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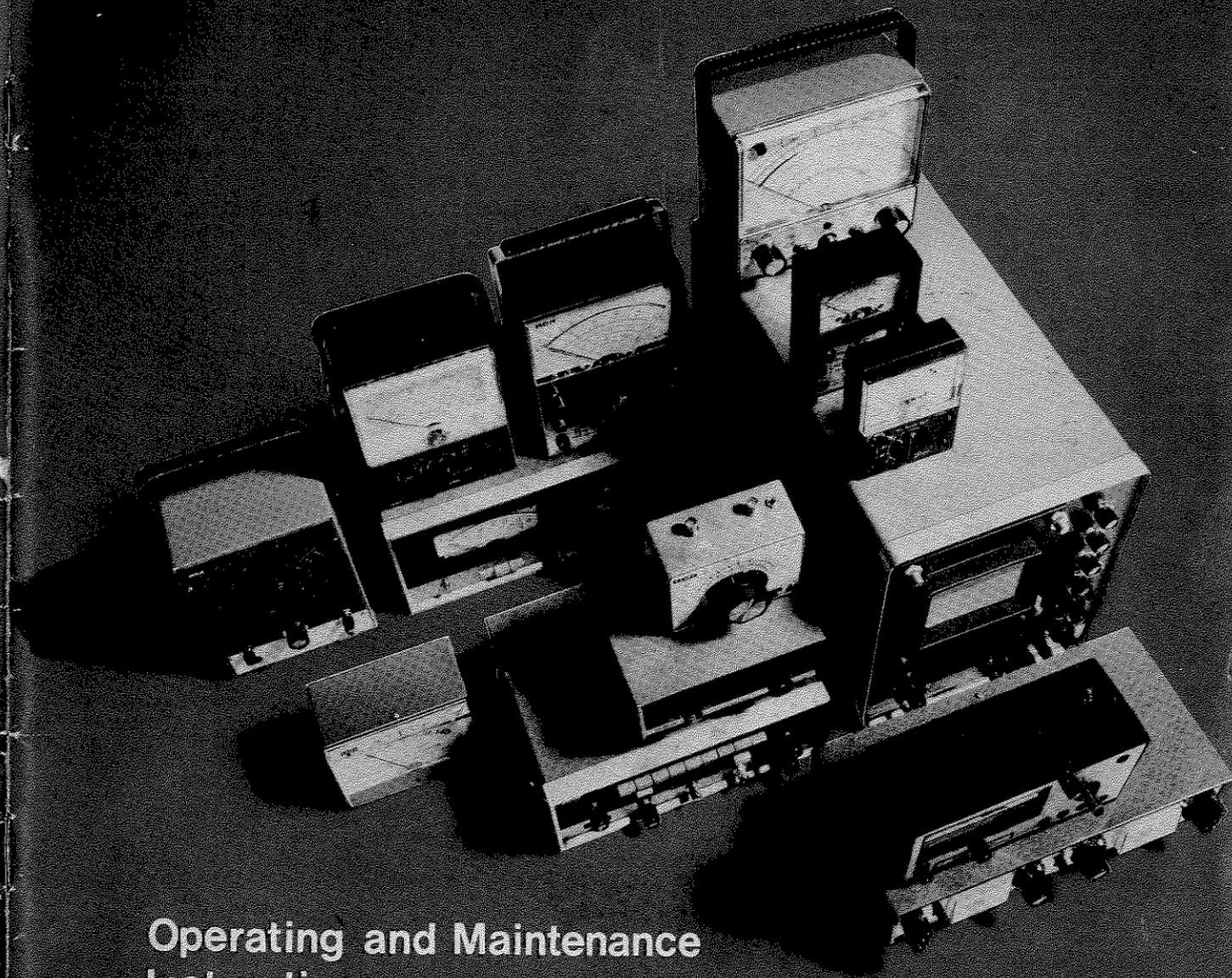
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# 3-Inch Oscilloscope WO-33B



Operating and Maintenance  
Instructions

**RCA** Electronic  
Instruments

## Safety Precautions

This instrument is equipped with a three-wire power cord which connects the metal case and ground lead to the power-line ground. To prevent lethal shocks or equipment damage when servicing equipment not equipped with a three-wire power cord, ALWAYS ELECTRICALLY ISOLATE SUCH EQUIPMENT WITH AN ISOLATION TRANSFORMER, such as RCA WP-25A\*, WP-26A\*, or WP-27A Isotap.

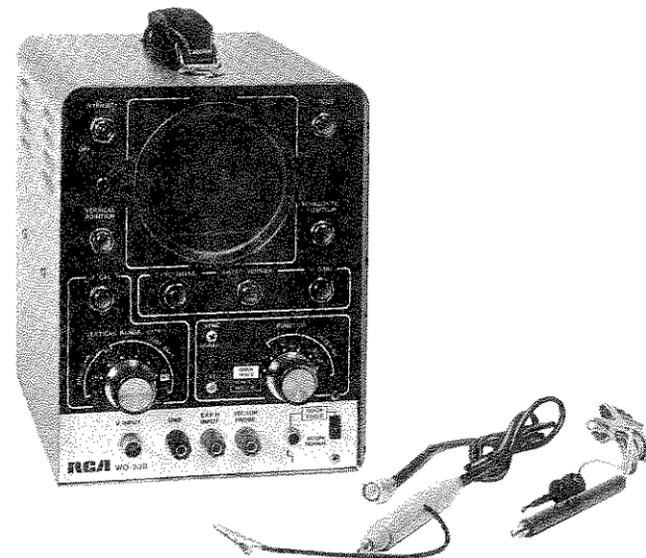
Care should be exercised to avoid striking the cathode-ray tube or subjecting it to more than moderate pressure in handling. Because the tube contains a high vacuum, implosion might result in injury from flying glass.

Always become familiar with the equipment under test before working on it, bearing in mind that high voltages may appear at unexpected points in defective equipment. Additional precautions which experience in the industry has shown to be important are listed below:

1. It is good practice to remove power before connecting test leads to high-voltage points. If this is impractical, be especially careful to avoid accidental contact with equipment racks and other objects which can provide a ground.

Working with one hand in your pocket and standing on a properly insulated floor lessens the danger of shock.

2. Filter capacitors may store a charge large enough to be hazardous. Therefore, discharge filter capacitors before attaching test leads.
3. Remember that leads with broken insulation provide the additional hazard of high voltages appearing at exposed points along the leads. Check test leads for frayed or broken insulation before working with them.
4. To lessen the danger of accidental shock, disconnect test leads immediately after test is completed.
5. Remember that the risk of severe shock is only one of the possible hazards. Even a minor shock can place the operator in hazard of more serious risks such as a bad fall or contact with a source of higher voltage.
6. The experienced operator continuously guards against injury and does not work on hazardous circuits unless another person is available to assist in case of accident.



### Signal-Tracing Probe

"Slip-On" type RF demodulator probe. Applications include display of sweep-response curves of IF amplifiers, video amplifiers, and tuners.



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## Description

The RCA WO-33B is a portable, 3-inch oscilloscope with many special features not found in other oscilloscopes. In addition to being a high-performance, general-purpose oscilloscope, the WO-33B has a built-in "Quicktracer" Transistor/Diode Tester, a Vectorscope input function, and a "Ringing Test" function.

These special features make the WO-33B one of the most versatile instruments available for troubleshooting and servicing electronic products. The Quicktracer function with its distinctive waveforms permits rapid point-to-point checks of transistors,\* diodes, and even many resistors and capacitors. The Vectorscope function is for use in aligning color TV AFPC circuits. The Ringing Test provides a fast, convenient method of checking flyback transformers, yokes (including the permanent yokes on some newer picture tubes), coils, etc.

Performance features of the oscilloscope include wide frequency response—usable from 3 Hz to 10 MHz, and high gain requiring only ten millivolts to produce one inch of deflection. The frequency compensated vertical attenuator system consists of two bands; one for high

\*Except FETs

## Specifications

Note: Performance figures are for a line voltage of 120 volts, 60 Hz.

### Frequency Response

Vertical Amplifier	
Wide Band Positions (1.5 V to 150 V Range)	3 Hz to 5 MHz, $\pm 1$ dB Usable to 10 MHz
High Gain Positions (.05 V to .5 V Range)	20 Hz to 150 kHz, -3 dB
Horizontal Amplifier	10 Hz to 200 kHz, -3 dB

### Deflection Sensitivity

	Wide-Band Positions	High-Gain Positions
Vertical Amplifier		
Direct Probe	0.3 V P-P/In (118 mV P-P/cm)	10 mV P-P/In (3.9 mV P-P/cm)
Lo-Cap Probe	3 V P-P/In (1.18 V P-P/cm)	100 mV P-P/In (39 mV P-P/cm)
Horizontal Amplifier	2.5 V P-P/In (0.94 V P-P/cm)	

gain and the other for wide frequency response. An internal calibration signal together with a calibrated graph screen provide direct peak-to-peak voltage measurement capability. The vertical input positions are calibrated in convenient 3-to-1 "Volt Ohmyst-type" ranges. A phase control varies the phase of the internal sweep oscillator when the "line" function is used, enabling the WO-33B to be phased with an external sweep generator in TV alignment applications.

The popular WG-400A Probe and Cable is supplied with the Oscilloscope. This high-quality probe features convenient switch selection of "direct" or "low-capacitance" mode, shielding along its entire length, and easy-to-use BNC type connector. A special probe for the Quicktracer function is also supplied.

Weighing only 14 pounds and measuring 8-3/4 inches by 6-1/2 inches by 10-1/4 inches, the WO-33B is easily portable. In addition to radio, TV, and Hi-Fi servicing, typical uses for the WO-33B include industrial maintenance, general waveform analysis, and educational applications both in the lab and classroom.

### Rise Time

Vertical Amplifier (Wide-Band Positions) . . . . . 0.1  $\mu$ s

### Input Resistance and Capacitance

Vertical Amplifier  
 At V INPUT connector . . . . . 1 M $\Omega$  shunted by approx. 12 pF  
 With probe on "direct" . . . . . 1 M $\Omega$  shunted by 80 pF  
 With probe on "Lo-Cap" . . . . . 10 M $\Omega$  shunted by 13 pF  
 Horizontal Amplifier . . . . . 250 K $\Omega$   
 Sync Input Terminal . . . . . 250 K $\Omega$  to 55 K $\Omega$

### Sweep Oscillator

Frequency Range . . . . . 15 Hz to 75 kHz

Sync . . . . . Internal Pos. or Neg., and External

Maximum AC Input Voltage . . . . . 600 Volts P-P  
 (In presence of 400 V DC)

Phase Control Range . . . . . 0 to 160 Degrees

Other Functions . . . . . "Quicktracer" Transistor Diode Test  
 Vectorscope Input  
 Ringing Test

### Power Requirements

Voltage . . . . . 105-130 Volts (Can be revised  
 for 240 V. Refer to page 27).  
 Frequency . . . . . 50-60 Hz  
 Average Power Consumption . . . . . 45 Watts

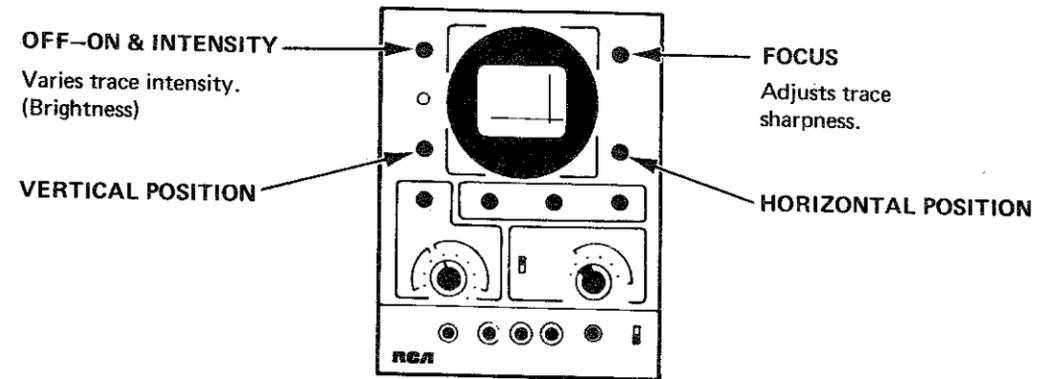
### Mechanical

Height . . . . . 8 $\frac{3}{4}$  inches (22.2 cm)  
 Width . . . . . 6 $\frac{1}{2}$  inches (16.5 cm)  
 Length . . . . . 10 $\frac{1}{4}$  inches (26 cm)  
 Weight (Net) . . . . . 14 lbs. (6.35 kg)

