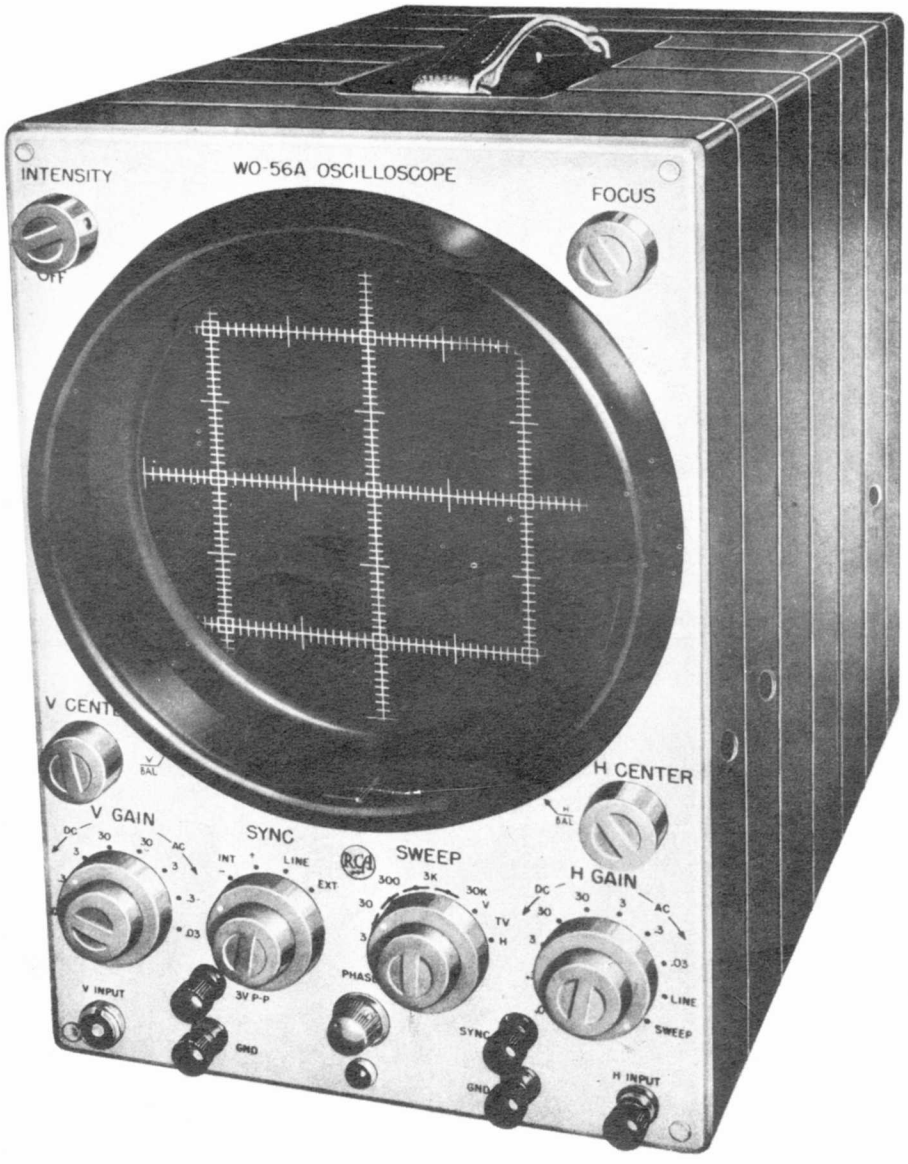
PRICE 50 CENTS

RCA CATHODE-RAY OSCILLOSCOPE

Type WO-56A



- Specifications
- Operation
- Applications
- Maintenance

RADIO CORPORATION of AMERICA
TEST AND MEASURING EQUIPMENT
HARRISON, N. J.

Safety Precautions

High-Voltages are dangerous! Always observe the following precautions:

1. Do not work alone. Another person should be present to remove power and apply resuscitation in case of accident.

2. Avoid close proximity to high-voltage points. If you are unfamiliar with the equipment, find out where the high-voltage points are located. Remember that high voltage may appear at unexpected points in defective equipment.

3. Power should be removed from high-voltage points, if possible, before the test leads are connected.

4. If it is impractical to turn power off, make sure that the ground clip of the test equipment is securely attached. Keep fingers far back from probe tip. Avoid contact between any part of the body and ground. Obtain dry insulating material to stand on, if floor is not insulated. Do not lean against equipment racks, metal bulkheads, or any object which can provide a ground.

5. Short-circuit all filter capacitors, if possible, before attaching test leads.

6. Never use leads with broken insulation.

7. Always disconnect test leads immediately after measurement is completed.

8. Do not connect ground lead of the WO-56A to a high-voltage point! The ground lead of the instrument is connected internally to the case.

