scope is by checking the values of the voltages at the tube sockets. The normal values, which can be expected to be found when the instrument is working properly under the specified power rating (117-volt, 60 cycle), are indicated adjacent to the socket positions in Figure 4. 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. Some of the voltages are not measurable with low resistance voltmeter.

REPLACEMENT PARTS

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

Stock No.	DESCRIPTION
47068	Capacitor—Silvered mica, 91 mmfd. (C-28)
39652	Capacitor—Silvered mica, 1000 mmfd. (C-33)
37617	Capacitor—.001 mfd. (C-27)
33806	Capacitor—.0015 mfd. (C-3, C-6)
36474	Capacitor—.002 mfd. (C-32)
47067	Capacitor—.008 mfd. (C-26)
11315	Capacitor—.015 mfd. (C-31)
47066	Capacitor—.06 mfd. (C-25)
47070	Capacitor—0.15 mfd. (C-30)
12484	Capacitor—0.25 mfd., 350 volts (C-1, C-2, C-4, C-5, C-17, C-18, C-23)
15943	Capacitor—Oil-filled paper, 0.25 mfd., 800 v. (C-12, C-13)
47069	Capacitor—1 mfd., 400 volts (C-29)
46705	Capacitor—Electrolytic, 8 mfd., 250 volts (C-16)
32342	Capacitor—Electrolytic, comprising two sections of 10 mfd., 450 volts each (C-19, C-21)
47052	Clamp—Tube clamp for 3AP1-A tube
4867	Coil—Plate choke coil (L-2, L-3)
14086	Cord—Power cord
14133	Fuse—1 ampere (F-1)
30925	Handle—Case carrying handle
13526	Holder—Fuse holder
47061	Jack—Binding jack
7960	Knob—Bar knob
47059	Mounting—Comprising 1 felt ring and 1 felt liner to mount tube
47053	Nut—#8-32 hex nut to hold tube clamp
47089	Plug—Solderless locking pin plug (use with 47061) (not supplied with instrument)

Stock No.	DESCRIPTION
47062	Post—Binding post (use with 47061)
31898	Potentiometer—"Centering" or "Focus" control (R-16, R-22, R-23)
47065	Potentiometer—"Frequency" control (R-32)
31893	Potentiometer—"Gain" control (R-1, R-5)
31897	Potentiometer—"Intensity" control (R-14)
50953	Potentiometer—"Range Adjustment" control (R-30)
31894	Potentiometer—"Sync Adjust" control (R-8)
13111	Reactor—Filter reactor
3581	Resistor—200 ohms, ½ watt (R-29)
30731	Resistor—1200 ohms, ½ watt (R-2, R-7)
30436	Resistor—12,000 ohms, ½ watt (R-27)
13669	Resistor—22,000 ohms, 2 watts (R-20, R-21, R-34)
30434	Resistor—39,000 ohms, 1 watt (R-13)
14138	Resistor—68,000 ohms, ½ watt (R-31)
30679	Resistor—68,000 ohms, 1 watt (R-3, R-6)
3252	Resistor—100,000 ohms, ½ watt (R-15)
31899	Resistor—270,000 ohms, 1 watt (R-17)
30649	Resistor—2.2 megohms, ½ watt (R-24, R-25)
47060	Screen—Calibrated screen and support ring
47055	Shield—Light shield for cathode-ray tube
47057	Socket—Cathode-ray tube socket
33084	Socket—Tube socket
30927	Spring—Panel mounting spring
31902	Switch—"Horizontal Input" switch (S-1)
47054	Switch—"Sweep Range" switch (S-4)
47064	Switch—"Sync Selector" switch (S-2)
46361	Transformer—Power transformer (T-1)

Replacement parts supplied may not necessarily be identical to those in the instrument, because of necessary substitutions, but are within Engineering Specification Tolerance.
45-12-7

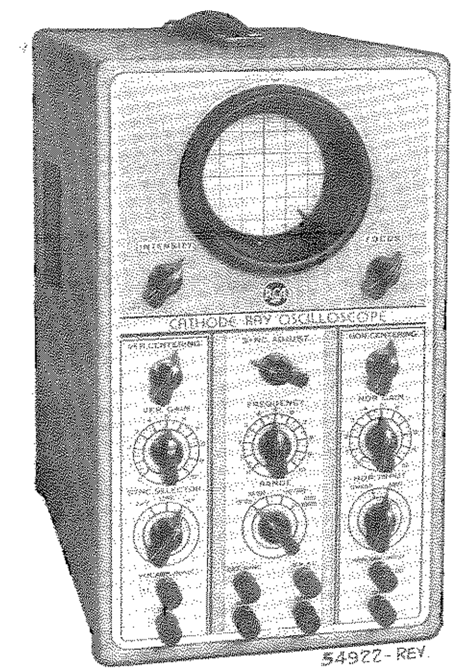
Printed in U. S. A.

