates, preferably through the amplifier and its gain control, then apply the 60-cycle vertical supply through the other amplifier and its gain control. The result will be a diagonal line. Horizontal amp. switch must be turned to "on" to do this (see "A General Discussion of the Cathode-Ray Tube," RCA-IB-26453, Figure 5 and explanation.)

AC VOLTMETER WITH AMPLIFIER—For this application, the characteristics of the unit are as follows: Input resistance—1.1 megohm, input capacity—approximately 8 mmfs; voltage range—approximately 175 volts (higher with external attenuator); calibration—approximately 0.64 peak volts per inch or 0.4 r-m-s volts per inch.

Procedure—Make connections and adjust controls. With the "*Vertical Gain*" control in the extreme clockwise position, a line one inch long is obtained on the screen for about 0.64 peak volts input. Intermediate positions of the gain control give different calibrations, of course, and if considerable use is made of this feature, it may be advisable to plot a curve of the inputs required to give a one-inch deflection at various intermediate positions of the gain control. If working at a frequency above 10,000 cycles, it must be remembered that retarding the gain control from maximum impairs the linearity of the amplifier.

A particular application of operation as an a-c voltmeter is in making hum measurements in a power supply unit. In this case, the "*Gnd.*" pin jack or cable ground lead ("*Vertical*") is connected to the common lead of the filter circuit of the unit under test and the input cable is used to check the a-c ripple present at the various circuit component terminals.

AUDIO QUALITY MEASUREMENTS—Use of the "saw-tooth oscillator" feature of the oscillograph provides a check which cannot be made with an ordinary voltmeter. This is extremely helpful in determining the audio quality of a receiver or similar instrument and also in locating causes of audio distortion.

Procedure—Apply the output from a constant frequency record or audio oscillator to the input cable. Turn the "*Range*" switch to that tap giving a range including the frequency of the input signal and adjust the "*Freq.*" control until the saw-tooth oscillator frequency is near that of the input signal. If the two frequencies are identical, one cycle of the input signal will be observed on the screen; if the saw-tooth oscillator frequency is one-half that of the input signal, two cycles of the latter will appear; if one-third, three cycles, etc. Next, connect this constant frequency record or audio oscillator output to the audio input of the unit under test and connect the output of the unit under test to the input cable of the oscillograph. If the resultant wave does not correspond to that obtained when the input was direct to the oscillograph, audio distortion is present.

If it is desired to measure the overall audio fidelity of a receiver, for instance, the procedure is similar to that above except that the voltage modulating an r-f oscillator is fed into the oscillograph, adjusted as above. Then the modulated oscillator is connected to the r-f input terminals of the receiver and the loudspeaker voice coil connected to the oscillograph. Comparison of the two resultant waves will indicate how much distortion occurs in the receiver under test. Observing the quality of the input to the receiver from the test oscillator will also show how much distortion is being fed into the receiver from the test oscillator. This is desirable since it may show that all the distortion present in the receiver output may not be due to the receiver characteristics, but to those of the test oscillator (assuming no distortion from modulation).

MODULATION INDICATOR—(1) One method of measuring the modulation of a transmitter is to place the modulated r-f output of the transmitter into the vertical plates of the cathode-ray tube and the audio input signal to the transmitter on the "*Sync.*" pin jack.

Procedure—Connect a constant-frequency input to the transmitter and connect a small pickup coil, located near the transmitter tank coil, to the input cable. The pickup on this coil should be from 1.2-10 volts. Connect the "*Sync.*" pin jacks of the oscillograph to the transmitter audio amplifier at a point providing a 2- to 4-volt signal.

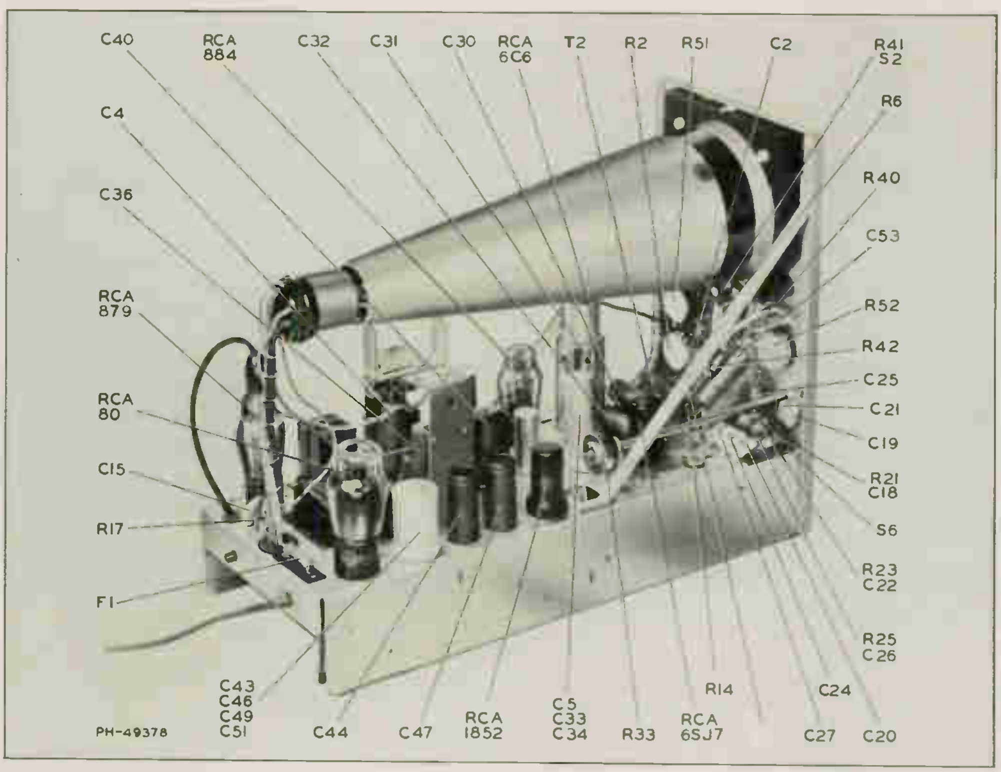


Figure 4—Top View of Chassis

Set "*Horizontal Amplifier*" switch to "*Ext.*" position. Turn the "*Range*" switch to the tap which includes the frequency of the input signal and adjust "*Freq.*" control until the saw-tooth oscillator interlocks with the signal on the vertical plates. Adjustment of the "*Sync.*" control provides control of the voltage from the audio amplifier to the grid of the RCA-884 tube. Adjustment of "*Horizontal Gain*" control varies the horizontal deflection.

(2) Another and somewhat similar method of modulation measurement is to connect the pickup coil to the input cable as before, but connect the audio signal (from the transmitter audio amplifier) to the "*Horizontal*" pin jacks. Adjust "*Horizontal Gain*" control until desired horizontal deflection is obtained. The percentage modulation can then be readily determined. See Figure 31, "A General Discussion of the Cathode-Ray Tube," RCA-1B-26453.

ALIGNMENT OF INTERMEDIATE-FREQUENCY STAGES—For alignment of the intermediate-frequency stages of a receiver, it is essential that an auxiliary apparatus, a frequency modulator, be available to sweep the intermedite frequency for which the receiver is designed. One type of frequency modulator consists of sweep condenser and a synchronizing generator rotated in synchronism by a driving motor. The condenser is arranged to "sweep" the frequency of the r-f input to the receiver (or i-f stages) and the synchronizing generator connects to the "sync." jack of the oscillograph so as to synchronize the saw-tooth oscillator with the frequency variation of the test oscillator input to the receiver. An electronic sweep test oscillator may be used to provide both a frequency-modulated signal and a synchronizing signal, so that no other frequency modulator is required.

The test oscillator output should be coupled to the grid of the tube preceding the i-f stage under alignment. It is essential that this connection be made without altering any of the operating characteristics of this stage. If the grid of the tube to which connection is to be made is at zero d-c potential with respect to ground, connect the oscillator to the grid of the tube and disconnect the lead normally on the grid, the low side of the test oscillator output returning to chassis ground. If the grid is not at zero d-c potential with respect to ground, connect the high side of the oscillator to the grid (disconnecting the lead on the grid) and the other side to the "—C" lead for this grid.

The "*Vertical*" input cable of the oscillograph should be connected to the audio output of the second detector. For a diode detector, this connection may be across the volume control alone or across both the volume control and automatic volume control resistor, if this connection is convenient. When the second detector is a triode, tetrode or pentode, resistance-coupled to the first audio stage, the connection to the input cable may be to the plate of the tube, the "*Gnd*" lead being connected to ground. In the case of a triode, tetrode or pentode, transformer- or impedance-coupled to the first audio stage, connect a resistor

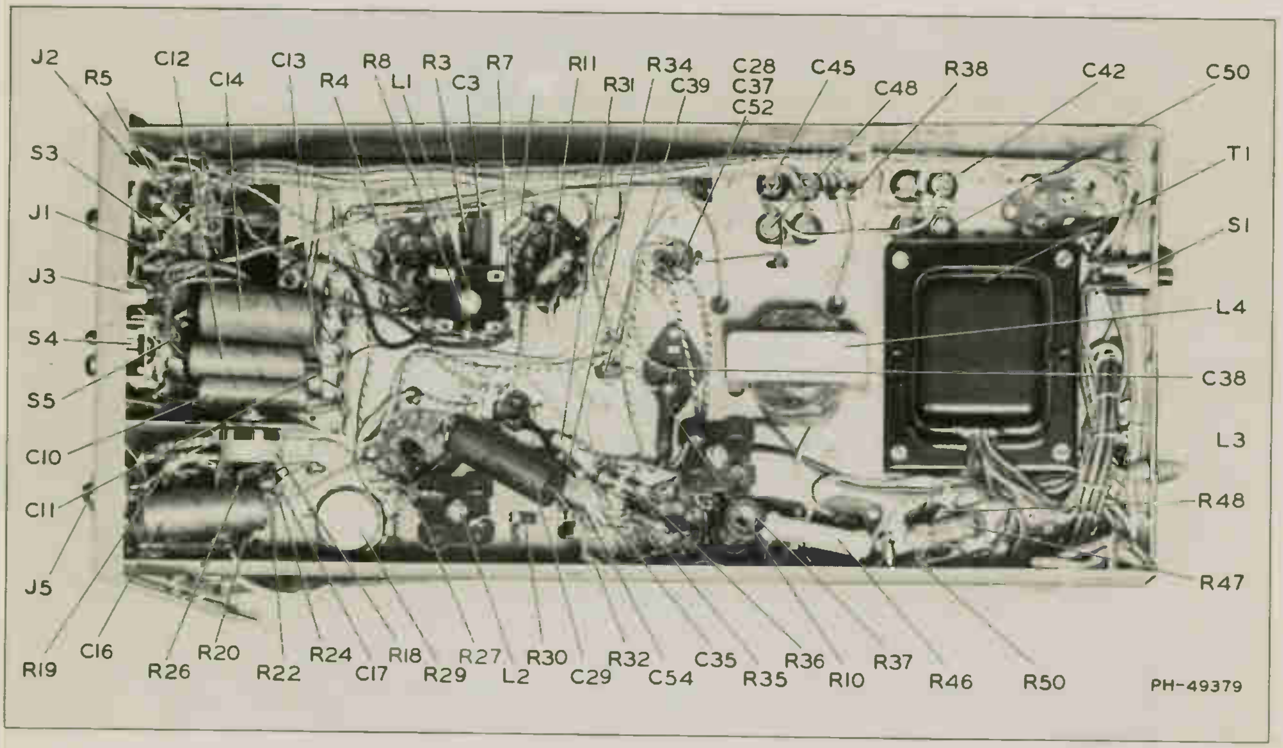


Figure 5—Bottom View of Chassis

of approximately 20,000 ohms in series with the plate of the tube and by-pass the inductance in the plate circuit by a 1.0 mfd or larger capacitor. This changes the impedance of the plate circuit to resistance rather than inductive reactance; the input cable should be connected to the plate of the tube and the *"Gnd."* lead to ground in order to take the audio voltage off his resistor.

ALIGNMENT OF RADIO-FREQUENCY STAGES—The equipment used for r-f alignment is identical to that for i-f alignment, except that the test oscillator output is connected to the antenna lead of the receiver, and different frequencies are employed.

