RCA CATHODE-RAY OSCILLOSCOPE

Type WO-33A

• Specifications
• Operation
• Applications
• Maintenance

RADIO CORPORATION OF AMERICA
ELECTRON TUBE DIVISION
HARRISON, N.J.
ELECTRONIC INSTRUMENTS
CAMDEN, N.J.
Safety Precautions

The metal case of this instrument is connected to the ground of the internal circuit. For proper operation, the ground terminal of the instrument should always be connected to the ground of the equipment under test. The WG-349A Direct/Low-Capacitance Probe and Cable has a shield throughout its entire length which is connected to the instrument ground and case.

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.

An important point to remember is that there is always danger inherent in testing electrical equipment which operates at hazardous voltages. Therefore, the operator should thoroughly familiarize himself 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.

Items Supplied with WO-33A

<table>
<thead>
<tr>
<th>ITEM</th>
<th>DESCRIPTION</th>
<th>TYPE NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 6KB7A</td>
<td>Direct/Low-Capacitance Probe and Cable</td>
<td>Type No. WG-349A</td>
</tr>
<tr>
<td>2 12AT7</td>
<td>1 6X4</td>
<td></td>
</tr>
<tr>
<td>1 6C4</td>
<td>1 6BR8</td>
<td>1 RCA 3AQPI</td>
</tr>
</tbody>
</table>

Available on Separate Order

- For rf applications from 500 Kc to 250 Mc: Demodulator Probe ........ Type No. WG-350A
- Instruction Booklet

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Cathode-Ray Oscilloscope

Type WO-33A

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The RCA WO-33A is a 3-inch oscilloscope designed for "on-location" and service-shop use in servicing color and black-and-white television receivers, Hi-Fi equipment, PA and sound reenforcement systems, broadcast station and remote equipment, communications and industrial electronic equipment.

A novel feature of the WO-33A is the Vertical Input Attenuator which automatically switches the amplifier from Wide Band to Narrow Band when in the three highest gain positions.

Another important feature of the WO-33A is the exceptionally high gain in its vertical amplifier. There is enough sensitivity to provide a useful display of signals from low-level microphones, phonograph pickups and other weak signals found in radio/TV receivers, audio amplifiers, etc.

A voltage-calibrated, frequency-compensated vertical-input attenuator, an internal calibrating-voltage source, and a glass screen scaled directly in volts make it possible to use the WO-33A as a visual voltmeter. The unique system of calibrating the glass screen provides for scaling voltages directly from the screen. The measurement procedure is very similar to that employed with a vacuum-tube voltmeter. A calibrating voltage is automatically applied to the vertical amplifier when the bandwidth control is set to the calibration position. This switch also disconnects internally the input and attenuator circuits, making it unnecessary to remove leads and probes from the external circuit under test. These unique facilities make voltage calibration and measurement a simple, almost automatic procedure.

The sweep-frequency control is continuously adjustable from 15 cps to 75 Kc. The sweep oscillator has excellent stability at high sweep rates, a fast retrace, and adequate linearity throughout its frequency range. The over-all frequency range of the oscillator is divided into four basic ranges: vernier adjustment, which overlaps the basic sweep ranges, provides exact adjustment of the sweep frequency. The amount of sync signal fed to the sweep oscillator may be adjusted by means of a front-panel control. Sweep synchronization is exceptionally stable throughout the sweep range of the oscillator.

A phase control is provided for varying the phase of the internal sweep voltage when the "LINE" position of the H/SWEEP SEL control is used, enabling the WO-33A to be phased with an external line-frequency sweep oscillator.

To facilitate its use, the WO-33A is equipped with a specially designed single-unit probe and input cable. This accessory, the WG-349A Direct/Low-Capacitance Probe and Cable, is provided with a blue input lead and a yellow input lead. When the blue input is used, the test signal is fed directly to the vertical-input terminal. When the yellow input is used, a special high-impedance circuit in the probe is connected in series with the test point and the scope. This high-impedance circuit presents an overall input resistance of 10 megohms and an input capacitance of approximately 10 µf to the test circuit. This feature reduces circuit-loading effects and permits use in circuits which would not function properly if loaded down by a conventional oscilloscope.

The WO-33A can be used to trouble-shoot and signal trace all sections of both black-and-white and color-TV receivers. The voltage-calibrating facilities, wide band-pass, and high-impedance input characteristics make possible observations and measurements of color-burst signals and other critical, high-frequency waveforms in circuits which are sensitive to loading effects.