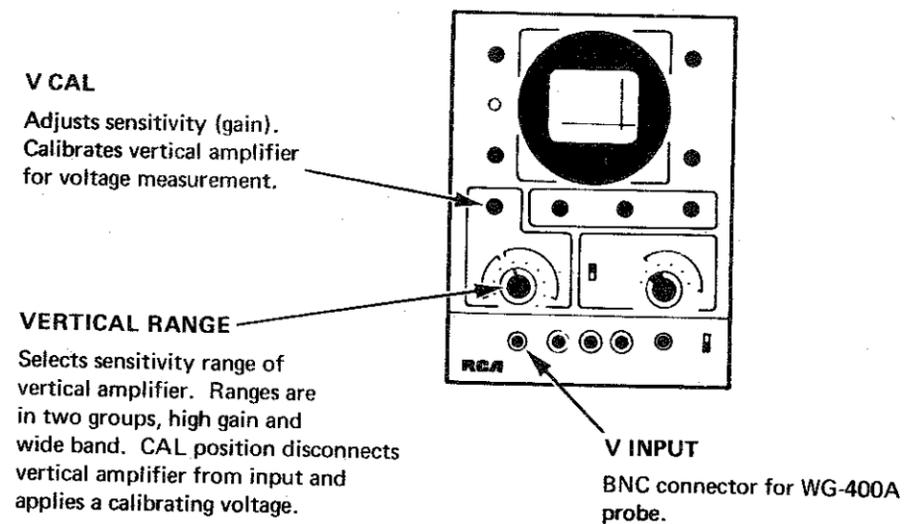
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# Functions of Controls and Terminals

## SET-UP CONTROLS



## VERTICAL INPUT CONTROLS

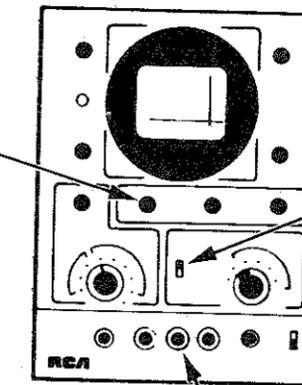


## SYNC CONTROLS

### SYNC/PHASE

Controls the amplitude of synchronizing voltage applied to the sweep oscillator. Turn clockwise for + sync, and counterclockwise for -sync. Adjust to minimum setting necessary to lock pattern in a stationary position. Operates at zero-center for internal sync. Adjusts external sync by regular clockwise rotation.

Also controls phase of the sinusoidal sweep voltage when the Function Switch is in the "LINE" position.

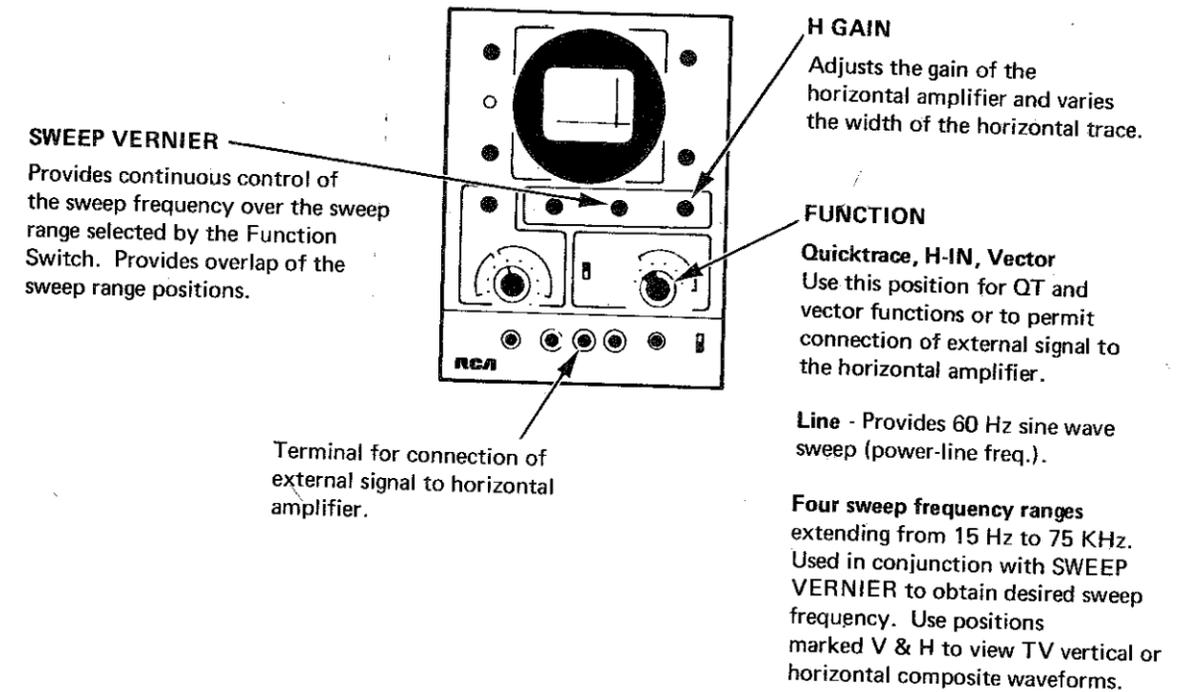


### SYNC SWITCH

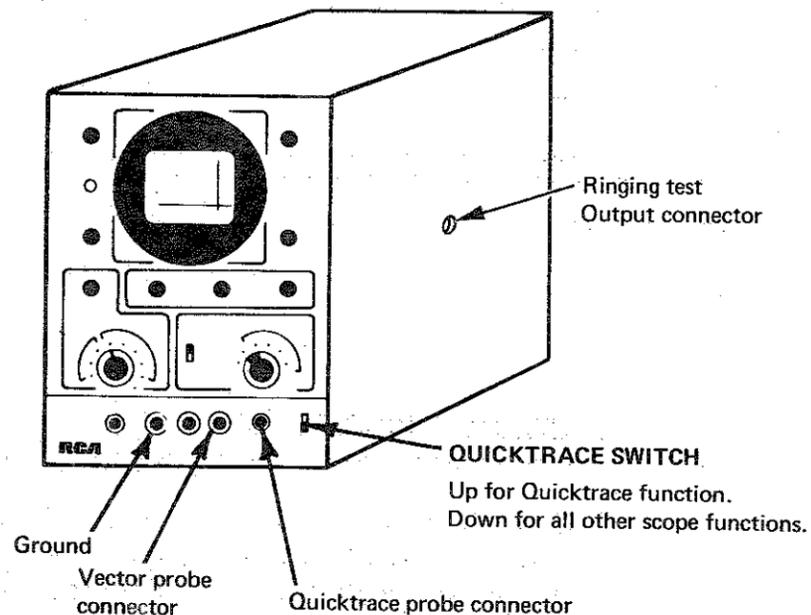
Selects internal or external sync.

Terminal for connection of external sync signal. (Also used for ext. H Amp input, see below).

## HORIZONTAL AMP. and SWEEP CONTROLS



## SPECIAL CONTROLS and TERMINALS



## Oscilloscope Operation

Before using the oscilloscope, you should become familiar with the functions of the controls and terminals as described in the previous section.

### WG-400A DIRECT/LOW-CAPACITANCE PROBE

The WG-400A is a single-unit probe equipped with a sliding switch in the probe housing which permits setting the probe for direct measurements or for connecting a built-in, high-impedance network in series with the test point and the probe cable. When the switch is set to the "LOW CAP X 10" position, the input capacitance of the cable and scope is reduced to approximately 12 picofarads and the input resistance is raised to 10 megohms. These high-impedance characteristics permit use of the WO-33B in high-impedance circuits, such as those found in TV sync-separator and video-amplifier stages, which would not operate properly if loaded down by a conventional scope probe and cable.

Whenever the probe is used in its low-capacitance position, the signal is attenuated by a factor of 10. Therefore, when voltage measurements are made with the WO-33B, the indicated voltage should be multiplied by 10.

### INITIAL PROCEDURE

1. Connect the power cord at the rear of the instrument to an AC outlet supplying 105-125 volts at 50-60 Hz. Connect the WG-400A cable to the V INPUT connector.
2. Pre-set the following controls as indicated:
 

FOCUS .....	Mid-Range
HORIZONTAL POSITION .....	Mid-Range
VERTICAL POSITION .....	Mid-Range
V CAL .....	Fully Clockwise
SYNC/PHASE .....	Mid-Range
H GAIN .....	Mid-Range
SYNC (Slide Switch) .....	"NORMAL"
QUICKTRACE (Slide Switch) .....	"NORMAL"

3. Turn on the instrument by rotating the INTENSITY Control clockwise from the "OFF" position, and wait a few seconds for the instrument to warm up. Rotate the INTENSITY Control farther clockwise until either a spot or a horizontal line appears on the screen. The spot or line should increase in brilliance as the control is turned clockwise. NOTE: Do not allow a small spot of high brilliance to remain stationary on the screen for an appreciable length of time because discoloration or burning of the screen may result.
4. Adjust the FOCUS Control for an image of maximum sharpness.

### VERTICAL AMPLIFIER

5. Set the WG-400A probe switch to DIRECT or LO-CAP, as appropriate (see "WG-400A Probe" Section). Connect the probe ground lead to the ground of the circuit under test, and the probe tip to the waveform test point.
6. Turn the V CAL Control fully clockwise and set the VERTICAL RANGE Switch to a position that produces a trace with the desired height. Unless you intend to make voltage measurement, further trace height adjustment can be made by readjusting the V CAL Control.
7. Adjust the position of the trace as desired with the HORIZONTAL and VERTICAL POSITION Controls.

### HORIZONTAL AMPLIFIER/SWEEP OPERATION (WAVEFORM LOCK-IN)

8. Set the FUNCTION Switch to an appropriate sweep frequency position and adjust the SWEEP VERNIER Control to select a sweep rate that produces the desired pattern. Note: If the sweep rate is set to the same frequency as the input signal, a one-cycle pattern will be produced. If the sweep rate is set to one-half the frequency of the input signal, a two-cycle pattern will be produced, etc.
9. Readjust SWEEP VERNIER and adjust SYNC/PHASE slightly as required to lock-in the desired pattern. For proper sync adjustment, start at mid-range and turn the SYNC/PHASE Control slightly clockwise for positive sync (sync on positive pulse), or counterclockwise for negative sync (sync on negative pulse). If in doubt, use the sync polarity that provides the best pattern stability.

**IMPORTANT:** Always start with the SYNC/PHASE Control at mid-range, and use only the minimum amount of sync adjustment required to provide solid lock-in.

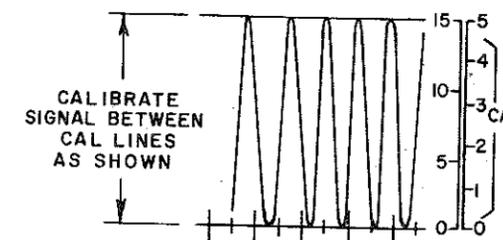


Figure 1. WO-33B graph screen with voltage scales.

### CALIBRATION AND VOLTAGE MEASUREMENT

The WO-33B Oscilloscope has been designed to permit simple and quick voltage calibration of the vertical amplifier and the cathode-ray screen. Once the instrument is calibrated, the graph screen scales can be used to measure the deflection amplitude of a displayed waveform directly in peak-to-peak volts.

When the VOLTAGE RANGE switch is set to "CAL", the probe and input attenuator circuits of the scope are automatically disconnected from the vertical amplifier and an internal calibrating voltage is applied.

#### Calibration Procedure:

1. Set the VOLTAGE RANGE Switch to "CAL", and the FUNCTION to "15-150".
2. Adjust the VERTICAL POSITION and V CAL Controls so that the vertical trace just fills the area on the graph screen between the two horizontal lines marked "CAL". The oscilloscope will remain calibrated on all ranges as long as the V CAL Control is not readjusted.