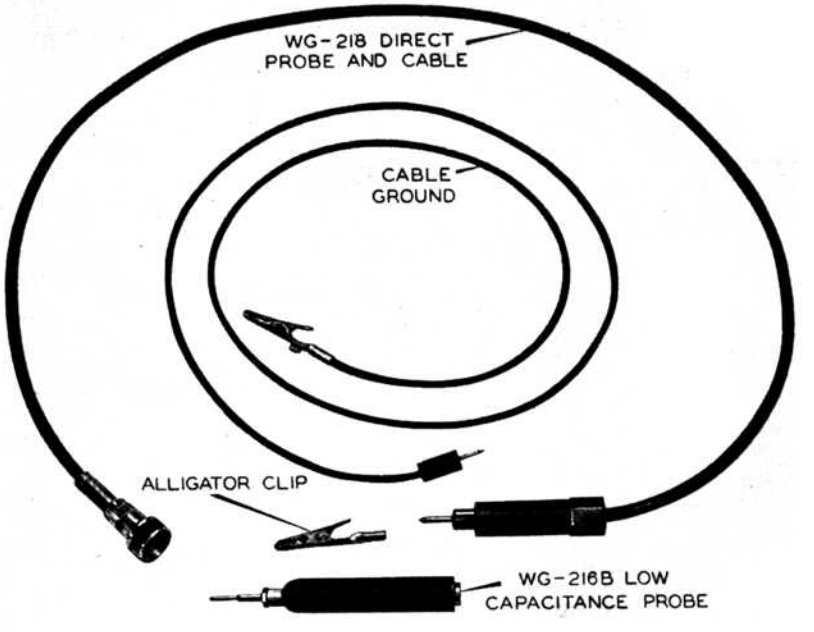
Accessories

Supplied with the WO-56A

Tubes: 4 RCA-6BH6, 5 RCA-12AU7, 1 RCA-6X4, 1 RCA-1V2, 1 RCA-7VP1; WG-218 Direct Probe and Cable, WG-216B Low-Capacitance Probe, Ground Cable, Alligator Clip, Clip Insulator, Green Graph Screen, Instruction Booklet, and Registration Card.

Available on Separate Order

For rf applications from 500 Kc to 250 Mc: Demodulator Probe, Type WG-291.



Cables and Probes Supplied with the WO-56A

INSTR. WO-56A (4) 6-55
Photolithographed
in U.S.A.

CATHODE-RAY OSCILLOSCOPE

Type WO-56A

Contents

(Continued)

List of Illustrations

General Description

The RCA WO-56A Cathode-Ray Oscilloscope features a frequency range, a square-wave response, and a sensitivity which provide waveshape reproductions of unusual accuracy and clarity on its seven-inch screen. Designed with a view toward practical applications in television servicing, the WO-56A provides facilities which allow the rapid, accurate, and efficient trouble-shooting of television receivers. This instrument has a sensitivity of 10.6 rms millivolts per inch. The frequency response of both the vertical and horizontal amplifiers from 0 to 500 kc is within 2 db down from maximum response; the frequency response from 0 to 1 Mc is within 6 db down from maximum response.

The vertical and horizontal amplifiers of the WO-56A are electrically identical. Each amplifier consists of three push-pull stages of amplification, a feature which provides high deflection sensitivity with good stability. The trace can be expanded to approximately three times the diameter of the screen and centered on any portion for examination of waveshape details. The use of push-pull stages also reduces astigmatic distortion, thus producing a uniformly sharp trace over the entire useful area of the screen.

Both the vertical and horizontal amplifiers are designed to provide low-frequency response flat down to dc, a feature which not only allows amplification of the ac component of a signal but of its dc component as well. Low-frequency square-wave response, essential to correct sweep alignment, is assured. High-frequency square-wave response up to at least 100 kc insures faithful reproduction of blanking and pulse waveshapes. A square-wave response with negligible tilt and overshoot provides a reliable display of sync-pulse, vertical- and horizontal-deflection, video-amplifier, and composite-television waveshapes. Frequency-compensated step and vernier attenuators maintain response independent of changes in gain.

Both peak-to-peak and dc voltage measurements can be made directly from the screen of the WO-56A. A voltage for calibrating either the vertical or horizontal amplifier is available at a panel terminal.

The sweep, or time-base, oscillator produces a linear sawtooth voltage with an extremely fast retrace, further insuring faithful waveshape reproduction. This oscillator is of the Potter type, with a range of 3 to 30,000 cycles per second. Two preset sweep frequencies of 30 cps and 7875 cps speed up signal tracing and trouble shooting in television rf, deflection, and video circuits.

The sweep oscillator can be synchronized by an internally supplied voltage of power-line frequency, by an externally supplied sync voltage, or by a voltage which is either positive or negative in direction and which is internally selected from the vertical amplifier. This feature insures a steady pattern on the oscilloscope screen. When the sweep oscillator is synchronized with the line voltage, the phase control can be used to center any portion of the waveshape on the oscilloscope screen.

A phase-controlled sinusoidal sweep of power-line frequency, essential in sweep-alignment applications, is available internally; its phase can be adjusted by the phase control. This arrangement eliminates the need for an external phase-controlled line-voltage source.

The seven-inch cathode-ray tube gives a large, clear display for accuracy in alignment applications. The metal shield which surrounds this tube greatly minimizes hum pickup, thereby eliminating the necessity of carefully arranging sets and equipment on the service bench to avoid hum deflection. A retractable light shield and a green calibrating screen reduce ambient-light reflections on the face of the cathode-ray tube.

Although designed primarily for television servicing, the WO-56A can be used in industrial applications as well as in the usual oscilloscope applications, such as waveshape analysis, adjustment of radio receivers and transmitters, determination of peak-to-peak and instantaneous voltages, and tracing of vacuum-tube characteristics. For information on the application of the WO-56A to unusual industrial processes, you are invited to send the details of your application to Commercial Engineering, Radio Corporation of America, Harrison, New Jersey.