IB-26455-2

RCA

CATHODE-RAY OSCILLOSCOPE

TYPE NO. 155C



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

WARNING—A POTENTIAL OF 1000 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.

Cathode-Ray Oscilloscope

(Also widely known as Cathode-Ray Oscillograph)

Type No. 155C

TECHNICAL SUMMARY

Power Supply

- Rating .... 110-120 volts, 50-60 cycles
- (Specifications based on. 117 volts, 60 cycles)
- Power Consumption .... 50 watts
- Fuse Protection .... 1 ampere

Overall Dimensions

- Height (including handle) ..... 14⅜ inches
- Width .... 8 inches
- Depth .... 14¼ inches
- Net Weight .... 21 pounds

Tube Complement

- RCA-6SJ7 (GT/G) ...... Vertical Amplifier
- RCA-6SJ7 (GT/G) ... Horizontal Amplifier
- RCA-6C8G .... Timing Axis Oscillator
- RCA-3AP1-A ... Cathode-Ray Tube (3-inch)
- RCA-5Y3GT/G ...... Low Voltage Rectifier
- RCA-5Y3GT/G ..... High Voltage Rectifier

Operating Data

	When Amplifiers are used (Gain controls max.)	Direct connection to Deflecting plates (through external D-C Blocking Capacitor)
Deflection sensitivity at 1 kc.	2.8 peak-to-peak volts (1 volt r-m-s) per inch*	77 peak-to-peak volts (27 volts r-m-s) per inch*
Polarity of deflection	Positive direction is DOWN for vertical input, to the RIGHT for horizontal input	Positive direction is UP for vertical input, to the LEFT for horizontal input
Sine-Wave Response—Vertical and Horizontal Amplifiers	Uniform ±10% ... 7 c.p.s. to 40 kc.* Uniform ±20% .... to 80 kc.* Useful Range .... to 200 kc.*	Low frequency limit determined by value of Blocking Capacitor used. High frequency limit determined by length of connecting leads and external circuit
Input Impedance	0.5 megohm in parallel with 22 mmfd.	2.2 megohms in parallel with 24 mmfd.

Frequency Range of Timing Axis Oscillator = 10 c.p.s. to 60 kc.*
Sweep Direction—Left to right.
Input Impedance at External Sync. Terminals 0.1 megohm.

* Average values.

DESCRIPTION

The Type No. 155C Cathode-Ray Oscilloscope 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. It facilitates 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 110 to 120 volts, 50 to 60 cycles, an integral power supply unit furnishing all voltages required for operation. Construction is of rugged design, making an instrument ideally suited for field service, laboratory, industrial, and school requirements.

The type 155C features the following improvements over the previous models:

The image on the tube screen may be observed through normal viewing angle with lower intensity due to an improved, permanently mounted deep light-shield.

The graph screen is ruled in divisions of one-tenth inch and is readily removable.

The deflection plates are accessible through an opening in the case, permitting connections of very low input capacity.

Terminals are new combination pin-jacks and binding posts which afford greater flexibility in making connections to the instrument.

The timing axis oscillator circuit is of an improved design, allowing the oscilloscope to be synchronized with low voltages in the audio, supersonic, and low R-F ranges. Linearity is practically uniform throughout the range of 10 c.p.s. to 60 kc.

A 6.3 volt, 60 cycle supply is brought out to a binding-jack for convenient general use in oscilloscope observations.

Both the Vertical and Horizontal amplifiers have improved response characteristics.