Calibration will hold for both wide band and high gain positions. After calibration, an input signal may be read directly in peak-to-peak volts by measuring the vertical deflection with the proper graph screen scale.

The graph screen has two vertical scales as shown in Figure 1. The scale to use depends upon the setting of the VERTICAL RANGE Switch. On the .05, .5, 5, and 50 volt ranges the 0 to 5 scale is used. On the .15, 1.5, 15, and 150 volt ranges, the 0 to 15 scale is used.

*.05 - .15 - .5 These Ranges are narrow Band with Specifications of 20 Hz to 150 kHz*

### Measurement Procedure

The procedure for measuring the peak-to-peak voltage of an input signal is provided below:

1. Calibrate the instrument as described above. DO NOT READJUST V CAL IN THE FOLLOWING STEPS.
2. Connect the black lead of the probe to the ground of the test circuit. Connect the probe tip to the signal to be measured.
3. Set the Voltage Range switch to a position that provides a trace with as much vertical amplitude as possible, but falling within the base line and the upper scale markings. Adjust VERTICAL POSITION so that the bottom of the trace rests on the base line of the graph screen.
4. Adjust the sweep and sync controls to lock-in the waveform.
5. Using the appropriate scale, read the peak-to-peak voltage amplitude from the scale point opposite the top of the waveform.

For example, with the VOLTAGE RANGE Switch set on the ".05" range, a trace extending vertically from the base line to the "5" mark on the 0-to-5 scale of the graph screen would be .05 volts peak-to-peak.

As another example, with the VOLTAGE RANGE Switch set on the "150" range, a trace extending vertically from the base line to the "10" mark on the 0-to-15 scale would be 100 volts peak-to-peak.

**Note:** When observing waveforms and measuring voltage of signals in high-impedance circuits, it is advisable to set the probe switch on "LO-CAP." In this position, the signal is attenuated by a factor of 10 to 1, therefore it is necessary to multiply the indicated voltage reading by 10.

### APPLYING AN EXTERNAL SIGNAL TO THE HORIZONTAL AMPLIFIER

In normal use, the signal from the oscilloscope sweep oscillator is applied to the horizontal amplifier. For some special applications, it is necessary to connect an

external signal to the horizontal amplifier. This can be done easily by setting the FUNCTION Switch to "H IN", then connecting the external signal to the "EXT H IN" Terminal (also connect the ground of the external signal to the scope "GND" Terminal).

### USING AN EXTERNAL SYNC SIGNAL

With internal sync, a portion of the signal applied to the vertical input is applied to the sweep oscillator to obtain synchronization. In some applications, for proper sync it may be necessary instead to synchronize the sweep oscillator with an external signal. To use an external sync signal, set the SYNC Slide Switch to "EXT," and connect the external signal to the "EXT/H INPUT" Terminal (also connect the ground of the external signal to the scope "GND" terminal). Adjust the SYNC/PHASE Control in the normal manner, starting at mid-range to obtain sync with either the positive or negative pulse of the sync signal.

### USING "LINE" SWEEP

For some special applications, notably TV sweep alignment, it is desirable to have the scope sweep at the 60 Hz power-line frequency. This is required in TV alignment because many TV sweep generators also sweep at a 60 Hz rate.

When using the line sweep function, just set the FUNCTION Switch to "LINE" for the 60 Hz sweep function. Set the SYNC/PHASE Control to adjust the phase of the 60 Hz sweep so that it is phased with the sweep generator signal (see page 26 for further information).

**Note:** If the TV sweep generator supplies a sawtooth output, connect that output to the H INPUT Terminal, and set the FUNCTION Switch to "H IN".

## The Quicktracer (QT) Function

Combining the features of a curve tracer and diode checker, the Quicktracer Function, or "QT," permits a fast, reliable check of bipolar transistors, diodes, and even many resistors and capacitors. In addition, it makes an excellent continuity tester.

The Quicktracer can be used to check devices either in-circuit or out-of-circuit. The distinctive QT waveforms indicate at a glance whether the component under test is functioning properly.

In-circuit transistor testing with the QT becomes even more meaningful if you have a second circuit like the one under test so that an actual comparison can be made of corresponding QT waveforms (in a stereo amplifier, the other channel makes a convenient reference). In some cases, reference QT waveform photographs are made available by the product manufacturer.

Another helpful technique is to sketch the normal waveforms on various schematics adjacent to the transistors and diodes. This will provide a ready reference for future troubleshooting of the same chassis type. To save time, any transistor which exhibits no loading effects may be marked "normal," rather than being marked with waveform sketches.

### The Special QT Probe

The special QT Probe supplied with the WO-33B includes a convenient E-Z Hook connector, and a sharp "phonograph needle" probe tip to pierce rosin, oxide or other coating that may be on the test point.

**Note:** For safety, the probe is shipped with the sharp tip inside. Reverse the tip simply by loosening the knurled bushing, removing the tip and re-installing it with the sharp point outward.

### TEST PROCEDURE

#### Set-Up

1. Turn on the WO-33B. Set the VERTICAL RANGE Switch to "QT" (also 50V), the FUNCTION Switch to "QUICKTRACE," and the QUICKTRACE Slide Switch to the "up" position. Insert the special Quicktracer Probe into the panel connector.
2. Adjust the Scope GAIN Control for a line trace about 1-1/2 inches wide. Adjust FOCUS and INTENSITY for a sharp trace of suitable brightness, and adjust the VERTICAL and HORIZONTAL POSITION Controls to center the trace.

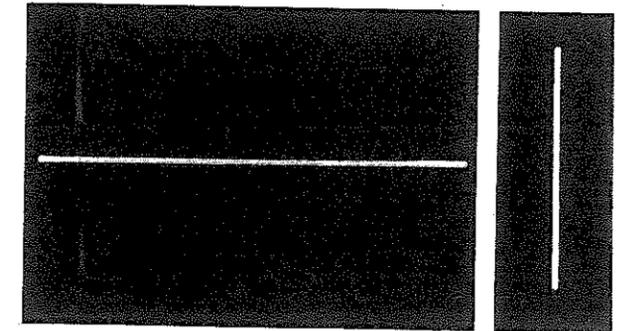


Figure 2. The horizontal line is produced when there is an open between the test leads; a short produces a vertical line. The scope may be adjusted to produce the desired lengths.

3. Connect together the Quicktracer Probe Tip and the E-Z Hook Connector contact. Adjust the V CAL control for a vertical line trace about 1-1/2 inches high.

**Note:** When making in-circuit tests, turn off equipment under test. If it is an AC/DC chassis, unplug the power cord.

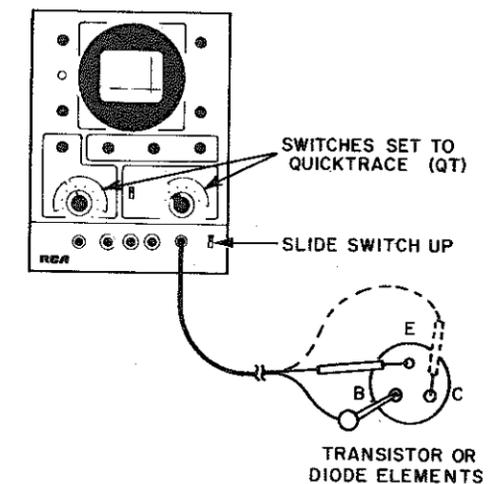


Figure 3. QT Testing.

**Transistor Test (In-or Out-of-Circuit)**

Connect the black test lead to the transistor base. Connect the probe to the collector, then to the emitter. If the elements are unidentified, connect the QT leads at random until a proper waveform is obtained. (See Figure 4).

A normal junction will result in a variation of the special Quicktrace waveform. For most out-of-circuit transistors, the display will resemble one of the waveforms in Figure 4.

A straight vertical line indicates a *shorted* junction.

A straight horizontal line indicates an *open* junction.

The display for an in-circuit device may be affected by the other components in the circuit. Several examples of typical in-circuit Quicktrace waveforms are shown in Figure 5.

**Note:** A straight vertical line normally indicates a shorted device, except for an in-circuit test of a power supply where the shunt current through the filter capacitors causes an apparent short. If leakage is indicated by slanted "horizontal" deflection, it may be determined if this is a device fault or a shunt circuit by disconnecting the device and checking it out of the circuit, or by comparison of the waveform with a standard.

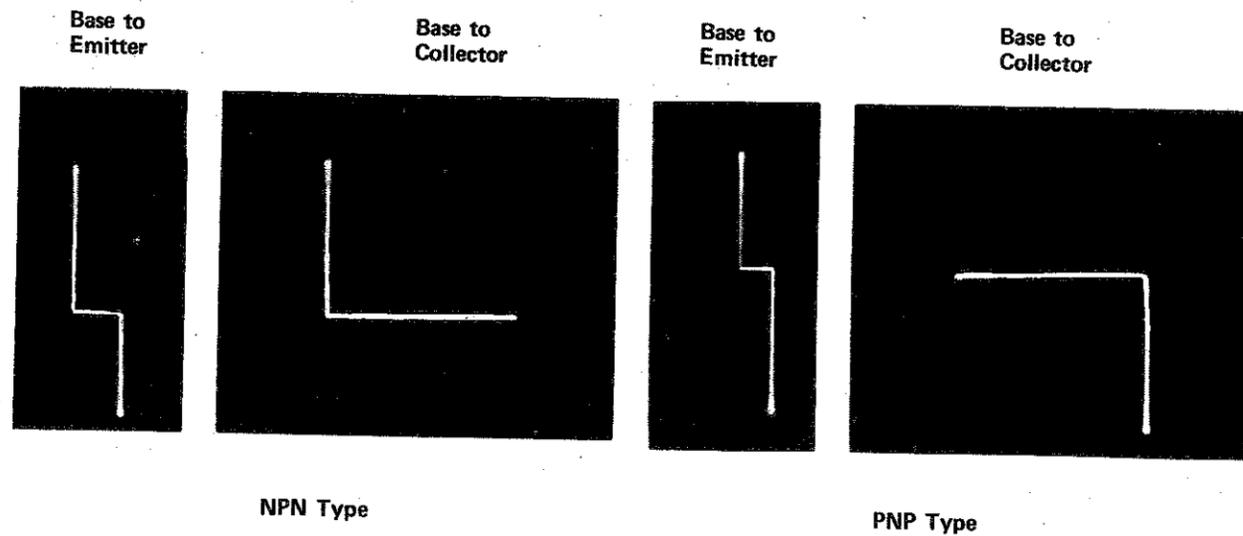


Figure 4. Typical waveforms produced by good transistors.