FREQUENCY MEASUREMENTS—In using the oscillograph for frequency measurement, either Lissajou figures (sine waves on both axes) may be used, or the linear timing axis may be employed on the horizontal axis. The most flexible method for frequencies up to 100,000 cycles is the linear timing axis method. The frequency stability of the saw-tooth oscillator running free is not good enough to depend upon for accurate measurements, but when this oscillator is synchronized with a standard-frequency voltage, its frequency stability is the same as that of the standard, and it can be synchronized at any sub-multiple of the standard frequency down to about one-tenth. This allows convenient calibration of a device at many points between one-hundredth of—and ten times a single standard-frequency source, and every point is as accurate as the standard. If a 1000-cycle standard source is used, calibration points between 10 and 10,000 cycles are easily obtained. Using Lissajou figures, calibration points between 100 and 10,000 cycles can be obtained. A frequency standard which is almost universally available is the 60-cycle a-c supply. Since the advent and rapid spread of electric clocks, the frequency of nearly all commercial power is held to a very close tolerance. This allows accurate calibration at frequencies up to about 600 cycles. *"Sync."* switch S-4 reverses the input to the saw-tooth oscillator and in so doing provides synchronization with impulses of opposite polarity.

CHECKING PHASE SHIFT—To check phase shift of electrical equipment with the oscillograph, observe the screen pattern with the input to the equipment connected to the *"Horizontal"* jacks and the output from the equipment connected to the input cable. If no phase shift exists, a sloping straight-line image will appear. The internal amplifiers in the oscillograph introduce some phase displacement which must be considered.

CIRCUITS

The schematic arrangement of the entire circuit is shown in Figure 2.

An amplifier consisting of two stages constitutes the means of obtaining gain for the signal applied to the vertical deflecting system. The input to this stage is a high-resistance step attenuator connected to provide stepped gain control. An isolation capacitor is made a part of the input circuit to exclude from the grid any direct current which may be associated with the circuit being observed. The plate circuit of the output tube (RCA-1852) is composed of two elements in series, a resistor and an inductance whose values are so designed as to effect a broad and uniform frequency response in the amplifier stage. Coupling from the amplifier plate to the cathode-ray tube is made through a capacitor.

The amplifier for the signal applied to the horizontal deflecting plates is a single stage. A switch is provided to disconnect the Horizontal Amplifier, thereby applying the voltage to be studied directly to the deflecting plate. Extra contacts are used on the input switch to the horizontal amplifier for feeding in the timing or "saw-tooth" oscillator signal.

A synchronization system is included, as shown in the input circuit of the RCA-884. This is included in the Horizontal Amplifier switch and is described under "Operation." The timing axis oscillator stage, using the RCA-884, is designed to have a frequency range of approximately 4-18,000 cycles, controlled through the *"Range"* switch and *"Frequency"* control. The signal from this oscillator has a "saw-tooth" wave shape, obtained as follows: A d-c potential is applied across a capacitor and resistor in series in the plate circuit of the RCA-884 tube. This voltage charges the capacitor until the ionization potential (plate voltage at which the gas in the tube ionizes) is reached. When the RCA-884 ionizes, the capacitor is short-circuited and the voltage across it drops nearly to zero. The tube immediately deionizes and allows the capacitor to start charging again. In this manner, the voltage across the capacitor has a "saw-tooth" characteristic. The capacitor referred to above is selected by the position of the *"Range"* switch as described in "Operation." With the *"Horizontal Amplifier"* switch on *"Timing,"* the voltage across this capacitor passes through the horizontal amplifier to the plates of the cathode-ray tube. The operation of the *"Sync."* control, in the grid circuit of the RCA-884 is described under "Operation."

The cathode-ray tube is described under "General Discussion of Cathode-Ray Tube," RCA-IB-26453. Controls used to alter the intensity, focus and zero adjustments are described under "Operation."

Power required for operation of the instrument is obtained through the power unit from a 110- to 120-volt, 50- to 60-cycle supply. Voltage rectification is accomplished by one RCA-80 and one RCA-879 rectifier tube, one being used full-wave and the other half-wave. One of these tubes supplies plate voltages for the amplifier stages and sweep oscillator, filtered through a reactor-capacitor combination. The other supplies the high voltage to the cathode-ray tube for polarization purposes.

MAINTENANCE

Under ordinary circumstances no adjustments need be made on the instrument but if these are disturbed they can be readjusted only with the use of square wave inputs obtained from a reliable square generator. Normally this means returning the instrument to the factory.

Radiotrons

Under ordinary usage within the ratings specified for voltage supply, tube life will be consistent with that obtained in other applications. The amplifier, oscillator and rectifier tubes will wear in accordance with loss of emission; where as the determining factor in the life of the cathode-ray tube is the deterioration of the fluorescent screen. It is therefore advisable to avoid leaving a bright, concentrated "spot" on the screen. Also, the image of the phenomena under observation should be removed from the screen when not actually being studied or measured; this item of care will enable a long and useful life to be obtained from the tube.

It is ordinarily not possible to test the Radiotrons in their respective sockets, due to the likelihood of circuit effects causing error. However, through the use of the RCA Chanalyst, amplifier tubes may be checked while in their circuits and under operating conditions by the signal-tracing method.

The tubes may also be removed and checked with standard tube testing apparatus or the questionable tube may be replaced with one known to be in good condition.

On the cathode-ray tube, excessive wear and approach to its limit of life is indicated by inability to obtain a satisfactory focus, and also by the screen becoming streaked and spotted. When it becomes necessary to install a new cathode-ray tube, some rotational adjustment may be required to bring the axes of deflection into their proper horizontal and vertical planes. This is accomplished by loosening the wing nut on the cathode-ray tube shield clamp, rotating the socket as desired, and then tightening the wing nut.

Fuse Replacements

A small 1-ampere cartridge fuse is used in the primary circuit of the power transformer. This fuse is intended for protection of the entire power system of the oscillograph, and, therefore, should not be replaced by one having a higher rating, nor be shorted out. A fuse failure should be carefully investigated before making a replacement, since with fuses of accepted quality, there usually will be a definite cause for the breakdown. The cause may originate from a surge in the power-supply line, but the greater percentage of causes may be centered in the apparatus protected, such as shorted rectifier elements, and so forth. Occasionally, a fuse may open from heat generated at one of its clip contacts. These points should therefore be kept clean and in secure contact with the fuse.

Resistance and Continuity Tests

The chassis wiring layout giving color code and physical relation of the parts is shown in Figure 3. All resistor and capacitor values are given to facilitate a rapid and sure test for continuity of circuit and the condition of same. Coils and transformer windings have their d-c resistances shown.

In working on the chassis of the oscillograph, care must be observed to have the power supply completely disconnected. The high voltages associated with the circuits of the cathode-ray tube make it especially dangerous to attempt to handle or work on the chassis while the power is "On."

Care should be exercised in replacing any part that may be found faulty. All wiring associated with the part involved must be removed, and especial attention given to the possibility of damage to other wiring or parts. The relation of wiring and parts should be the same as in the original assembly. The insulation and spacing of the high-voltage leads is very necessary and an important item to be adhered to in servicing of the instrument.

Voltage Measurements

One means of learning the condition of operation and tracing the circuit faults of the oscillograph is by checking the values of the voltages and currents at the Radiotron sockets. The normal values, which can be expected to be found when the instrument is working properly under the specified power rating, are indicated by the Radiotron Socket Voltage Table. In general, the values shown are measured from the socket contacts to ground; however, the heater or filament voltages are a-c and appear between the F-F or H-H clips. All readings given are actual operating values, and do not allow for any errors likely to be caused by current drain of the measuring instrument.

TUBE SOCKET VOLTAGES

Approximate tube socket voltages read with respect to ground: (Measured with RCA VoltOhmyst). 115 volts applied to primary.

Tube	Function	E_f	E_k	E_g	E_{sg}	E_{sup}	E_p
RCA-6C6	Horizontal Amplifier		+1.8 to +27		+102 to +105	0	+232 to +330
RCA-6SJ7	Vertical Amplifier (1st Stage)		+2.4		+73	+2.65	+195
RCA-1852	Vertical Amplifier (2nd Stage)		+1.9		+157	0	+260
RCA-884	Sweep Oscillator		+7 to +9				+53
RCA-879	High-Voltage Rectifier	AC1190					—1165
RCA-80	Low-Voltage Rectifier	+520					AC435

Tube	Function	E_f	E_g	Deflection Plate			
				No. 3	No. 9	1st Anode	2nd Anode
RCA-1802 P-1	Cathode-Ray Tube	—850 to —960	—845 to —925	+88 to —72	+88 to —72	—620 to —820	0

REPLACEMENT PARTS

Insist on genuine factory-tested parts, which are readily identified and may be purchased from authorized dealers.

STOCK No.	DESCRIPTION
33873	Cable—Input cable complete
12814	Capacitor—5.6 mmfd. (C1, C18, C22, C26)
14079	Capacitor—6.8 mmfd. (C19, C21)
13001	Capacitor—8.2 mmfd. (C25)
12948	Capacitor—33 mmfd. (C15)
12813	Capacitor—82 mmfd. (C23)
13894	Capacitor—390 mmfd. (C7)
12537	Capacitor—560 mmfd. (C17)
13054	Capacitor—1,200 mmfd. (C8)
4881	Capacitor—3,300 mmfd. (C3, C35)
30856	Capacitor—.015 mfd. (C10)
30857	Capacitor—.035 mfd. (C11)
30848	Capacitor—0.1 mfd. (C12)
18000	Capacitor—0.1 mfd., 1,250 volts (C42, C45, C48, C50)
30849	Capacitor—0.25 mfd. (C4, C14, C36)
30860	Capacitor—0.5 mfd. (C16, C40, C41, C53)
18416	Capacitor—1 mfd. (C2, C13, C29, C30, C31, C32)
33879	Capacitor—10 mfd., 300 volts (C38, C39, C44, C47)
33880	Capacitor—10 mfd., 300 volts, 10 mfd., 300 volts, 10 mfd., 150 volts, 20 mfd., 25 volts (C43, C46, C49, C51)
33865	Capacitor—10 mfd., 450 volts, 10 mfd., 450 volts, 40 mfd., 25 volts (C5, C33, C34)
33159	Capacitor—250 mfd., 15 volts, 10 mfd., 350 volts, 10 mfd., 150 volts (C28, C37, C52)
12477	Choke—Filter reactor (L4)
33881	Choke—Horizontal amplifier plate choke (L1)
33867	Choke—Vertical amplifier plate choke (L2, L3)
11859	Condenser—3 to 30 mmfd., variable condenser (C27)
33866	Condenser—60 to 120 mmfd., variable condenser (C20, C24)
33870	Connector—Input cable connector (J5)
33874	Control—1,000 ohms—synchronizing control (R6)
17694	Control—10,000 ohms—low frequency compensating control (R29)
33861	Control—10,000 ohms—vertical gain control (R33)
13984	Control—50,000 ohms—compensating control (R18)
33863	Control—50,000 ohms—intensity control and power switch (R41, S2)
33864	Control—250,000 ohms—focus control (R43)
33859	Control—500,000 ohms — horizontal gain control or centering control (R2, R51, R52)
33860	Control—2 meg.—frequency control (Fine) (R12)
33872	Escutcheon—Front panel escutcheon
30926	Foot—Elastic foot for case
14133	Fuse—1 ampere line fuse (F1)
32059	Holder—Tubular type fuse holder with screw cap
30925	Handle—Carrying handle for case
47061	Jack—Black binding jack (J1, J4)
47228	Jack—Red binding jack (J2, J3)
32116	Knob—Control knob
47062	Post—Binding post (use with 47061 and 47228)
13428	Resistor—150 ohms, ¼ watt (R35)
30546	Resistor—470 ohms, ¼ watt (R5)
12414	Resistor—560 ohms, ¼ watt (R34)
14076	Resistor—820 ohms, ¼ watt (R27)
14720	Resistor—1,000 ohms, ¼ watt (R3)
12267	Resistor—1,200 ohms, ¼ watt (R49)
6134	Resistor—1,200 ohms, 1 watt (R10)
13716	Resistor—2,200 ohms, ¼ watt (R32)
13714	Resistor—5,600 ohms, ¼ watt (R30)
14559	Resistor—10,000 ohms, ¼ watt (R7, R17, R20)
3219	Resistor—18,000 ohms, ½ watt (R48)
33862	Resistor—18,000 ohms, 20 watt (R37)
30409	Resistor—27,000 ohms, ½ watt (R11)
14167	Resistor—27,000 ohms, 2 watt (R47)
12454	Resistor—33,000 ohms, ¼ watt (R31)
12487	Resistor—33,000 ohms, 2 watt (R46)
6143	Resistor—43,000 ohms, ¼ watt (R22)
14560	Resistor—100,000 ohms, ¼ watt (R8, R19)
3252	Resistor—100,000 ohms, ½ watt (R28, R39)
30154	Resistor—100,000 ohms, 1 watt (R4)
13483	Resistor—120,000 ohms, 1 watt (R36, R38)
11676	Resistor—200,000 ohms, ¼ watt (R24)
14583	Resistor—220,000 ohms, ½ watt (R42)
30784	Resistor—330,000 ohms, ½ watt (R14, R50)
12285	Resistor—470,000 ohms, ¼ watt (R13, R40)
36243	Resistor—470,000 ohms, 1 watt (R44, R45)
30963	Resistor—820,000 ohms, ¼ watt (R25)
13730	Resistor—1 meg., ¼ watt (R23, R26)
30652	Resistor—1 meg., ½ watt (R1, R21)
12201	Resistor—1.5 meg., ¼ watt (R15, R16)
33871	Screen—Calibration screen for cathode-ray tube
31769	Socket—4-contact tube socket (V6, V7)
18351	Socket—6-contact tube socket (V1)
33084	Socket—8-contact octal tube socket (V2, V3, V4)
33001	Socket—11-contact magnal socket for cathode-ray tube (V5)
33886	Switch—Horizontal amplifier switch (S3)
33887	Switch—Range switch (S5)
33885	Switch—Safety interlock switch (S1)
33868	Switch—Sync switch (S4)
33869	Switch—Vertical amplifier switch (S6)
33884	Transformer—105-125 V, 60 cycle power transformer (T1)
14119	Transformer — Synchronizing transformer (T2)

Replacement Parts supplied are within Engineering Specification Tolerances.

