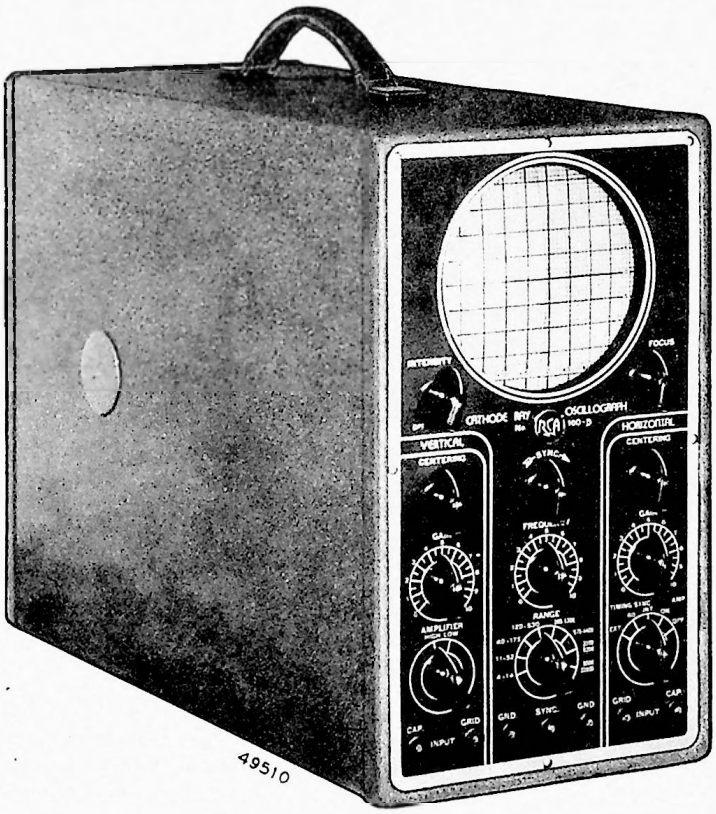
CATHODE-RAY OSCILLOGRAPH

STOCK NO. 160-B



RADIO CORPORATION OF AMERICA

Camden, New Jersey, U. S. A.

1B-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.