Specifications

Electrical

Frequency Response:

Vertical and Horizontal Amplifiers:

From 0 to 500 kc
within 2 db down from maximum response

From 0 to 1 Mc
within 6 db down from maximum response

Input Resistance and Capacitance:

Vertical Amplifier:

Without cable and probes..... 1 megohm shunted by 30 $\mu\mu$f

With Direct Probe & Cable WG-218
1 megohm shunted by 75 $\mu\mu$f

With Low-Capacitance Probe WG-216B
10 megohms shunted by 9.5 $\mu\mu$f*

Horizontal Amplifier:

Without cable and probes..... 1 megohm shunted by 35 $\mu\mu$f

Sync Input:

Without cable and probes..... 1 megohm shunted by 35 $\mu\mu$f

Deflection Sensitivity:

Vertical Amplifier:

	millivolts per inch	
	rms	*p-p*
With Direct Probe & Cable WG-218.....	10.6	30.0
With Low-Capacitance Probe WG-216B ..	106	300
Horizontal Amplifier:		
Without cable and probes.....	21.2	60.0

Sweep-Circuit Frequency:

Variable..... 3 cps to 30,000 cps

Preset..... "TV/V" position..... 30 cps
"TV/H" position..... 7875 cps

Maximum Input Voltage:

With no ac present..... 700 volts dc
With 400 volts dc present..... 600 volts rms

Power Supply:

Voltage Rating ..... 105-125 volts
Frequency Rating ..... 50-60 cps
Power Consumption ..... 65 watts

Tube Complement:

4 RCA-6BH6, 5 RCA-12AU7, 1 RCA-6X4, 1 RCA-1V2, 1 RCA 7VP1

Mechanical

Dimensions:

Height ..... 13⅜ inches
Width ..... 9 inches
Depth ..... 16⅝ inches

Weight.....(approx.) 31 pounds

Finish..... blue-gray hammeroid case, satin-aluminum panel

*When the WG-216A is used, input characteristics are 1 megohm shunted by 9.5 $\mu\mu$f.

Installation

The RCA WO-56A Oscilloscope has been designed to give excellent performance on the TV-service bench and in a variety of other applications which require a high-gain, wide-band oscilloscope. The instrument was carefully adjusted and then given a trial run before shipment from the factory. However, minor readjustments may be necessary if the instrument has been subjected to rough handling during shipment. The simple electrical checks and adjustments outlined below are important if amplifier balance and maximum gain are to be maintained.

Adjustment of Amplifier Balance

The WO-56A is equipped with high-gain, direct-coupled, push-pull deflection amplifiers which should be kept in balance for maximum stability, best linearity, and freedom from effects of line-voltage fluctuations. Adjustment screws for balancing the vertical and horizontal amplifiers are accessible when the light shield is pulled forward (see page 8).

To check and adjust the amplifier balance, proceed as follows:

1. Connect the power cord to an ac outlet supplying 105-125 volts at 50-60 cycles.

2. Apply power to the instrument by turning the INTENSITY control clockwise.

3. Fasten the cable fitting of the Direct Probe to the V INPUT terminal and attach the probe tip to one of the ground binding posts.

4. Set V GAIN to "3" on "AC", H GAIN to "30" on "AC", and V GAIN vernier and H GAIN vernier controls fully counterclockwise. Center the spot with the V CENTER and H CENTER controls.

5. Rotate the V GAIN vernier clockwise. If the spot moves off center, recenter it by adjusting the V BAL adjustment screw.

6. Rotate the H GAIN vernier clockwise. If the spot moves off center, recenter it by adjusting the H BAL adjustment screw.

NOTE: If the balance adjustments are made when the power is first applied, readjustment may be necessary after warm-up.

Adjustments of Amplifier Gain and Linearity

During initial service, tube and component characteristics may change enough to affect the operation of high-gain direct-coupled amplifiers such as are used in the WO-56A. However, the WO-56A circuit provides compensation for these changes so that maximum gain and excellent linearity of the sweep amplifier can be maintained.

To check normal operation of the instrument, first check the amplifier balance and then proceed as follows:

1. With the cable attached to the V INPUT terminal, connect the Direct Probe tip to the 3V P-P binding post; set V GAIN at "3" on "AC", H GAIN at "LINE", V GAIN vernier fully clockwise, and H GAIN vernier fully counterclockwise. Before proceeding to step 2, allow at least one hour for warm-up time.

2. Adjust the PHASE control to obtain maximum horizontal width.

NOTE: If the internal gain adjustments are properly set, the pattern should be at least one inch high and should not change shape appreciably when moved within the useful area of the screen by means of the centering controls.

If 1-inch vertical deflection cannot be attained, it will be necessary to reset the internal gain adjustment, R9, to insure adequate height. R9 is a screw-driver adjustment which is accessible through a hole in the left side of the instrument case. On earlier models of the WO-56A, this control is located on top of the chassis and the instrument must be removed from the case for adjustment. Rotate R9 for maximum vertical deflection. If horizontal gain is insufficient, R47 should be adjusted. Locations of these adjustments are shown in Figures 23A and 23B.

Operation

General

Before proceeding with initial operation of the WO-56A, it is important that the operator acquaint himself with the vertical and horizontal amplifier adjustments for gain level and push-pull balance. The procedure for checking these adjustments is given under the section "Installation" above.