DISTORTION AND NOISE METER

TYPE 69-C

Manufactured by

RCA VICTOR DIVISION

of

RADIO CORPORATION OF AMERICA

Camden, N. J., U. S. A.

IB-32021-3

ADDENDA

January 1945

DISTORTION AND NOISE METER
TYPE 69C
IB-32021-3

Page 7 - MAINTENANCE -
Add a new paragraph at end of section to read: "In the event that R55A, C8 or T2 require replacement, it will be necessary to readjust R-55A so that the Low Audio response is flat within ± .5 db from 20 cycles to 40,000 cycles, and down not more than 1 db at 45,000 cycles. Potentiometer R-55A is located underneath the chassis, on the shield."

Page 8 - PARTS LIST-
Add in Column 2 after R-55.

R-55A	Potentiometer - 5,000 ohms, 1/2 watt	14885

Page 16 - Figure 14 - For Revised Schematic, see end of book.

Figure 15 - For Revised Connections, see end of book.

ADDENDA

September 1944

DISTORTION AND NOISE METER

TYPE 69C

IB-32021-3

Page 3 - TECHNICAL SUMMARY - Electrical Characteristics
Change "Frequency Range - High or low - - - - - - - - at 30,000 cycles."
to read
"Frequency Response - High or low audio input within ±0.5 db. of 400 cycle response 30 - 40,000 cycles, may be down 1.0 db. at 45,000 cycles. Bridging input, within ±0.5 db. of 400 cycle response 30 - 15,000 cycles, may be down 1.5 db. at 30,000 cycles.

Page 5 - OPERATION - NOISE LEVEL MEASUREMENTS
1st Paragraph, 4th line.
Following "----"one milliwatt in a 600-ohm line."
INSERT - "The standardizing voltage in the 69-C is 0.775 volts (1 m.w. in a 600-ohm line) ±1.0 db."

DISTORTION AND NOISE METER

TYPE 69-C

MI-7512E	Finish 432 Black	Rack Mounting
MI-7512F	Finish 680 Gray	Rack Mounting
MI-7512G	Finish Black Panel	Blue Gray Cabinet
MI-7512H	Finish 685 Umber Gray	Rack Mounting

INSTRUCTIONS

Manufactured by

RCA Victor Division of Radio Corporation of America

Camden, N. J., U. S. A.

Printed in U. S. A.

IB-32021-3

Figure 1—Type 69-C Distortion and Noise Meter (Rack Model)

Figure 2—Type 69-C Distortion and Noise Meter (Cabinet Model)

Figure 3—Type 69-C Distortion and Noise Meter (Cabinet Model, Rear View)

DISTORTION AND NOISE METER

TECHNICAL SUMMARY

Electrical Characteristics

Frequency Range—High or low audio input, ±0.5 db 30-40,000 cycles, down 1.0 db at 45,000 cycles; Bridging input, ±0.5 db, 30-15,000 cycles, down 1.5 db at 30,000 cycles.

Distortion Range	0.3% to 100% r-m-s
Noise Level Range	0 to –75 db
Line Rating	110-120 volts, 25-60 cycles
Power Consumption	50 watts
Fuse Protection	1.5 amperes

Tube Complement

Voltage Amplifiers	1 RCA-6C5
Voltage Amplifiers	1 RCA-6C5G
Voltage Amplifiers	2 RCA-6SJ7
R-F Rectifier	1 RCA-6X5G
Power Rectifier	1 RCA-6X5G
Voltage Amplifier and Vacuum Tube Voltmeter	1 RCA-6F8G
Voltage Regulator	1 RCA-VR-150
Voltage Regulator	1 RCA-VR-105
Ballast Tube	1 Amperite 6-8

Mechanical Specifications

Dimensions	Rack Type	Cabinet Type
Height	8¾ inches	9 inches
Width	19 inches	19¼ inches
Depth	13 inches	14¾ inches
Weight (Net)	44 pounds	55 pounds

DESCRIPTION

The Type 69-C Distortion and Noise Meter was developed to supply an accurate and reliable instrument for measuring the harmonic distortion and noise level in the output of radio transmitters, audio amplifiers, or modulated radio frequency equipment of any type. Distortion or noise measurements are read directly from the meter scale, which is calibrated for several ranges. When used with the Type 68-A or 68-B Low Distortion Oscillator, distortion measurements may be made at any frequency from 50 to 8,500 cycles per second or higher with weighting of the harmonics as indicated in the TECHNICAL SUMMARY under Frequency Range. Reliable readings as low as 0.3 percent. may be made on any equipment having less than 180 degrees phase shift throughout its frequency range. Under these conditions, the inherent distortion in the oscillator approximates 0.1 percent. r-m-s, which will have a negligible effect upon the distortion meter readings. Under the worst possible phase conditions, a residual reading of approximately 0.2 percent. would be obtained.

Distortion measurements may be made at frequencies down to 20 cycles per second with reasonable accuracy if the amount of distortion to be measured is not too small. Using one mw in a 600-ohm line as a zero reference level, distortion can be measured at volume levels as low as –17 db and noise levels may be measured as low as –75 db.

The essential elements of the 69-C Distortion and Noise Meter are as follows:

(1) An input circuit for the essentially sinusoidal signal from the 68-A or 68-B Beat Frequency Oscillator, including a level control, marked "CALIBRATE," and a phase-shift network comprising three controls—coarse, medium and fine, as shown in Figure 6.

(2) An input circuit for the distorted signal from the equipment under test. This includes a rectifier for demodulating an r-f signal when desired, a selector switch marked "INPUT," a source of voltage for standardizing the gain of a voltage amplifier, and three level controls—coarse, medium and fine, as shown in Figure 8.

(3) A push-pull amplifier stage which is used as a normal amplifier for noise level measurements, and as a cancellation stage for distortion measurements.

(4) A "DISTORTION-NOISE LEVEL" switch, which is used for circuit switching and for controlling the attenuation between the push-pull amplifier stage ((3) above) and the voltage amplifier.

(5) A three-tube voltage amplifier with negative feedback. The "GAIN" control determines the gain of this amplifier by controlling the amount of feedback.

(6) A detector and output meter, for measuring the r-m-s value of signal. A small amount of bucking current is fed through this meter to buck out the no-signal plate current of the detector. The amount of bucking current is controlled by the "ZERO" control. Figure 9 illustrates the distortion measurement circuit.

(7) A power supply furnishing heater, plate, and screen voltages, and the standardizing voltage mentioned in (2) above.

In making distortion measurements, the meter indicates the distortion factor—i. e., the ratio of r-m-s total distortion to the fundamental amplitude. This is accomplished by suppressing the fundamental frequency component of the wave in question and measuring the r-m-s total of the remaining components. Elimination of the fundamental frequency component is accomplished by adding to the distorted wave a sine wave of the same frequency, equal in amplitude to the fundamental component, but 180 degrees displaced in phase. This voltage is secured from the same oscillator which supplies the signal to the equipment under test and is adjusted in amplitude and phase by the use of the controls on the panel of the Distortion and Noise Meter. Distortion readings directly in percent. of the fundamental amplitude are obtained by first adjusting the meter to read full scale (100%) with only the sine wave input connected.

Measurements of noise levels are made by adjusting the meter for full scale deflection at the desired equipment output level and then removing the input signal from the equipment under test. The remaining noise and hum is amplified until a reliable meter deflection is obtained. The noise level is then read directly in decibels from the meter and attenuator scales.

INSTALLATION

The Type 69-C Distortion and Noise Meter is supplied in two models, the rack model shown in Figure 1 and the cabinet model illustrated in Figure 2. The cabinet model is supplied in a substantial metal cabinet, while the rack model is supplied with a standard rack mounting panel and dust cover. In every other respect, both models are identical.

The power cable should be connected between the a-c receptacle of the meter and a power supply outlet furnishing 105-125 volts, 25-60 cycles and delivering 50 watts. The power line fuse on the chassis should be in the proper position corresponding to the applied line voltage. Terminals for connecting the Distortion and Noise Meter with the associated equipment are located on the rear of the chassis with parallel-connected jacks located on the front panel. These terminals are clearly identified on Figure 3.

The pickup circuit used for modulated r-f signals must provide a low resistance d-c path between the r-f and ground terminals of the distortion meter as well as low audio frequency impedance.

These conditions will be met by the use of a small pickup coil consisting of several turns. Capacitative coupling or an antenna may be used if a radio frequency choke or a parallel resonant circuit is connected across the r-f and ground terminals. A low resistance, untuned coil is the most desirable for this purpose, as it is least likely to introduce hum into the circuit or to cause frequency discrimination.

The chassis of the Distortion and Noise Meter should be well grounded to minimize stray r-f pickup. This can be accomplished by the use of a heavy strap or braid, as short as possible.

OPERATION

Distortion and noise measurements are read from the same meter, which is calibrated to the following full scale readings:

Distortion	Noise Level
1%	–50
3%	–40
10%	–30
30%	–20
100%	–10
	0

The desired meter range is selected through the meter range switch, which is controlled by means of the large knob and scale. The desired distortion range may be selected by rotating the knobs over the left-half of the scale. The desired noise level range may be selected by rotating the knob over the right-half of the scale.

INPUT LEVELS—For accurate distortion or noise measurements, the input levels to the instrument should be adjusted to within the following limits:

Modulated r-f—10 volts to 80 volts.

To determine the proper r-f input level modulate the transmitter approximately 100 percent. and set the "DISTORTION-NOISE LEVEL" switch at "0." Adjust the input level until full-scale meter reading is obtained with the "AMPLITUDE" control set between "0" and "+16."

Audio frequency from 68-A or 68-B—2 volts to 4 volts.

Audio frequency from equipment under test—

1. Bridging input terminals or jacks (balanced)
   Minimum—0.14 volts or −15 db below 1 mw on 600-ohm line.
   Maximum—9.0 volts or ± 22 db above 1 mw on 600-ohm line.
2. Audio and ground input terminals
   (a) "Audio Low"—0.12 volts to 8.0 volts.
   (b) "Audio High"—1.2 volts to 80 volts.

COUPLING METHODS—Modulated radio frequency voltages to be measured are obtained through inductive coupling. The pickup coil should be designed with a low audio frequency impedance in order to eliminate any a-c hum component that may be picked up.

When the Distortion and Noise Meter is to be used in conjunction with a balanced audio line having an impedance of 600 ohms or less, a bridging transformer having an impedance of 20,000 ohms is provided. This impedance is sufficiently high to have no appreciable effect upon the low impedance line. The three transformer input connections terminate in three binding posts, marked "BRIDGING," located at the rear of the chassis, and a pair of parallel connected jacks located on the front panel. The center tap of the transformer winding is not grounded.

CONNECTIONS—Following are tabulated the correct connections to be made for distortion and noise measurements under various conditions:

For Modulated Radio Frequency Input—Connect the pickup coil between the "R-F" and "GROUND" terminals at the rear of the instrument and remove all connections from the audio terminal. Set the "INPUT" switch to "R-F" position.

For Audio Frequency Input Balanced Lines, Up to 600 Ohms—Connect the audio line either to the "BRIDGING" terminals at the rear or to the "BRIDGING" jacks on the front panel. The center tap connection may be connected, left open or grounded as desired. Set the "INPUT" switch to "BRIDGING" position.

For Unbalanced Audio Frequency Input—

(a) Below 4 volts
    Connect the audio line to "LOW AUDIO" and ground binding posts.
    Set the "INPUT" switch to "LOW AUDIO."

(b) Above 4 volts
    Connect the audio line to "HI. AUDIO" and ground binding posts.
    Set the "INPUT" switch to "HI. AUDIO."