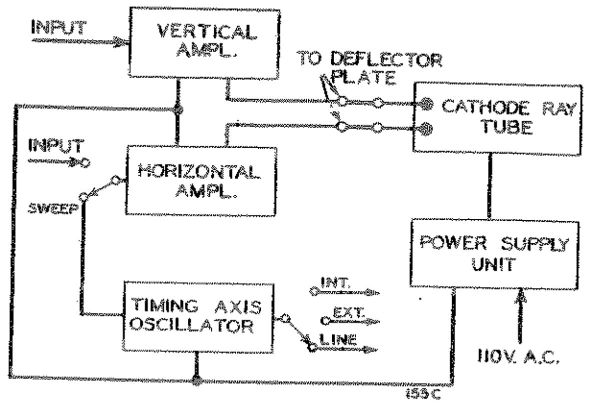


Figure 1—Block Diagram

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

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.

PREPARATION FOR USE

Unpack the instrument from the shipping container and remove the screws at the rear. 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 the grid-cap connection is in place, then replace the chassis in the case and replace the securing screws. With the INTENSITY control in the extreme counterclockwise (OFF) position, plug the power-supply cable into an electrical outlet supplying 110-120 volts at 50-60 cycles. The instrument is then ready for operation.

NOTE: DO NOT ATTEMPT TO OPERATE THE EQUIPMENT WHEN WITHDRAWN FROM THE CASE AS THE HIGH POTENTIALS USED ARE DANGEROUS.

CONTROL FUNCTIONS AND TERMINAL CONNECTIONS

Refer to cover illustration for location of controls and the schematic diagram (Figure 2) for the location of circuit units designated by symbols.

1. **INTENSITY control, turned in a clockwise rotation from the OFF position, closes the power supply switch. Additional rotation increases the brilliancy of the image on the tube screen.** This control (R-14) is a potentiometer in the low side of the high voltage bleeder. Its position 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 brilliancy.

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.

2. **FOCUS control determines the distinctness of the spot or image on the tube screen and should be varied to correspond to changes in INTENSITY.** The control (R-16) is a potentiometer in the high-voltage bleeder and it controls the first anode voltage, which with constant second anode voltage, determines the distance at which the electron beam focuses.

3. **VER. CENTERING and HOR. CENTERING. These centering controls govern the position of the spot or image on the tube screen and should be adjusted in conjunction with INTENSITY and FOCUS controls. Start with both controls at about mid-position, as it is possible for spot to be completely off-screen.** The controls are potentiometers (R-23, R-22) that control the amount of d-c potential between the two deflecting plates of each pair, and thereby allow adjustment of the position of the spot or image.

4. **VER. AMP. INPUT. Voltage impressed on these terminals will give vertical deflection.**

5. **VER. GAIN. This control governs the input voltage to the amplifier, thus controlling vertical deflection.** It consists of a potentiometer (R-1) in the input circuit of the vertical amplifier.

6. **HOR. AMP. INPUT. Voltage impressed on these terminals will give horizontal deflection.**

7. **HOR. GAIN. This control governs the input voltage to the horizontal amplifier, thus controlling horizontal deflection.** It consists of a potentiometer (R-5) in the input circuit of the horizontal amplifier and is effective with the HOR. INPUT switch in either the SWEEP or AMP. position.

8. **HOR. INPUT switch. Horizontal input switch (S-1) has two positions:**

AMP. (amplifier) position which connects the HOR. AMP. INPUT terminals to the input of the horizontal amplifier.

SWEEP position which causes the internal timing axis oscillator voltage to be applied to the cathode-ray tube through the horizontal amplifier. In this position the HOR. AMP. INPUT terminals are disconnected but the HOR. GAIN control is still effective.

9. **RANGE.** Sweep range switch (S-4) selects **one of four timing circuits.** It thus changes the timing-axis oscillator frequency in steps giving four ranges approximately as shown on the front panel. As the frequency ranges overlap, the switch setting giving the highest frequency should be used.

10. **FREQUENCY. This control changes the timing-axis oscillator frequency gradually as it is rotated and should be used in conjunction with the RANGE switch to give continuous range between the extremes of frequency.** The control is a dual potentiometer (R-32) located in the timing circuits.

11. **EXT. SYNC. terminals are used when it is desired to synchronize the timing-axis oscillator with some external source** (see SYNC. ADJUST.).