Base to Emitter      Base to Collector      Base to Emitter      Base to Collector

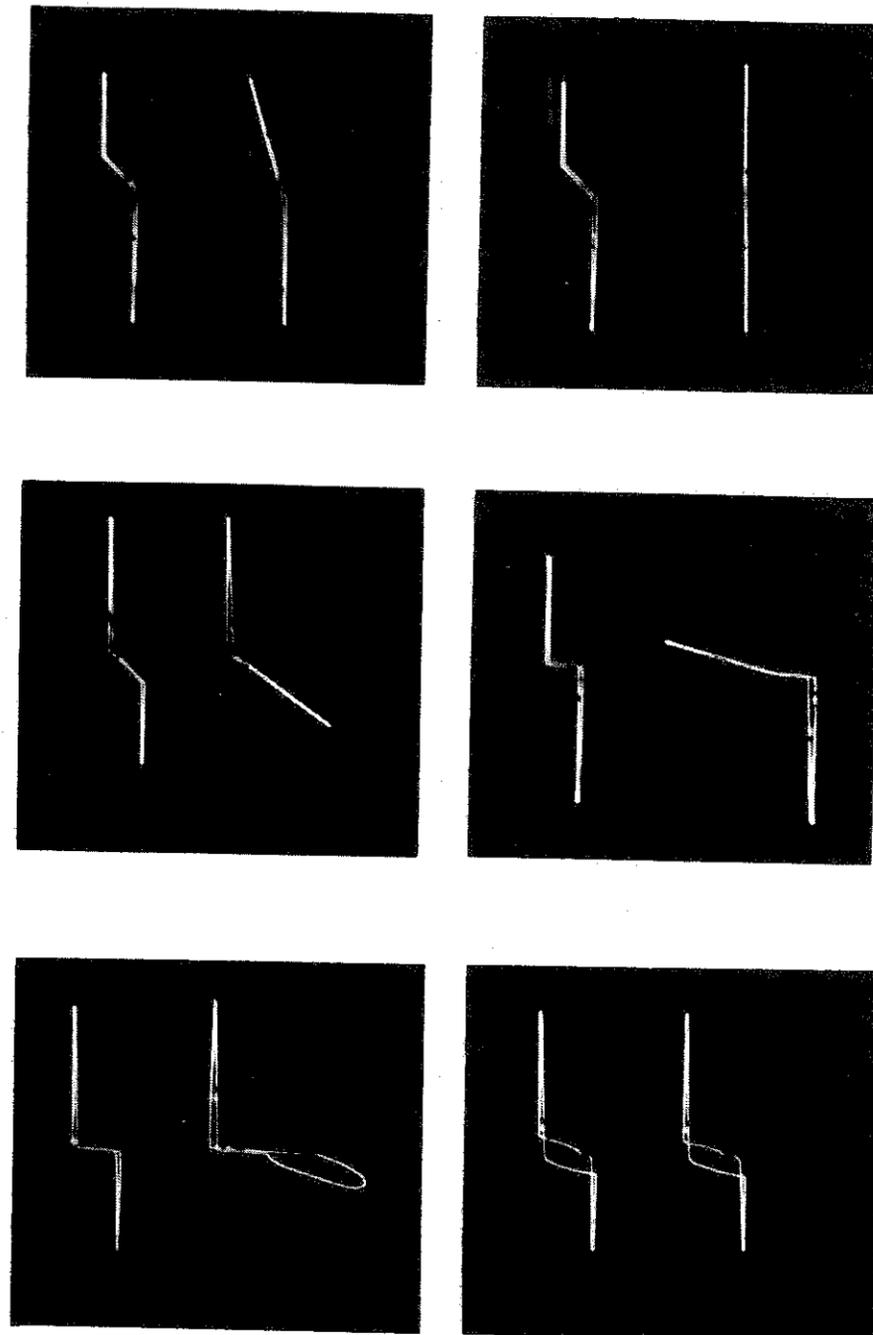


Figure 5. A selection of typical in-circuit QT waveforms.

### Diode Test

Connect the QT test leads across the diode elements. Interpret results in a similar manner as for transistor junctions. Typical waveforms of good diodes are shown in Figure 6.

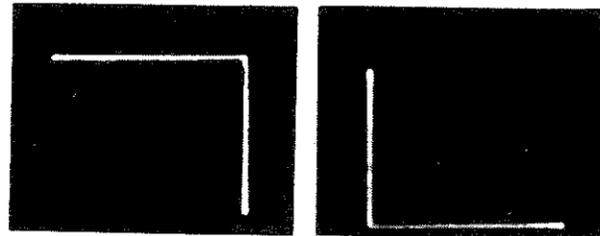


Figure 6. Waveforms generated when a diode is connected to the test leads. The one at the left results when the black test lead is connected to the diode cathode. Reversing the diode connections produces the waveform at the right.

### UHF DIODE TESTS (OUT-OF-CIRCUIT)

The QT limits the maximum power applied to the device under test to 100 milliwatts. However, certain types of small UHF diodes, "Schottky" diodes, and point-junction diodes can be damaged in an out-of-circuit test, or even by static discharge in handling.

If you are not sure if the diode will withstand the 100 milliwatt level, connect a 10 K ohm resistor in series with the Quicktracer probe. This will provide enough additional current limiting to protect the type of diodes noted above.

### CHECKING RESISTORS OR CAPACITORS

As mentioned above, the QT waveform for an open connection is a horizontal line, and for a shorted connection is a vertical line. Consequently, the waveform for various resistance values are slanted lines, somewhere in between these extremes.

Resistance values from approximately 100 ohms to 10 K ohms can be observed. Several sample values are shown in Figure 7.

Approximations of capacitance also are possible within the range of about 0.2  $\mu\text{F}$  to 20  $\mu\text{F}$ . The photographs in Figure 8 show the waveforms produced by various capacitors. Naturally, any shunt impedance across the capacitor being tested will change the waveform.

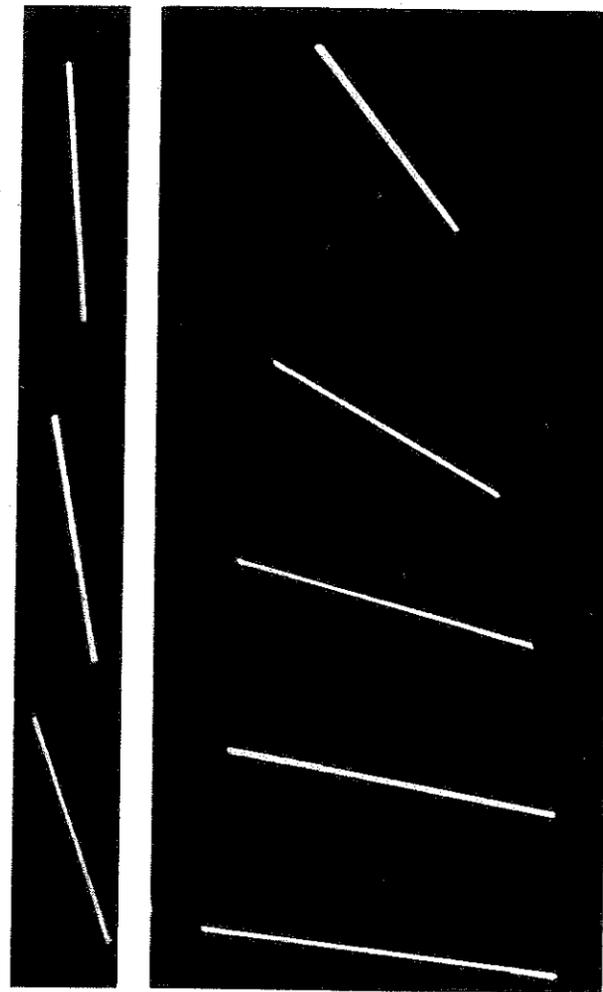


Figure 7. QT resistance waveforms. The "slant" of the baseline indicates the resistance between the test leads of the Quicktracer. A short produces a vertical line and an open produces a horizontal line. The resistances used to produce the waveforms above were 100 ohms (upper left), 220, 470, 1000, 2.2K, 4.7K, 6.8K and 10K (lower right).

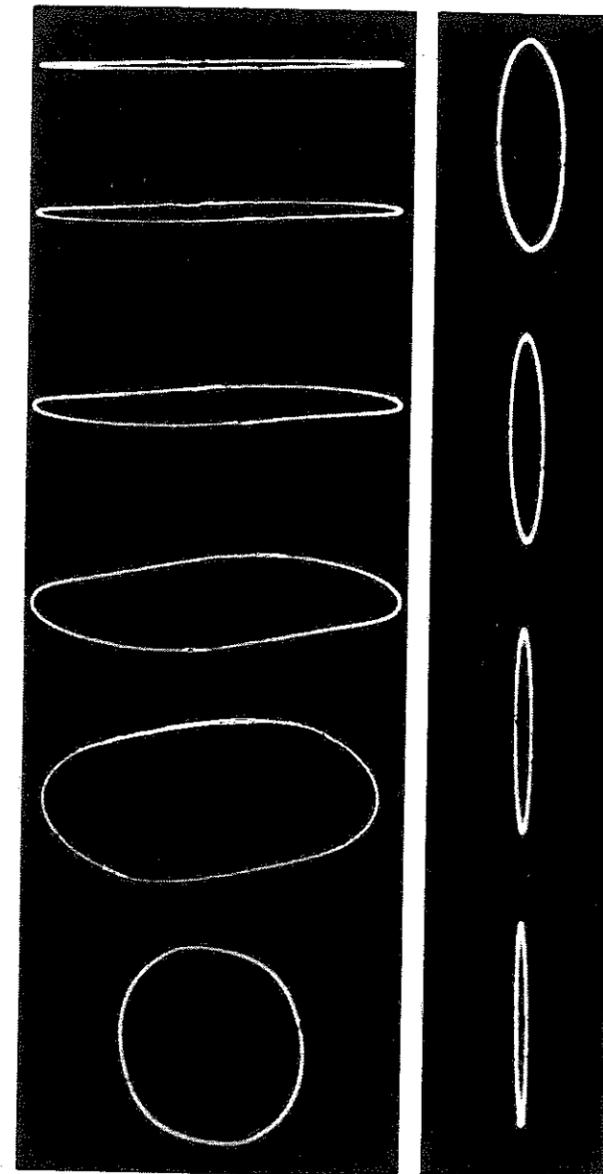


Figure 8. QT capacitance waveforms. Capacitance may be approximated by comparison with these waveforms. From top to bottom in the left column the capacitors used were .047 $\mu\text{F}$ , .1 $\mu\text{F}$ , .22 $\mu\text{F}$ , .47 $\mu\text{F}$ , 1 $\mu\text{F}$ , and 2 $\mu\text{F}$ . To produce the waveforms in the right column, capacitances of 5, 10, 20, and 30 $\mu\text{F}$  were used.

### ELEMENT-TO-GROUND TESTING

A technique that can greatly speed up in-circuit QT testing is to connect the black E-Z Hook to the test circuit ground, then simply use the red probe to make point-to-point tests at each device junction. Usually, there will still be an identifiable QT waveform, although it may vary from the waveform obtained by connecting directly to the device elements.

This technique is particularly useful if you have another circuit like the one under test (but in good operating condition) so that waveforms between the two circuits can be compared.

If a questionable waveform is obtained, retest the device using the normal procedure, connecting the test leads directly to the device elements.

