PRICE ONE DOLLAR

RCA CATHODE-RAY OSCILLOSCOPE

Type WO-91B

- Specifications
- Operation
- Applications
- Maintenance

RADIO CORPORATION of AMERICA
ELECTRONIC COMPONENTS AND DEVICES
ELECTRONIC INSTRUMENTS HARRISON, N. J.

TP-WO-91B
2/66

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-300B Direct/Low-Capacitance Probe and Cable has a shield throughout its entire length which is connected to the instrument ground and case. Always handle the WG-300B by the insulated probe housing.

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-91B

Direct/Low-Capacitance Probe and Cable.....Type No. WG-300B
Ground Cable.....Stock No. 96794
Instruction Booklet Clip Insulator Alligator Clip

Available on Separate Order

For rf applications from 5000 Kc to 250 Mc:
RF-IF-VF Signal-Tracing Probe..Type No. WG-302A

For high voltage measurements up to 5000 volts:
Capacitance-Type Voltage Divider Probe—Type WG-354A

Cathode-Ray Oscilloscope

Type WO-91B

Contents

Description

The RCA WO-91B is a 5-inch oscilloscope designed primarily for production-line and service-shop use in servicing color and black-and-white television receivers. The WO-91B Oscilloscope incorporates several circuit and operational features which greatly increase its versatility and help to speed up the servicing process.

A primary feature of the RCA WO-91B is a front-panel bandwidth selector switch which changes the bandpass of the vertical-amplifier section from wide-band to narrow-band (high-sensitivity) operation. In the wide-band position, the frequency response is flat within ±1 db from 3 cps to 4.5 Mc.

A voltage-calibrated, frequency-compensated vertical-input attenuator, an internal calibrating-voltage source, and a graph screen scaled directly in volts make it possible to use the WO-91B as a visual voltmeter. The unique system of calibrating the graph 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 test circuit. The WO-91B can be calibrated in either the wide-band or high-sensitivity position and on any setting of the input attenuator switch. These unique facilities make voltage calibration and measurement a simple, almost automatic procedure.

A feature of special value in television work is the presetting of the sweep positions to provide automatic lock-in on vertical- and horizontal-frequency signals. These positions, marked TV "V" and "H", will provide instant synchronization and lock-in on horizontal and vertical sync and blanking pulses and other wave-shapes whose frequencies are based on 60 cps and 15,750 cps. A two-stage sync separator, similar to those utilized in many RCA Victor TV receivers, is used to provide positive lock-in on video signals. The vertical pulses from the integrator network and the horizontal pulses from the differentiator network are automatically fed to the sync amplifier input when the sweep frequency control is set at the TV "V" or "H" positions.

The sweep-frequency control is continuously adjustable from 10 cps to 100 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; a 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 Z-axis input terminal is provided on the front panel to permit direct modulation of the control grid of the cathode-ray tube. This feature is especially useful in special applications requiring trace blanking and time calibration of the sweep trace. A control switch is also provided for reversing the vertical polarity of the trace. By means of this control, the trace may be displayed in an upright or inverted position.

A separate phase control is provided for varying the phase of the internal sweep voltage when either the "LINE SYNC" or "LINE" position of the SYNC-H SEL control is used, enabling the WO-91B to be phased with an external line-frequency sweep oscillator or other equipment.

Terminals are provided on the back of the case for direct connection to the vertical deflection plates of the cathode-ray tube. This feature makes it possible to observe high frequency rf waveforms that are beyond the bandwidth of the vertical amplifier.

To facilitate its use, the WO-91B is equipped with a specially designed single-unit probe and input cable. This device, the WG-300B Direct/Low-Capacitance Probe and Cable, is provided with a sliding switch in the probe housing which is marked "DIR." and "LOW CAP." When the switch is set to the "DIR." position, the test signal is fed directly to the vertical-input terminal. When the switch is set to "LOW CAP", 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 approx. 12.5 $\mu\mu$f 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 WG-300B probe and cable, as well as a separate ground cable, is supplied with the WO-91B.

The WO-91B 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 waveshapes in circuits which are sensitive to loading effects.

The general construction of the WO-91B makes it a readily 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-91B is a versatile and reliable instrument, well suited to applications which require a dependable oscilloscope for extended operating periods.

Specifications

NOTE: Performance figures are for a line voltage of 117 volts, 60 cps.

Electrical

Frequency Response:

Vertical Amplifier:
- Wide-Band Positions (3 cps to 4.5 Mc) ..... flat within ±1 db
- High-Sensitivity Positions:
  - 3 cps to 0.5 Mc ..... flat within −1 db
  - 3 cps to 1.5 Mc ..... flat within −6 db

Horizontal Amplifier (3 cps to 500 Kc) ..... flat within −6 db

Deflection Sensitivity:

Vertical Amplifier:

	4.5 Mc (Wide-Band) Positions		1.5 Mc (High-Sensitivity) Positions		
	rms	*p-p*	*rms*	*p-p*	
At V INPUT connector	0.053	0.15	0.018	0.05	volt/in
With WG-300B set to "DIRECT"	0.053	0.15	0.018	0.05	volt/in
With WG-300B set to "LOW CAP"	0.53	1.5	0.18	0.5	volt/in

Horizontal Amplifier (at H INPUT terminal) ..... 0.18 rms volt/in

Vertical Deflection Plate Terminals ..... approx. 40 volt p-p/in

Rise Time (Vertical Amplifier):
- 4.5-Mc Positions ..... 0.1 μsec
- 1.5-Mc Positions ..... 0.5 μsec

Input Resistance and Capacitance:

Vertical Amplifier:
- At V INPUT connector ..... 1 megohm shunted by 40 $\mu\mu$f
- With WG-300B set to "DIRECT" ..... 1 megohm shunted by 75 $\mu\mu$f
- With WG-300B set to "LOW CAP" ..... 10 megohms shunted by 11 $\mu\mu$f

Horizontal Amplifier (at H INPUT terminal) ..... 2.2 megohms shunted by 30 $\mu\mu$f

SYNC Input Terminal ..... 0.5 megohm shunted by 35 $\mu\mu$f

Sweep Oscillator:

Frequency Range (continuously adjustable) ..... 10 cps to 100 Kc

Preset Positions ..... 30 cps (TV "V"); 7875 cps (TV "H")

Maximum AC Input Voltage (at V INPUT terminal):

(In presence of 400 volts dc) ..... 600 p-p volts

Phase-Control Range ..... 0 to 160 degrees

Z-Axis Input:

Minimum input voltage for blanking ..... 12 rms volts

Frequency Response ..... 3 cps to 500 Kc

Power Requirements:

Voltage ..... 105-125 volts

Frequency ..... 50-60 cps

Average Power Consumption ..... 70 watts

Tube Complement

Vertical Amplifier 1 RCA-6BQ7-A, 1 RCA-6CB6/6DK6, 2 RCA-6J6

Horizontal Amplifier 1 RCA-12AT7

Synchronizing Amplifier 1 RCA-12AU7-A

Sync Separator 1 RCA-12AU7-A

Sweep Oscillator 1 RCA-12AX7

Power Supply 1 RCA-6AX5-GT, 1 RCA-1V2

Cathode-Ray Tube 1 RCA-5UP1

Mechanical

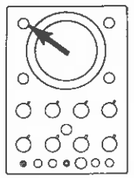
Height ..... 13½"

Width ..... 9"

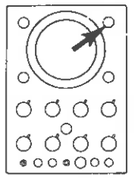
Length ..... 16½"

Weight (Net) ..... 30 lbs.

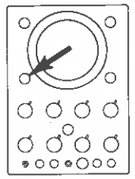
Functions of Controls and Terminals



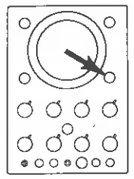
OFF-INTENSITY—Applies power to the instrument and increases intensity of the trace on the screen of the cathode-ray tube when control is turned clockwise from "OFF" position.



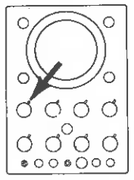
FOCUS — Adjusts the sharpness of the trace. Normally requires adjustment when setting of the INTENSITY control is changed.



V CENTERING — Adjusts vertical position of trace.



H CENTERING — Adjusts horizontal position of trace.

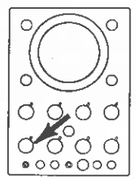


4.5 MC-CAL-1.5 MC — (Bandwidth) Switches circuitry in vertical amplifier. Has two important functions: (1) Changes bandpass and sensitivity of vertical amplifier and (2) automatically disconnects input circuit and attenuator and applies calibrating voltage.

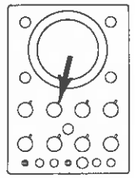
"4.5 Mc" Position — Frequency response of vertical amplifier is essentially flat from 3 cps to 4.5 Mc; maximum sensitivity is 0.05 rms volt per inch.

"CAL" Position — Used in voltage calibrating. Automatically disconnects probe, input circuit, and attenuators from vertical amplifier and applies a fixed calibrating voltage to the grid of the first vertical amplifier.

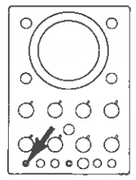
"1.5 Mc" Position — Frequency response is within −6 db from 3 cps to 1.5 Mc; maximum sensitivity is 0.018 rms volt per inch.