12. **SYNC. SELECTOR switch (S-2) has three positions:**

EXT.—On external position the EXT. SYNC. binding jack is connected to the SYNC. ADJUST. control. This allows the use of an external source of synchronizing voltage to be applied.

LINE.—On line position the SYNC. ADJUST. control is connected to a power line frequency source. The actual frequency is dependent on that of the power line itself, usually being 50 or 60 cycles. The line sync. source is supplied by the 6-volt heater circuit.

INT.—On internal position, the SYNC. ADJUST. control locks the image with the frequency of the applied vertical input voltage. It derives a signal from the output of the vertical amplifier by being connected to the cathode of the 6SJ7 tube. The timing-axis oscillator can be synchronized with the signal on the vertical axis at the fundamental frequency or at any small submultiple, such as 1/2, 1/3, etc. Synchronization is not effective if it is attempted to operate the timing axis oscillator at a higher frequency than that of the synchronizing voltage.

13. **SYNC. ADJUST. This control should be set as far counterclockwise as is consistent with a locked image, since over-synchronization causes poor wave-form from the timing-axis oscillator.** The control (R-8) is a potentiometer controlling the amount of synchronizing voltage fed to a grid of the 6C8-G tube.

14. **GND.** The terminals marked GND. are common ground and are connected to the chassis.

15. **6V. A-C.** This terminal and GND. supplies approximately 6 volts at the frequency of the electrical power supply. The source may be used as a synchronizing voltage or as a filament for an external diode rectifier.

16. **DEFLECTING PLATE.** Direct connections to the vertical and horizontal deflecting plates of the cathode-ray tube may be made by removing the "U" shaped jumper connecting the two binding jacks in the amplifier-to-plate circuit (accessible through a door in the side of the case).

The input voltage must be connected between the upper binding jack and ground. The binding jack on the right-hand side facing the terminal board is the horizontal plate connection and that on the left, the vertical plate connection. In applications using low frequencies, a blocking capacitor of .25 mfd. should be used in series with the deflecting plates. For high frequencies (R-F) a 1,000 mmfd. or smaller, capacitor should be used, the exact value being relative to frequency.

OPERATION

GENERAL. 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.

Most applications of this instrument are performed with the output of the unit under test connected to the vertical input terminals of the oscilloscope, and the wave shape studied by application of the sawtooth timing voltage between the horizontal plates of the tube. Before any measurements are attempted, the operator is urged to go through the following procedure in order to