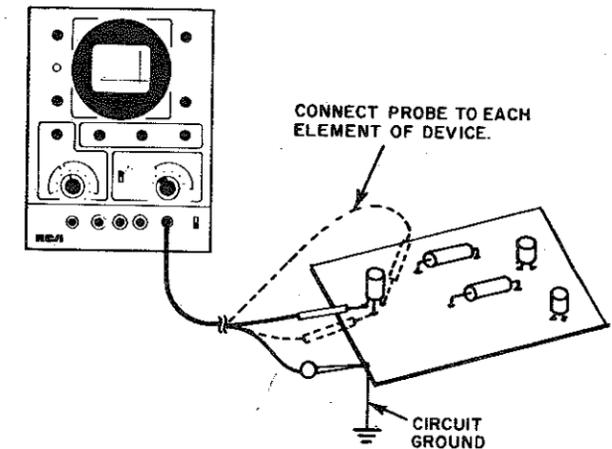
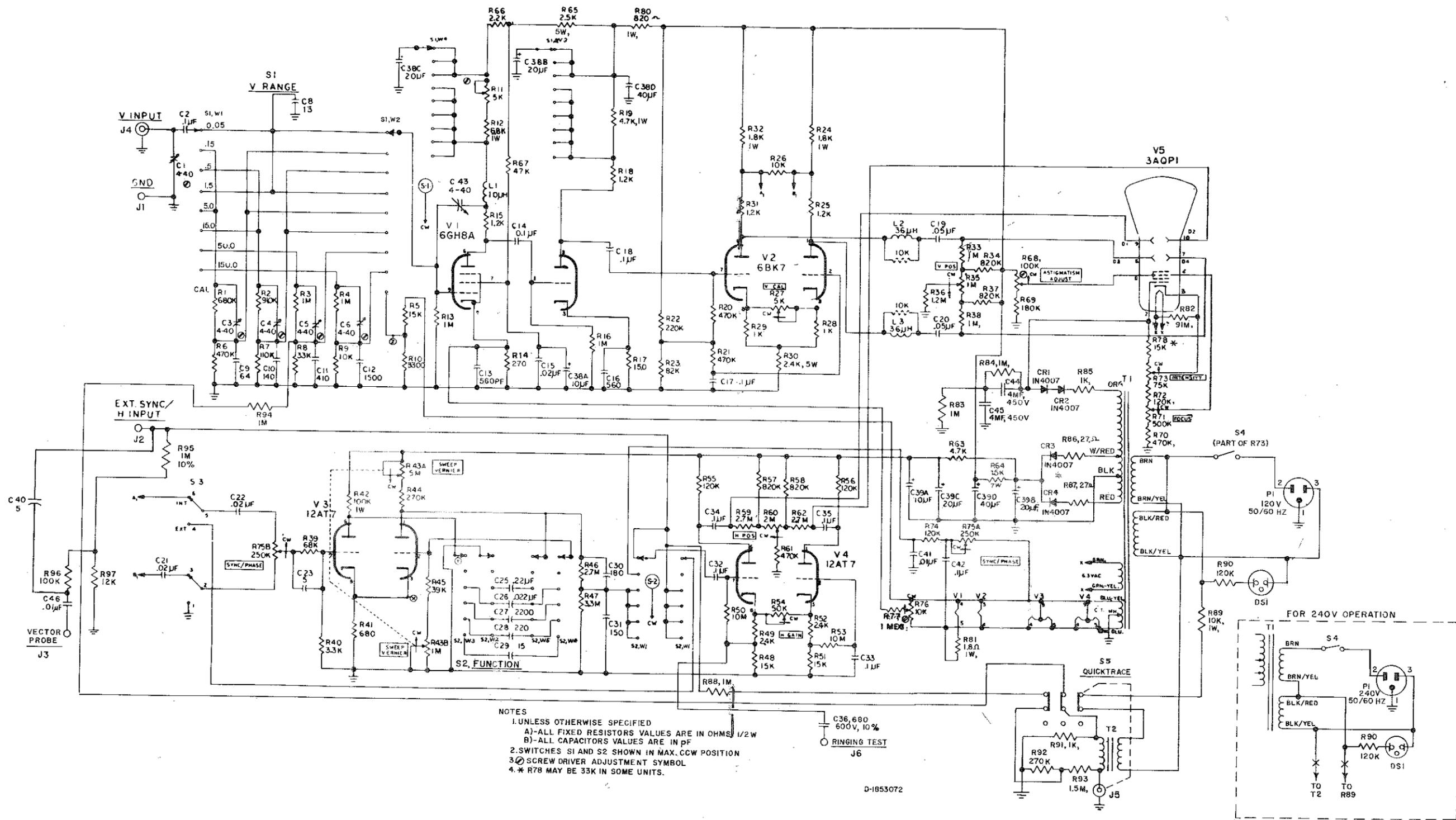


Figure 9. Element-to-ground test procedure.

### ADDITIONAL INFORMATION ABOUT QT TESTING

For purposes of testing, a transistor may be considered as two diodes connected in series with opposing polarities. If the transistor is PNP, the base material serves as a cathode; the emitter and collector are the two anodes. Therefore, if the QT black test lead is connected to the base of the transistor, connecting the other test lead to either the emitter or collector will produce downward deflection at the right end of the trace. If an NPN transistor is tested, deflection will be upwards at



WO-33B Schematic Diagram

the left, because the base serves as an anode, rather than a cathode.

The output voltage of the Quicktracer was designed to exceed the peak-inverse voltage (PIV) of most emitter-base junctions. (The QT circuit limits current so no damage is done.) Because of this, the waveform produced when the emitter-base junction is tested has vertical excursions at both ends of the horizontal trace. In all cases, the PIV of the emitter-base junction is greater than its forward barrier potential, so the vertical deflection representing reverse (zener) conduction will be shorter than deflection caused by forward

conduction. The QT output voltage is normally less than the PIV of the base-collector junction, hence, vertical deflection occurs at only one end of the trace. This allows the base-emitter junction of most transistors to be identified.

Transistor leakage current appears to the tester as a resistor shunted across the junction under test. When the transistor is forward biased and conducting, the junction resistance is practically nil and the shunt resistance has no effect on the waveform. When the junction is reverse biased the effect of the shunt resistance is noticeable because it is much lower than the back resistance of a normal junction.

## Vectorscope Function

The WO-33B oscilloscope includes a built-in vectorscope function for checking and aligning color TV AFPC (automatic frequency and phase control) circuits. A color bar generator is required to supply the necessary input signal to the TV set.

When the AFPC circuit in a color TV receiver is adjusted properly, the tint control will have sufficient range to handle all variations of hue in the transmitted picture; the hue control will change only the hue and not the intensity; color sync will not be lost on weak signals; and color balance of the picture will not change with varying luminance.

In the vector method of AFPC alignment, a circular rosette pattern will appear on the WO-33B screen. The pattern will have ten petals, or vectors, one for each color bar. The illustration in Figure 10 shows a typical rosette pattern. However, the pattern will vary substantially, and the shape of the petals will vary considerably with different types of color bar generators and with different TV receivers.

### EQUIPMENT SETUP

1. Set oscilloscope probe switch to "LO CAP," and connect the probe to the grid (G1) of the picture tube red gun. Connect probe ground lead to the TV chassis.
2. Connect a length of hookup wire (install an alligator clip on one end if desired) from the

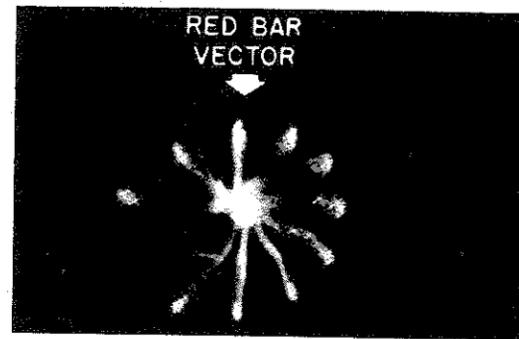


Figure 10. Typical "rosette" pattern. Pattern shape will vary somewhat with different receivers and color bar generators.

"VECTORPROBE" connector on the panel to the grid (G1) of the blue gun.

3. Disconnect the antenna from the receiver, and connect the output leads from the color bar generator to the antenna terminals. Reset the channel selector, fine tuning and other controls to obtain a color bar pattern on the receiver screen. Turn off any special color controls, such as "Accutint."
4. Set the 'scope FUNCTION Switch to "H IN", and adjust the H GAIN, VOLTAGE RANGE and V CAL Controls to obtain a circular rosette pattern on the CRT. The illustration in Figure 10 shows a typical rosette pattern. Note that the pattern has ten (10)

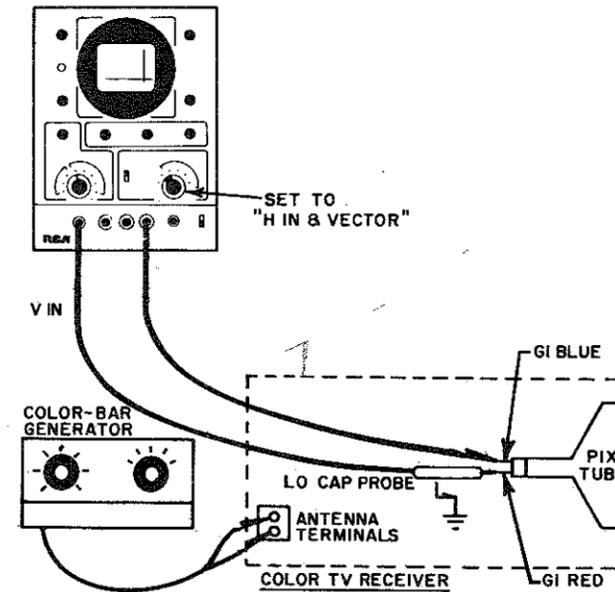


Figure 11. Equipment set-up using Vectorprobe Function.

petals or vectors, one for each color bar. The third petal (counting clockwise from the upper left area of the trace) represents the red bar. With proper adjustment of the hue control, the third bar should be located at or near the top of the pattern, that is, near a twelve o'clock position.

Note: The demodulation system used in some receivers will provide a pattern that is upside-down from that shown in Figure 10. With this difference in mind, the procedure as described below can be followed.

There are several different demodulation systems used in various color TV receivers. The AFPC alignment procedure for the particular type of receiver should be used. Refer to the service notes or other publications describing the vector AFPC alignment procedure for the receiver.

The alignment procedure given below can be used for most receivers.

### ALIGNMENT PROCEDURE

1. Turn the tint (or hue) control through its range and note the effect on the vector pattern. The pattern will turn, but should not change in size. If necessary, adjust the 3.58 MHz oscillator coil until the pattern is the same size throughout the range of the hue control.
2. Set the tint control to the center of its range. Adjust the reactance coil (oscillator trimmer capacitor in some sets) so that the color signal stays in sync as the chroma control on the color bar generator is turned to minimum. The vector pattern will reduce in size, but it should not rotate. Rapid spinning of the vector pattern indicates loss of color sync, and indicates misadjustment of the reactance coil.
3. Set the tint control to the center of its range. Adjust the burst-phase transformer to move the third vector (Corresponding to red bar) to the 12 o'clock position. Readjust the reactance coil (or trimmer cap) simultaneously to maintain color sync (no rotation of vector pattern.)
4. Rotate the tint control fully in each direction from its center-range position and note the effect on the vector pattern. If necessary, readjust the burst-phase transformer so that the third vector moves an equal distance each side of its normal vertical position as the tint control is varied in each direction from its center-range position. The tint control should have sufficient range to rotate the pattern so that the third vector moves to each side at least as far as the normal position of the adjacent bar (vectors 2 and 4). In many sets, it will be possible to rotate the red vector as much as 45 degrees in each direction.
5. Repeat steps 2, 3 and 4 until best results are obtained, if proper adjustment cannot be made, check to make sure the cores are set to their proper peak, which may be either above or below the coil. Refer to receiver manufacturer's service notes.

## Ringling Test Function

One troublesome task occasionally confronted by TV service technicians is to determine whether a yoke, flyback transformer, or coil is defective. Of course, if the component is completely open or shorted, it's usually easy to find by simple voltage or resistance measurements. The problem may not always be that obvious, however, because the coil may have just a few shorted turns or have developed a high resistance condition.

With the WO-33B, you can perform a "ringing" test on these horizontal deflection circuit components. In this procedure, a pulse obtained from the oscilloscope sweep circuit, made available from the convenient jack on the side of the 'scope case, is applied to the component under test. The condition of the component can then be evaluated by the amount of damping observed in the waveform. Typical waveforms obtained from a good component and one that has shorted turns are shown in Figures 12 and 13.

The Ringing Test is actually a visual display of the "Q" characteristics of the coil winding, at the frequency and load conditions of the test function.

To make a Ringing Test, simply connect the WG-400A probe (set to LO CAP) and ground lead to the terminals of the component under test, then connect a lead from the Ringing Test jack to the same test point as the probe tip. (See Figure 14.) Note that power is not applied to in-circuit components being tested.

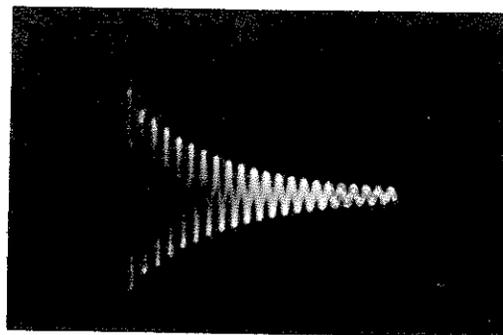


Figure 12. Typical ringing waveform obtained from good component.

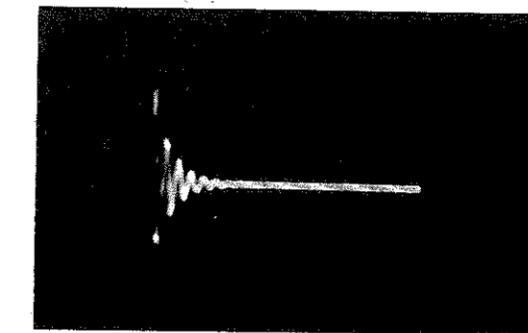


Figure 13. Ringing waveform obtained from component with shorted turns.

Although many components can be tested in-circuit, it may be necessary to remove circuit connections, especially in solid-state circuits where the semiconductor devices have a loading effect on the component.