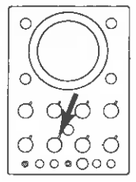
V RANGE -- Has two ranges of settings. The 4.5-MC range is used when the 4.5 MC-CAL-1.5 MC control is set to "4.5 MC". The 1.5-MC range is used when the 4.5 MC-CAL-1.5 MC control is set to "1.5 MC". When the WO-91B has been calibrated, the number on the V RANGE position selected corresponds to the full scale peak-to-peak voltage value on the appropriate graph-screen scale. (See "Calibration of the Vertical Amplifier".)



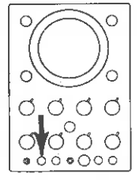
V POLARITY — Reverses internally the polarity of the vertical-deflection signal applied to the cathode-ray tube for "upright" or "inverted" trace display. When the switch is set to the left-hand position, a waveshape of positive polarity will be displayed above the base-line trace. In the right-hand position, the waveshape will be displayed below the base-line trace. (When using the preset TV "V" or "H" functions for observation of composite TV signals, the V POLARITY switch MUST be set to the position in which the sync pulses extend downward, as shown in Figure 5 on page 12.)



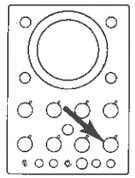
V INPUT — Feeds the input signal to the vertical amplifier through the attenuator circuits.



V CAL — Permits continuous adjustment of the vertical-amplifier gain and also provides overlap of steps on the V RANGE control. During calibration of the vertical amplifier, the V CAL control should be adjusted to give two inches deflection on the screen.



GND — Connected directly to case and chassis.



SYNC-H SEL — Has three functions; selects sync voltages for the sweep oscillator, applies an external horizontal-deflection voltage to the horizontal amplifier, and applies a sine wave of power-line frequency to the horizontal amplifier.

SYNC Function

"EXT" — Feeds the external synchronizing voltage applied at the "SYNC" terminal to the sweep oscillator.

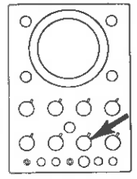
"LINE SYNC"—Feeds an ac signal from the power supply to the sweep oscillator to sync the oscillator at the power-line frequency.

"INT+" and "INT−" — Permits reversal of the phase of the internal synchronizing signal applied to the horizontal sweep oscillator. (When using the TV "V" or "H" preset sweep positions for observation of composite TV waveforms, set the SYNC-H SEL switch to "INT−".)

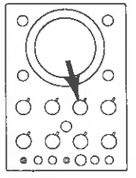
H SEL Function

"LINE" — Feeds an ac signal from the power supply to the horizontal amplifier to provide a sinusoidal horizontal sweep at power-line frequency.

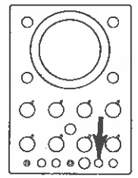
"INPUT" — Feeds the external voltage applied at the H INPUT terminal to the horizontal amplifier.



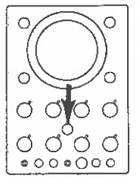
SWEEP — Selects the frequency range of the sweep oscillator. Used in conjunction with the SWEEP VERNIER control. The TV "V" and "H" positions are preset at 30 cps and 7875 cps, respectively, to provide automatic lock-in on "vertical" and "horizontal" sync pulses.



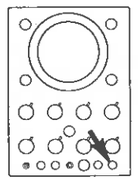
SWEEP VERNIER — Provides continuous control of the oscillator sweep frequency over the range selected by the SWEEP control. Also provides overlap of the SWEEP control positions. (In the TV "V" and "H" preset sweep positions, the SWEEP VERNIER range is intentionally restricted.)



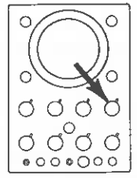
SYNC — An external synchronizing signal for the sweep oscillator should be connected between this terminal and the ground terminal. The SYNC-H SEL switch should be set to "EXT".



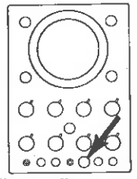
SYNC ADJ — Controls the amplitude of the synchronizing voltage applied to the grid of the sweep oscillator; should be adjusted to minimum setting necessary to lock pattern in a stationary position.



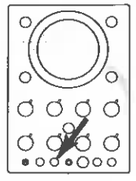
H INPUT — An external signal for the horizontal amplifier should be connected between this terminal and the ground terminal and the SYNC-H SEL control set to "INPUT". A positive-going signal will cause the spot to deflect to the right; a negative-going signal will cause the spot to deflect to the left.



H GAIN — Adjusts the gain of the horizontal amplifier and varies the width of the horizontal trace.



PHASE — Controls the phase of the synchronizing voltage when the SYNC-H SEL switch is turned to the "LINE SYNC" position and is used to vary the phase of the sinusoidal sweep voltage when the SYNC-H SEL switch is in the "LINE" position.



Z AXIS — Connects through a blocking capacitor to grid No. 1 of the cathode-ray tube. Trace blanking requires application of an ac signal of approximately 12 volts between this terminal and ground.

Operation

To become familiar with the operation of the WO-91B 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 and the block diagram on page 28 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. Set V RANGE switch in fully counterclockwise position. Turn bandwidth switch to "4.5 MC" position. Disconnect probe from V INPUT connector.

2. Turn the INTENSITY control clockwise from the "OFF" position.

3. Rotate the INTENSITY control farther clockwise until either a spot or a horizontal line appears on the screen. Adjust centering controls if necessary. The spot or line should increase in brilliance as the INTENSITY 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 SYNC-H SEL control to the "INPUT" 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 CENTERING and H CENTERING controls.

Vertical-Amplifier Operation

1. Set the 4.5 MC-CAL-1.5 MC 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 tube.

2. Connect the WG-300B probe and cable to the V INPUT connector. Set the band-width control to the "4.5 MC" position. Connect the ground lead of the probe to the ground side of the 6.3 volt 60 cps heater circuit in a radio or TV receiver. Set the switch on the probe to the "DIRECT" position, then connect the tip of the probe to the "hot" side of the 6.3 volt circuit. Turn V RANGE switch to a position which provides a pattern height of one-to-three inches.

3. Set SYNC-H SEL to either "INT+" or "−INT". Turn SYNC ADJ fully counterclockwise. Set SWEEP switch to the "10-100" cps position, and adjust SWEEP VERNIER so that the pattern is almost stationary. Advance SYNC ADJ to lock in the pattern. Turn V RANGE switch to each of its settings and note that the height of the pattern is changed in approximately three-to-one steps.

4. Leave V RANGE switch in a position that gives a pattern of about two inches. Turn V CAL (which is a vernier attenuator), and note that the pattern height changes gradually, not in steps. By setting V RANGE and adjusting V CAL, any desired height of pattern can be obtained.

5. Turn the V POLARITY control to its opposite setting. Note that the displayed waveshape is inverted.

Horizontal-Amplifier Operation

1. Disconnect probe from the 6.3 volt source. Turn V RANGE switch to "150" (on red scale), and SYNC-H SEL to "INPUT". Apply an AC signal of 1 to 10 volts to the H INPUT circuit, connecting the ground side to GND and the "hot" side to the H INPUT terminal. The 6.3 volt source used in the preceding section may be used. A horizontal line will appear on the screen, indicating that an external signal has been applied to the horizontal-deflecting electrodes of the cathode-ray tube. Turn H GAIN and note that the length of the horizontal line can be changed as desired.

2. Disconnect the lead from the voltage source. The horizontal line will be replaced by a spot.

3. Turn the SYNC-H SEL to the "LINE" position. A horizontal line should appear. NOTE: When the SYNC-H 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.

4. Turn the SYNC-H SEL Control to the "LINE SYNC" position. A horizontal trace should appear. NOTE: When the SYNC-H SEL switch is set to the "LINE SYNC" position, part of the power-line signal is fed internally to the sweep oscillator which, in turn, provides a sawtooth output voltage, synchronized by the power-line frequency, to the horizontal amplifier.

5. Turn the SYNC-H SEL control to either the "INT+" or "INT−" position. Either of these positions will provide a horizontal trace. NOTE: When the SYNC-H SEL control is set to either "INT+" or "INT−", 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. Connect the probe and cable to the V INPUT connector. Connect the ground lead of the probe to the ground side of the 6.3 volt 60 cps heater circuit in a radio or TV receiver. Connect the tip of the probe to the "hot" side of the 6.3 volt AC circuit. Turn the V RANGE switch to the position in which the pattern height is about one-to-three inches.

2. Set the SWEEP control to the "10-100" cps position. Turn SYNC ADJ fully counterclockwise. Adjust SWEEP VERNIER for a single cycle trace on the screen, drifting slowly leftward. Advance SYNC ADJ just far enough to lock in the pattern. Readjust SWEEP VERNIER and SYNC ADJ slightly if necessary to obtain solid lock-in.

3. Turn SWEEP VERNIER slowly counterclockwise and note that the pattern will go out of sync. Continue turning SWEEP VERNIER counterclockwise and note that the pattern will lock-in with two cycles, then with three cycles, etc., up to about six or more cycles. In this example, when the SWEEP VERNIER is set to produce two cycles in the pattern control, the horizontal sweep rate is 60/2 or 30 cycles. When SWEEP VERNIER is set to produce three cycles, the horizontal sweep rate is 60/3 or 20 cycles, etc.