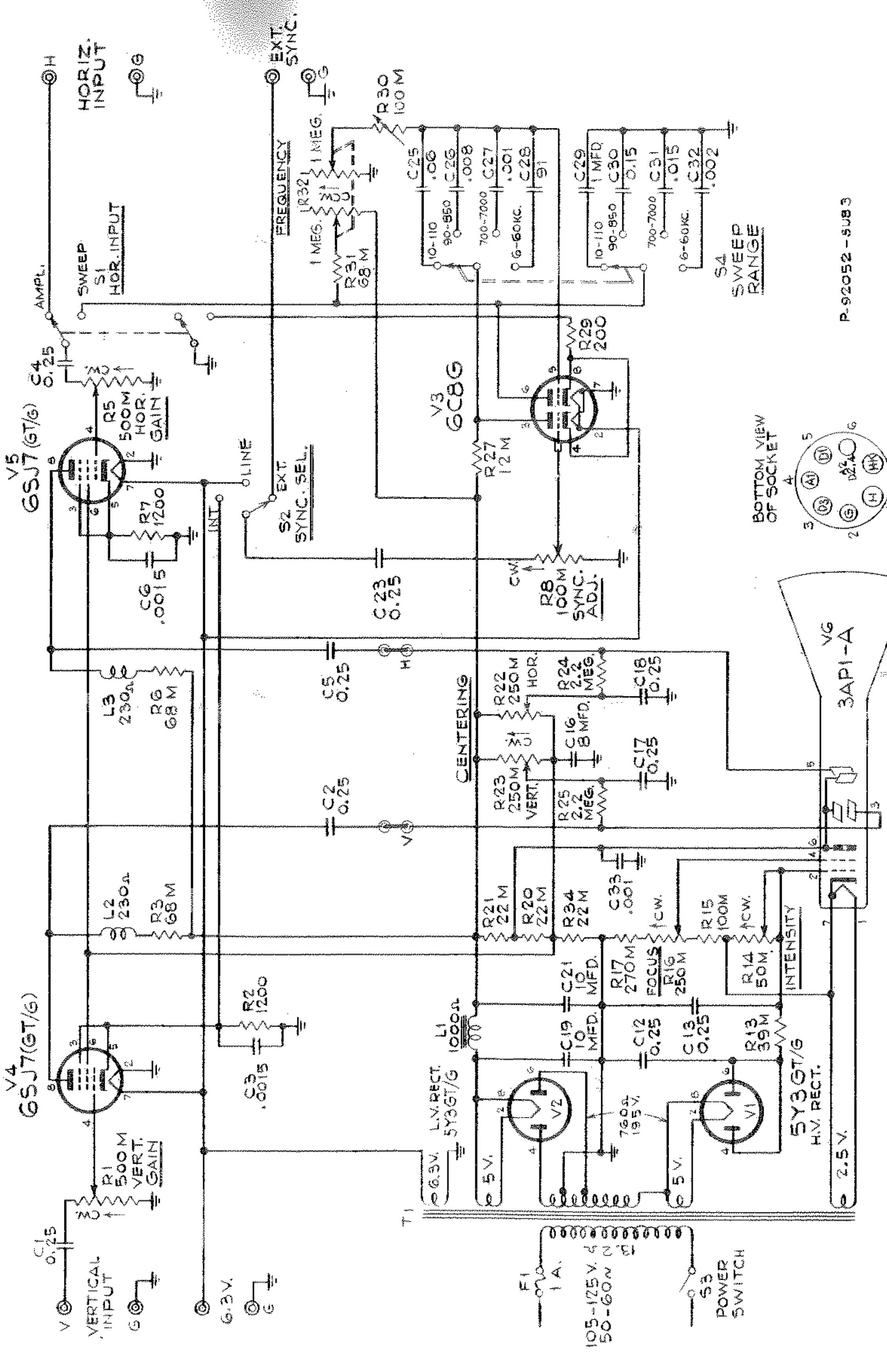


Figure 2—Schematic Circuit Diagram, Type No. 155C

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 brilliancy 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.

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 voltage to the VER. AMP. INPUT terminal. The 6 V. A-C terminal may be used as this source of voltage. To adjust the length of the resultant vertical line appearing on the screen, adjust the VER. GAIN control until the length is as desired. Application of the same 60-cycle source to the HOR. AMP. INPUT with the HOR. INPUT switch on AMP. will similarly show a horizontal line on the screen, the length of which may be varied by manipulation of HOR. GAIN control.

3. To expand (2) further, apply 60 cycle voltage to both HOR. AMP. INPUT and VER. AMP. INPUT terminals.

Since all ground binding jacks are common, it is only necessary to connect the high-side (jack marked 6 V. A-C) of the 6 volt supply to the VER. AMP. INPUT or HOR. AMP. INPUT when marking the above test.

CAUTION. When using the 6 volt supply of oscilloscope, it should be remembered that one side is at chassis ground and that shorting or grounding the source may cause serious damage to the instrument.

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. HOR. INPUT switch must be turned to AMP. to do this. (See "A General Discussion of the Cathode-Ray Tube," RCA IB-26453, Figure 5 and explanation.)

APPLICATIONS

A-C Voltmeter without Amplifier—For this application, the characteristics of the unit are as follows: Input resistance—2,200,000 ohms, input capacity—approximately 24 mmf.; voltage range—80 volts r-m-s (higher with external attenuator); calibration—approximately 77 volts per inch peak-to-peak or 27 r-m-s volts per inch.

Procedure—Make connections to the Oscilloscope 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 77. This gives the approximate peak-to-peak value of the unknown voltage. For approximate r-m-s value, if voltage being measured is sinusoidal, divide peak-to-peak value by 2.8.

A-C Voltmeter with Amplifier—For this application, the characteristics of the unit are as follows: Input resistance—500,000 ohms; input capacity—approximately 22 mmf.; frequency range—20-40,000 cycles; calibration—(roughly) 2.8 volts per inch peak-to-peak, or 1.0 r-m-s volts per inch with gain control at maximum.