To gain experience in evaluating the ringing waveform, it is helpful to try the procedure several times, both with good components and components that have purposely been shorted with various resistance.

One way to obtain reliable test results is to compare the ringing waveform obtained from the component being tested with the waveform from a duplicate component that is known to be good.

There are many times however, when a duplicate component is not available for this comparison. Fortunately, there are other testing techniques that can be used to help determine if a component is defective even though a "normal" ringing waveform is produced. These techniques are explained below in the instructions for testing the particular type of component.

### PROCEDURE

1. Remove power from the component or circuit to be tested. Do not apply power to the circuit at any time during the test procedure.

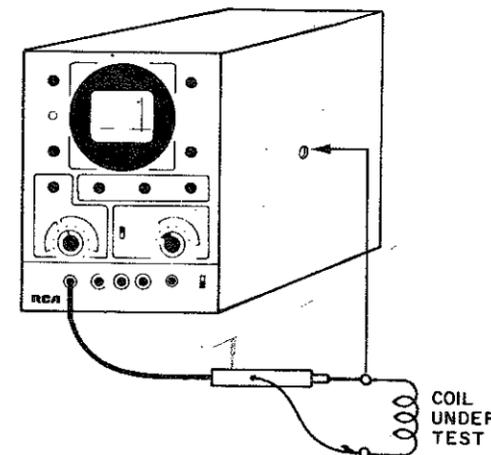


Figure 14. Equipment Set-Up.

2. Connect the WG-400A probe tip and ground lead to the component terminals. Set probe switch to LO CAP.
3. Connect a length of hookup wire from the "RINGING TEST" jack on the side of the 'scope to the probe tip connection. Connections to the jack can be made using a test lead probe tip, a piece of #14 wire, or even a resistor lead. For convenience in point-to-point tests, clip the test lead from the Ringing Test Jack directly to the probe tip.

Note: If preferred, a plug to fit the jack can be used. This plug is available from your local RCA Test Equipment Distributor. The stock number is 93857.

4. Turn on the 'scope. Set the SYNC Slide Switch to "NORMAL," the SWEEP RANGE Switch to the 1500 to 10 K Hz range, and the SYNC Control to mid-range. Adjust the V CAL, VOLTAGE RANGE, and H GAIN and the Positioning Controls to provide a suitable trace.
5. Adjust the SWEEP VERNIER Control to provide a waveform similar to that shown in Figure 12. If the correct pattern cannot be obtained, re-set the FUNCTION Switch to the 10 K to 100 kHz range and adjust the SWEEP VERNIER as required. If the component is open or is badly shorted, it will not be possible to obtain the correct waveform.

### Coils

To test the television width, linearity, focus, or other similar coils, obtain a ringing waveform across the coil winding as described above, then make a loop using several turns of solder, and pass the loop over the coil. If the solder loop causes a significant change in the waveform, the coil is probably good.

### TV High-Voltage Transformers (Flyback)

To test the high-voltage transformer in a TV receiver, remove the horizontal output and the high-voltage rectifier tubes or disconnect the equivalent leads in semiconductor circuits. Obtain a ringing waveform across the transformer primary. Connect a short across the filament winding. If a significant change in the waveform is noted, the transformer is probably good. Little or no waveform change indicates that the transformer is defective.

### Yokes

To test the horizontal windings of the deflection yoke disconnect the yoke from the circuit.

#### HORIZONTAL YOKE WINDINGS

There are two horizontal yoke sections, and they can be connected in series or in parallel, depending on the particular chassis. If they are in series, ring the combined coils at one time. Alternately short each section, if the windings are good, the effect on the waveform should be about the same as each section is shorted. If the coils are parallel, disconnect the junction of the two windings at one end so that they can be tested separately. The waveforms for the two sections should resemble each other.

#### VERTICAL YOKE WINDINGS

To test the vertical windings of the deflection yoke, disconnect the yoke from the circuit and remove the damping resistors. Check the vertical windings using the same technique described above for testing the horizontal windings.

#### RCA "PRECISION IN-LINE" TUBES WITH PERMANENT YOKES

The Ringing Test can be used to check the yoke/tube assemblies, such as the RCA 15VADTC01, etc., where the yoke is permanently installed on the tube. These yoke windings are quite different from other yokes,

however, and the Ringing Test procedure varies slightly as described below.

Unplug the yoke plug from the chassis. Refer to the schematic diagram for the chassis for the appropriate coil winding terminal identification.

The two vertical windings are separate and must be tested individually. The normal Ringing Test procedure can be used with the 1500 to 15 kHz sweep range, however a distorted version of the typical ringing pattern will be produced. A proper pattern can be obtained simply by connecting a 2200 pF (the actual capacitor value is not critical) across, or in parallel to, the winding being tested. Use the 150-1500 Hz sweep range and adjust the scope controls in the normal manner to obtain a ringing pattern.

Compare the ringing test waveform obtained for each of the two vertical windings. If the windings are good, the waveforms will be identical and it will not be

necessary to adjust the scope controls to make one pattern resemble the other.

The two horizontal deflection windings are connected in parallel. To perform the Ringing test, it is necessary to disconnect the junction of the two windings at one end so they can be tested separately. Fortunately, this usually is a simple procedure; just unsolder one end of the jumper wire connecting these coil windings at the yoke terminals.

Set the probe switch to "direct" for this test. Use the 150-1500 Hz sweep range. As with the vertical windings, connect a 2200 pF capacitor across (in parallel with) each winding as it is tested. Adjust the scope controls to obtain a normal ringing pattern. The pattern obtained for each winding should be the same. A bad coil is indicated if a ringing pattern cannot be obtained or if it is necessary to readjust the scope controls to make the pattern obtained from one winding resemble the pattern for the other winding.

## Applications

There are hundreds of applications in service shops, design labs, industrial labs, schools, etc., where a general purpose oscilloscope, such as the WO-33B is required. This section includes a few typical applications, along with detailed procedures describing the use of the WO-33B for TV servicing. Before using the WO-33B in any application, be sure you completely understand the function of the controls and the proper way to use them, as described on pages 6 through 8. To obtain the proper waveform, it is especially important that the Probe Switch, the Function Switch, and the Sweep Vernier and Sync/Phase controls be properly adjusted. The Quicktrace Slide Switch must be set to "Scope Normal."

### SQUARE-WAVE TESTING OF AUDIO AMPLIFIERS

The use of square waves for testing the characteristics of audio equipment has distinct advantages over other methods. A square-wave generator, such as the RCA WA-504B/44D and the WO-33B Oscilloscope, when set

up as shown in Figure 15 can provide a quick and accurate means of checking an amplifier and its adjustments. In this test setup, it is possible to check simultaneously the amplitude, phase, and frequency characteristics of the amplifier.

The value of the load resistance used depends upon the output impedance of the amplifier. The output is usually identified with the impedance, normally 4, 8, or 16 ohms. It is important that the correct value be used, and that the resistors have a suitable voltage rating to handle the amplifier power output. For an overall check of amplifier response, the WO-33B should be connected directly across the load resistance, as shown.

Separate tests should be made at least with two fundamental frequencies. The lowest fundamental frequency should be equal to approximately ten times the low-frequency limit of the amplifier being tested. A 100 Hz square wave should serve to check response from a few cycles to over 1000. If a square wave

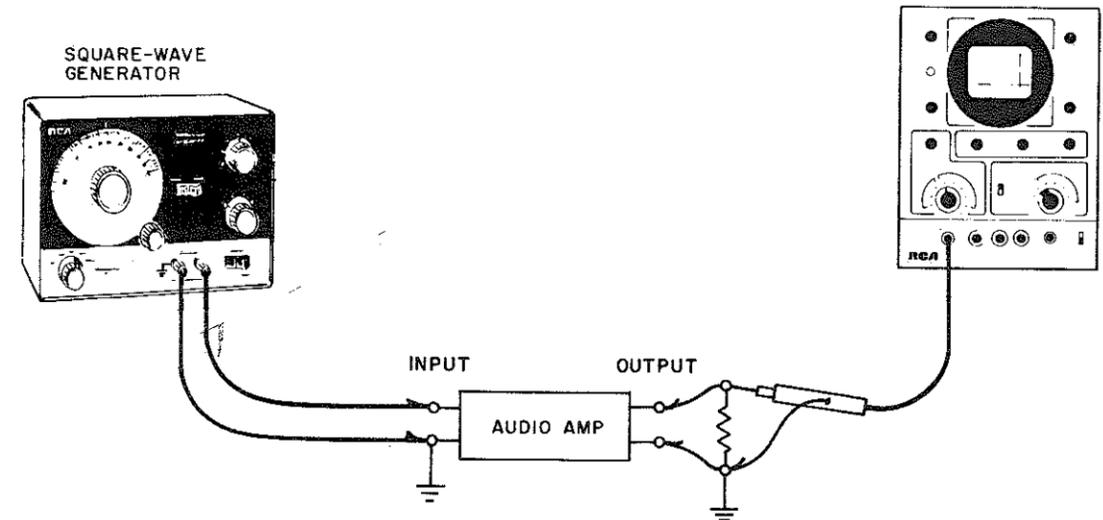


Figure 15. Audio amplifier test.

having a fundamental frequency of 2 KHz is used, the amplifier can be checked through the balance of the audible range.

The square-wave generator should be set to the proper frequency and connected to the regular input terminal of the amplifier. The WO-33B may be connected temporarily directly across the generator for a reference check of the waveform. The oscilloscope may then be connected to various points in the amplifier to determine how each stage is functioning. The effect of various adjustments may be seen on the screen.

Care should be taken to prevent too large a signal from the square-wave generator from overloading the amplifier and causing distortion of the square wave.

### PHASE-SHIFT MEASUREMENTS

To measure the phase shift of an audio network, apply a sine wave to the circuit under test and connect the direct probe to the output terminal of the network. This test signal should also be fed to the oscilloscope through the EXT/H INPUT and GND terminals. Set the FUNCTION Switch to the "H IN" position. If no phase shift exists, a sloping straight line will appear.

Phase shift is indicated as an elliptical or circular trace. The method of calculating the degree of phase shift is shown graphically in Figure 17.

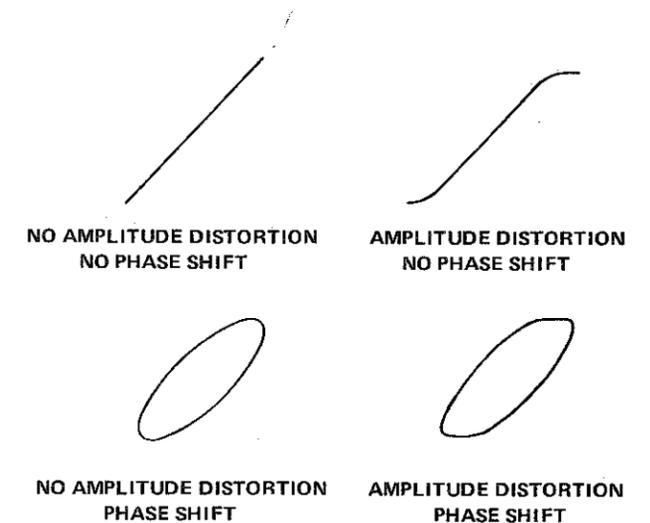


Figure 16. Distortion and phase shift in audio amplifier.

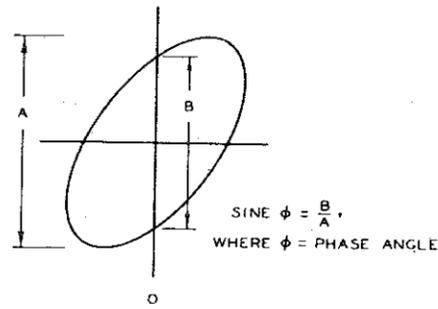


Figure 17. Measurement of phase shift.

### FREQUENCY MEASUREMENTS

Two methods may be used to determine frequency. In one method, a sine wave of known frequency is applied to the EXT/H IN terminal and the FUNCTION Switch is set to "H IN". The unknown signal is fed to the V INPUT terminal. The resulting pattern, or Lissajous figure, indicates the ratio between the two frequencies. Typical Lissajous figures are shown in Figure 18.