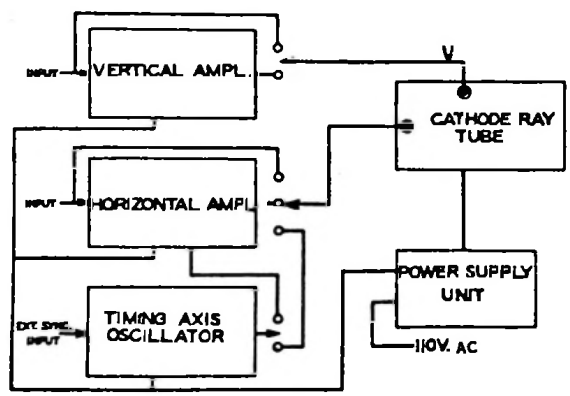


Figure 1—Block Diagram

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

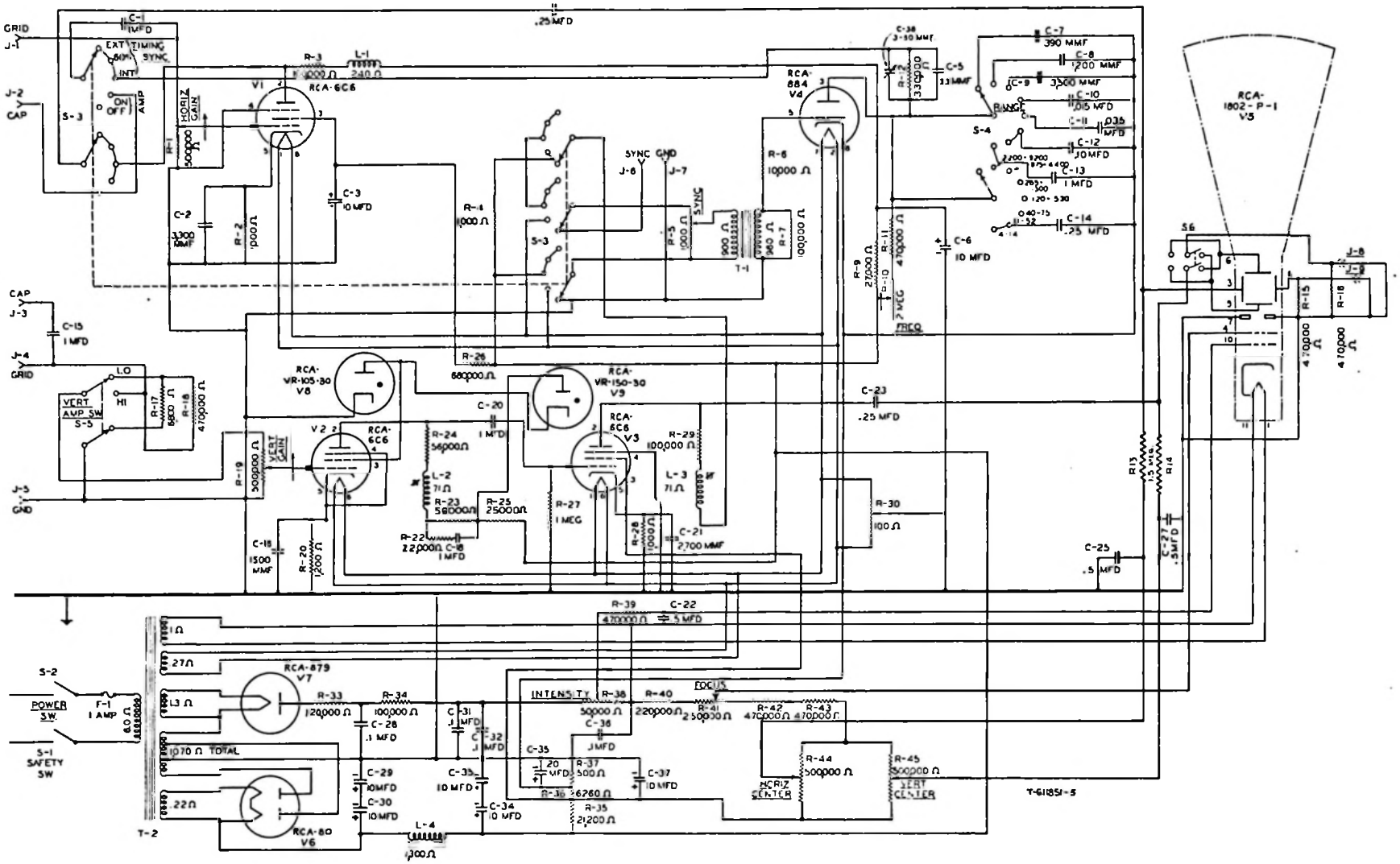


Figure 2—Schematic Circuit Diagram, Stock No. 160B