4. If an audio frequency signal generator, such as the RCA WA-44C is available, it is interesting and instructive to use the generator as a source of external signal, repeating the experiment described in the two preceding paragraphs at various frequencies.

Use of the WG-300B Direct/Low-Capacitance Probe

The WG-300B Direct/Low-Capacitance Probe and Cable is designed especially for use with the WO-91B Oscilloscope. This single-unit probe is equipped with a sliding switch in the probe housing which permits setting the probe for direct measurements or for automatically connecting a built-in high-impedance network in series with the test

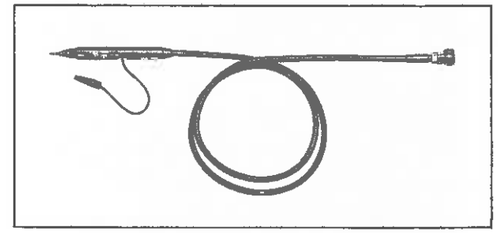


Figure 1. WG-300B Direct/Low-Capacitance Probe and Cable supplied with WO-91B

point and the probe cable. When the switch is set to the "LOW CAP X10" position, the input capacitance of the cable and scope is reduced to less than 11 $\mu\mu$f and the input resistance is raised to 10 megohms. These high-impedance characteristics permit use of the WO-91B 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, however, the signal is attenuated by a factor of ten. Therefore, when voltage measurements are made with the WO-91B, the indicated voltage should be multiplied by 10.

Calibration and Voltage Measurement

Special facilities on the WO-91B 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 waveshape directly in volts.

The removable green-graph screen has two vertical sets of scales, as shown in Figure 2. The *set* of scales used depends upon the setting of the 4.5 MC-CAL-1.5 MC bandwidth control. When this control is set to the "4.5 MC" position, the left-hand set of scales, marked "4.5 MC" is used. When the bandwidth control is set to "1.5 MC", the right-hand set of scales, marked "1.5 MC" is used. The setting of the bandwidth control also determines which set of switch-position marks on the V RANGE control is used.

If the bandwidth control is set to "4.5 MC", the V RANGE switch positions marked "4.5 MC" are employed. With the bandwidth switch in the "1.5 MC" position, the V RANGE settings marked "1.5 MC" are employed.

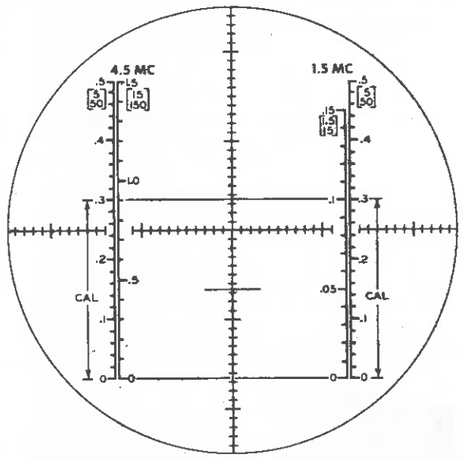


Figure 2. WO-91B graph screen with voltage scales

The setting of the V RANGE control determines which individual graph-screen scale is used. For 4.5-Mc bandwidth operation, for example, the V RANGE positions of .5, 5, or 50 require use of the ".5" scale under "4.5 MC". The V RANGE settings of 1.5, 15 or 150 require use of the "1.5" scale.

Calibration is accomplished as follows:

Set the bandwidth control to "CAL". When the bandwidth control is set to the "CAL" position, 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 SYNC-H SEL control may be set to any position during calibration. A straight vertical line is obtained by setting this control to "INPUT". A sinusoidal waveshape is obtained when the SYNC-H SEL is set to any other position. Adjust V CAL, and readjust V CENTERING as necessary, so that the pattern produced by the calibrating voltage exactly matches the height marked by the "CAL" arrows on either side of the graph screen. The WO-91B is now calibrated.

Calibration will hold for both the 4.5-Mc and 1.5-Mc 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 horizontal-deflection-output stage in a TV receiver. Procedure is as follows:

1. Set the bandwidth control to "CAL" and set the SYNC-H SEL to "INPUT".

2. Adjust V CAL and V CENTERING as described above.

3. Reset the bandwidth control to "1.5 Mc".

4. Connect the ground cable from the scope to the TV chassis. Set the WG-300B to "DIR." and connect the probe tip to the appropriate tube-socket pin.

5. Set V RANGE switch to the position which provides a pattern of convenient height, neither too small nor too large.

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

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

8. Read the peak-to-peak voltage amplitude of the waveshape from the appropriate scale on the right-hand (1.5 MC) side. The peak-to-peak voltage is read from the scale point opposite the top of the waveshape.

NOTE: When observing waveforms and measuring amplitude of signals in high-impedance circuits, it is advisable to set the switch on the WG-300B probe to the "LOW CAP" position. In this position, the signal is attenuated by a factor of 10 to 1, hence it is necessary to multiply the indicated voltage readings by 10.

Z-Axis Input

The Z-Axis input terminal connects directly to grid number one of the cathode-ray tube through a capacitor. By means of this circuit, the trace displayed on the screen may be modulated in applications which require frequency or scaling markers. An input signal in the order of 12 rms volts is required at the Z-Axis terminal to produce trace blanking. Two examples of Z-Axis modulation are shown in the photographs of Figure 3. The modulating frequencies are several times the sweep frequency. A sine/square wave generator, such as the RCA WA-44C may be used to provide the Z-Axis signal.

Trace Displacement

When the WG-300B probe is connected into a circuit containing dc voltage, the trace may be deflected off screen temporarily but it will return to its original position within a short time. The displacement of the trace is caused by charging of the input

dc-blocking capacitor by the dc test-circuit voltage. This capacitor has a large value and is charged through the series resistance of the input attenuators. If the input attenuator is set to the highest sensitivity position, a large resistance is in series with the capacitor. Consequently, a longer charging time is required and a longer period of time will be needed for the trace to return to an on-screen position.

When the WG-300B is used in its low-capacitance position, the increased input resistance of the probe may delay return of the trace for many seconds. This characteristic is perfectly normal. Trace-return time may often be reduced by first setting the range control to the minimum gain position, connecting the probe to the test circuit, and resetting the range control to the desired input position.

Connection To Vertical Deflection Plates

The two terminals on the back of the WO-91B are provided for direct connection to the vertical plates of the cathode-ray tube. When the NORMAL-DIRECT slide switch is set to "DIRECT", each of these terminals is connected through a blocking capacitor and isolating resistor to one of the vertical deflection plates.

RF waveforms too high in frequency to pass through the vertical amplifier can be observed by connecting the rf source to these terminals.

Procedure:

1. Turn power off. Remove the metal plug-button on the rear of the case.

2. Connect shielded leads from rf source to one or both of the terminals on the back of the chassis. One of the terminals can be connected to ground if desired. A ground terminal is provided just below the two deflection plate terminals.

3. Set the NORMAL-DIRECT switch to "DIRECT." Turn on the instrument.

The horizontal amplifier, sweep circuits, and position controls can be adjusted in the usual manner to obtain the desired trace. The vertical amplifier is inoperative in this function, thus the vertical attenuator switch and vertical gain control will have no affect. The vertical attenuator switch should be set to the full clockwise (least sensitive) position, however, to prevent the possibility of stray pick-up through the vertical amplifier.

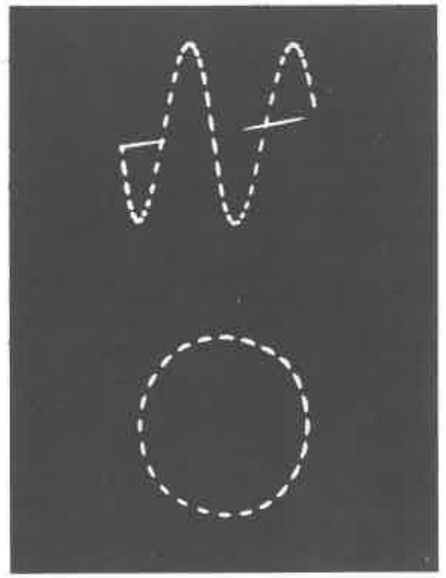


Figure 3. Oscilloscope traces showing Z-axis modulation

NOTE: The NORMAL-DIRECT switch must be reset to the "NORMAL" position to resume normal operation of the vertical amplifier.

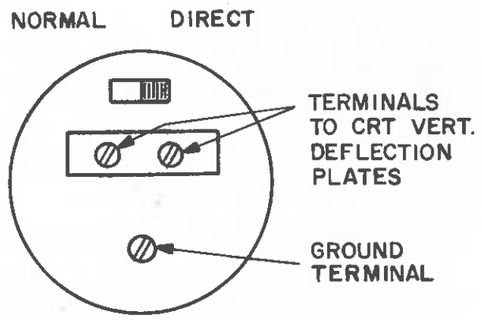


Figure 4. Rear view of WO-91B, showing switch and terminals for connection to vertical deflection plates of the cathode-ray tube.