Procedure—Make connections and adjust controls. With the VER. GAIN control in the extreme clockwise position, a line one inch long is obtained on the screen for about 2.8 volts peak-to-peak 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 frequency response 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. binding post (VER. AMP. INPUT) is connected to the common lead of the filter circuit of the unit under test and a test lead, connected to the VER. AMP. INPUT binding post, is used to check the a-c ripple present at the various points in the circuit.

A-C Ammeter with Amplifier—For this application, the unit is used as an a-c voltmeter with an external shunt. The range with a one-megohm shunt is, roughly, 1-2000 microamperes, and the audio-frequency impedance is about 330,000 ohms.

Procedure—The oscilloscope should be connected as for the a-c voltmeter with amplifier, except the circuit with the unknown current should be connected to the VER. AMP. INPUT binding posts across an external shunt of 1000 ohms or one megohm, depending on the amplitude of the current. Variation of the VER. GAIN control will adjust the length of line appearing on the screen. As when used as an a-c voltmeter, it may be advantageous to plot a curve of inputs vs. gain control settings for one-inch deflection on the screen in order to obtain the values of unknown currents more quickly.

AUDIO QUALITY MEASUREMENTS—Use of the "sweep oscillator" feature of the oscilloscope 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 VER. AMP. INPUT binding-jacks. Turn the RANGE switch to that tap giving a range including the frequency of the input signal and adjust the FREQUENCY control until the sweep 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 sweep 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 VER. AMP. INPUT binding posts of the oscilloscope. If the resultant wave does not correspond to that obtained when the input was direct to the oscilloscope, 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 oscilloscope, 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 oscilloscope. 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 binding post.

Procedure—Connect a constant-frequency input to the transmitter and connect a small pickup coil, located near the transmitter tank coil, to the DEFLECTORS "V" binding jacks (accessible through a door in the side of the case) as explained in item 16 on page 5. The pickup on this coil should be from 50-75 volts. Connect the EXT. SYNC. binding post of the oscilloscope to the transmitter audio amplifier at a point providing a 2- to 4-volt signal. Turn the RANGE switch to the tap which includes the frequency of the input signal and adjust FREQUENCY control until the sweep oscillator interlocks with the signal on the vertical plates. Adjustment of the SYNC. ADJUST. control provides control of the voltage from the pickup coil to the grid of the RCA-6C8G tube. Adjustment of HOR. GAIN control varies the horizontal deflection.

(2) Another and somewhat similar method of modulation measurement is to connect the pickup coil to the DEFLECTORS "V" binding jacks (accessible through a door in the side of the case) as explained in item 16 on page 5, as before, but connect the audio signal (from the transmitter audio amplifier) to the HOR. AMP. INPUT binding posts. Adjust HOR. 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 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 EXT. SYNC. binding posts of the oscilloscope so as to synchronize the sweep 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 VER. AMP. INPUT binding-jack of the oscilloscope 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 VER. AMP. INPUT binding-jack may be to the plate of the tube, the GND. post 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 VER. AMP. INPUT binding jack should be connected to the plate of the tube and the GND. post to ground in order to take the audio voltage off this 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.

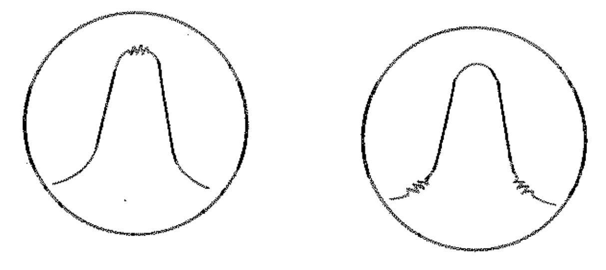


Figure 3—Effect of Marker Frequencies on an I-F Response Curve

A marker can be inserted at any point on the trace by applying an additional unmodulated signal to the R-F or I-F circuits of the receiver. By varying the frequency of this signal, the point at which the marker appears can be moved to any point on the oscilloscope trace, thus serving to identify or mark that point on the curve. The frequency corresponding to that point on the trace is the frequency of the oscillator providing the marker signal. This permits a very accurate check to be made of band width, peaks, and important points of the response curve.

FREQUENCY MEASUREMENTS—In using the oscilloscope 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 sweep 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 of from 6 to 600 c.p.s.