To place the WO-56A into general operation, connect the power cord at the rear of the instrument to an ac outlet supplying 105-125 volts at 50-60 cycles; set the H GAIN selector to "SWEEP"; and adjust the H GAIN vernier to approximately center position. Turn the INTENSITY control clockwise from "OFF" and allow 15 minutes for the instrument to warm up.

Calibration of Vertical Amplifier

When the instrument is to be used as a voltmeter, the vertical amplifier should be calibrated according to the following procedure:

1. Connect the WG-218 Direct Probe and Cable to the V INPUT terminal and the Ground Cable to a GND terminal.

2. Connect the probe of the WG-218 to the 3V P-P terminal.

3. Set the V GAIN selector on either "3" AC or "3" DC and adjust the V GAIN vernier until one inch of vertical deflection is obtained on the oscilloscope screen.

4. Disconnect the cable from the 3V P-P terminal.

NOTE: Do not touch the V GAIN vernier while voltage measurements are being made. Otherwise the vertical amplifier will have to be recalibrated.

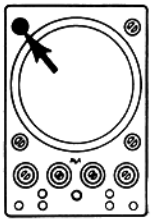
5. Connect the Direct Probe and Cable and the Ground Cable across the voltage to be measured and set the V GAIN selector for a convenient vertical deflection.

The peak-to-peak voltage at the probe tip is the V GAIN-selector setting multiplied by the number of inches of vertical deflection. When a sine-wave voltage is being measured, the above value can be multiplied by .354 to give the rms voltage.

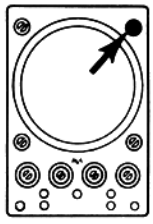
The WG-216B Low-Capacitance Probe may also be used for voltage measurements. The procedure is the same, except that the results obtained above are multiplied by 10, in order to compensate for the greater signal attenuation of the WG-216B.

When the WG-216A Low-Capacitance Probe is used in critical high-impedance circuits where dc is present, such as the grid circuit of the vertical-blocking oscillator of a television receiver, a blocking capacitor should be used to prevent dc-loading effects. A high-quality, low-leakage paper capacitor of 0.5 μf or larger is suggested.

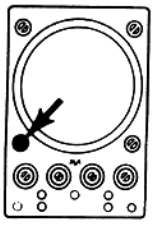
Functions of Controls and Terminals



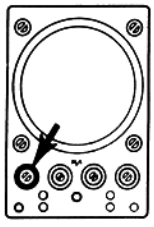
INTENSITY control—Has two functions; applies power to the instrument when turned clockwise from "OFF" position, and controls the intensity of the spot on the CRT screen.



FOCUS control — Adjusts sharpness of pattern on CRT screen. Normally requires adjustment when setting of INTENSITY control has been changed.



V CENTERING control — Adjusts vertical position of trace.



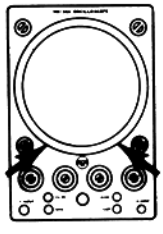
V GAIN selector—Controls degree of attenuation of input voltage to vertical amplifier. This control is marked for both ac and dc voltages. To determine amplitude of signal voltage when vertical amplifier has been calibrated, multiply V GAIN selector setting by total deflection in inches. When the WG-218 Direct Probe is used, attenuation is as indicated below for each selector position. With the WG-216B Low-Capacitance Probe, attenuation is 10 times as great.

Position ".03" — Zero attenuation. Signal voltage attenuated 1 to 1.

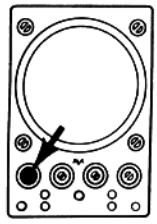
Position ".3" — Signal voltage attenuated 10 to 1.

Position "3" — Signal voltage attenuated 100 to 1.

Position "30" — Signal voltage attenuated 1000 to 1.

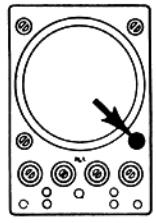


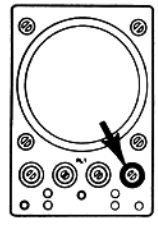
V BAL—H BAL controls—If the spot changes position when the V GAIN or H GAIN controls are varied, the balance controls should be adjusted as described under "Amplifier - Balance Adjustment," page 28.



V GAIN vernier—Permits continuous adjustment of vertical-amplifier gain. Use with V GAIN selector to adjust trace height to desired value. See "Operation" section for calibration procedure.

H CENTERING control — Adjusts horizontal position of trace.





H GAIN selector—Has three functions, as indicated below:

(1) Controls degree of attenuation of input voltage to horizontal amplifier. This control is marked for both ac and dc voltages. Attenuation is as indicated below for each selector position.

Position ".03" — Zero attenuation. Signal voltage attenuated 1 to 1.

Position ".3" — Signal voltage attenuated 10 to 1.

Position "3" — Signal voltage attenuated 100 to 1.

Position "30" — Signal voltage attenuated 1000 to 1.

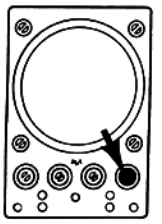
(2) When an internal linear sweep is desired, set this control to "SWEEP" position.

Position "SWEEP" — Applies plate voltage to sweep oscillator tube, and couples output of sweep oscillator to input of horizontal amplifier.