The size and weight of the WO-33A make it an especially portable instrument, useful in such applications as industrial maintenance and trouble-shooting, general waveform analysis, adjustment of radio receivers and transmitters, square-wave and general testing of audio equipment, peak-to-peak voltage measurements, and observation of vacuum-tube characteristics. The WO-33A is a versatile and reliable instrument, well suited to applications which require a dependable oscilloscope.

### Specifications

#### Frequency Response:

<table>
<thead>
<tr>
<th>Vertical Amplifier</th>
<th>Wide-Band Positions (5.5 cps to 5.5 Mc)</th>
<th>Flat within ~3 db</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-Sensitivity Positions:</td>
<td>20 cps to 150 Kc</td>
<td>Flat within ~3 db</td>
</tr>
<tr>
<td></td>
<td>3 cps to 1.5 Mc</td>
<td>Flat within ~6 db</td>
</tr>
<tr>
<td>Horizontal Amplifier (3.5 cps to 350 Kc)</td>
<td>Flat within ~6 db</td>
<td></td>
</tr>
</tbody>
</table>

#### Deflection Sensitivity:

<table>
<thead>
<tr>
<th>Vertical Amplifier</th>
<th>Positions</th>
<th>(Wide-Band) p-p</th>
<th>(High-Sensitivity) p-p</th>
</tr>
</thead>
<tbody>
<tr>
<td>At V INPUT connector</td>
<td>0.10</td>
<td>0.003</td>
<td>0.01 volt/in</td>
</tr>
<tr>
<td>With WG-349A Blue Lead</td>
<td>0.10</td>
<td>0.003</td>
<td>0.01 volt/in</td>
</tr>
<tr>
<td>With WG-349A Yellow Lead</td>
<td>1.0</td>
<td>0.03</td>
<td>0.1 volt/in</td>
</tr>
<tr>
<td>Horizontal Amplifier (at H INPUT terminal)</td>
<td>0.9 rms volt/in</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Input Resistance and Capacitance:

<table>
<thead>
<tr>
<th>Vertical Amplifier</th>
<th>Positions</th>
<th>Resistances</th>
<th>Capacitances</th>
</tr>
</thead>
<tbody>
<tr>
<td>At V INPUT connector</td>
<td>1 megohm shunted by approx. 50 µf</td>
<td></td>
<td></td>
</tr>
<tr>
<td>With WG-349A Blue Lead</td>
<td>1 megohm shunted by approx. 90 µf</td>
<td></td>
<td></td>
</tr>
<tr>
<td>With WG-349A Yellow Lead</td>
<td>10 megohms shunted by approx. 10 µf</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horizontal Amplifier (at H INPUT terminal)</td>
<td>10 megohms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EXT SYNC Input Terminal</td>
<td>250 K to 55 K</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Sweep Oscillator:

| Frequency Range (continuously adjustable) | 15 cps to 75 Kc |
| Sync | External, ± Internal |
| Sync Range | 7 to 4.5 Mc |

#### Maximum AC Input Voltage (at Lo-Cap Probe): (In presence of 400 volts dc) | 600 p-p volts |

#### Power-Range Controls:

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Average Power Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>105-125 volts, 50-60 cps</td>
<td>20 watts</td>
</tr>
</tbody>
</table>

#### Tube Complement

| 1-6BBS | 2-12AX7 | 1-6G6 |
| 1-6BK7A | 1-6X4 | 1-340F1 |

#### Mechanical

| Height | 8½" |
| Length | 10" |
| Width | 6½" |
| Weight | 14 lbs |
Functions of Controls and Terminals

**OFF-INTENSITY** — Applies power to the instrument and increases intensity of the trace on the screen of the cathode-ray tube when control is turned clockwise from "OFF" position.

**FOCUS** — Adjusts the sharpness of the trace. Normally requires adjustment when setting of the INTENSITY control is changed.

**V RANGE** — In "CAL" position, disconnects vertical amplifier from input connector, and supplies a calibrating voltage which should be adjusted with "V-CAL" control to full-screen deflection. Adjusts overall sensitivity of vertical amplifier in "3-to-1" steps. Automatically changes bandwidth of vertical amplifier when going from "2" to "6" positions.