CHECKING PHASE SHIFT—To check phase shift of a device with the oscilloscope, observe the screen pattern with the input to the device on the HORIZONTAL binding posts and the output from the device on the VERTICAL posts. If no phase shift exists, a sloping straight-line image will appear. The internal amplifiers in the oscilloscope introduce some phase displacement which must be considered. If sufficient voltage is available, the internal amplifiers should not be employed.

THE FLUORESCENT PATTERN—The fluorescent screen used in the type RCA-3AP1-A cathode-ray tube has very good visual and photographic properties, as well as high luminous efficiency. The phosphorescent effect is of medium persistence which is an aid in visual work and has no undesirable effect on the photographing of cathode-ray tube patterns. With the new "deep light-shield," the pattern appearing on the screen may be observed with lower intensity.

To further aid in viewing the pattern, a light filter, such as the Wratten No. 61N made by the Eastman Kodak Co., may be used. This green filter transmits light of approximately the same frequency as that of the pattern, allowing the trace to be viewed with greater contrast.

If it is desired to photograph the image, the following hints may be helpful:

The screen of the tube is made of No. 1 phosphor, which emits light peaking at a wave-length of approximately 525 millimicrons. Therefore, the photographic emulsion used should be sensitive to blue and green light. Film of the panchromatic type "B" or "C" is recommended.

The camera used should be sharply focused on the fluorescent pattern and have a lens speed of f 4.5 or better. Exposure time will, of course, depend upon lens and photographic emulsion speed, the magnification, brilliance and steadiness of the pattern.

CIRCUITS

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

An amplifier consisting of a single RCA-6SJ7-GT constitutes the means of obtaining gain for the signal applied to the vertical deflecting system. The input to this stage is a high-resistance potentiometer connected to provide gain control. An isolation capacitor is made a part of the input circuit to exclude any direct current which may be associated with the circuit being observed. The plate, or output circuit of the RCA-6SJ7-GT 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 identical to that described above. Jumpers are provided to disconnect either or both amplifiers, thereby allowing the voltage to be studied to be applied directly to the deflecting plates. When the HOR. INPUT switch is in the SWEEP position the sweep oscillator signal is fed into the horizontal amplifier.

A synchronization system is included, as shown in the input circuit of the RCA-6C8G. The timing axis oscillator stage, using the RCA-6C8G, is designed to have a frequency range of approximately 10-60,000 cycles, controlled through the RANGE switch and FREQUENCY control. The signal from this oscillator has a "saw-tooth" wave shape.

The purpose of this timing axis oscillator (6C8-G), is to provide a saw-tooth voltage whose frequency and phase may be synchronized with any desired signal. The circuit employed, which is known as the "Potter Oscillator circuit," is a form of multi-vibrator. The two triode units of the 6C8-G, are coupled together by a common cathode resistor, R-29, and also by an adjustable capacitor (C25, C26, C27, C28). The second triode section is blocked off during most of each cycle of oscillation; plate current flowing in the form of a pulse of extremely short duration. These pulses of current periodically discharge the plate capacitor (C29, C30, C31, C32) which is charged through resistor R31, R32 between pulses. The plate voltage of this tube has, therefore, the required "sawtooth" shape, and may be applied to the horizontal deflecting plates after amplification, to provide a timing axis.

The first section of the 6C8-G draws plate current during the entire cycle, excepting the "pulse interval," acting as an amplifier for synchronizing voltage applied to its grid.

The advantages of this type sweep oscillator over the gas triode (884) type formerly used, include its ability to operate at higher sweep frequencies, more stable operation, and ability to synchronize on extremely small input signals.

The RCA-3AP1-A 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 110- to 120-volt, 50- to 60-cycle supply. Voltage rectification is accomplished by two RCA-5Y3G rectifier tubes, 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

Tubes

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 RCA-3AP1-A 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 tubes in their respective sockets, due to the likelihood of circuit effects, causing error. Their removal and check with standard tube-testing apparatus is therefore desirable. Replacement of the questionable tube with one known to be in good condition is another acceptable and definite means of tracing tube troubles.