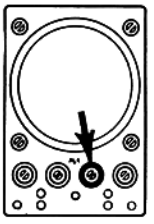
(3) When sinusoidal sweep of power-line frequency is desired, set this control to "LINE" position.

Position "LINE"—Applies sinusoidal voltage at power-line frequency to horizontal-amplifier input.

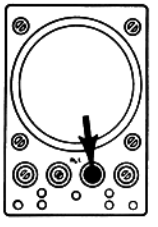
NOTE: The outer knob of each of the four dual controls is the selector control; the inner knob is the vernier control.



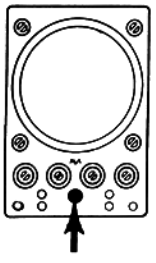
H GAIN vernier—Permits continuous adjustment of horizontal-amplifier gain. Use with H GAIN selector to adjust horizontal trace to desired width.



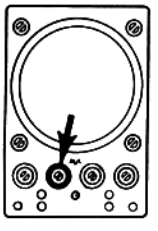
SWEEP selector—Selects frequency band of sweep oscillator. Positions "TV/V" and "TV/H" give preset sweep frequencies of 30 cps and 7875 cps, respectively, for viewing vertical- and horizontal-deflection-circuit waveshapes, sync-separator waveshapes, and composite television signals.



SWEEP vernier—Provides continuous control of sweep frequency over bands selected by SWEEP selector.



PHASE control—Controls the phase of the sinusoidal sweep voltage fed to the horizontal amplifier when the H GAIN selector is set at "LINE" position, and controls the phase of the line-frequency voltage used to synchronize the sweep oscillator when the SYNC selector is at "LINE" position and the H GAIN selector is at "SWEEP" position.



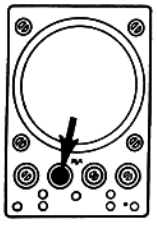
SYNC selector—Selects sync voltages for sweep oscillator.

Position "INT—"—Selects synchronizing voltage from vertical amplifier. Sweep-trace flyback starts during negative-going excursion of voltage applied to vertical amplifier.

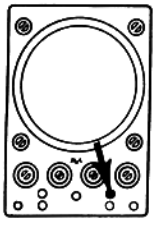
Position "INT+"—Selects synchronizing voltage from vertical amplifier. Trace flyback starts during positive-going excursion of voltage applied to vertical amplifier.

Position "LINE"—Selects synchronizing voltage from power supply. Sweep oscillator synchronized with power-line frequency. When the SYNC selector is in "LINE" position and the H GAIN selector in "SWEEP" position, the PHASE control can be used to adjust the phase of the sweep voltage with respect to the input voltage.

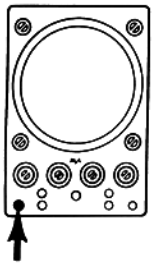
Position "EXT" — Feeds external sync voltage applied at SYNC terminal to sweep oscillator.



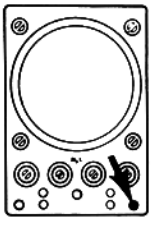
SYNC vernier—Controls amplitude of synchronizing voltage applied to grid of sweep oscillator. Adjust to minimum setting necessary to lock pattern in a stationary position on the CRT screen.



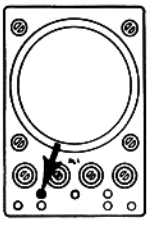
SYNC terminal — An external synchronizing voltage can be applied at this terminal.



V INPUT terminal—The voltage to be applied to the vertical amplifier is introduced at this terminal through the Direct Probe and Cable WG-218. When the V GAIN selector is on its ac positions, the signal is applied to the vertical amplifier through a blocking capacitor; when the V GAIN selector is on its dc positions, the signal is applied directly to the vertical amplifier.