**V POS** — Adjusts vertical position of trace.

**V INPUT** — Feeds the input signal to the vertical amplifier through the attenuator circuits.

**H POS** — Adjusts horizontal position of trace.

**H/SWEEP SEL** — Selects the frequency range of the sweep oscillator. Used in conjunction with the SWEEP VERNIER control. Also switches the Horizontal Amplifier to "H INPUT" or to a sine-wave sweep voltage of power-line frequency.

**SYNC/PHASE** — Controls the amplitude of the synchronizing voltage applied to the grid of the sweep oscillator, should be adjusted to minimum setting necessary to lock pattern in a stationary position. Works zero-center for internal sync. Adjusts external sync by regular clockwise rotation. Also controls phase of the sinusoidal sweep voltage when the H/SWEEP SEL switch is in the "LINE" position.

**H GAIN** — Adjusts the gain of the horizontal amplifier and varies the width of the horizontal trace. Does not provide enough control to reduce trace length to zero.

**EXT SYNC/H INPUT** — An external synchronizing signal for the sweep oscillator should be connected between this terminal and the ground terminal. The "SYNC" switch should be set to "EXT". An external signal for the horizontal amplifier should also be connected between this terminal and the ground terminal and the H/SWEEP SEL control set to "H IN". A positive-going signal will cause the spot to deflect to the right; a negative-going signal will cause the spot to deflect to the left.

**GND** — Connected directly to case and chassis.

**SWEEP VERNIER** — Provides continuous control of the oscillator sweep frequency over the range selected by the SWEEP control. Also provides overlap of the SWEEP control positions.
Operation

To become familiar with the operation of the WO-33A Oscilloscope, it is recommended that the operator follow the procedure outlined below in the order given. The section "Function of Controls and Terminals" on pages 6 and 7 of the block diagram on page 20 will also be helpful.

Initial Procedure

1. Connect the power cord at the rear of the instrument to an ac outlet supplying 105-125 volts at 50-60 cps.
2. Turn the INTENSITY control clockwise from the "OFF" position and wait a few seconds for the instrument to warm up.
3. 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.
5. Turn the H/SWEEP SEL control to the "H-IN" position. In this position, without an external signal being applied to the H-INPUT terminals, no sweep voltage appears at the horizontal-deflecting electrodes of the cathode-ray tube and, therefore, only a spot will appear on the screen.
6. Position the spot in the center of the screen by adjusting the V POS and H POS controls.

Vertical-Amplifier Operation

1. Connect the WG-349A probe connector to the V INPUT connector. Set the V RANGE control to "CAL". The screen should now display a vertical trace, indicating that a signal has been applied to the vertical-deflecting electrodes of the cathode-ray trace, indicating that a signal has been applied to the cathode-ray tube and, therefore, the instrument to warm up.
2. Disconnect the lead from the voltage source. The horizontal line will be replaced by a spot.
3. Turn the H/SWEEP SEL to the "LINE" position. A horizontal line should appear. NOTE: When the H/SWEEP SEL switch is set to the "LINE" position, part of the power-line signal is fed internally to the horizontal amplifier, providing a sinusoidal horizontal-deflection voltage of power-line frequency. The SYNC/PHASE control can be used to adjust the phase of the internal sinusoidal sweep.
4. Turn the H/SWEEP SEL control to any of the sweep positions. The sawtooth output from the sweep oscillator is applied internally to the horizontal amplifier and a linear horizontal trace appears on the screen.

Sweep-Oscillator Operation

1. Adjust the H/SWEEP SEL and the SWEEP VERNIER control to give a sweep of approximately power-line frequency. Connect the ground lead from the WG-349A to the ground side of an ac-voltage source. An audio-frequency generator or a power-line signal can be used as a source. With the cable connector of the WG-349A attached to the V INPUT connector of the WO-33A, connect the blue lead to the other side of the low-voltage source. Adjust the SWEEP VERNIER control for a single cycle on the oscilloscope screen. Rotate the SYNC/PHASE control and note that it should be adjusted to a minimum position necessary to lock pattern in a stationary position.

2. With a single pattern on the screen, notice whether the pattern drifts across the face of the tube. Horizontal drift indicates that the SYNC/PHASE control should be rotated toward its clockwise or counterclockwise limits or that the SWEEP VERNIER control should be adjusted until the waveform is locked in.
3. Connect the WO-349A connector to an external signal of a different frequency.
4. Set the H/SWEEP SEL control to "H IN" and adjust the H/SWEEP and SWEEP VERNIER controls to produce a suitable sweep frequency. Apply a synchronizing voltage from the external signal to the EXT SYNC terminal. Set the SWEEP switch to "EXT". Adjust the SYNC/PHASE control until the pattern locks in on the oscilloscope screen.