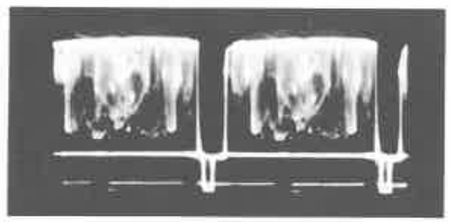
Applications

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.

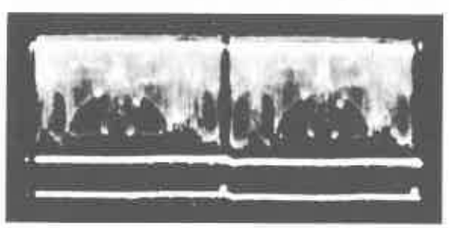
The oscilloscope is of especial importance in the servicing of color receivers. A good television-service oscilloscope, such as the RCA WO-91B, may be used in signal tracing in every section of the receiver; the 'scope may also be used for making peak-to-peak voltage measurements in such important sections of the receiver as the sync and deflection circuits and in the video, chrominance, and luminance sections. In alignment work, where video, chrominance, and luminance circuit adjustments must be made to produce the desired waveshape, the oscilloscope is indispensable. The WO-91B 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-300B probe should be set to the "LOW CAP" postion 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-91B 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.



Horizontal-sync pulse in composite signal



Vertical-sync pulse in composite signal

Figure 5.

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 Figure 5. 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-91B at various points in the video amplifier. Traces similar to those shown in Figure 5 may be obtained on the WO-91B as follows:

1. Tune the television receiver to a television signal.

2. Rotate the INTENSITY control on the WO-91B clockwise. Set the SYNC-H SEL control to "INT—" and adjust the H GAIN control for a horizontal line

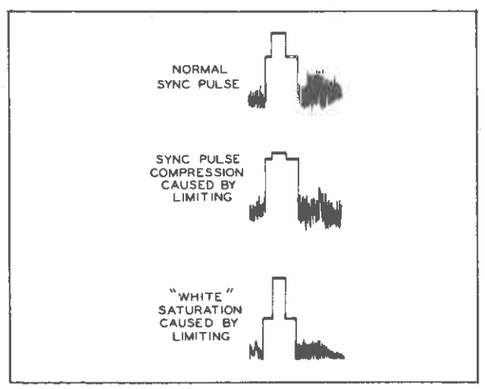


Figure 6. Sync-pulse compression

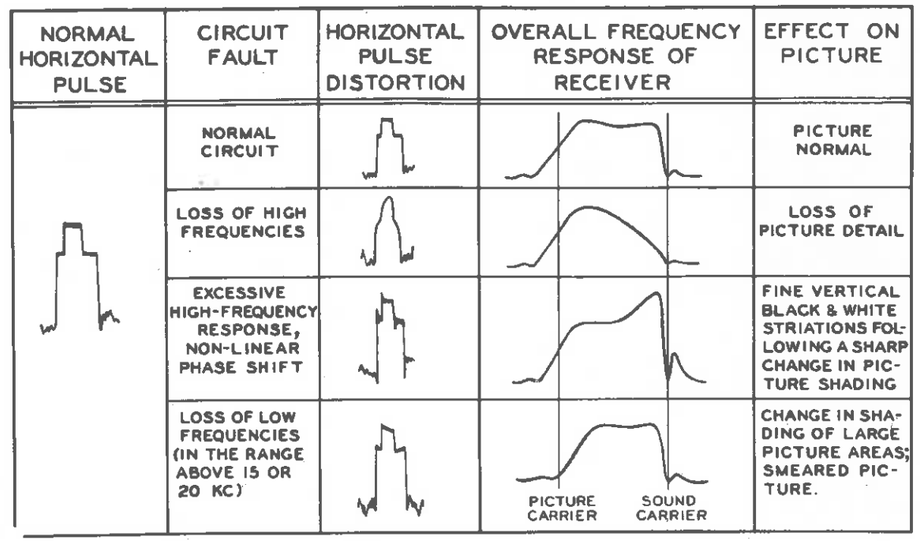


Figure 7. Sync-pulse distortion

of convenient length. Set the INTENSITY and FOCUS controls for the desired brightness and best focus.

3. Connect the WG-300B 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.

4. Set the V RANGE switch and the V CAL control for a pattern of convenient height.

5. To obtain the horizontal-sync pulse on the WO-91B screen, set the SWEEP control to the TV "H" position. Adjust the SYNC ADJ control, if necessary, to obtain lock-in on the sync pulse. To obtain the vertical-sync pulse, set the SWEEP control to the TV "V" position. The pulse should lock in automatically. The pulses should resemble those shown in Figure 5. Set the SYNC-H SEL to "INT—", and set V POLARITY to the position in which the sync pulses of the composite TV signal extend downward, as shown in Figure 5.

Alignment

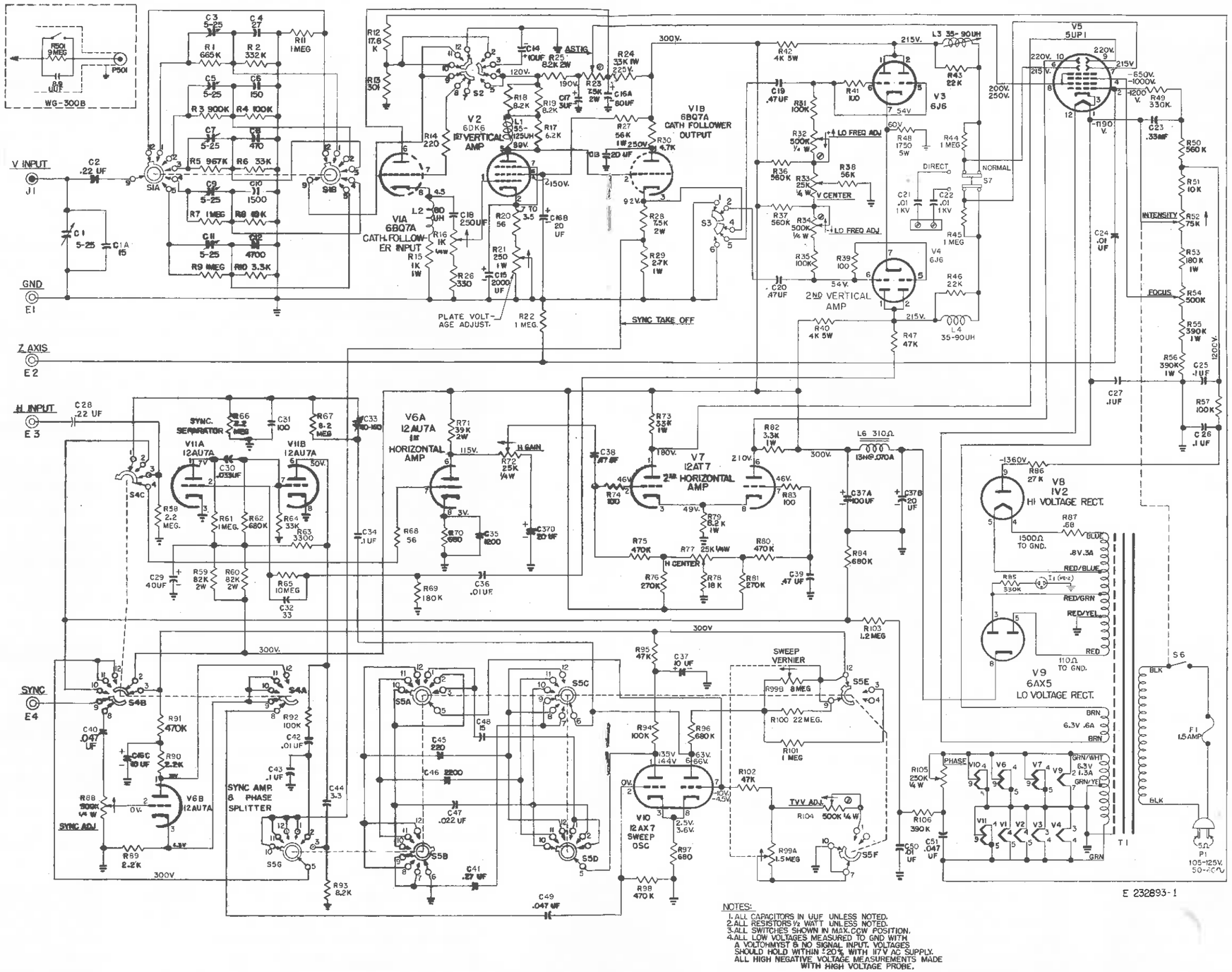
The process of television-receiver alignment probably requires a greater amount of skill and understanding on the part of the service technician than does any other service function. Before undertaking alignment, it is important that the technician recognize the symptoms of a misaligned receiver.

The order in which various sections of the television receiver are aligned may differ between split-channel sound and intercarrier types. Different receivers of one system may also differ in the order of alignment. In all cases, however, the alignment order given by the manufacturer in his service notes should be followed.