For Distortion Measurements—Connect the 250- or 500-ohm 68-A or B terminals to the two terminals at the rear of the distortion meter marked "OSCILLATOR," or to the pair of jacks on the front panel marked "OSCILLATOR."

For Oscillograph Indication—When desired, a cathode-ray oscilloscope may be connected to the "CRO" binding posts to observe wave form of distortion or noise, or to assist in balancing out the fundamental. Any circuit connected across these binding posts should have an impedance of at least 100,000 ohms, and when an r-f field exists, such as around a transmitter, a shielded lead should be used.

CALIBRATION—Prior to making measurements, the instrument should be calibrated in the following manner:

1. Turn the power on by rotating the "CALIBRATE" control in a clockwise direction, and wait at least five minutes to allow voltages to stabilize.
2. With no input signal to the "OSC." binding posts or jacks and with the "DISTORTION-NOISE LEVEL" switch at the "CALIBRATE" position, adjust the "ZERO" control for a meter reading of zero percent. (not 0 db).
3. Set the coarse and medium "AMPLITUDE" controls to "0" positions and the "FINE" control with the pointer approximately vertical. Also set the "DISTORTION-NOISE LEVEL" switch to the "0" position, and the "INPUT" switch to the "CHECK" position. Adjust the "GAIN" control for full-scale meter reading (0 db).

NOISE LEVEL MEASUREMENTS—

Noise levels may be measured in either of two ways. One method gives a result in terms of the standard zero level of the 69-C, which is one milliwatt in a 600-ohm line. The other method gives a result in decibels below some arbitrary output level of the equipment under test. The first method is accomplished as follows:

(a) When using "LOW AUDIO" input, it is only necessary to remove input from equipment under test and adjust the "AMPLITUDE" controls and the "DISTORTION-NOISE LEVEL" switch until the meter reads on scale. The noise level (based on a 600-ohm line) is then read from the control settings and the meter readings.

(b) When using "HI. AUDIO" input, a close approximation can be obtained by using the above procedure and adding −20 db to the result.

(c) When using "BRIDGING" input, a close approximation can be obtained by using the above procedure and adding −1.5 db to the result.

The second method, which is the most accurate, is accomplished as follows:

1. Adjust the input to the device under test to obtain the output level below which it is desired to measure the noise level.
2. Adjust the "AMPLITUDE" and "DISTORTION-NOISE LEVEL" controls to obtain a meter reading of "0" db.

3. Remove the input signal from the device under test and move the "AMPLITUDE" and "DISTORTION-NOISE LEVEL" controls until the meter reads on the db scale. The sum of the amount that it was necessary to move the controls and the established meter reading denotes the noise level with respect to the original level.

DISTORTION MEASUREMENTS:

(a) Audio measurements—

1. Apply input signal from the low-distortion oscillator to the "OSCILLATOR" input of the Distortion and Noise Meter, place the "DISTORTION-NOISE LEVEL" switch on "CAL." and adjust the "CALIBRATE" control for a full-scale meter reading. This setting should remain unchanged.
2. Adjust the input to the equipment under test to the desired level, remembering that output must be within the limits specified in input levels above.
3. Place the "DISTORTION-NOISE LEVEL" switch on "0," the "INPUT" switch on appropriate position, and adjust the "AMPLITUDE" controls for full-scale deflection of the meter.
4. Place the "DISTORTION-NOISE LEVEL" switch on "100" and adjust the "PHASE" controls until meter reading is below the calibrated portion of its scale. Turn the "DISTORTION-NOISE LEVEL" switch to "30" and by further adjustment of the "PHASE" and "AMPLITUDE" controls, obtain a minimum meter reading, turning the "DISTORTION-NOISE LEVEL" switch for increased sensitivity as required.

With the selector switch placed on "CAL," during distortion measurements, the meter reading may vary with the position of the "PHASE" controls. This is a normal characteristic resulting in an error of not more than 10 percent. on the "% DISTORTION" scale indication. In order to eliminate this error, place the selector switch on "CAL," after adjusting the phase controls for a balanced condition and readjust the "CALIBRATE" control for a full scale meter indication. A slight readjustment of the "FINE" amplitude control will then be necessary for the final balance.

After obtaining an exact balance, the amount of total distortion is obtained by reading both the "meter" and "switch" scales. After a reading has been taken, the switch should be returned to the "CAL." position before making any adjustments to the equipment, in order to protect the meter.

CIRCUIT LOADING—The output of the Type 68-A Beat Frequency Oscillator should terminate in the correct impedance in order to secure minimum distortion of the oscillator signal. The correct terminating impedance is indicated at each pair of output terminals. To illustrate, an impedance of 500 ohms should be connected between the two terminals marked 500, or an impedance of 250 ohms between each terminal marked 500 and the center tap terminal. The Type 89-A Attenuator Panel will provide proper impedance loading.

EFFECT OF NOISE ON DISTORTION MEASUREMENTS—The Type 69-C Distortion and Noise Meter indicates the r-m-s total of all components of the input signal which fall within the limits of the frequency range. The exception is the fundamental frequency component, which is cancelled by the voltage taken directly from the oscillator. The reading of the meter will therefore include the following components:

Component	Frequencies for 1,000 cycle modulation (60-cycle power supply)
(1) Harmonics ...	2,000, 3,000, 4,000..20,000, etc.
(2) Modulation cross products between hum and fundamental	1,000 + 60 = 1,060 1,000 − 60 = 940 1,000 + 120 = 1,120 1,000 − 120 = 880 1,000 ± 180 = etc.
(3) Modulation cross products between hum and harmonics	2,000 ± 60 = 2,060 and 1,940 2,000 ± 120 = 2,120 and 1,880 2,000 ± etc. 3,000 ± 60 = 3,060 and 2,940 3,000 ± 120 = 3,000 ± etc. 4,000 ± etc.
(4) Hum components	60, 120, 180, etc.
(5) Noise components	All frequencies

The Distortion and Noise Meter sums all these quantities and thus indicates, as percent. distortion, the ratio of the sum of all undesired components to the fundamental frequency component. If it is desired to determine the distortion due to the harmonic and cross product components alone, either of two methods may be used.

One method is to operate the equipment under test at a high output level, which results in making the hum and noise components negligible compared to the other components. Another method is as follows:

1. Measure distortion in the normal manner at the desired output level.
2. Measure the noise level in decibels, using the same output level as a reference level.
3. Convert the reading in decibels to percent.; for example, −40 db = 1%, − 60 db = 0.1%.
4. These values may then be substituted in the following equation:

$$H = \sqrt{D^2 - N^2}$$

Where H = total harmonic and cross section distortion in percent.

D = distortion percent. obtained as per (1).

N = noise (in percent.) obtained as per (2) and (3).

When making distortion measurements, it should be kept in mind that the noise level in the output of the beat frequency oscillator approximates 50 db below 1 milliwatt and is substantially independent of the actual oscillator output voltage. While the design of the distortion meter is such that the effects of noise and distortion present in the oscillator output tend to be cancelled out, in most cases the cancellation will be more complete for the distortion than for the noise components.

Therefore, it is desirable to operate the oscillator at as high an output as practicable, thus improving the signal to noise ratio to the point where the noise output of the oscillator (expressed in percent. of signal) is small compared to the percent. distortion being measured. High oscillator output may not always be consistent with the input voltage requirements of the meter, but this difficulty can readily be overcome by the use of one or two attenuator pads or the 89-B attenuator panel.

When operating the Noise and Distortion Meter at a point remote from the oscillator, the effects of noise and distortion in the line may be great enough to seriously affect the accuracy of the measurements. Hence this type of operation is not recommended.

Normally, when taking measurements near 0 or 180 degrees phase shift, a balance cannot be obtained at frequencies which are transmitted through the equipment under test with phase shifts which fall within these narrow limits. This, however, can be overcome by inserting a capacitor in series with one of the two outside terminal connections (not the center tap) between the distortion meter and oscillator. The value of the capacitor and the choice of which connection to use is best decided by trial.

MAINTENANCE

Service generally consists of replacing tubes which have become defective through usage. All tubes should be tested at regular intervals in a tube tester.

The Distortion and Noise Meter is protected by a 1.5-ampere fuse. Should the clips holding this fuse become unduly heated through improper contact, the fuse will blow. Hence the holding contacts should be free from foreign matter and hold the fuse firmly in place.

Figures 4 and 5 show respectively the top and bottom view of the chassis, with the components comprising the circuit identified by numerals corresponding to like values on the list of spare parts. This facilitates replacement of circuit elements which have developed a breakdown. Schematic circuit and connection diagrams are shown in Figures 6 and 7.

Resistance elements through constant usage, sometimes become altered in value. This change, if sufficiently great, will affect operation in that portion of the circuit in which the resistance element is located.

Check tube socket voltages against the values in the table below. In event that the check on the tubes does not remove the cause of fault, disconnect the Distortion and Noise Meter from its source of power. With an ohmmeter, check through the entire equipment for continuity.

If such procedure shows the circuit to be intact, then check each element therein with the ohmmeter and compare the resistance readings of the resistors against the corresponding resistor given in the spare parts list.

In testing capacitors for open, short and leaky circuits, it is necessary to remove one side of the capacitor under test from the circuit in which it is connected. The probes of the ohmmeter are then placed across the terminals of the capacitor under inspection and from the nature of the ohmmeter deflection, the condition of the capacitor can readily be ascertained.

TUBE SOCKET VOLTAGES

(120-volt line, fuse in 120-volt position)

All voltages except filament are d-c to ground, measured with a 20,000-ohm-per-volt voltmeter.

Tube	E_f a-c	E_p	E_{sg}	E_k	E_p #2	E_k #2
6X5G R-F Diode	6.3					
6C5	6.3	120	—	3.7	—	—
6C5	6.3	120	—	3.5	—	—
6SJ7	6.3	152	112	3.8	—	—
6SJ7	6.3	152	112	3.8	—	—
6F8-G	6.0	105	—	3.6	250	11.5
6X5-G	6.3	d-c out = 357, a-c pl. to pl. 600 volts r-m-s				
VR105/30		105				
VR150/30		255				
Amperite 6-8	12.0					

PARTS LIST

ITEM	DESCRIPTION	Stock No.
C-1	Omitted	
C-2	Capacitor—47 mmfd.	13141
C-3	Capacitor—56 mmfd.	12723
C-4	Capacitor—0.25 mfd.	30849
C-5, C-6	Capacitor—2 sections 15 mfd., 1 section 40 mfd.	34150
C-7	Capacitor—2 sections 10 mfd., 1 section 40 mfd.	33865
C-8	Capacitor—560 mmfd.	39646
C-9, C-10	Capacitor—Same as C-4	
C-11, C-12, C-13	Capacitor—Same as C-7	
C-14	Capacitor—Same as C-4	
C-15	Capacitor—Same as C-7	
C-16	Capacitor—Same as C-4	
C-17	Capacitor—Same as C-7	
C-18	Capacitor—0.025 mfd.	30859
C-19, C-20	Capacitor—Same as C-7	
C-21	Capacitor—3 sections 40 mfd. each	19805
C-22	Capacitor—Same as C-4, 2 req.	
C-23	Capacitor—0.01 mfd.	19801
C-24	Capacitor—0.05 mfd.	19802
C-25	Capacitor—0.25 mfd.	19803
C-26	Capacitor—1.0 mfd.	19804
C-27, C-28, C-29	Capacitor—2 sections 15 mfd., 1 section 5 mfd.	19806
C-30	Capacitor—Same as C-5	
C-31	Capacitor—1 section 40 mfd.	19807
C-32	Capacitor—Same as C-7	
C-33	Capacitor—100 mfd.	12720
C-34, C-35	Capacitor—3,900 mmfd.	13763
C-36	Capacitor—3,300 mmfd.	4881
C-37	Same as C-36	
L-1	Omitted	
L-2, L-3	Filter Reactor	19812
M-1	Meter	44311
R-1	Resistor—180,000 ohms, 2 watts	19734
R-2	Resistor—10,000 ohms	13097
R-3	Resistor—1.29 ohms	19778
R-4	Resistor—3,300 ohms	30150
R-5	Resistor—18,000 ohms	19779
R-6	Resistor—8,750 ohms	19757
R-7	Resistor—2,270 ohms	19755
R-8	Resistor—2,165 ohms	19754
R-9	Resistor—544 ohms	19751
R-10	Resistor—170 ohms	19747
R-11	Resistor—10,800 ohms	19758
R-12	Resistor—4,930 ohms	19756
R-13	Resistor—2,100 ohms	19753
R-14	Resistor—1,030 ohms	19752
R-15	Resistor—538 ohms	19750
R-16	Resistor—290 ohms	19748
R-17	Resistor—360 ohms	19749
R-18	Resistor—1,120 ohms	19759
R-19	Resistor—1,700 ohms	19760
R-20	Resistor—Same as R-8	
R-21	Resistor—1,600 ohms	19761
R-22	Resistor—1,500 ohms	19762
R-23	Resistor—Same as R-17	
R-24	Resistor—412 ohms	19763
R-25	Resistor—260 ohms	19764
R-26	Resistor—308 ohms	19765
R-27	Resistor—154 ohms	19766
R-28	Resistor—Same as R-16	
R-29	Resistor—1,390 ohms	19767
R-30, R-31	Resistor—1,300 ohms	19768
R-32, R-33	Resistor—1,100 ohms	19769
R-34	Resistor—900 ohms	19770
R-35	Resistor—1,000 ohms	19771
R-36	Resistor—13,500 ohms, ½ watt	19735
R-37	Resistor—100,000 ohms, ½ watt	19736
R-38	Resistor—91,000 ohms, ½ watt	19737