If the 6C8G tube is replaced, it may be necessary, because of differing tube characteristics, to adjust R-30. This adjustment should be made as follows: Set SYNC. SELECTOR to INT., and HOR. INPUT to SWEEP. Advance FREQUENCY control to maximum clockwise position. With a beat frequency oscillator connected to the VER. AMP. INPUT, apply a frequency ten per cent greater than the maximum frequency shown on the RANGE control scale for the RANGE setting in use. For example, if the first position of the control is chosen, apply a frequency of 110 plus 10 per cent,

or 121 cps. Then adjust R-30 until a single cycle is observed on the screen. Check other positions of the RANGE control to insure correct coverage of each range.

On the RCA-3AP1-A, 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 RCA-3AP1-A 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 screw on the cathode-ray tube socket clamp, rotating the socket as desired, and then tightening the screw.

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 oscilloscope, 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 schematic diagram giving values of the parts is shown in Figure 2. 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 oscilloscope 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 oscillo-

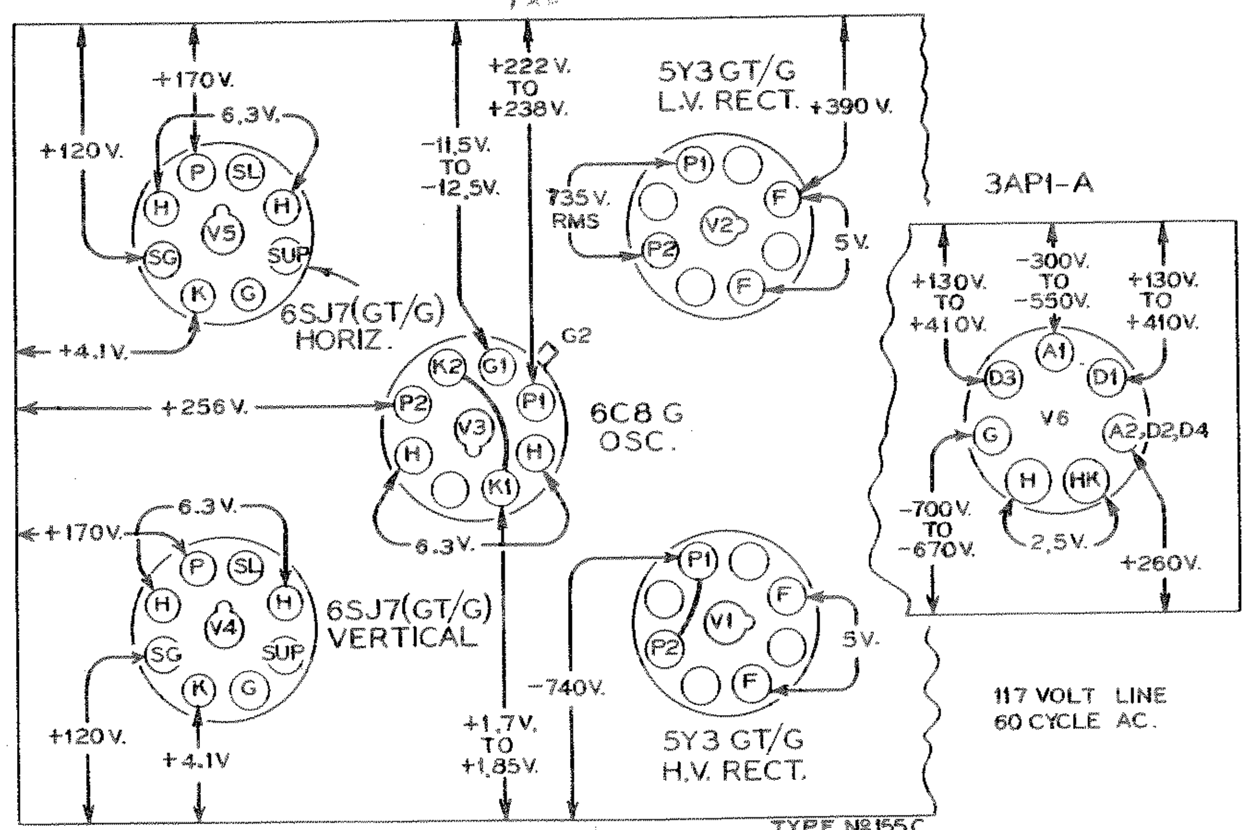


Figure 4—Approximate Tube Socket Voltages (Measured with RCA VoltOhmyst)