In the other method of frequency measurement, the FUNCTION Switch is set at "LINE" to provide a sweep at the 60 Hz power-line frequency. The signal of unknown frequency is then applied to the V INPUT terminal. If a stationary pattern is obtained on the

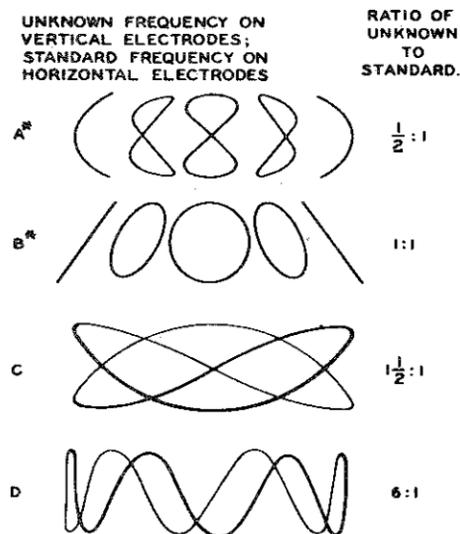


Figure 18. Lissajous figures.

oscilloscope screen, the frequency of the input signal must be equal to, a submultiple of, or a multiple of the line frequency.

### TV SERVICING APPLICATIONS

The use of an oscilloscope is essential for proper service of television receivers. The scope is used for signal tracing, analyzing waveforms, measuring peak-to-peak voltages, and alignment.

The signals can be traced through various sections of the television receiver to determine how circuits are functioning, as indicated by the shape and voltage value of the waveform. When observing waveforms in the video amplifier and chrominance circuits, the probe switch should be in the LO-CAP position to prevent loading the test circuit.

When the scope is calibrated as described under "Operation", the peak-to-peak voltage value can be measured.

**Note:** When the probe is in the LO CAP position, voltage readings must be multiplied by ten.

### USING COMPOSITE TELEVISION WAVEFORMS

Probably the most important waveform encountered in television service work is the composite video waveform consisting of the video signal, the blanking pedestals, and the sync pulses. Photographs of the composite video signal are shown in Figures 19 and 20.

The television service technician should devote some time to the study of such waveforms by setting up a television receiver known to be in good operating condition and noting the waveforms on the WO-33B at various points in the video amplifier. Traces similar to those shown may be obtained as follows:

1. Tune the receiver to a television signal.
2. Rotate the scope INTENSITY Control clockwise. Set the SYNC Switch to "NORMAL". Adjust the H GAIN Control for a horizontal line of appropriate length. Set the INTENSITY and FOCUS Controls for the desired brightness and best focus.
3. Connect the WG-400A probe and cable connector to the V INPUT Connector and set the sliding switch on the probe to "LOW CAP". Connect the ground cable to the receiver chassis. Connect the probe tip to the grid terminal of the picture tube socket. It is not necessary that the picture tube be connected for this test.

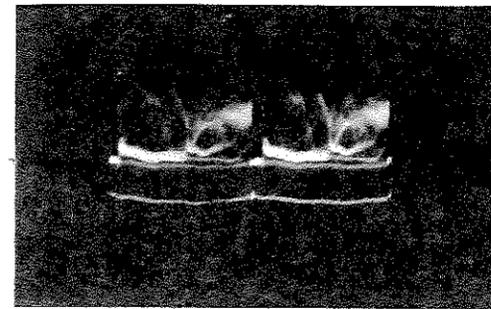


Figure 19. Composite TV waveform showing video information, vertical blanking interval, and vertical sync pulse.

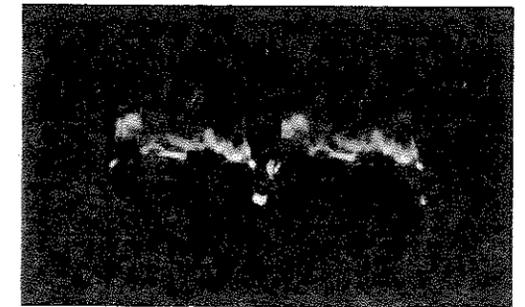


Figure 20. Composite TV waveform showing video information, horizontal interval, and horizontal sync pulse.

4. Set the VERTICAL RANGE Switch and the V CAL Control for a pattern of suitable height.
5. To obtain the horizontal-sync pulse on the screen, set the Function Switch to the position marked "H." Adjust the Sync/Phase Control slightly clockwise (+) to obtain the best lock-in on the sync pulse. If good lock-in is not obtained, readjust SYNC/PHASE counterclockwise to lock-in on negative (-) sync.

To obtain the vertical sync pulse, set the Function Switch to the "V" position.

The pulses should resemble those shown in Figures 19 and 20.

The horizontal sync pulse can be used as a reference of the overall waveform quality. Several typical circuit faults and the resulting horizontal pulse distortion are shown in Figure 21.

NORMAL HORIZONTAL PULSE	CIRCUIT FAULT	HORIZONTAL PULSE DISTORTION	OVERALL FREQUENCY RESPONSE OF RECEIVER	EFFECT ON PICTURE
	NORMAL CIRCUIT			PICTURE NORMAL
	LOSS OF HIGH FREQUENCIES			LOSS OF PICTURE DETAIL
	EXCESSIVE HIGH-FREQUENCY RESPONSE, NON-LINEAR PHASE SHIFT			FINE VERTICAL BLACK & WHITE STRIATIONS FOLLOWING A SHARP CHANGE IN PICTURE SHADING
	LOSS OF LOW FREQUENCIES (IN THE RANGE ABOVE 15 OR 20 KC)			CHANGE IN SHADING OF LARGE PICTURE AREAS; SMEARED PICTURE.

Figure 21. Sync-pulse distortion.

## TELEVISION ALIGNMENT

The information below is provided as a guide for using the WO-33B to align television receivers. The detailed procedure in the manufacturer's service notes for the particular receiver should be followed.

Other test equipment required includes a TV sweep generator, such as the RCA WR-514A.

### Picture IF Alignment

1. Disable AGC and horizontal deflection circuits, apply proper bias voltages, and otherwise prepare the chassis for alignment as described in the service notes. Usually, it is recommended that the tuner be set to the UHF position or to an unused channel to reduce tuner interference.
2. Connect the WG-400A probe, set to "DIR", to the video detector test point through a 10 K $\Omega$  isolating resistor. Set the generator controls to provide a suitable IF sweep signal. Connect the output from IF sweep generator to the mixer input test point of the receiver through an appropriate mixer input pad.
3. Set the WO-33B FUNCTION Switch to LINE sync. Turn the V CAL and adjust the VERTICAL RANGE switch to the position that provides adequate trace height. For most receivers, the 5-volt range is used.  
  
**Note:** If the TV sweep generator provides sawtooth output, connect this output to the "EXT H INPUT" Terminal, and set the FUNCTION Switch to "H IN".
4. Adjust the generator output level to provide a trace with the peak-to-peak voltage level specified in the service data. The sweep signal level must be kept low enough so that the amplifier does not become overloaded, thus flattening the top of the curve or otherwise distorting the trace. Adjust the oscilloscope intensity, focus, sweep sync, horizontal gain, and positioning controls to produce a good trace.
5. Remove blanking from the sweep signal (most generators have a "blanking off" switch) and adjust the WO-33B SYNC/PHASE control to obtain a single, in-phase trace. If the control is not set properly, the sweep curve may be distorted, or appear as a double image as shown in Figure 22.

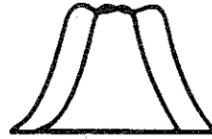


Figure 22. Double rf-response curve caused by improper setting of phasing control. No blanking used.

6. Apply the IF frequency markers as described in the service data. Markers usually required are 47.25, 45.75, 42.67, 42.17, 41.67, and 41.25 MHz.
7. Adjust traps, IF coils and transformers for IF response curve as described in service data. Typical IF response curves are shown in Figure 23. The general shape of the curve obtained will depend largely on the particular receiver being aligned. The effect of the various IF adjustments for most receivers is listed below:  
  
1st IF Output transformer — 45.75 Marker Position  
2nd IF Output transformer — 42.17 Marker Position  
3rd IF Output transformer — Overall Tilt/Symmetry

### AFPC Alignment — General

When the AFPC circuit in a color TV receiver is adjusted properly, the tint control will have sufficient range to handle all variations of hue in the transmitted picture; the hue control will change only the hue and not the intensity; color sync will not be lost on weak signals; and color balance of the picture will not change with varying luminance. The AFPC (automatic frequency and phase control) alignment procedure recommended by most color TV manufacturers uses a color-bar generator as a signal source and an electronic voltmeter for reference in adjusting the 3.58 MHz oscillator and the phase detector transformer. An oscilloscope is often used to check the alignment of the phase detector transformer. The usual procedure for adjusting the reactance coil is to ground the reactance tube input, then set the coil for zero-beat of the color signal as observed on the receiver screen.

### Vector AFPC Alignment

AFPC circuits can also be aligned using a vector pattern. The WO-33B can be used as a vectorscope for this application, as described on page 18.



Figure 23. Typical IF curves for two types of receivers.

## Maintenance

**CAUTION:** Do not strike or subject the cathode-ray tube to more than moderate pressure as breakage of the tube may result in injury from flying glass. When the case of the instrument is removed, high voltages are exposed and the safety precautions outlined on Page 2 should be observed.

### GENERAL

Performance of the WO-33B depends upon the quality of the components employed. If it should be necessary to replace any of the component parts, only RCA replacement parts or equivalents of those shown in the Replacement Parts List of this instruction booklet should be used.

The chassis may be removed from the case by removing two screws on each side of the case, and three screws from the bottom of the case. The panel and chassis assembly may then be pulled forward and out of the case.

If any alignment adjustments are made, the line voltage should be 120 volts at 50-60 Hz. If trouble is encountered, conventional trouble-shooting techniques should be used to locate trouble. Voltage, resistance and continuity checks can then be made to isolate the defective section or stage.

### 240 VOLT OPERATION

The WO-33B is supplied wired for operation from a 120-volt power line. To convert the instrument for operation on a 240-volt power line, reconnect the transformer primary leads to the terminal strip at the rear of the instrument, following the wire color-code reference provided in the schematic diagram, page 16.

### VERTICAL ATTENUATOR ALIGNMENT

Alignment of the frequency-compensated step-attenuator requires the use of a square-wave generator such as the RCA WA-504B/44D.

1. Set the WG-400A probe to "DIRECT", and connect it to the generator output. Adjust the generator to provide a 1000 Hz signal.
2. Set the VERTICAL RANGE Switch to 150.
3. Adjust the scope controls so that two square waves, about an inch high and two inches wide are displayed on the screen.
4. Adjust C-6 so that the square waves are flat-topped, without overshoot spikes or drooping corners.
5. Reset the VERTICAL RANGE control to 50, and reset the amplitude of the square wave generator. Adjust C-5 as in "4" above.

- Repeat this process for VERTICAL RANGE positions 15 and 5. The desired trimmer capacitor can be identified on the range switch by touching it with the finger and noting the appearance of a random noise signal on the CRT screen.
- Reset the VERTICAL RANGE switch to .15. Reduce the generator output to keep trace amplitude at about one inch. Identify trimmer capacitor C-43, connected from the range switch to the circuit board. Adjust C-43 for flat-topped square wave. Set VERTICAL RANGE switch first to .05, then to .15. Square wave should be flat.
- Connect the WG-400A probe to square wave generator. Set the probe switch to "LO-CAP." With the VERTICAL RANGE control on position 5, adjust capacitor C-1 for a flat top trace without overshoot spikes or drooping corners.

#### ASTIGMATISM ADJUSTMENT

- Turn on the WO-33B and allow at least 15 minutes warm-up time.
- Set the FUNCTION Switch to "LINE", the VERTICAL RANGE Switch to "CAL", and adjust the SYNC/PHASE, V CAL, and H GAIN controls for a circular pattern approximately one inch in diameter.
- With a screw driver, adjust potentiometer R-68 for best possible focus at all points on the circle. R-68 is located on top of the vertical metal chassis.