For these reasons, it is not feasible to present a general alignment procedure applicable to all receivers. Some general precautions and suggestions for using the WO-91B Oscilloscope, however, are provided below to aid the television technician in servicing a receiver according to his service notes.

Receiver alignment requires, in addition to the WO-91B, 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-99A Calibrator, and an RCA Volt-Ohmyst*, such as the WV-77E, WV-87B, or WV-98C are recommended. *(Continued on page 17)*

* Trade Mark "VoltOhmyst" Reg. U.S. Pat. Off.



NOTES:
1. ALL CAPACITORS IN UUF UNLESS NOTED.
2. ALL RESISTORS ½ WATT UNLESS NOTED.
3. ALL SWITCHES SHOWN IN MAX. CCW POSITION.
4. ALL LOW VOLTAGES MEASURED TO GND WITH A VOLTOHMYST & NO SIGNAL INPUT. VOLTAGES SHOULD HOLD WITHIN ±20% WITH 117 V AC SUPPLY. ALL HIGH NEGATIVE VOLTAGE MEASUREMENTS MADE WITH HIGH VOLTAGE PROBE.

Schematic Diagram WO-91B Cathode Ray Oscilloscope

Replacement Parts List

WO-91B

Oscilloscope

When ordering replacement parts please include serial number and code number of instrument. Order replacement parts through a local RCA distributor.

Symbol No.	Description	Stock No.
	Capacitors	
C1, C3, C5 C7, C9, C11	Trimmer, 5-25 pf, 350 v	204811
C1A	Ceramic, 15 pf ±5%, 500 v	
C2	Paper, .22 μf, 400 v	
C4	Ceramic, 27 pf ±2½%, 500 v	213447
C6	Mica, 150 pf ±2%, 500 v	213177
C8	Mica, 470 pf ±2%, 500 v	213178
C10	Mica, 1500 pf ±2%, 500 v	39656
C12	Mica, 4700 pf ±2%, 500 v	204822
C13	Electrolytic, 20 μf +100% —10%, 350 v	213175
C14	Electrolytic, 10 μf +50% —10%, 250 v	210137
C15	Electrolytic, 2000 μf +250% —10%, 3 v	210142
C16A, B, C	Electrolytic, 3 sections 80 μf + 100% —10%, 300 v 20 μf + 100% —10%, 250 v 10 μf + 100% —10%, 150 v	210135
C17	Electrolytic, 3 μf + 50% —10%, 250 v	210138
C18	Electrolytic, 250 μf + 250% —10%, 6 v	207780
C19, C20	Paper, .47 μf ±10%, 200 v	
C21, C22	Ceramic, .01 μf, 1000 v	
C23	Paper, .33 μf ±20%, 400 v	
C24	Paper, .01 μf ±2%, 1500 v	
C25, C26, C27	Tubular, .1 μf ±20%, 1600 v	
C28	Paper, .22 μf ±10%, 400 v	
C29	Electrolytic, 40 μf + 100% —10%, 350 v	222633
C30	Tubular, .033 μf ±20%, 600 v	
C31	Ceramic, 100 pf ±10%, 500 v	
C32	Ceramic, 33 pf ±10%, 600 v	
C33	Variable, 10–160 pf, 500 v	210133
C34	Paper, .1 μf ±20%, 200 v	73551
C35	Mica, 1200 pf ±10%, 500 v	39654
C36	Tubular, .01 μf ±20%, 400 v	
C37A, B, C, D	Electrolytic, 4 sections 100 μf + 100% — 10%, 350 v 20 μf + 100% — 10%, 350 v 10 μf + 100% — 10%, 350 v 20 μf + 100% — 10%, 150 v	210136
C38, C39	Paper, .47 μf ±10%, 200 v	
C40, C49, C51	Paper, .047 μf ±20%, 400 v	
C41	Paper, .27 μf ±10%, 200 v	
C42	Tubular, .01 μf ±20%, 600 v	
C43	Tubular, .1 μf ±20%, 600 v	
C44	Ceramic, 3.3 pf ±10%, 600 v	
C45	Ceramic, 220 pf ±5%, 500 v	
C46	Mica, 2200 pf ±5%, 500 v	
C47	Paper, .022 pf ±5%, 600 v	210134
C48	Ceramic, 15 pf ±5%, 500 v	
C50	Paper, .01 μf, ±10%, 200 v	
	Resistors	
R1	665,000 ohm ±1%, ½ watt	210159
R2	332,000 ohm ±1%, ½ watt	209784
R3	900,000 ohm ±1%, ½ watt	210155
R4	100,000 ohm ±1%, ½ watt	72893
R5	967,000 ohm ±1%, ½ watt	210156
R6	33,000 ohm ±1%, ½ watt	55663
R7, R11	1 meg ±1%, ½ watt	208022
R8	10,000 ohm ±1%, ½ watt	55665
R9	1 meg ±1%, ½ watt	208022
R10	3300 ±1%, ½ watt	55885
R12	17,800 ohm ±1%, ½ watt	210158
R13	301 ohm ±1%, ½ watt	210157
R14	200 ohm ±20%, ½ watt	
R15	1000 ohms ±5%, 1 watt	512210
R16	Variable, 1000 ohms ±20%, ¼ watt	210147
R17	6200 ohms ±10%, ½ watt	
R18, R19	8200 ohms ±5%, ½ watt	
R20, R67	56 ohms, ±10%, ½ watt	
R21	Variable, 250 ohms ±10%, 1 watt	213176
R22	1 meg ±10%, ½ watt	502510
R23	Variable, wire wound, 7500 ohms ±10%, 2 watts	210144
R24	3300 ohms ±5%, 1 watt	
R25	8200 ohms ±5%, 2 watts	
R26	330 ohms ±5%, ½ watt	
R27	56 K, ±5%, 1 watt	512356
R28	7500 ohms ±5%, 2 watts	
R29	2700 ohms ±5%, 1 watt	
R30	4700 ohms ±10%, 1 watt	
R31, R92	100K ±10%, ½ watt	
R32	Variable, 500K ±20%, ¼ watt	210152
R33	Variable, 25K ±20%, ¼ watt	210143
R34	Variable, 500K ±20%, ¼ watt	210152
R35	100K ±10%, ½ watt	
R36, R37	560K ±5%, ½ watt	
R38	56K, ±5%, ½ watt	
R39, R83	100 ohm ±10%, ½ watt	
R40, R42	4000 ohm, ±5%, wire wound, 5 watts	210153
R41, R74	100 ohms ±10%, ½ watt	
R43, R46	22K ±10%, ½ watt	
R44, R45, R61, R101	1 meg ±10%, ½ watt	
R47, R95, R102	47K, ±10%, ½ watt	
R48	1750 ohms ±5%, wire wound, 5 watts	210154
R49, R85	330K ±10%, ½ watt	
R50	560K ±10%, ½ watt	
R51	10K ±10%, ½ watt	
R52	Variable, 75K, ±20%, ½ watt (incl. S6)	210150
R53	180K ±10%, ½ watt	
R54	Variable, 500K, ±20%, ½ watt	210151
R55, R56	390K ±10%, 1 watt	
R57, R94	100K ±10%, ½ watt	
R58, R66	2.2 meg ±10%, ½ watt	
R59, R60	82K, ±10%, 2 watts	
R62, R84, R96	680K, ±10%, ½ watt	
R63	3300 ohm ±10%, ½ watt	
R64, R73, R82	33K ±10%, ½ watt	
R65	10 meg ±10%, ½ watt	
R67	8.2 meg ±10%, ½ watt	
R69	180K ±10%, ½ watt	
R70, R97	680 ohms ±5%, 1 watt	
R71	39K ±10%, 2 watts	
R72	Variable, 25K ±20%, ¼ watt	210149
R75, R80, R91, R98	470K ±10%, ½ watt	
R76, R81	270K ±5%, ½ watt	
R77	Variable, 25K, ±20%, ¼ watt	210143
R78	18K ±5%, ½ watt	
R79	8.2K ±5%, ½ watt	
R86	27K, ±10%, ½ watt	
R87	0.68 ohm ±10%, ½ watt, wire wound	93468
R88	Variable, 500K, ±30%, ¼ watt	210148
R89, R90, R93	2200 ohms ±5%, ½ watt; 8200 ohms ±10%, ½ watt	
R99A, B	Variable, dual, 1.5 meg and 8 meg, ±20%, ½ watt	98475
R100	22 meg ±5%, ½ watt	
R103	1.2 meg ±10%, ½ watt	