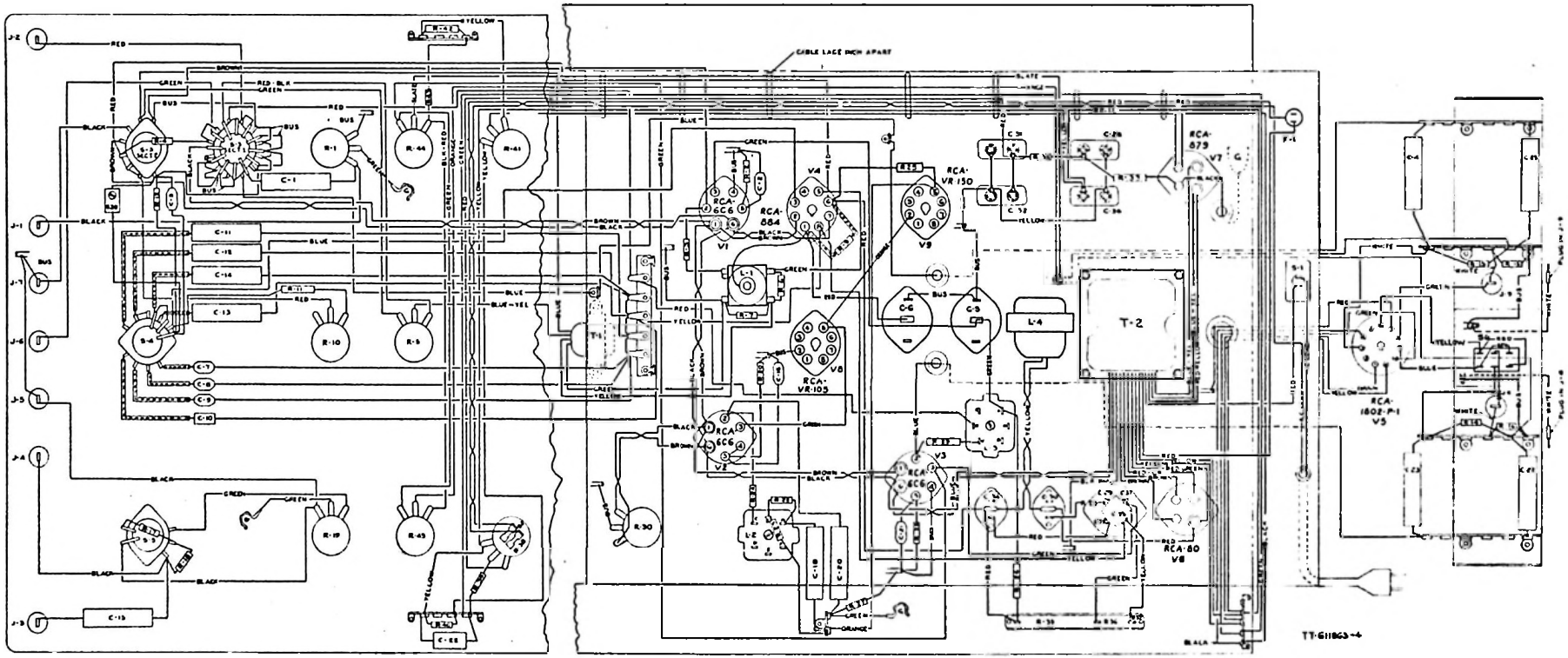


Figure 3 Chassis Wiring Diagram, Stock No. 165B

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-to-peak) 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-