Use of the WO-349A Direct/Low-Capacitance Probe

The WG-349A Direct/Low-Capacitance Probe is designed especially for use with the WO-33A Oscilloscope. This single-unit probe is equipped with two clips from the probe housing which permits connecting a built-in high-impedance network in high-impedance circuits, such as those found in 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, however, the signal is attenuated by a factor of ten. Therefore, when voltage measurements are made, the indicated voltage should be multiplied by 10.

Calibration and Voltage Measurement

Special facilities on the WO-33A provide for simple and quick voltage calibration of the vertical amplifier and the cathode-ray tube screen. When the oscilloscope has been calibrated as indicated below, the graph-screen scales can be used to measure the deflection amplitude of a displayed waveareshape directly in volts.

The green-graph screen has two vertical scales, as shown in Figure 2. The scale used depends upon the setting of the V RANGE control.

Calibration is accomplished as follows:
1. Set the V RANGE control to "CAL".
2. Adjust the V POS and V CAL controls for zero horizontal deflection to fill the graph screen between the two horizontal lines indicated by the "CAL" arrow on the side of the graph screen. The WO-33A is now calibrated.

When the V RANGE control is set to "CAL", the probe, cable, and input attenuator circuits in the scope are automatically disconnected from the vertical amplifier and an internal calibrating voltage is applied. The H/SWEEP SEL control may be set to any position during calibration. A straight vertical line is obtained by setting this control to "H IN".

A sinusoidal waveform is obtained when the H/SWEEP SEL is set to any other position.
Calibration will hold for both the wide band and narrow bandwidth positions. After calibration, an input signal may be read directly in peak-to-peak volts by measuring the vertical deflection against the correct graph-screen scale.

Example: It is desired to simultaneously display and measure the peak-to-peak voltage amplitude of the horizontal driving pulse at the grid pin of the screen. After calibration, an appropriate tube-socket pin is now calibrated.

1. Connect the ground lead from the WG-349A to the TV chassis. Connect the blue probe clip to the appropriate tube-socket pin.

2. Set the V RANGE control to a position which gives the desired on-screen deflection of the waveform.

3. Lock in the waveshape as described under "Sweep Oscillator Operation".

4. Adjust the V POS control to position the bottom of the trace on the graph-screen base line.

5. Read the peak-to-peak voltage amplitude of the waveform from the appropriate scale on the graph-screen. The peak-to-peak voltage is read from the scale point opposite the top of the waveform.

NOTE: If the WG-349A is used in its low-capacitance position, an attenuation factor of 10 is introduced and it will, therefore, be necessary to multiply the voltage reading by 10 to obtain the correct peak-to-peak voltage amplitude.

Successful servicing and maintenance of black-and-white and color-television receivers requires special techniques, not usually employed in the servicing of other electronic equipment. The general complexity and variety of circuits used in modern television receivers requires a great deal of knowledge on the part of the service technician and demands that test equipment be used properly.

The oscilloscope is of especial importance in the servicing of color receivers. A good television-service oscilloscope, such as the RCA WO-33A, may be used in signal tracing in every section of the receiver; the scope may also be used for making peak-to-peak voltage measurements in such important sections of the receiver as the sync and deflection circuits and in the video, chrominance, and luminance sections of color-TV receivers. In alignment work, where video, chrominance, and luminance circuit adjustments must be made to produce the desired waveform, the oscilloscope is indispensable. The WO-33A may be used in all these applications.

Signal-tracing means tracing the television signal through various sections of the television receiver to determine how circuits are functioning in terms of the shape and voltage value of the waveform. As the signal passes from one stage to another in the receiver, the shape of the waveform may be altered, and the height, or voltage amplitude of the waveform may be changed. Whenever possible, the WG-349A probe should be used in the "LOW CAP" position for signal tracing the video amplifier and chrominance circuits because of the low input capacitance and consequent negligible loading of the circuit under test. When the WO-33A is calibrated as described under "Operation", it is possible to simultaneously read the voltage value and observe the shape of the waveform. The process of signal tracing is thus speeded up and it is possible to ascertain a circuit condition quickly.