Symbol No.	Description	Stock No.
	Resistors (continued)	
R104	Variable, 500K ±20%, ¼ watt	210152
R105	Variable, 250K ±20%, ¼ watt	210146
R106	390K ±10%, ½ watt	
	Switches	
S1	Switch, rotary: 6 positions, 2 sections, 2 circuits	210129
S2	Switch, rotary: 3 positions, 1 section, 3 circuits	210131
S3	Switch, rotary: 2 positions, 1 section, 2 circuits	210132
S4	Switch, rotary: 6 positions, 2 sections, 4 circuits	210130
S5	Switch, rotary: 6 positions, 3 sections, 9 circuits	223188
S6	(Part of R45)	210150
	Coils	
L1	Coil, adjustable: 55–125 μH	213482
L2	Coil, rf choke: 80 μH	213173
L3, L4	Coil, rf choke: 35–90 μH	213174
	Miscellaneous	
E1, E2 E3, E4	Post, binding: with blue fluted knob	212151
F1	Fuse: 1.5 amp, type 3AG	2725
I1	Lamp, pilot: Mazda type 51	11765
J1	Connector, coaxial: male, microphone type	96257
L6	Reactor, filter: 13H, 0.07 amp	93442
P1	Cord, power: 78" long, with male plug	70392
T1	Transformer, power	220939
	Board, circuit	222549
	Clamp: for cathode-ray tube shield	210117
	Clamp: for cathode-ray tube	210116
	Handle, carrying	53704
	Holder, fuse: board type	55316
	Knob, control: push-on type, ¾" dia.	204824
	Knob, control: push-on type, 1⅛" dia.	219557
	Jewel, pilot-light	54660
	Socket, pilot-light	57760
	Socket, tube: miniature, 7-pin, with printed-circuit type tube-shield contact	210161
	Socket, tube: miniature, 7-pin	204825
	Socket, tube: octal	54414
	Socket, tube: miniature, 9-pin	210160
	Socket, tube: miniature, 9-pin, with center shield	94926
	Socket, tube: 12-pin, for 5UP1	210162
	Test-lead assembly, with ground clip and pin plug	96794
	Graph Screen	210114
	WG-300B Probe and Cable	
	Bushing, tip: for front end	213257
	Clip: for ground lead	210207
	Connector: brass, internal cable	213260
	Connector: female, microphone type, with set screw	203574
	Insulator: for ground clip	210209
	Ring, grounding: for center probe section	213262
	Shell, probe: front section	212161
	Shell, probe: center section, includes bushing and insulator and two shields	213256
	Shell, probe: rear section	213261
	Spring, coil: for front probe section	210197
	Spring, switch contact: includes insulation and insulator	213259
	Tip, probe: includes switch slide, 1-meg resistor, and capacitor	213258
	Washer, stabilizing: for probe tip	213271

(Continued from page 13)

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 cable of the WO-91B should be clipped directly to the tuner shield to minimize hum pickup on the sweep trace, and the WG-300B probe, set to "DIR", should be connected to the mixer grid circuit test point. If no test point is provided, the WG-300B may usually be connected to the grid circuit through a 5,000 to 10,000-ohm composition resistor.

It is important that the WG-300B be connected directly to the proper test point or, if a series resistor is used, that the lead length between the probe tip 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-91B. Hum pickup is evidenced by twisting of the base line when return-trace blanking is used on the sweep generator. This precaution is necessary because of the high-gain level at which the WO-91B 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 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-91B 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 8 and 9, are sometimes misinterpreted as being caused

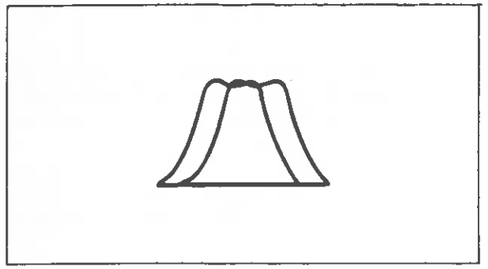


Figure 8. Double rf-response curve caused by improper setting of phasing control. No blanking used

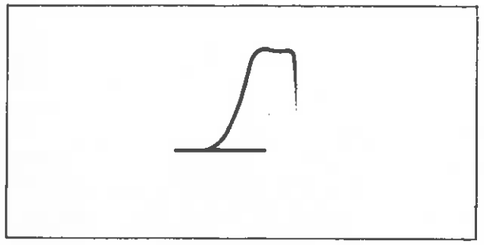


Figure 9. Sharp cutoff of response curve and misplaced base line with blanking indicate improper setting of phasing control

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-91B may be driven internally by setting the SYNC-H 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-91B. The SYNC-H SEL should be set to "INPUT". An internal sawtooth sweep may also be obtained by setting the SYNC-H SEL to the "LINE SYNC" position.

If no blanking is used, the PHASE control should be adjusted until the two response curves coincide on the oscilloscope screen. If blanking is used, the PHASE control should be adjusted until the base line on the WO-91B screen extends 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 PHASE control should be adjusted to obtain the appearance of a single trace having only one marker. The setting of the PHASE control

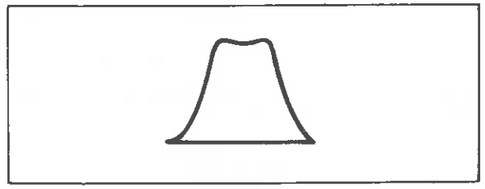


Figure 10. Typical rf-response curve

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 WG-300B probe, set to "DIR," 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 cable 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. (The RCA WR-70A Marker Adder is highly recommended for use in all sweep-alignment work.)

Adjustment of the PHASE control is also important when aligning the if sections of the receiver. The

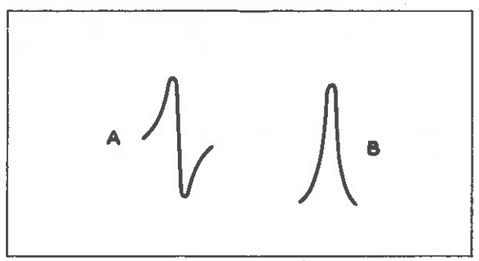


Figure 11. (A) Ratio-detector curve and (B) sound-if curve

precautions and recommendations described under the section on tuner alignment, above, should be observed here. Controls on the WO-91B 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 picture-if amplifier, the WG-302A RF-IF-VF Signal Tracing 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-302A, which slips onto the front end of the WG-300B, is equipped with a short ground lead and clip. For alignment work, the ground clip of the probe should always be connected to ground near the test point being used for the WG-302A. If only the ground cable of the WO-91B is used, some sloping of the response curve may result.

When the WG-302A is used to check individual stages, it should be connected on 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.

Sound-IF and Detector Alignment — Most television receivers use either a discriminator or ratio detector. For either type, the WG-300B probe should be set to "DIR" and the probe tip 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 11A, should be obtained on the oscilloscope screen. The setting of controls on the WO-91A should remain the same as before. A typical sound-if curve is shown in Figure 11B. To obtain the sound-if response curve, the probe should be connected to either the grid return of the limiter stage or to the grid return of the last sound-if stage. The SYNC ADJ control should be set no farther clockwise than necessary to lock in the waveshape.

* Available on separate order.

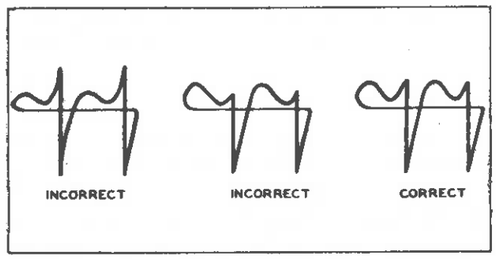


Figure 12. Horizontal-oscillator waveforms

Horizontal-Oscillator Adjustment — The WO-91B is well suited to adjustment of the horizontal oscillator and may be used as follows:

Set the SWEEP control to the TV "H" position.

Adjust the SYNC ADJ control to give stable lock-in of the waveshape, if necessary.

With the ground cable of the WO-91B connected to the receiver chassis, set the WG-300B probe switch to "LOW CAP" and connect the probe to the output of the horizontal oscillator, as described in the service notes. Connection to a typical horizontal-oscillator circuit is shown in Figure 13. Because the horizontal oscillator is a high-impedance circuit, the low-capacitance probe should always be used to reduce capacitance-resistance loading effects. Usually it is necessary to adjust the oscillator for suitable output waveshape. Typical horizontal-oscillator waveshapes which can be observed on the WO-91B are shown in Figure 12.

Sync-Separator Waveshape — To observe waveshapes in the sync-separator stage, the probe switch should be set to "LOW CAP". Controls of the WO-91B should be set the same as for observation of composite TV signals. The probe should be connected to the plate of the sync separator or to the plate or grid of the sync amplifier.