ITEM	DESCRIPTION	Stock No.
R-39	Resistor—11,000 ohms, ½ watt	19738
R-40	Potentiometer	19798
R-41, R-42	Resistor—1,000 ohms, ½ watt	19739
R-43, R-44	Resistor—10,000 ohms, 2 watts	19740
R-45	Resistor—47.5 ohms, ½ watt	19741
R-46	Resistor—103 ohms	19772
R-47	Resistor—8.1 ohms	19773
R-48	Resistor—316 ohms	19774
R-49	Resistor—Same as R-14	
R-50	Resistor—81 ohms	19775
R-51	Resistor—3,160 ohms	19776
R-52	Resistor—10,300 ohms	19777
R-53	Resistor—100,000 ohms, ½ watt	3252
R-54	Resistor—470,000 ohms, ½ watt	30648
R-55	Potentiometer—2,000 ohms	19799
R-56	Resistor—1,000 ohms	4687
R-57	Resistor—120,000 ohms	30180
R-58	Resistor—22,000 ohms, ½ watt	30492
R-59, R-60	Resistor—6,800 ohms	14659
R-61	Resistor—220,000 ohms, ½ watt	14583
R-62	Resistor—Same as R-56	
R-63	Resistor—Same as R-57	
R-64	Resistor—22,000 ohms, 1 watt	30736
R-65, R-66	Resistor—Same as R-59	
R-67	Resistor—Same as R-61	
R-68	Resistor—1,800 ohms, ½ watt	30930
R-69	Resistor—27,000 ohms, 1 watt	13477
R-70, R-71	Resistor—27,000 ohms	30409
R-72	Resistor—470,000 ohms, ½ watt	30648
R-73	Resistor—1,800 ohms	19742
R-74	Potentiometer—12,000 ohms	19800
R-75	Resistor—40,000 ohms	44313
R-76	Resistor—1,000 ohms	19744
R-77	Resistor—3,700 ohms	19745
R-78	Resistor—1,500 ohms, 2 watts	19746
R-79	Resistor—3,300 ohms, 1 watt	30150
R-80 & S-7	Potentiometer	19796
R-81, R-82	Resistor—Same as R-58	
R-83	Resistor—430 ohms, ½ watt	19781
R-84	Resistor—470 ohms, ½ watt	19782
R-85	Resistor—560 ohms, ½ watt	19783
R-86	Resistor—620 ohms, ½ watt	19784
R-87	Resistor—910 ohms, ½ watt	19787
R-88	Resistor—1,300 ohms, ½ watt	19790
R-89	Resistor—680 ohms, ½ watt	31024
R-90	Resistor—300 ohms, ½ watt	19780
R-91	Resistor—Same as R-84	
R-92	Resistor—Same as R-85	
R-93	Resistor—Same as R-41	
R-94	Resistor—1,200 ohms, ½ watt	19789
R-95	Resistor—1.800 ohms, ½ watt	19792
R-96	Resistor—Same as R-83	
R-97	Resistor—Same as R-87	
R-98	Resistor—750 ohms, ½ watt	19785
R-99	Resistor—820 ohms, ½ watt	19786
R-100	Resistor—Same as R-94	
R-101	Resistor—Same as R-95	
R-102	Resistor—2,700 ohms, ½ watt	19793
R-103	Resistor—Same as R-99	
R-104	Resistor—1,600 ohms, ½ watt	3560
R-105	Resistor—1,100 ohms, ½ watt	19788
R-106	Resistor—1,600 ohms, ½ watt	19791
R-107	Resistor—3,000 ohms, ½ watt	19794
R-108	Resistor—9,100 ohms, ½ watt	19795
R-109	Potentiometer	19797
R-110	Resistor—82,000 ohms, ½ watt	8064
R-111	Omitted	
R-112, R-113	Resistor—68 ohms, ½ watt	32808
R-114	Resistor—330 ohms, ¼ watt	30538
R-115	Resistor—56,000 ohms, ½ watt	30650

PARTS LIST—Continued

ITEM	DESCRIPTION	Stock No.	ITEM	DESCRIPTION	Stock No.
S-1	Switch—1 section, 5 positions	19818		Binding Post (marked "HIGH")	4857 and 4605
S-2	Switch—2 sections, 8 positions	19813		Cover—Insulating for capacitor	28451
S-3	Switch—2 sections, 10 positions	19814		Fuse Mounting	4774
S-4	Switch—3 sections, 12 positions	19815		Fuse—2 amperes	3883
S-5	Switch—2 sections, 4 positions	19817		Grid Cap	30314
S-6	Switch—6 sections, 12 positions	19816		Insulator	16531
S-7	Included in R-80			Jack Assembly	30079
T-1	Bridging Transformer, XT-3100	19809		Knob (small size)	4323
T-2	Balancing Transformer, XT-3103	19810		Knob Assembly (medium size)	17268
T-3				Knob Assembly (large size)	17269
T-4	Input Transformer, XT-3118	19811		Lamp	11891
T-5	Power Transformer, XT-3150	19808		Motor Connector Base	23225
				Mounting Plate	19820
	MISCELLANEOUS			Mounting Plate	28452
	Binding Post (marked "O")	4860		Pilot Light	34258
	Binding Post (marked "LOW")	4606		Scale—Dial for meter No. 44311	44312
				Tube Socket	18467
				Tube Socket	31769
				Tube Shield Top	4629
				Tube Shield	3682
				Tube Shield	3950