NOTE: The applications described here apply both to color and to black-and-white receivers.

Analyzing 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 3 and 4.

The photographs are oscilloscope traces, and show what the composite video signal looks like as it proceeds through the video amplifier of a television receiver.

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-33A at various points in the video amplifier. Traces similar to those shown in Figures 3 and 4 may be obtained on the WO-33A as follows:

(Continued on page 14)
1. Tune the television receiver to a television signal.

2. Rotate the INTENSITY control on the WO-33A clockwise. Set the SYNC control to "INT". Set the INTENSITY and FOCUS controls for the desired brightness and best focus.

3. Connect the WO-349A probe and cable connector to the V INPUT connector. Connect the ground lead to the receiver chassis. Connect the yellow probe clip to the grid terminal of the picture tube socket. It is not necessary that the picture tube be connected for this test.

4. The order in which various sections of the television receiver are aligned may differ between receivers and may usually be connected to the grid circuit through a composition resistor.

5. To obtain the horizontal-sync pulse on the WO-33A, set the H/SWEEP SEL control to the 1500 • 15 Kc position. Adjust the SYNC/PHASE control, if necessary, to obtain lock-on the sync pulse, and adjust the SWEEP VERNIER control so that both complete waveforms appear on the screen. To obtain the vertical-sync pulse, set the H/SWEEP SEL to the 15 • 150 position. Readjust the SWEEP VERNIER for two complete waveforms. The pulses should resemble those shown in Figures 3 and 4.

Alignment

The process of television-receiver alignment probably requires a greater amount of skill and understanding on the part of the service technician than does any other service function. Before undertaking alignment, it is important that the technician recognize the symptoms of a misaligned receiver.

For these reasons, it is not feasible to present a general alignment procedure that is applicable to all receivers. Some general precautions and suggestions for using the WO-33A Oscilloscope, however, are provided below to aid the television technician in servicing a receiver.

Receivers alignment requires, in addition to the WO-33A, a sweep generator, a marker generator of crystal accuracy, and a vacuum-tube voltmeter. An RCA WR-59 or WR-69-series Sweep Generator, an RCA WR-39, WR-99 or WR-89 Calibrator, and an RCA VoltOhm™, such as the WV-77, WV-87, WV-97, or WV-98 are recommended.

Tuner Alignment — When preparing for tuner alignment, the manufacturer's recommendations should be followed closely. If the tuner has test points for connecting equipment, the test points should be used. The oscilloscope test point is usually connected internally to the mixer grid circuit where a demodulated signal is present.

The output cable of the sweep generator should be connected to the antenna input connectors. The ground lead of the WO-33A should be clipped directly to the tuner shield to minimize hum pickup on the sweep trace, and the WO-349A blue clip should be connected to the mixer grid-circuit test point. If no test point is provided, the WO-349A may usually be connected to the grid circuit through a 5,000 to 10,000-ohm composition resistor.

It is important that the WO-49A be connected directly to the proper test point or, if a series resistor is used, that the lead length between the probe clip and the mixer grid circuit be kept as short as possible to prevent hum pickup and possible distortion of the tuner curve on the WO-33A. Hum pickup is evidenced by twisting of the base line when return-trace blanking is used on the sweep generator. This prevention is necessary because of the high-gain level at which the WO-33A is operated for tuner alignment.

The INTENSITY control should be turned clockwise to obtain a trace of suitable brilliance. The vertical gain controls should be set for maximum or near maximum gain. The output from the sweep generator and marker calibrator should be set at a low level to avoid over-loading the TV receiver, distortion of the sweep curve, and an erroneous picture of alignment on the oscilloscope screen.

When the WO-33A is used with a sweep generator, it is important that the two instruments be adjusted so that blanking is correct and the sweep of both instruments is in phase. If the phase adjustment is not properly set before starting alignment, the sweep curve on the oscilloscope may be prematurely cut off or the curve may appear as a double or "mirror" image. These effects, shown in Figures 7 and 8, are sometimes misinterpreted as being caused by malfunctioning of test equipment although they may often be traced to improper tuner alignment.