General Applications

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 and

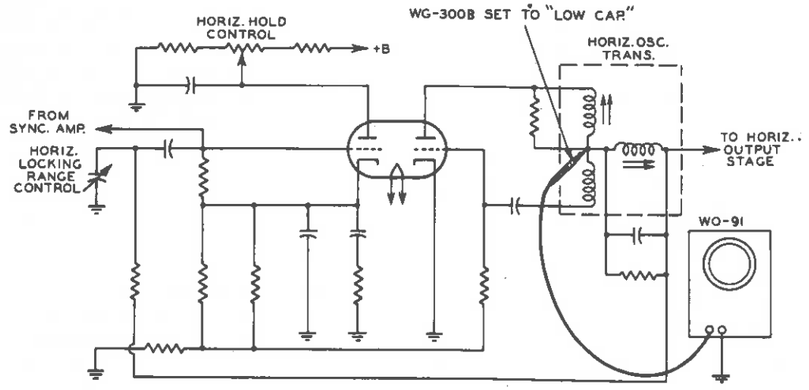


Figure 13. Adjustment of horizontal oscillator

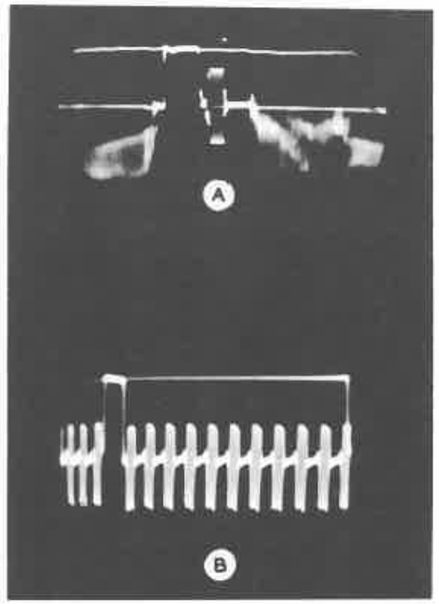


Figure 14. Color-TV signals as displayed by WO-91B. (A) Composite color-TV signal. Color-burst pulse can be seen to right of sync pulse. (B) Output signal from RCA WR-61A Color-Bar Generator showing color-sync pulses and 10 color-bar pulses.

the WO-91B 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. It is important that the correct value be used. For an

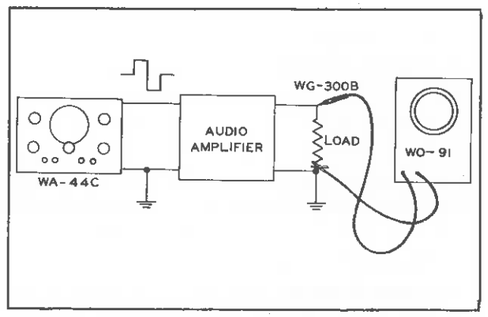


Figure 15. Audio amplifier test setup

over-all check of amplifier response, the WO-91B should be connected directly across the load resistance, as shown.

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 60-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-91B may be connected temporarily directly across the generator for a reference check of the waveform. The WO-91B may then be connected to various points in the amplifier to determine how each stage is functioning.

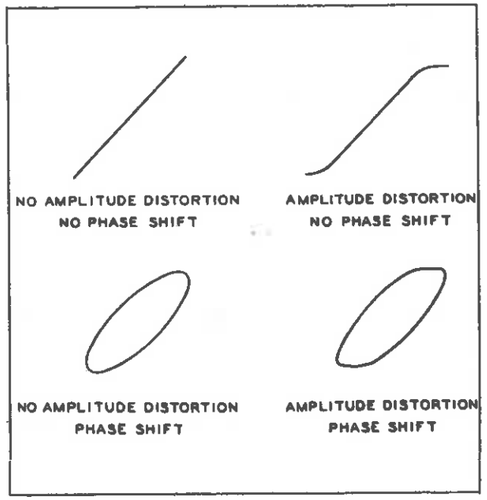


Figure 16. Distortion and phase shift in audio amplifier

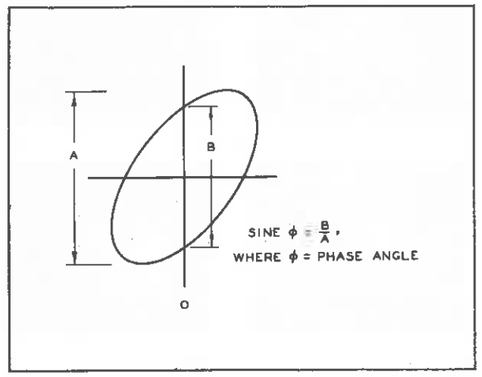


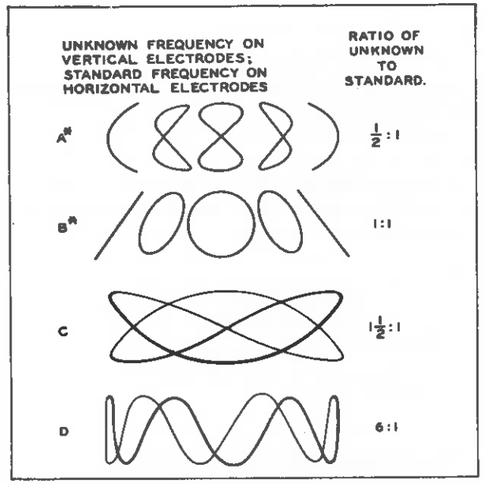
Figure 17. Measurement of phase shift

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 SYNC-H SEL control to the "IN-



* One of the five patterns illustrated appears on the oscilloscope, depending on the phase relationship of the two input frequencies.

Figure 18. Lissajou figures

PUT" 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.

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 SYNC-H SEL is set to "INPUT". The unknown signal is fed to the V INPUT terminal. The resulting pattern, or Lissajou figure, indicates the ratio between the two frequencies. Typical Lissajou figures are shown in Figure 18.

In the other method of frequency measurement, the SYNC-H 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-91B is used with auxiliary equipment such as is shown in Figure 19, 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.

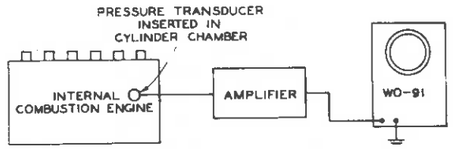


Figure 19. Engine-pressure analysis setup

Vibration Measurements

The WO-91B can also be used with a piezo-electric transducer or with the RCA type 5734 mechano-electronic transducer for measuring vibration. Figure 20 shows a typical setup for observing vibration waveforms, indicating relative amplitudes and other characteristics of vibration on the oscilloscope screen.

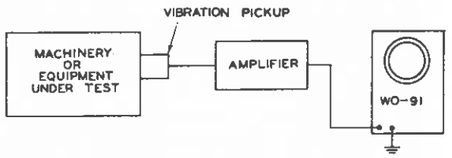


Figure 20. Vibration analysis setup

Modulated RF Waveforms

Modulated rf waveforms can be shown on the WO-91B screen by connecting the rf source directly to the vertical deflection plates of the cathode-ray tube. This application is particularly useful to amateur radio operators who wish to observe the rf modulation patterns of their transmitters.

The rf signal from the transmitter can be obtained by coupling a pick-up loop to the amplifier tank coil or antenna coil. Use shielded cable to make connections to the vertical deflection plates of the WO-91B, as described on page 11 of this manual.

Two basic types of waveforms are useful for interpreting the modulation characteristics of a transmitted signal. These are the "trapazoidal" pattern and the "wave-envelope" pattern.

A trapazoidal pattern is obtained by applying the rf signal to the vertical deflection plates and the audio-frequency modulating signal from the transmitter modulator to the "H IN" terminal. Use shielded cable to make these connections. Set the SYNC/H SEL switch to the "INPUT" position.

A wave-envelope pattern is obtained by applying the rf signal to the vertical deflection plates, setting the SYNC/H SEL switch to "INT", and adjusting the SWEEP switch and SWEEP vernier control to produce the desired pattern.

Examples of trapazoidal and wave-envelope patterns are shown in Figure 21.

For more information regarding methods of connection and interpretation of waveforms, consult an Amateur Radio publication such as the ARRL Handbook.

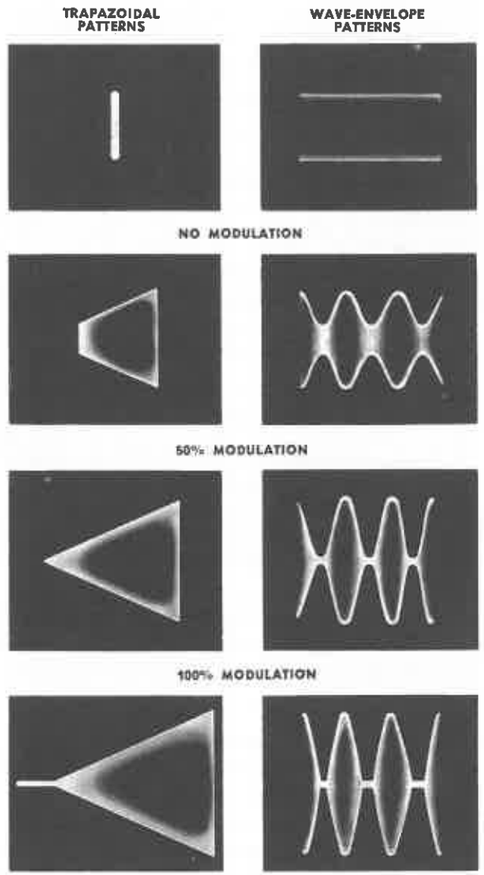


FIGURE 21

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-91B 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 4 screws from the bottom of the instrument and two screws from the top of the front panel and applying pressure on the rear apron of the chassis through the hole provided for the power cord. CAUTION: This oscilloscope uses high-voltage circuits.

If any alignment adjustments are made, the line voltage should be 117 volts at 50-60 cps. If trouble is encountered, voltage readings should be taken and compared with the operating voltages shown on the schematic diagram. Conventional trouble-shooting techniques should be used to locate trouble. Resistance and continuity checks can then be made to isolate the defective section or stage.