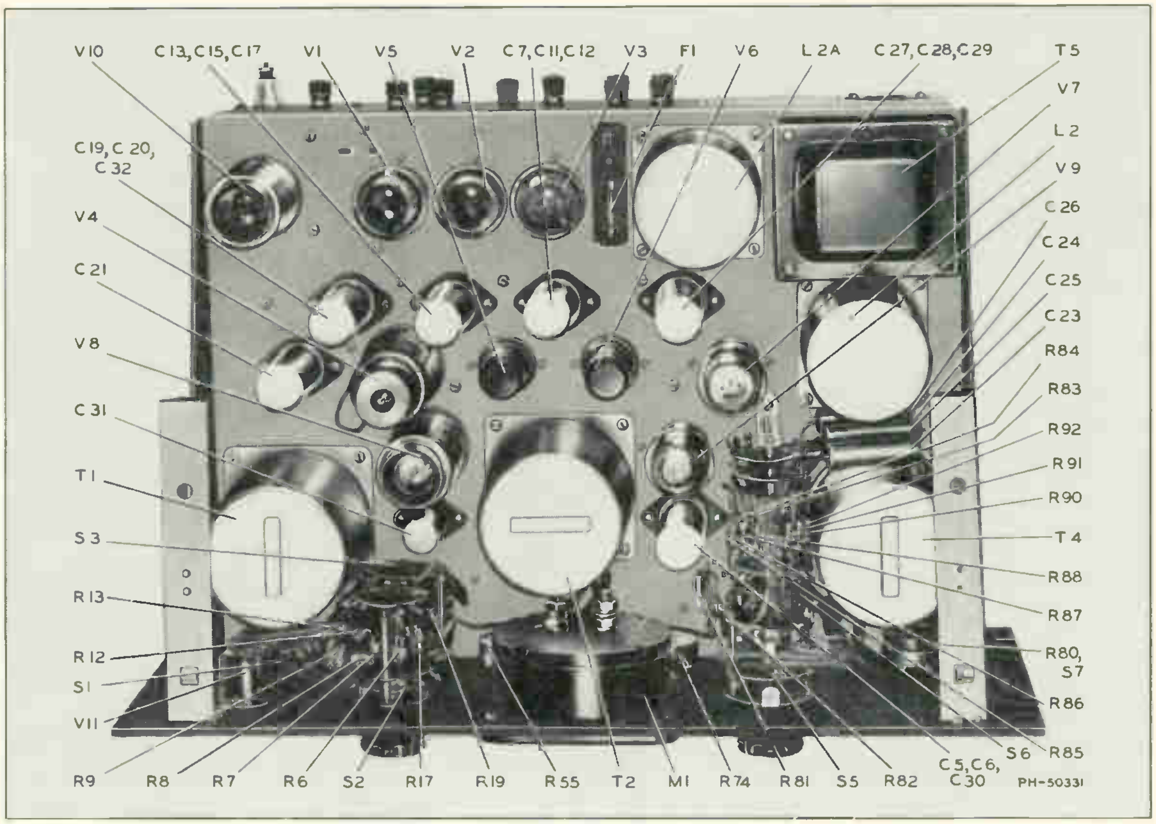


Figure 4—Chassis and Panel Assembly, Top View

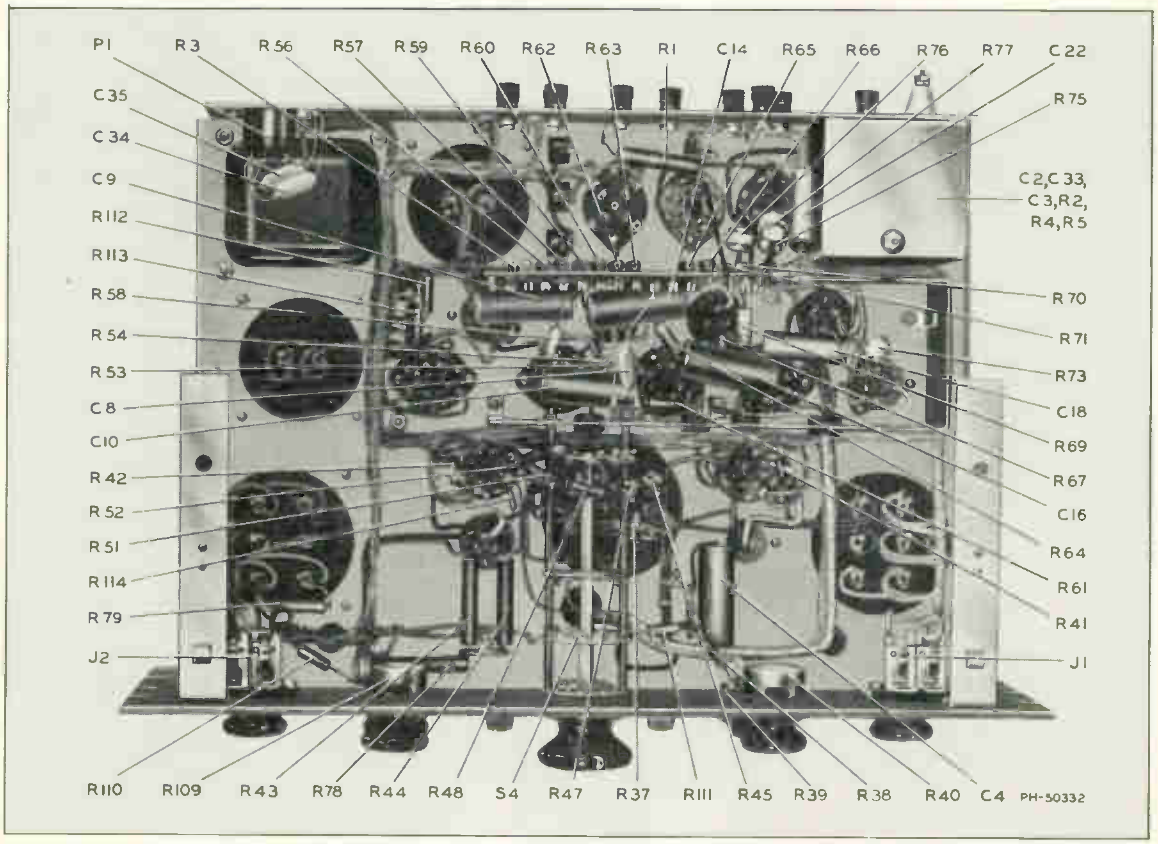


Figure 5—Chassis and Panel Assembly, Bottom View

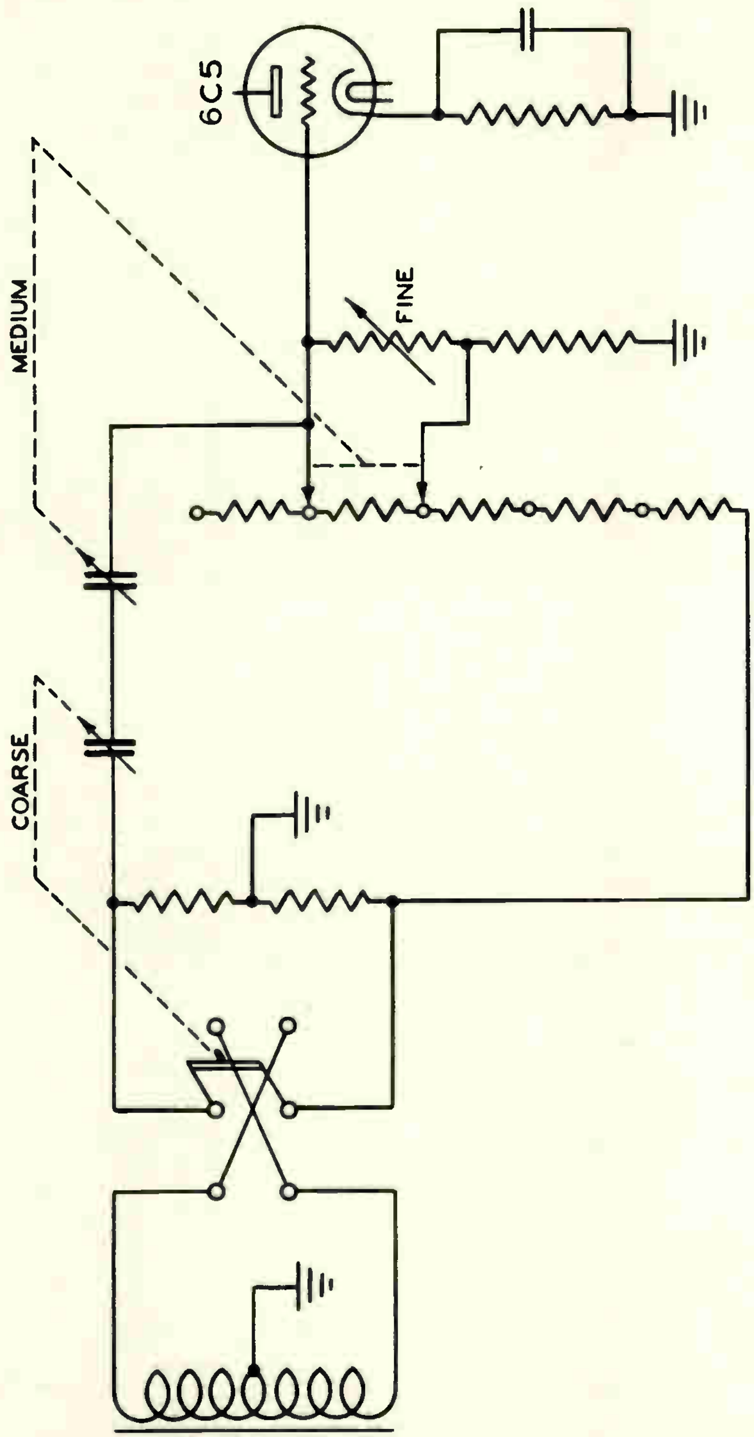


Figure 6—Phase Shifting Network
(Schematic K-849405)

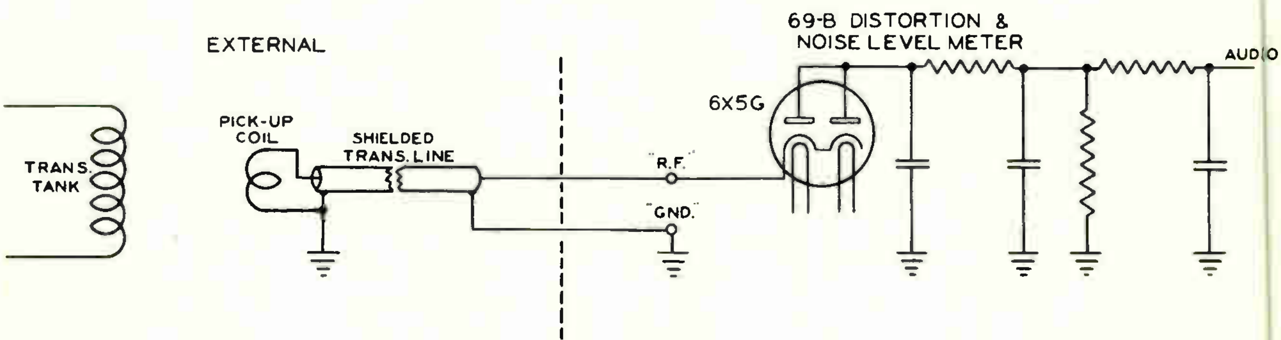


Figure 7—R-F Rectifier
(Schematic K-849404)

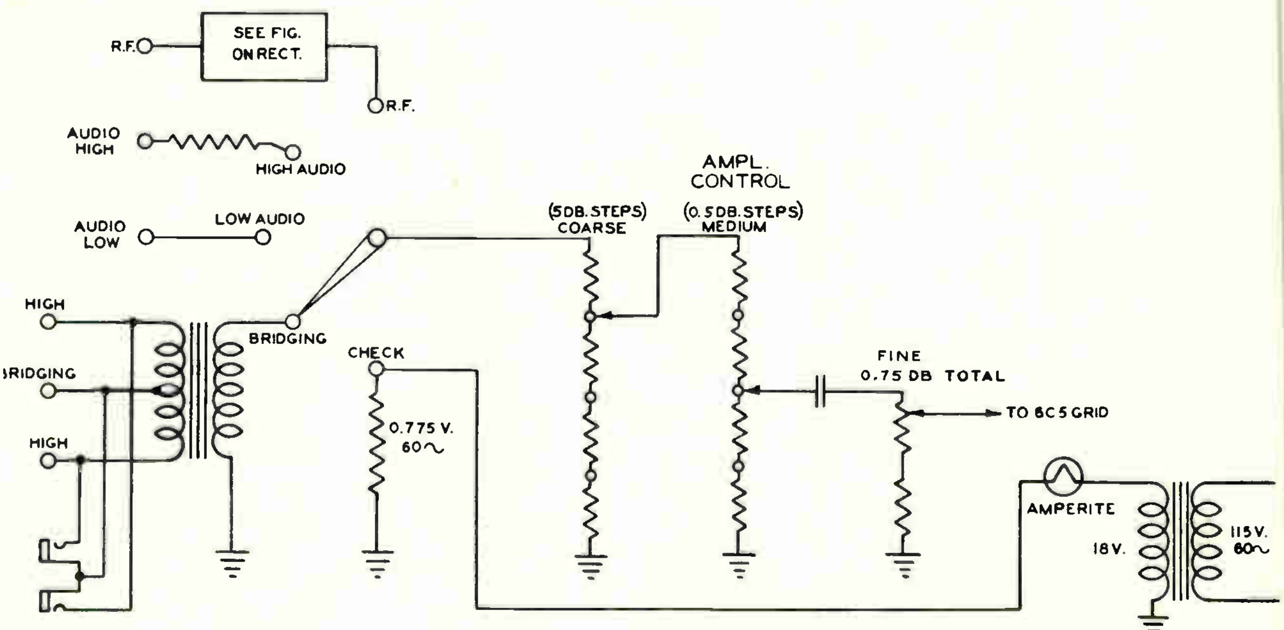


Figure 8—Input Circuit
(Schematic K-849407)

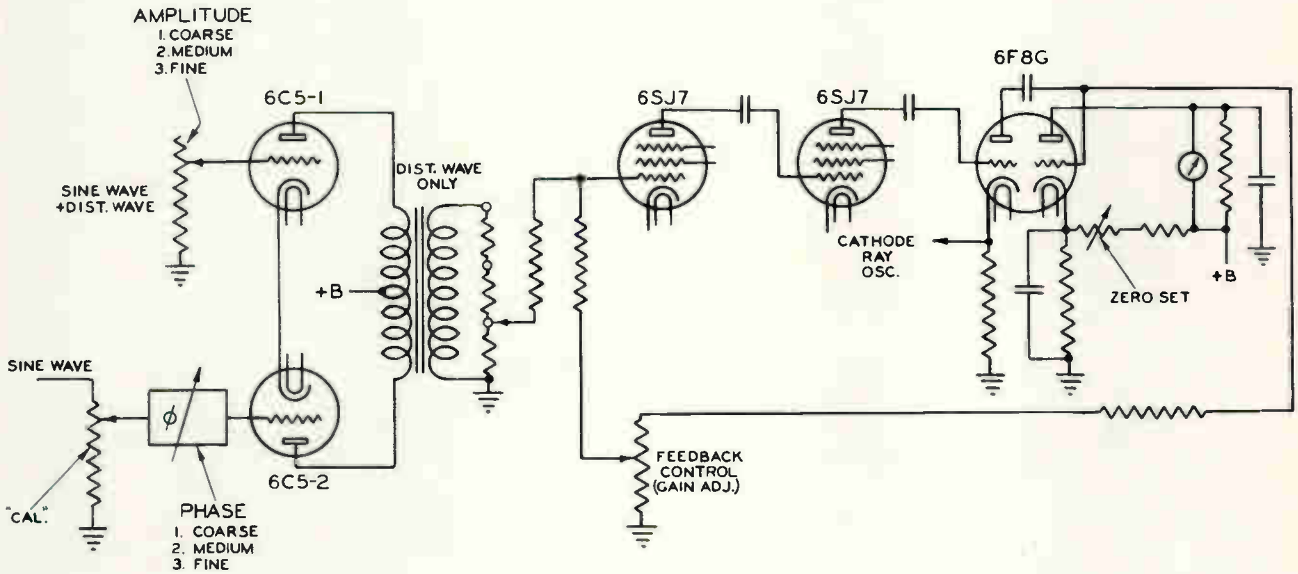


Figure 9—Distortion Measurement Circuit (Schematic K-849406)

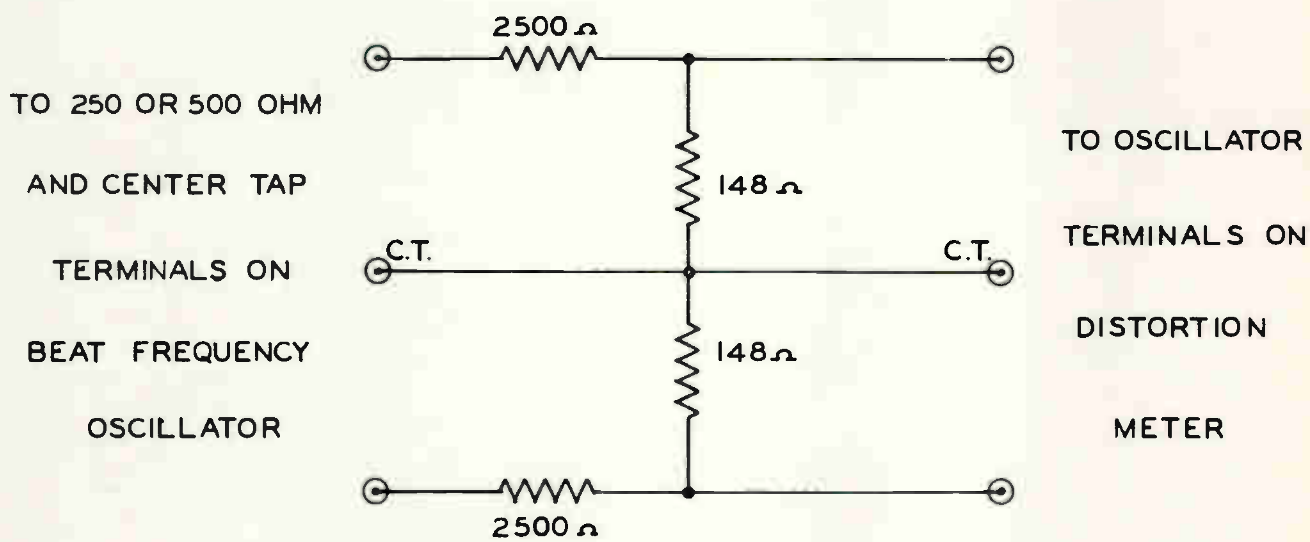


Figure 10—Typical Attenuator (Schematic K-841775)