The sweep generator may use either a sinusoidal or sawtooth sweep of line frequency. If a sinusoidal line-frequency sweep is used, the WO-33A may be driven internally by setting the H/SWEEP SEL control to "LINE." If a sawtooth sweep is used, the sweep generator deflection signal may be fed to the H INPUT terminal of the WO-33A. The H/SWEEP SEL should be set to "H IN." An internal sawtooth sweep may also be obtained by setting the H/SWEEP SEL to the 15 • 150 position.
If no blanking is used, the SYNC/PHASE control should be adjusted until the two response curves coincide on the oscilloscope screen. If blanking is used, the SYNC/PHASE control should be adjusted until the base line on the WO-33A screen extends to the full width of the curve trace. An extremely sharp drop-off point on the response curve, which gives a "chopped-off" appearance to the trace short of the end of its sweep range, also indicates improper phasing. When a marker is superimposed on the response curve, improper phasing will cause two markers to appear on the curve. The SYNC/PHASE control should be adjusted to obtain the appearance of a single trace having only one marker. The setting of the SYNC/PHASE control is also important during sweep alignment of other sections of the receiver.

Serious misalignment of the tuner or considerable difficulty or failure in alignment may be caused by an unsuspected defective component. If proper alignment procedure fails to produce correct tuner curves, the technician should check individual components in the RF unit.

**Picture-IF Alignment** — To obtain an over-all picture-if response curve, the blue clip of the WG-349A probe should be connected across either the second detector load resistor or to the grid of the first video stage; test points which can provide a demodulated signal to the oscilloscope. The ground lead should be connected to the chassis. Because of the additional amplification in this section of the receiver, the oscilloscope gain should be considerably reduced, but not to the point where it is necessary to increase sweep-generator output.

Depending upon manufacturer's recommendations, it may be necessary to adjust the age bias level, either through temporary wiring changes or by providing fixed battery bias. The service-notes should be followed closely because alignment procedure may involve considerable detail. Trap alignment is sometimes difficult because the marker disappears in the trap notch. This may often be overcome by magnifying the trap section of the trace with the V CAL and H GAIN controls.

Adjustment of the SYNC/PHASE control is also important when aligning the IF sections of the receiver. The precautions and recommendations described under the section on tuner alignment, above, should be observed here. Controls on the WO-33A should be set the same as for tuner alignment except that less vertical gain will be required.

For observation of the response of individual stages in the pictures-if amplifier, the WG-350A Demodulator Probe* should be used. This is a high-frequency rectifying-type probe. It is important that this probe be used properly and in accordance with service-note recommendations to prevent distortion of the response curve and an erroneous picture of alignment.

The WG-350A, which connects to the V INPUT of the WO-33A, is equipped with a short ground lead and clip. For alignment work, the ground clip of the probe should be moved to ground near the test point being used for the WG-350A.

When the WG-350A is used to check individual stages, it should be connected to the output side of the stage being adjusted. For example, if the alignment of a coupling transformer is to be checked, the probe should be connected to the plate of the tube which has its grid coupled to the transformer. The tube thus acts as a buffer between the high-impedance grid circuit and the probe.

For general signal-tracing work, the probe may be moved from grid to grid throughout the IF amplifier.

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*Available on separate order.

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**Sound-IF and Detector Alignment** — Most television receivers use either a discriminator or ratio detector. For either type, the WG-349A probe clip should be connected to the output of the sound detector. For detector alignment, the sweep and marker generators should be connected to the receiver as described in the service notes. An S-shaped curve, similar to that shown in Figure 10A, should be obtained on the oscilloscope screen. The setting of controls on the WO-33A should remain the same as before. A typical sound-if curve is shown in Figure 10B.

**Horizontal-Oscillator Waveforms** — To observe waveforms in the sync-separator stage, the low-cap yellow clip should be used. Controls of the WO-33A should be set the same as for observation of the horizontal waveform. The probe clip should be connected to the plate of the sync separator or to the plate or grid of the sync amplifier.
Wave Testing of Audio Amplifiers

It is desirable to employ square waves of at least 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-cycle square wave should serve to check response from a few cycles to over 1000. If a square wave having a fundamental frequency of 2 Kc is used, the amplifier may 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-33A may be connected temporarily directly across the generator for a reference check of the waveform. The WO-33A 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 H INPUT and GND terminals. Set the H/SWEEP SEL control 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 16.

Frequency Measurements

Two methods may be used to determine frequency. In one method, a sine wave of known frequency is applied to the H INPUT terminal and the H/SWEEP SEL 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 17.