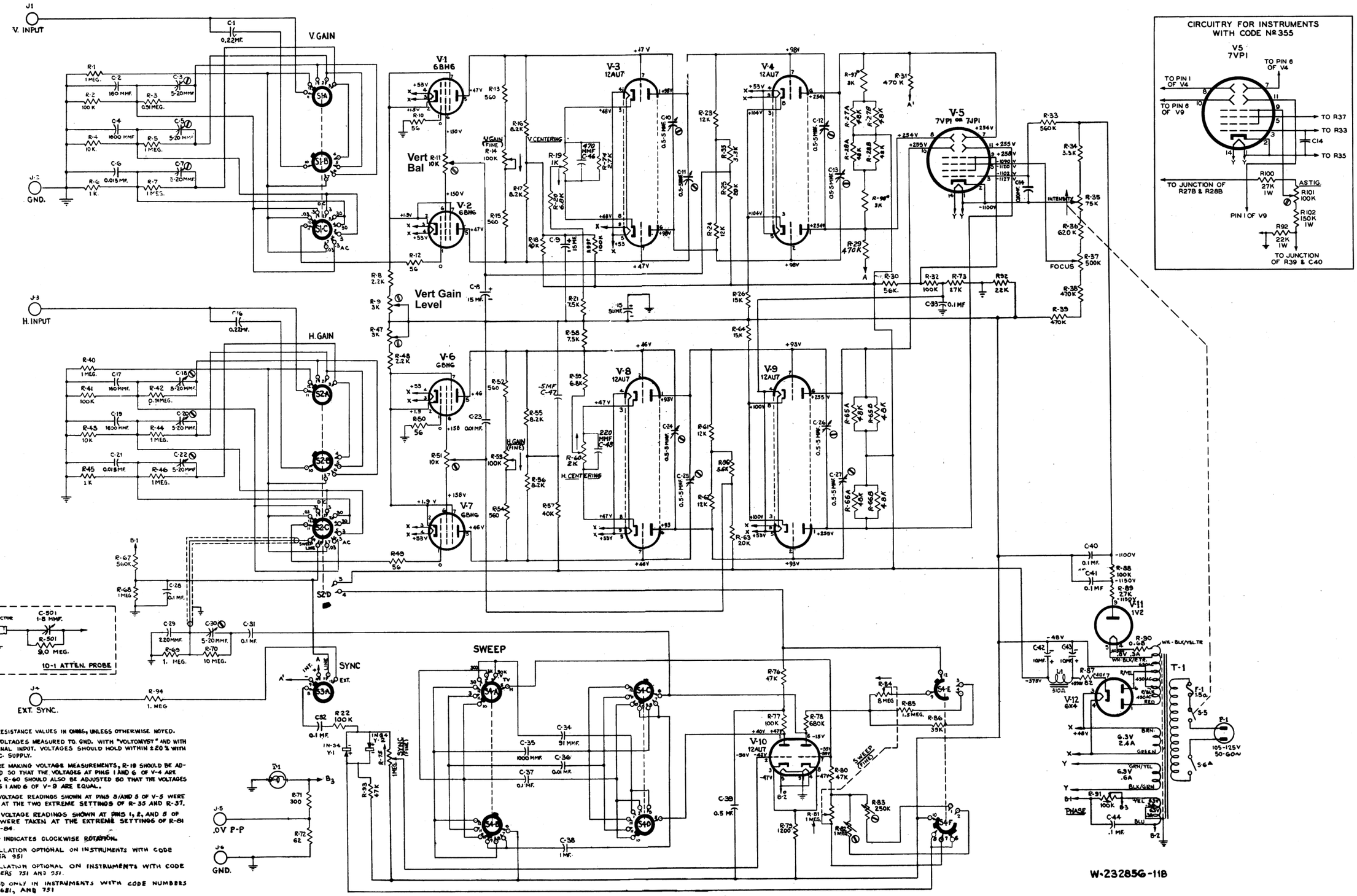


H INPUT terminal—The voltage to be applied to the horizontal amplifier is introduced at this terminal.



3V P-P terminal—Internal calibrating voltage is available at this terminal. See "Operation" section for calibration procedure.

GND terminals — Are directly connected to the chassis of the oscilloscope; serve as a common ground for the WO-56A and the chassis of the equipment under test or associated test instruments.



NOTE:

ALL RESISTANCE VALUES IN OHMS, UNLESS OTHERWISE NOTED.

ALL VOLTAGES MEASURED TO GND. WITH "VOLTOMYST" AND WITH NO SIGNAL INPUT. VOLTAGES SHOULD HOLD WITHIN ±20 % WITH 117V A.C. SUPPLY.

BEFORE MAKING VOLTAGE MEASUREMENTS, R-18 SHOULD BE ADJUSTED SO THAT THE VOLTAGES AT PINS 1 AND 6 OF V-4 ARE EQUAL. R-60 SHOULD ALSO BE ADJUSTED SO THAT THE VOLTAGES AT PINS 1 AND 6 OF V-9 ARE EQUAL.

DUAL VOLTAGE READINGS SHOWN AT PINS 3 AND 5 OF V-5 WERE TAKEN AT THE TWO EXTREME SETTINGS OF R-35 AND R-37.

DUAL VOLTAGE READINGS SHOWN AT PINS 1, 2, AND 5 OF V-10 WERE TAKEN AT THE EXTREME SETTINGS OF R-81 AND R-84.