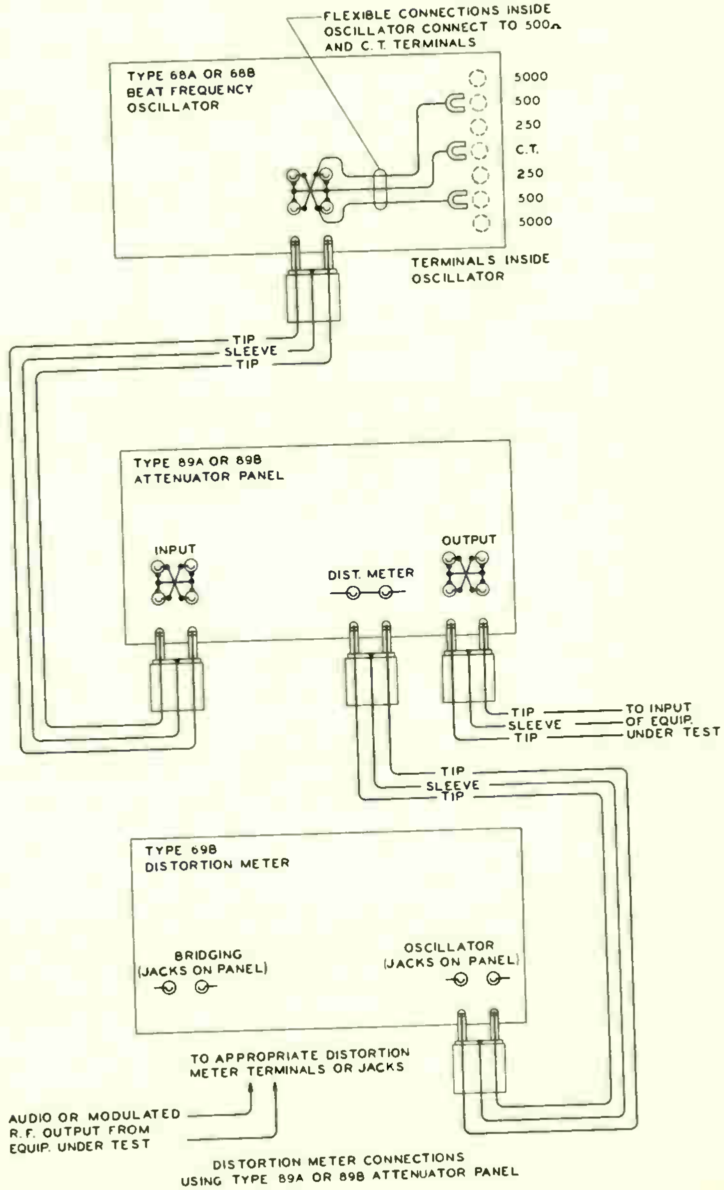


Figure 11—Distortion Meter Connections Using 89A or 89B Attenuator Panel (P-714628)

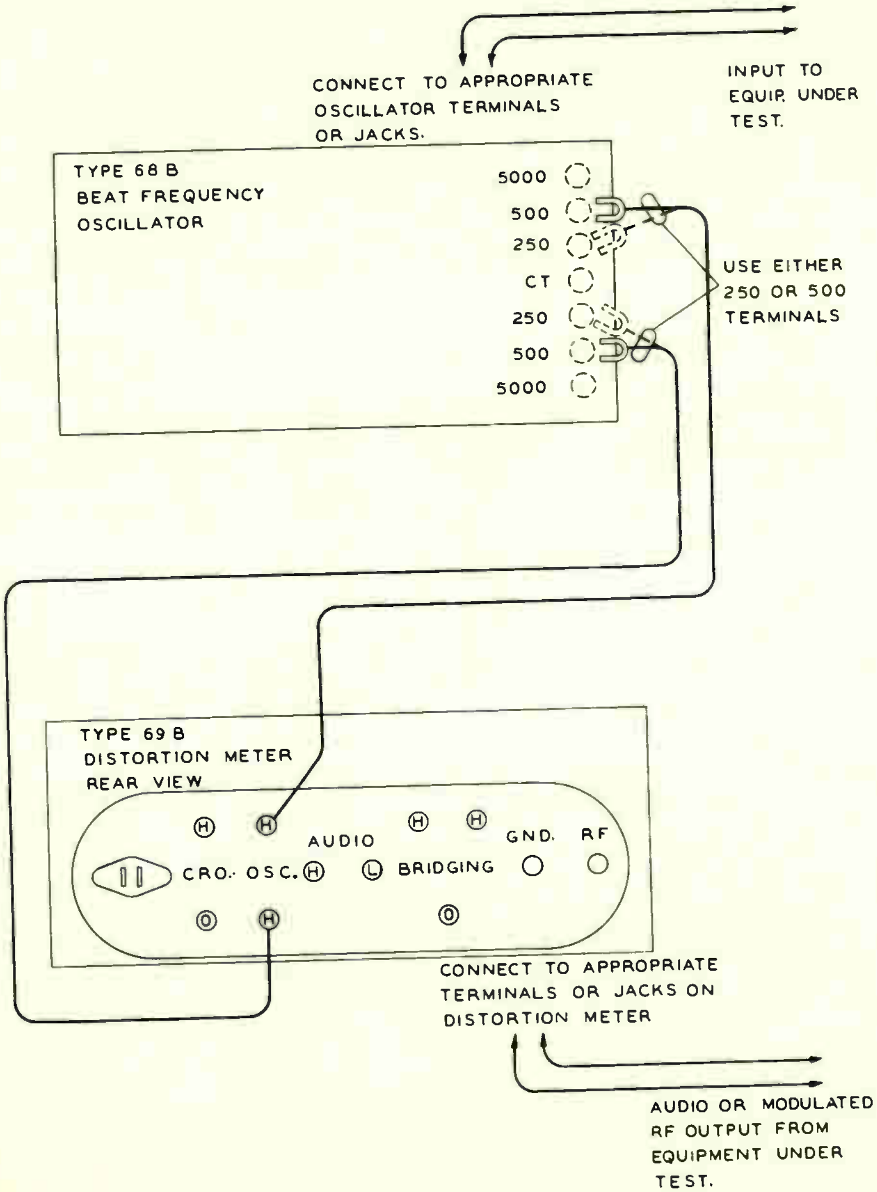


Figure 12—Distortion Meter Connections Using Direct Wiring (M-428492)

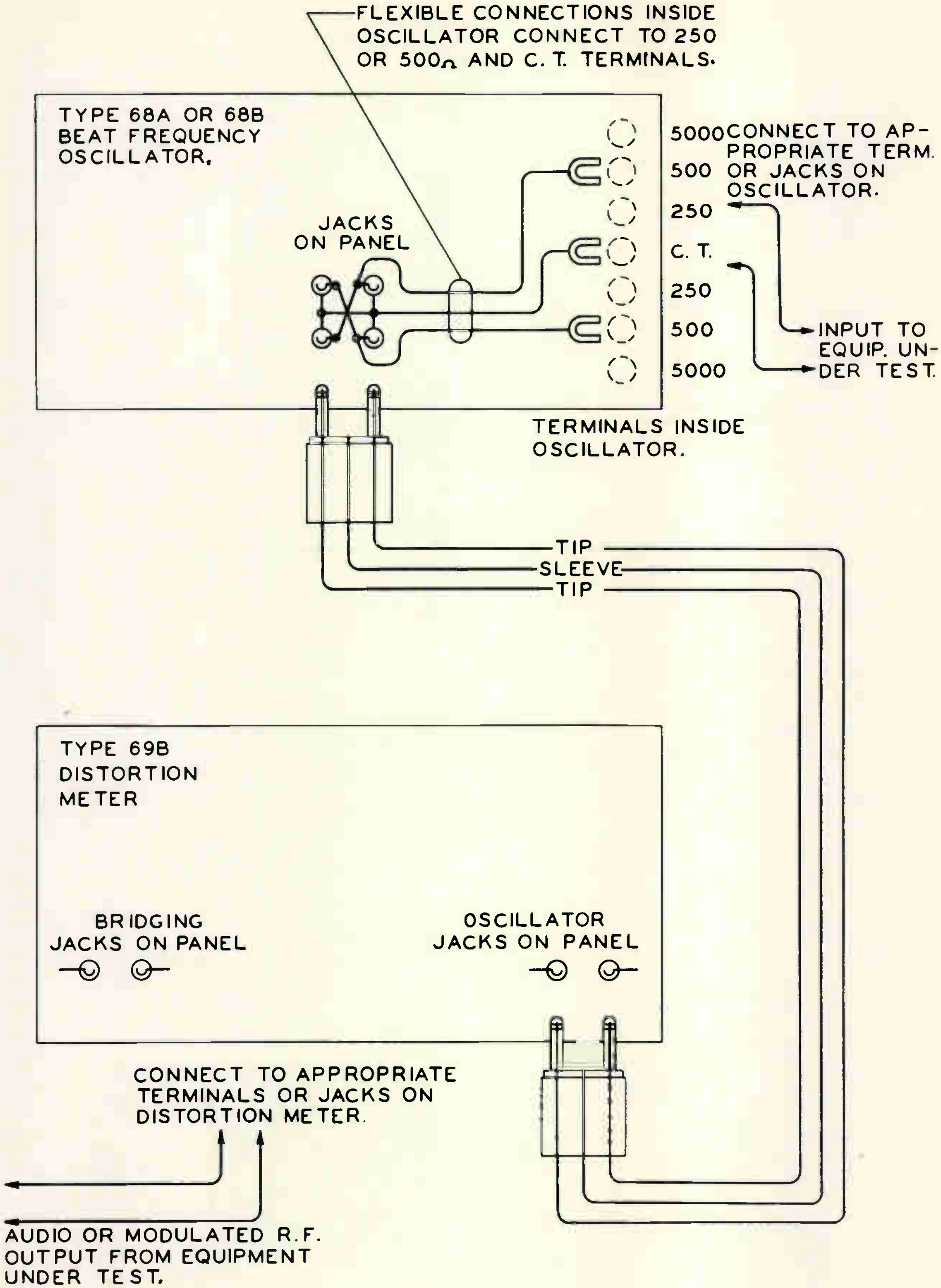


Figure 13—Distortion Meter Connections Using Patch Cords (M-428505)

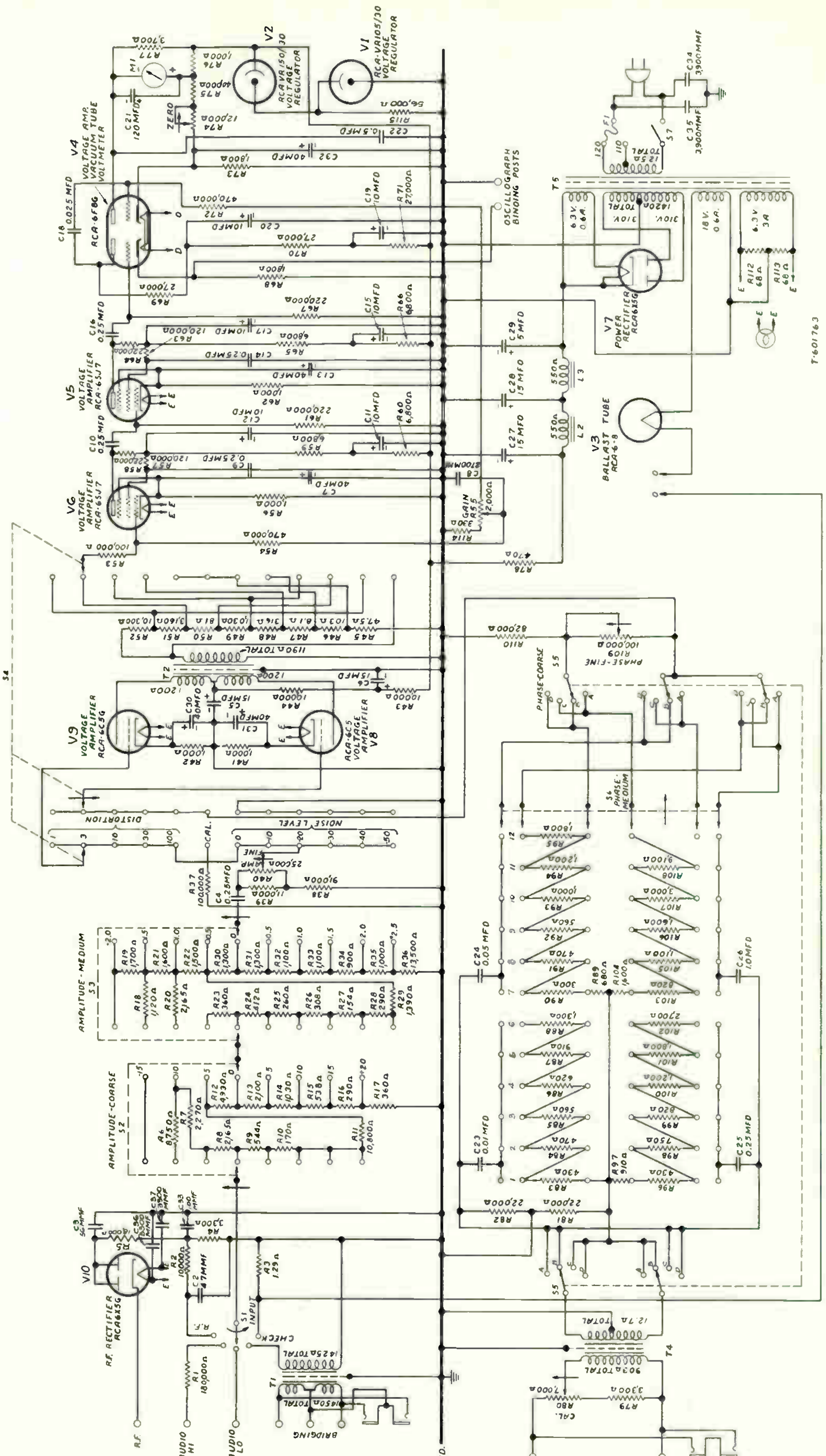


Figure 14—Distortion and Noise Meter (Schematic T-601763)