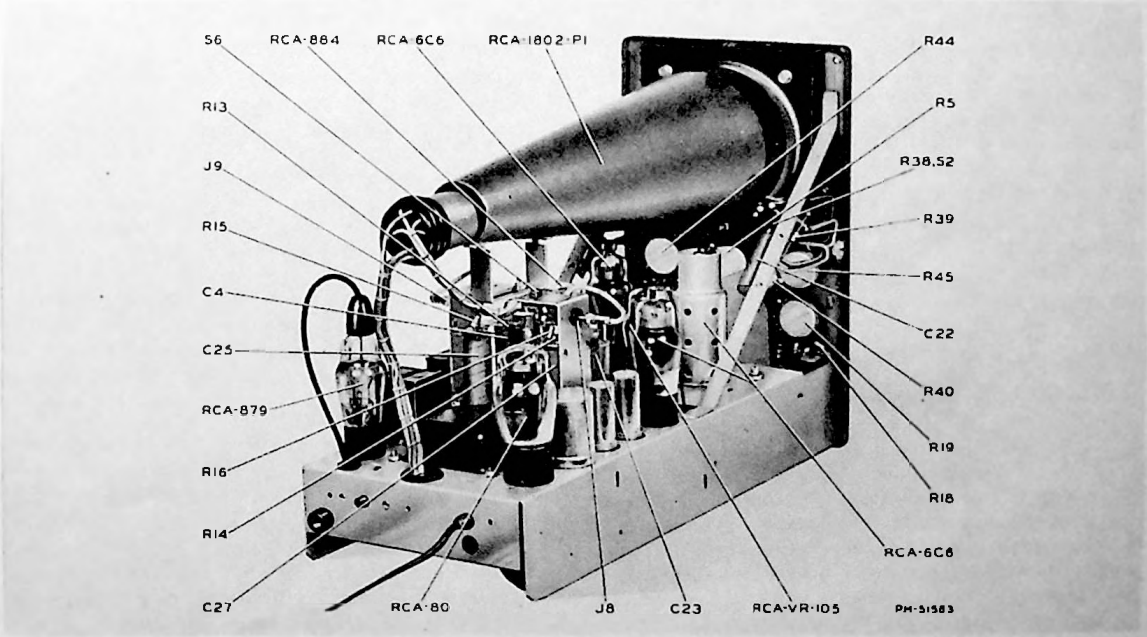


Figure 4—Top View of Chassis

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-

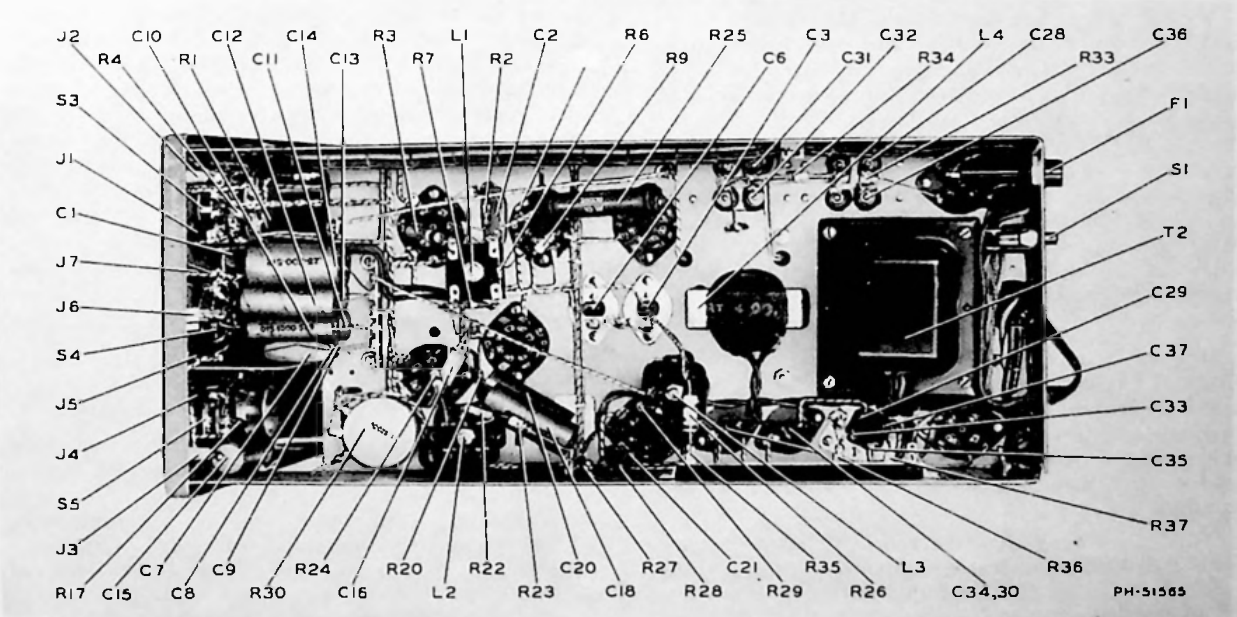


Figure 5—Bottom View of Chassis

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."

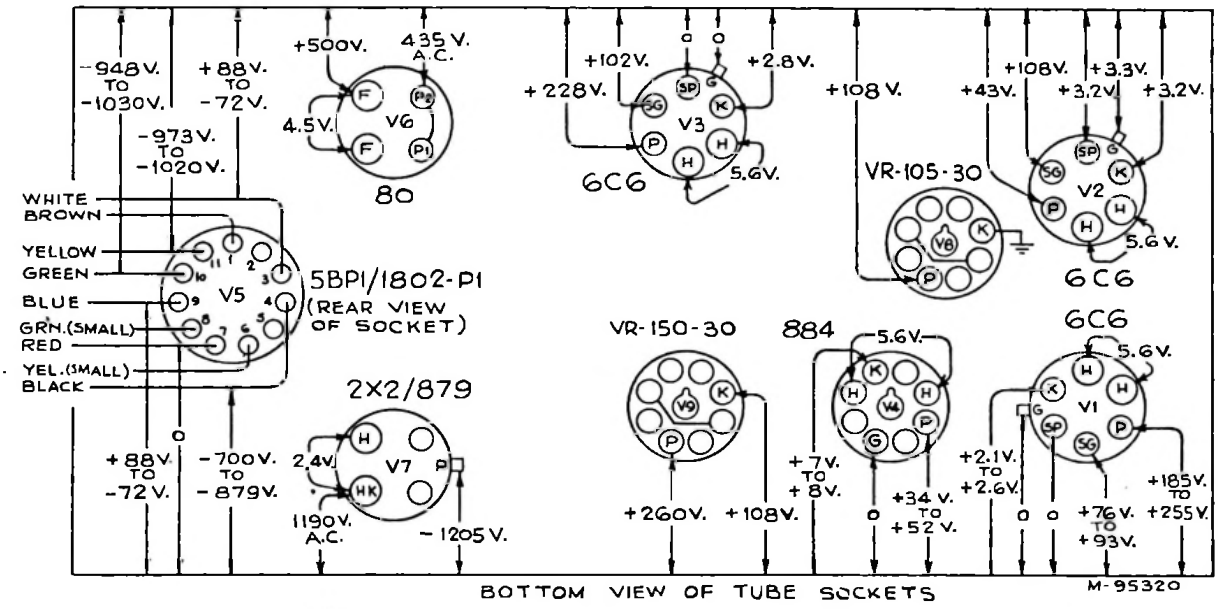
Care should be exercised in replacing any part that may be found faulty. All wiring associated with the part involved must be removed, and especial attention given to the possibility of damage to other wiring or parts. The relation of wiring and parts should be the same as in the original assembly. The 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)

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Replacement parts supplied are within Engineering Specification Tolerances.

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