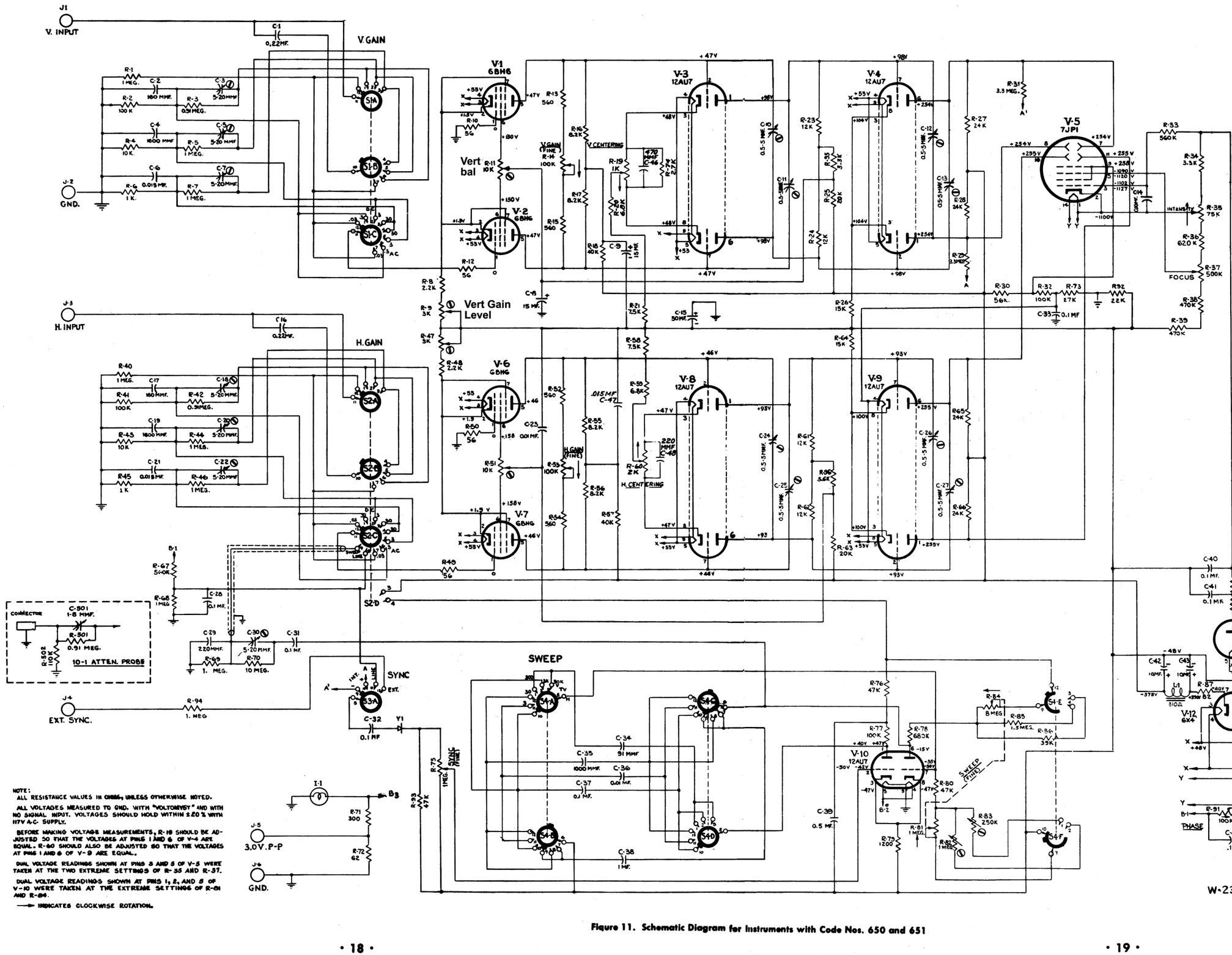
→ INDICATES CLOCKWISE ROTATION.

*INSTALLATION OPTIONAL ON INSTRUMENTS WITH CODE NUMBER 951

†INSTALLATION OPTIONAL ON INSTRUMENTS WITH CODE NUMBERS 751 AND 951.

▲USED ONLY IN INSTRUMENTS WITH CODE NUMBERS 650, 651, AND 751

Figure 10. Schematic Diagram for all Code Nos. Except 650 and 651



NOTE:
ALL RESISTANCE VALUES IN OHMS, UNLESS OTHERWISE NOTED.

ALL VOLTAGES MEASURED TO GND. WITH "VOLTOMYST" AND WITH NO SIGNAL INPUT. VOLTAGES SHOULD HOLD WITHIN ±20 % WITH 117V A-C. SUPPLY.

BEFORE MAKING VOLTAGE MEASUREMENTS, R-18 SHOULD BE ADJUSTED SO THAT THE VOLTAGES AT PINS 1 AND 6 OF V-4 ARE EQUAL. R-60 SHOULD ALSO BE ADJUSTED SO THAT THE VOLTAGES AT PINS 1 AND 6 OF V-9 ARE EQUAL.

DUAL VOLTAGE READINGS SHOWN AT PINS 3 AND 5 OF V-5 WERE TAKEN AT THE TWO EXTREME SETTINGS OF R-35 AND R-37.

DUAL VOLTAGE READINGS SHOWN AT PINS 1, 2, AND 5 OF V-10 WERE TAKEN AT THE EXTREME SETTINGS OF R-81 AND R-84.

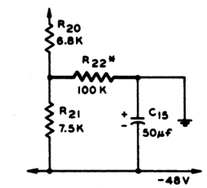
→ INDICATES CLOCKWISE ROTATION.

Figure 11. Schematic Diagram for Instruments with Code Nos. 650 and 651

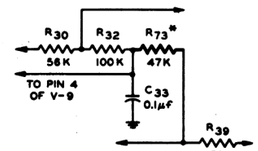
CIRCUITRY FOR INSTRUMENTS WITH CODE NO. 650

IN ADDITION TO THE DIFFERENCES IN COMPONENTS SHOWN IN THE REPLACEMENT PARTS LIST, THE FOLLOWING CIRCUIT MODIFICATIONS APPLY.

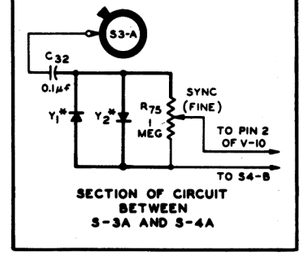
*DENOTES CHANGE



SECTION OF CIRCUIT BETWEEN V-1 AND V-3



SECTION OF CIRCUIT BELOW V-5



SECTION OF CIRCUIT BETWEEN S-3A AND S-4A

Replacement Parts List for Type WO-56A Oscilloscope

The components listed below are common to all WO-56A instruments except as indicated by footnotes. When ordering replacement parts, please include the code number and serial number of the instrument.