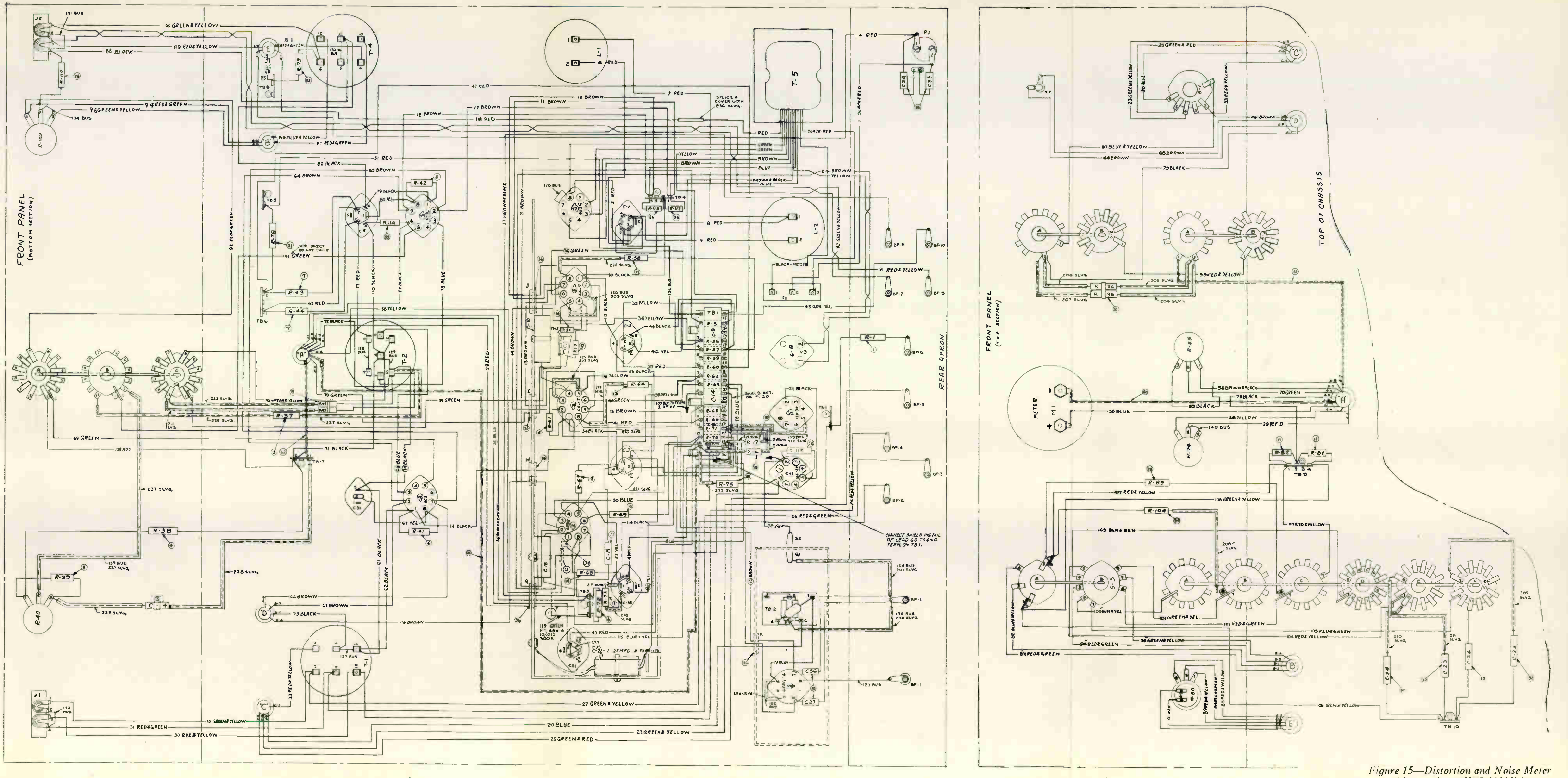


Figure 15—Distortion and Noise Meter (Connections WW-302287)

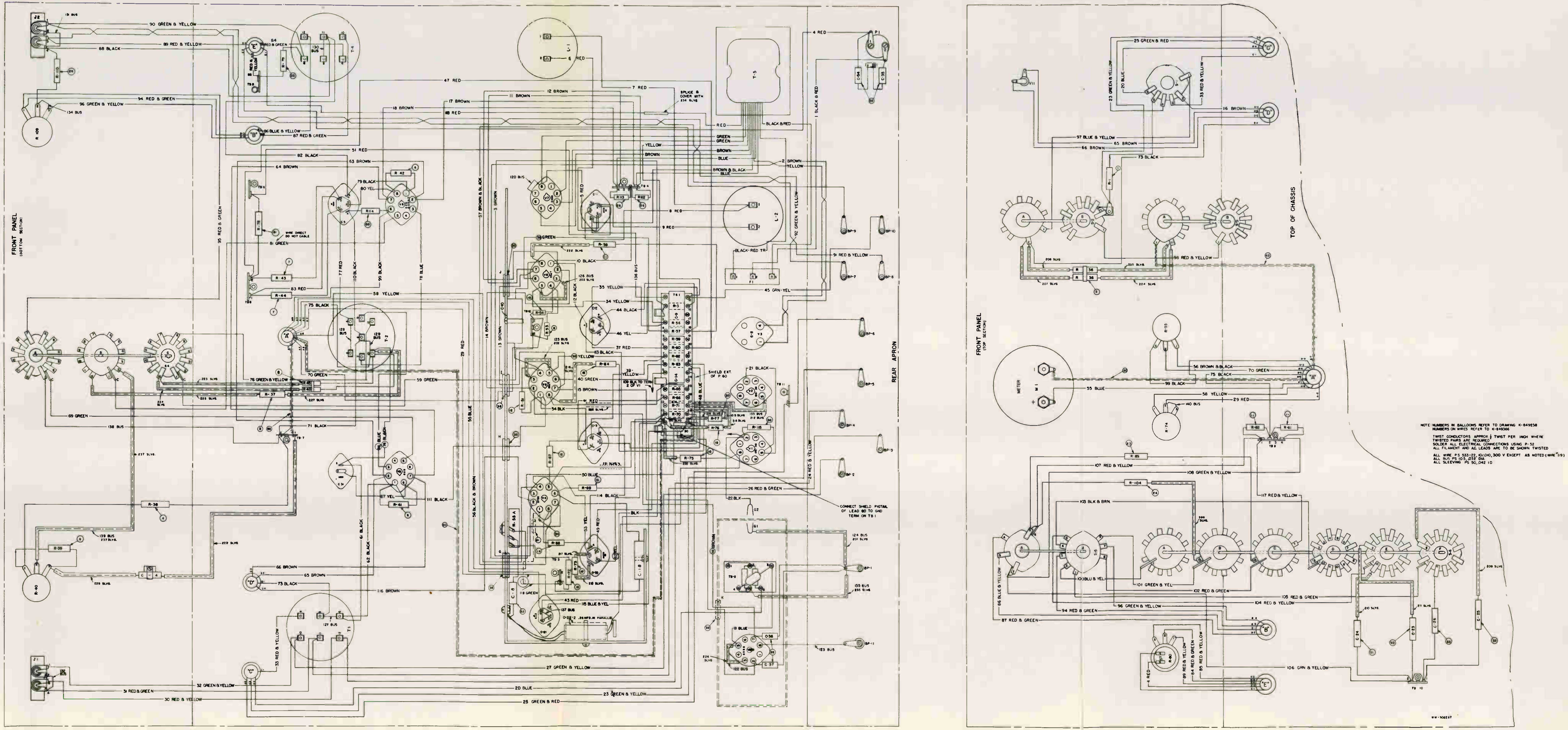


Figure 15—Distortion and Noise Meter (Connections WW-302287)

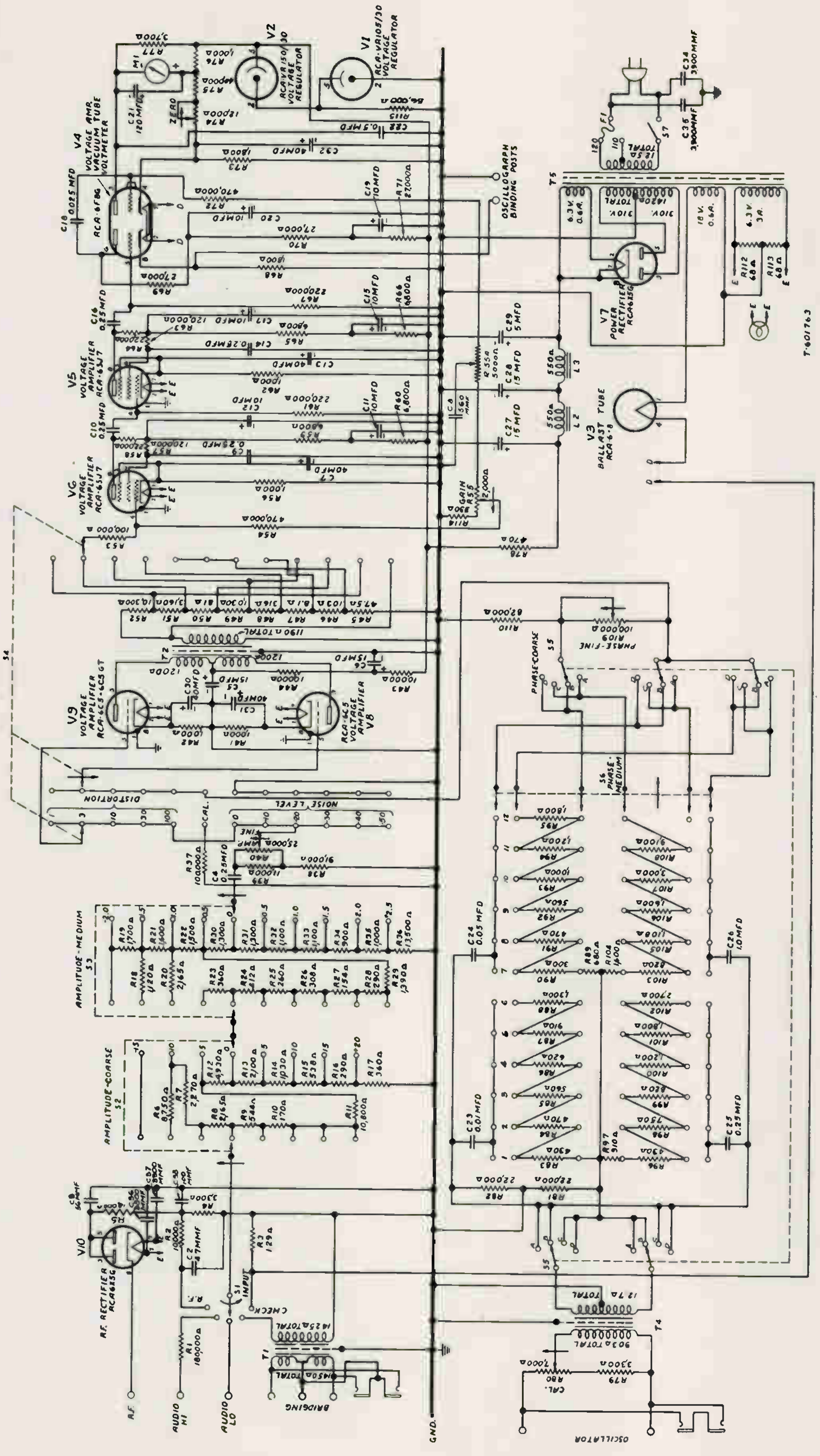


Figure 14—Distortion and Noise Meter (Schematic T-601763)