#### INTERNAL CALIBRATION ADJUSTMENT

- Connect the oscilloscope probe to the output of an audio generator, such as the RCA WA-504B/44D. Set the probe switch to "DIRECT." Set the VOLTAGE RANGE Switch to "5." Adjust the generator output on scope V CAL control so that the trace extends vertically between the two "CAL" lines.
- Set the probe switch to the "LO CAP" position, and set the VOLTAGE RANGE Switch to ".5". Adjust potentiometer R11 so that the trace extends vertically between the two "CAL" lines.

#### RCA Repair Service

Authorized RCA Service Depots throughout the United States are available for repair and calibration of RCA Electronic Instruments. For up-to-date listings of these Depots, contact your RCA Distributor, or write to RCA Electronic Instruments, 415 South 5th Street, Harrison, New Jersey 07029.

If it becomes necessary to service this equipment, fill out one of the Test Equipment Service order forms supplied with the instrument. It is important that:

- Test equipment be packed carefully. The instrument should be double-packed. It is best to pack the unit in its original carton, or similar container, then "float" this carton in at least a 3-inch layer of shredded paper inside the outer carton.
- A full description of the trouble be included in the report.
- All probes, cables, and test leads used with the equipment be included in the shipment.

Attention to these details will help prevent damage in transit and delay in repairs.

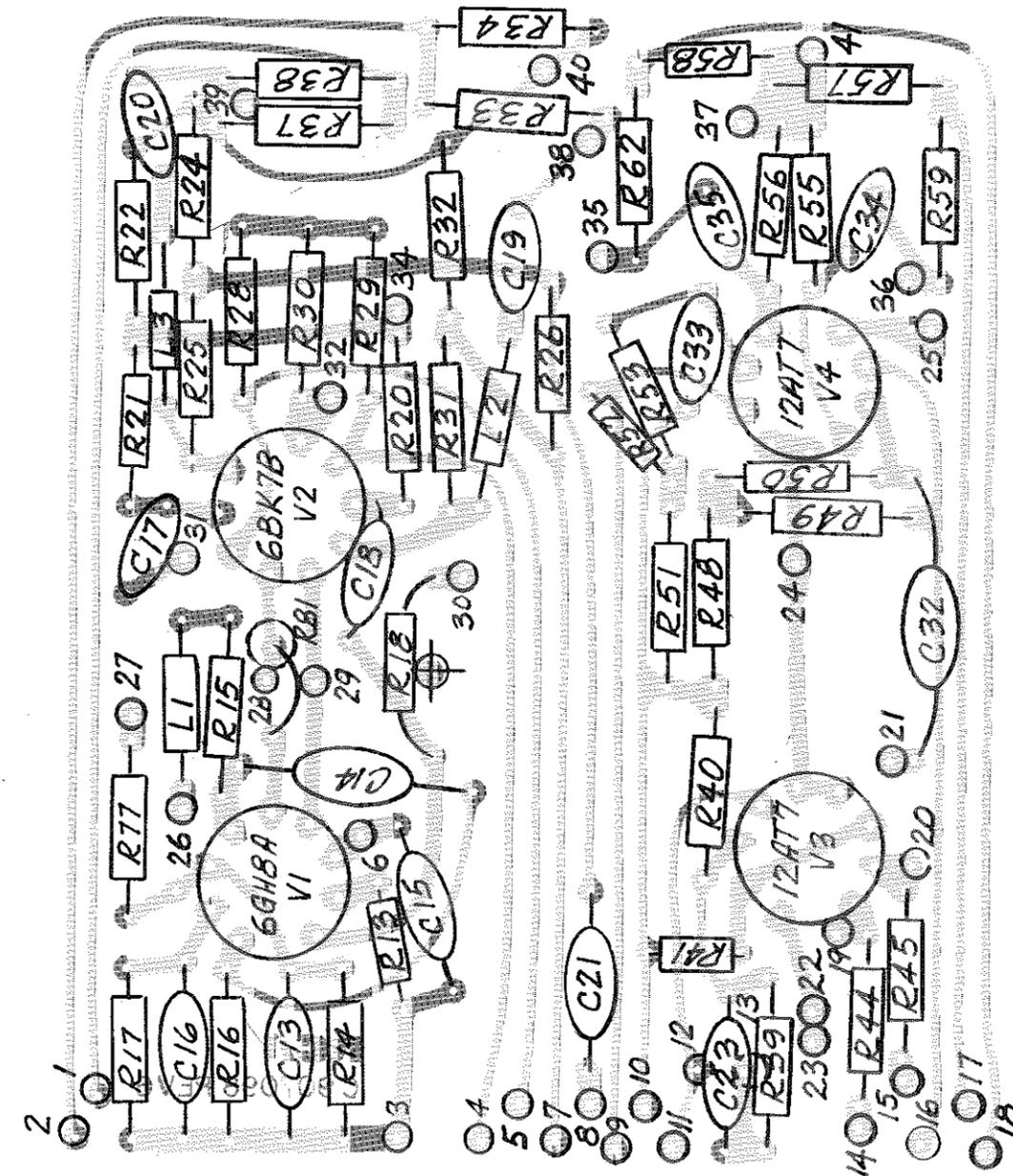


Figure 24. Circuit board component location, View from component side.

## Replacement Parts List

When ordering replacement parts, include serial number and code number of instrument. Order parts by stock number, through a local RCA Distributor.

Symbol	Description	Stock Number	Symbol	Description	Stock Number
	<b>CAPACITORS</b>				
C1	Trimmer, 4-40 PF	228502	C38, C39	Electrolytic, 40-20-20-10 MF, 450 V	219127
C2	0.1 MF 20% 400 V	242290	C40	Not Used	
C3 to C6	Trimmer, 4-40 PF	228502	C41	Ceramic Disc, .01 MF, 20%, 600 V	429598
C8	Ceramic Disc, 13 PF, 5%, 600 V	425097	C42	0.1 MF, 20%, 200 V	137086
C9	Ceramic Disc, 64 PF, 5%, 600 V	219214	C43	Trimmer, 4-40 MMF	228502
C10	Ceramic Disc, 140 PF, 5%, 600 V	219205	C44, C45	Electrolytic, 4 MF, 450 V	429597
C11	Ceramic Disc, 410 PF, 5%, 600 V NPO	219206	C46	Ceramic Disc, .01 MF, 20% 600 V	429596
C12	Ceramic Disc, 1500 PF, 5%, 600 V	219207		<b>RESISTORS</b>	
C13	Ceramic Disc, 560 PF, 5%, 600 V	219208		All resistors are film, 5%, ½ W, unless noted.	
C14	0.1 MF, 20%, 400 V	242290	R1	680 K	249767
C15	Ceramic Disc, .02 MF, 600 V	210685	R2	910 K	131041
C16	Ceramic Disc, 560 PF, 5%, 600 V	219208	R3, R4	1 Meg.	243004
C17, C18	0.1 MF, 20%, 400 V	242290	R5	15 K	229918
C19, C20	Ceramic Disc, .05 MF, 20%, 200 V	219213	R6	470 K	236998
C21, C22	Ceramic Disc, .02 MF, 600 V	210685	R7	110 K	126445
C23	Ceramic Disc, 5 PF, 20%, 600 V	429600	R8	33 K	229526
C24	Not Used		R9	10 K	228716
C25	0.22 MF, 10%, 400 V	235806	R10	3300 Ohms	228714
C26	.022 MF, 10%, 400 V	228034	R11	Variable, Wirewound, 5 K	429228
C27	Ceramic Disc, 2200 PF, 5%, 600 V	219209	R12	6800 Ohms, 10%, 1 W	135319
C28	Ceramic Disc, 220 PF, 5%, 600 V	219210	R13	1 Meg.	243004
C29	Ceramic Disc, 15 PF, 5%, 600 V	219204	R14	270 Ohms, 10%	228705
C30	Ceramic Disc, 180 PF, 10%, 600 V	219211	R15	1200 Ohms	228709
C31	Ceramic Disc, 150 PF, 10%, 600 V	219212	R16	1 Meg., 10%	243004
C32, C33,			R17	150 Ohms, 5%	224251
C34,	0.1 MF, 20%, 400 V	242290	R18	1200 Ohms, 5%	228709
C36, C37	Not Used		R19	4700 Ohms, 10%, 1 W	229668
			R20, R21	470 K, 10%	236998
			R22	220 K	237000
			R23	82 K	224259
			R24	1800 Ohms, 1 W	233383
			R25	1200 Ohms	228709
			R26	10 K	228716
			R27	Variable, 5 K	219597
			R28, R29	1 K	224254
			R30	Wirewound, 2400 Ohms, 5 W	219125
			R31	1200 Ohms	228709
			R32	1800 Ohms, 1 W	233383

Symbol	Description	Stock Number	Symbol	Description	Stock Number
R33	1 Meg., 10%	243004	R81	Wirewound, 1.8 Ohms, 10%, 1 W	233383
R34	820 K	502482	R82	91 Meg., 20%	227047
R35	Variable, 1 Meg.	219598	R83, R84	1 Meg., 10%	243004
R36	1.2 Meg., 10%	136722	R85	1 K, 10%	224254
R37	820 K	502482	R86, R87	27 Ohms, 10%,	239444
R38	1 Meg., 10%	243004	R88	1 Meg., 10%	243004
R39	68 K, 10%	224257	R89	10 K, 10%, 1 W	135018
R40	3300 Ohms, 10%	228714	R90	120 K, 10%,	224261
R41	680 Ohms	224253	R91	1 K, 10%	224254
R42	100 K, 1 W	128273	R92	270 K, 10%	124473
R43	Variable, Dual, 5 Meg., 1 Meg.	219603	R93	1.5 Meg., 10%	135231
R44	270 K	124473	R94, R95	1 Meg., 10%	243004
R45	39 K	227104	R96	100 K, 10%	224260
R46	2.7 Meg.	120998	R97	12 K, 10%	227100
R47	3.3 Meg.	243005		<b>SWITCHES</b>	
R48	15 K	229918	S1	Switch, Voltage Range	429232
R49	2400 Ohms	229950	S2	Switch, Function	429233
R50	10 Meg., 10%	243006	S3	Switch, Sync, DPDT	244569
R51	15 K	229918	S4	Switch, Intensity, Part of R73	
R52	2400 Ohms	229950	S5	Switch, Quicktrace, TPD	429560
R53	10 Meg., 10%	243006		<b>MISCELLANEOUS</b>	
R54	Variable, 50 K	219599	L1	Coil, Peaking, 10 UH, 5%	429561
R55, R56	120 K	224261	L2, L3	Coil, Peaking, 36 UH, 5%	219129
R57, R58	820 K	502482	T1	Transformer, Power, 120 V/240 V	429237
R59	2.7 Meg., 10%	120998	T2	Transformer, "QT"	429236
R60	Variable, 2 Meg.	219600	CR1 to CR4	Diode, Type 1N4007	239429
R61	470 K, 10%	236998	J1	Binding Post, Black	248291
R62	2.7 Meg., 10%	120998	J2, J3	Binding Post, Red	248117
R63	4700 Ohms, 10%	227102	J4	Connector, BNC	098512
R64	Wirewound, 1500 Ohms, 10%, 7 W	219123	J5	Jack, Phono, "QT"	425870
R65	Wirewound, 2500 Ohms, 10%, 5 W	219124	J6	Jack, Ringing Test	214783
R66	2200 Ohms, 10%	228712		Graticule	429229
R67	47 K	227105		Case Assembly	429227
R68	Variable, 100 K, 20%	429231		Front Panel	429238
R69	180 K, 10%	249313		Bezel, rubber	219128
R70	470 K, 10%	236998		Handle, Black	248070
R71	Variable, 500 K	219601		Shield, Circuit	223104
R72	120 K, 10%	224261		Power Cord, 3 Conductor	428063
R73	Variable w/switch, 75 K	219602		Knob, Plastic	249527
R74	120 K, 10%	224261		Knob, Rubber, Black	94878
R75	Variable, Dual, 250 K	219604		Lamp, Neon, NE2	48474
R76	Variable, 10 K, 20%	429230		Lens, Pilot Lamp, Red	429234
R77	1 Meg., 10%	243004			
R78	15 K, 10%	229918			
R80	820 Ohms, 10%, 1 W	229113			