In the other method of frequency measurement, the H/SWEEP SEL should be set at "LINE" to provide a sweep of line frequency. The signal of unknown frequency should be applied to the V INPUT terminal. If a stationary pattern is obtained on the oscilloscope screen, the frequency of the input signal must be equal to, a submultiple of, or a multiple of the line frequency.
Industrial Applications

Use of the cathode-ray oscilloscope with a few auxiliary instruments has solved many perplexing problems both in the laboratory and in the service shop. The important applications of the oscilloscope are many. A few which serve to illustrate the wide range of possible applications are described below.

Engine-Pressure Analysis

When the WO-33A is used with auxiliary equipment such as is shown in Figure 18, variations in cylinder-head pressure developed in an internal-combustion engine or similar type machine can be shown on the oscilloscope screen. The oscilloscope has proven useful in the development of internal-combustion engines when used with engine pressure-measuring devices.

Vibration Measurements

The WO-33A can also be used with a piezoelectric transducer or with the RCA type 5734 mechano-electronic transducer for measuring vibration. Figure 19 shows a typical setup for observing vibration waveforms, indicating relative vibration characteristics on the oscilloscope screen.

Maintenance

2. Set the V RANGE switch to 60.
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 V RANGE control to 20, and reset the amplitude of the square wave generator. Adjust C-5 as in "4" above.
6. Repeat this process for V RANGE positions 8 and 2. 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.
7. Now connect the square wave generator to the yellow clip of the WO-349A probe and cable. With the V RANGE control on position 2, adjust capacitor C-1 for a flat top trace without overshoot spikes or drooping corners.

Internal Calibrator Control Adjustment

1. Connect an audio oscillator or square wave generator to the blue clip of the WO-349A probe and cable. Set the V RANGE control to position 2. Adjust the signal source for full scale deflection on the CRT.
2. Transfer the signal source to the yellow clip of the WO-349A probe and cable. With the V RANGE control on position 2, adjust the potentiometer R-11 for full screen deflection.

RCA Repair Service

RCA maintains a complete repair service for the adjustment, calibration, and maintenance of RCA test equipment. If it becomes necessary to service this equipment, the report forms enclosed in this booklet should be filled out as described. It is important that:

1. Test equipment be packed carefully.
2. A full description of the trouble be included in the report.

Attention to these details will help prevent damage in transit and delay in repairs.
### Radio Corporation of America Warranties

#### Factory-Wired Instruments

Radio Corporation of America warrants its test and measuring equipment, when properly registered, to be free from defects under normal use and service for a period of three months from date of sale to original purchaser. Under this warranty, RCA's obligation is limited to repairing or replacing any defective parts except fuses, which are not covered by this warranty.

This warranty does not apply to any instrument which has been altered in an unauthorized manner, or which has been misused or damaged by accident or negligence, or which has had the serial number removed, altered, or effaced.

RCA tubes and RCA batteries used in such equipment are covered by our standard tube or battery warranty. Secondary damage, caused by leaky batteries, is not covered by this warranty.

### Kits

Radio Corporation of America warrants the parts (except fuses) supplied in its test instrument kits, when properly registered, to be free from defects under normal use and service for a period of three months from date of sale to original purchaser. Under this warranty, RCA's obligation is limited to repairing or replacing any such defective parts that are returned to its factory or authorized service depot.

This warranty is completely voided if acid-core solder or paste fluxes have been used in the wiring. Furthermore, RCA will not replace, repair, or service any kits thus mishandled.

RCA tubes and RCA batteries used in such equipment are covered by our standard tube or battery warranty. Secondary damage, caused by leaky batteries, is not covered by this warranty.

The facilities of RCA and its service depots are available to RCA's customers at a nominal fee for the repair of kits-instruments which have been completely assembled in accordance with RCA's assembly instructions. In the handling of such instruments, the service depots will adjudge the responsibility for the malfunctions found, and apportion the cost of repair according to the owners of the kit-instruments.

### Warranty Information

**Part Numbers:**

- Factory Robber, Atlantic Radio Robber No. 1
- General Purpose, Radio Robber, Phillips Robber No. 1

**Accessories:**

- Various, Part No. M-4

**Service Instructions:**

- Radio Corporation of America

**Patent Information:**

- RCA has the right to commemorate any patent that is described in the text. The use of any patent number in the text is not an indication of the patent's validity.

**Devices or Arrangements:**

- Devices or arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.