Astigmatism Adjustment

1. Turn on the WO-91B and allow at least 15 minutes warm-up time.

2. Set the SYNC-H SEL to "LINE", the bandwidth control to "CAL", and adjust the PHASE, V CAL, and H GAIN control for a circular pattern approximately two inches in diameter. Adjust FOCUS control for sharpest trace.

3. With a screw driver, adjust potentiometer R23 for best possible focus at all points on the circle. R23 is located on top of the chassis, as shown in Figure 23, and is accessible through a hole in the left side of the case.

Alignment of Vertical Amplifier

Before alignment is attempted, the oscilloscope should be checked to make sure that all tubes and components are in good operating condition. The alignment procedure requires the use of another oscilloscope, such as the RCA WO-33A, a demodulator (rf) probe, such as the RCA WG-350A, a video-sweep generator such as the RCA WR-69A, a video marker source such as the RCA WG-295C, a sine/square wave audio generator such as the RCA WA-44C, and a VTVM such as the RCA WV-77E, WV-98C or WV-87B VoltOhmysts.

1. Apply power to the instrument and allow at least fifteen minutes for warm-up.

2. Set the controls of the WO-91B as follows: Bandwidth Control, "4.5 MC"; V POLARITY, "+"; SWEEP, "100-1000"; SWEEP VERNIER, middle range; H GAIN, adjust for 4-inch trace on CRT screen, V RANGE ".5" on red scale; V CAL, maximum clockwise; SYNC-H SEL, "+INT".

3. Measure the voltage from V-2, pin 5 to ground. Adjust R-21 so that 89 volts is measured at this point.

4. Check the calibrating voltage in the WO-91B as follows: Set the Bandwidth Control to "CAL". With the V CAL control turned fully clockwise, the vertical trace should be at least as high as the distance between the two horizontal "CAL" lines on the CRT graph screen. If it is not, measure the voltage at the junction of R-12 and R-13 using a voltage-calibrated WO-33A oscilloscope. Set the V Range switch of the WO-33A to the ".6" position. A peak-to-peak voltage of 2.8 should be measured at this point, indicating that the calibrating voltage in the WO-91B is correct.

5. Set the bandwidth control to the "4.5 MC" position. Connect the WG-300B probe from the WO-91B to the WA-44C Sine/Square Wave Generator. Set the switch on the probe to the "DIRECT" position. Adjust the WA-44C for a 1,000 cps square-wave. Adjust the SWEEP VERNIER control so that approximately 5 square-waves appear on the CRT screen. Set the output of the generator so that the height of the pattern is approximately 3 inches. Note the square-wave response.

6. Set the switch on the WG-300B probe to the "LOW CAP" position. Adjust C-1 so that the quality of the square-wave is identical to that obtained when the probe switch is in the "DIRECT" position.

7. Set the probe switch to the "DIRECT" position. Turn the V RANGE switch to the "1.5" position (on red scale). Adjust SWEEP VERNIER control so that approximately 5 square-waves appear on the CRT screen. Adjust C-3 for best square-wave pattern.

8. Switch the bandwidth control to the "1.5 MC" position. Adjust the output of the square-wave generator so that the trace height is approximately 3 inches. Compare the square-wave to that obtained in step 7, above. Adjust C-3 so that the best possible square-wave pattern is obtained with the bandwidth control in either the "1.5" or "4.5" position.

9. Set the bandwidth control to the "4.5 MC" position, and the V RANGE switch to "5" (on red scale). Adjust the generator output so that a trace height of 3 inches is maintained. Adjust C-5 for best square-wave response.

10. Reset the V RANGE control to the "15", "50" and "150" position (on red scale) and adjust C-7, C-9, and C-11 respectively, for best square-wave response.

11. Adjust the square-wave generator to provide a 55 cycle signal. Set the V RANGE switch to the "1.5" position (on red scale). Set the SWEEP control to the "10-100" position, and adjust the SWEEP VERNIER control so that 3 square-waves appear on the CRT screen. Adjust R-31 and R-33 for best square-wave response.

12. Connect the test equipment as shown in Figure 22. Set the SYNC-H SEL control to "LINE". Adjust the H GAIN control for approximately 3 inches of horizontal deflection.

13. Turn the SYNC-H SEL of the WO-33A to "LINE" and adjust the H-GAIN control for approximately 2 inches of horizontal deflection.

14. Adjust the sweep width of the WR-69A Video-Sweep Generator for approximately 7 MC. Adjust the IF/VF attenuator of the WR-69A and the WO-33A V GAIN control for about 2 inches of vertical deflection on the WO-33A CRT screen.

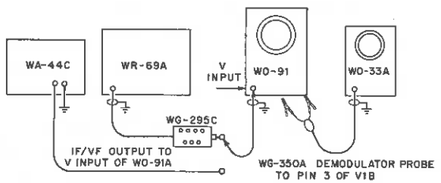


Figure 22. Test setup for alignment of vertical amplifier

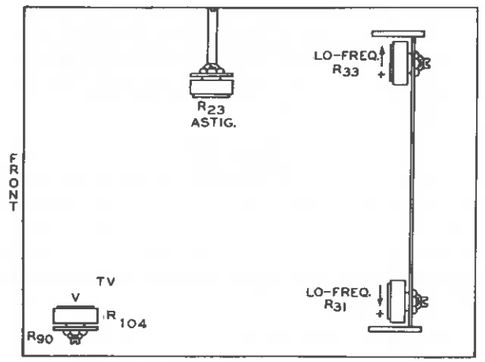


Figure 23. Top of chassis view showing locations of internal adjustments

15. Turn the BLANKING control on the WR-69A to "OFF". Adjust the PHASE controls on both the WO-91B and the WO-33A so that the pattern on each scope is in phase.

16. Turn the BLANKING control on the WR-69A to "ON". Adjust L-1 in the WO-91B so that a response pattern like that shown in Figure 24A appears on the WO-33A screen.

17. Disconnect the WO-33A demodulator probe from pin #3 of V1B in the WO-91B. Adjust L-3 and L-4 so that the pattern on the WO-91B screen indicates flattest response out to 5.5 MC, as shown in Figure 24B. The pips provided on the trace by the WG-295C can be used as frequency reference points.

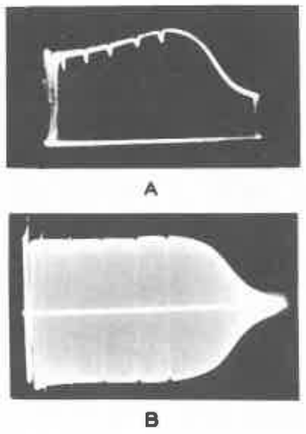


Figure 24. (A) Waveshape taken from output of cathode follower. (B) Overall response curve of WO-91B when set up for 4.5-Mc bandpass

Sweep Oscillator Adjustments

1. Set the bandwidth control to the "CAL" position, and the SYNC-H SEL to "INT –". Set SWEEP control to the "10-100" range, and adjust the SWEEP VERNIER control for 2 sine waves.

2. Adjust C-33 until the "tail" on the left side of the sweep trace just disappears.

3. Set the bandwidth control to "1.5 MC". Set the SWEEP control to "TV V" and turn the SWEEP VERNIER control to the center of rotation. Adjust the sine/square-wave generator for a 25 cps sine-wave signal. Adjust potentiometer R-103 to lock in a single waveform.

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 provided with the instrument 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.

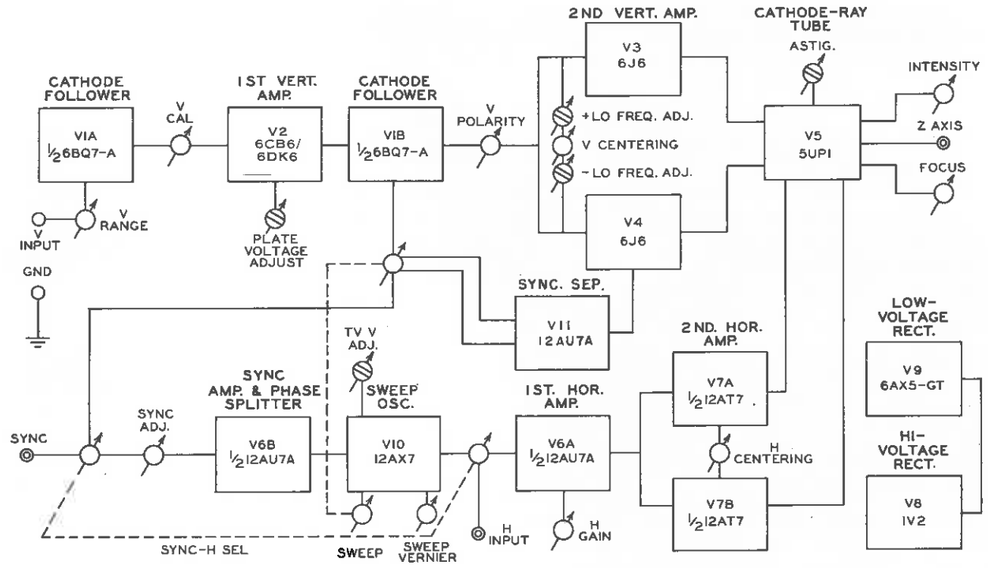


Figure 25. WO-91B Block Diagram