Symbol No.	Description	Stock No.
	Capacitors	
C1	Paper: oil impregnated, 0.22 μf ±20%, 400 v	73794
C2	Mica: 160 μμf ±2%, 500 v	93464
C3	Ceramic: 5-20 μμf	55301
C4	Mica: 1600 μμf ±5%, 500 v	39657
C5	Same as C3	—
C6	Paper: 0.015 μf ±10%, 200 v	73797
C7	Same as C3	—
C8	Electrolytic: 15 μf −10% +100%, 350 v	205292
C9	Electrolytic: 15 μf +100% −10%, 150 v	31323
C10 C11 C12 C13	Variable: 0.5 μμf-5 μμf, 500 v	93463
C14	Paper: oil impregnated, 0.1 μf ±20%, 200 v	73784
C15	Electrolytic: 50 μf −10% +100%, 50 v	91392
C16	Same as C1	—
C17	Same as C2	—
C18	Same as C3	—
C19	Same as C4	—
C20	Same as C3	—
C21	Same as C6	—
C22	Same as C3	—
C23	Paper: oil impregnated, 0.01 μf ±20%, 400 v	73561
C24 C25 C26 C27	Same as C10	—
C28	Same as C14	—
C29	Mica: 220 μμf ±10%, 500 v	39636
C30	Same as C3	—
C31 C32	Paper: oil impregnated, 0.1 μf ±20%, 400 v	73551
C33	Same as C14	—
C34	Mica: 91 μμf ±5%, 500 v	39627
C35	Mica: 1000 μμf ±2%, 500 v	53387
C36	Mica: 0.01 μf ±5%, 300 v	92036
C37	Paper: oil impregnated, 0.1 μf ±10%, 200 v	73784
C38	Special: 1 μf ±5%, 200 v	54861
C39	Special: 0.5 μf ±20%, 400 v	56870
C40 C41	Paper: metal encased, 0.1 μf ±20%, 1500 v	59325
C42 C43	Electrolytic: 10 μf ±10%, 525 v	93465
C44	Same as C14	—
C46	Mica: 470 μμf ±10%, 500 v	58243
C47 (b)	Paper: 0.015 μf ±10%, 200 v	73797
C47 (d)	Special. Same as C39	—
C48	Same as C29	—
	* * * * * *	
F1	Fuse: 1.5 amp	2725
I1	Lamp: pilot	11765
J1	Connector: chassis	96257
J2 J3 J4 J5 J6	Binding post	98479
L1	Filter reactor	93442
	Resistors	
R1	Carbon film: 1 meg ±1%, ½ w	55658
R2	Carbon film: 100,000 ohms ±1%, ½ w	72893
R3	Carbon film: 0.91 meg ±1%, ½ w	93471
R4	Carbon film: 10,000 ohms ±1%, ½ w	55665
R5	Same as R1	—
R6	Carbon film: 1000 ohms ±1%, ½ w	54198
R7	Same as R1	—
R8	Carbon film: 2200 ohms ±1%, 1 w	93472
R9	Variable: wirewound, 3000 ohms ±10%, 2 w	93456
R10	Wirewound: 56 ohms ±10%, ½ w	44095
R11	Variable: wirewound, 10,000 ohms ±10%, 2 w	93457
R12	Same as R10	—
R13	Composition: 560 ohms ±10%, ½ w	502156
R14	Variable: carbon, 100,000 ohms ±10% (part of S1)	93446
R15	Same as R13	5164
R16 R17	Carbon film: 8200 ohms ±1%, ½ w	93469
R18	Wirewound: 40,000 ohms ±5%, 5 w	93466
R19	Variable: carbon, 1000 ohms ±10%, 2 w	93454
R20	Composition: 6800 ohms ±5%, 1 w	512268
R21	Composition: 7500 ohms ±5%, 1 w	512275
R22 (e)	Composition: 100,000 ohms ±10%, ½ w	502410
R23 24	Carbon film: 12,000 ohms ±1%, ½ w	93470
R25	Composition: 20,000 ohms ±5%, 5 w	53362
R26	Composition: 15,000 ohms ± 5%, 5 w	53658
R27 R28	Carbon film: 48,000 ohms ±1%, 1 w	96321
R27A R27B R28A R28B (d)	Carbon film: 48,000 ohms ±1%, 1 w	96321
R29 (d)	Composition: 470,000 ohms ±10%, ½ w	502447
R29 (b)	Composition: 3.3 meg ±10%, ½ w	502533
R30	Composition: 56,000 ohms ±5%, 1 w	512356
R31 (d)	Composition: 470,000 ohms ±10%, ½ w	502447
R31 (b)	Composition: 3.3 meg ±10%, ½ w	502533
R32	Comp: 100,000 ohms ±5%, 1 w	512410
R33	Composition: 560,000 ohms ±10%, ½ w	502456
R34	Composition: 3300 ohms ±10%, ½ w	502233
R35	Variable: carbon, 75,000 ohms, with SPST switch (S5)	93461
R36	Composition: 620,000 ohms ±5%, 1 w	93467
R37	Variable: carbon, 500,000 ohms, high voltage insulated	93462
R38 R39	Composition: 470,000 ohms ±10%, 1 w	512447
R40	Same as R1	—
R41	Same as R2	—
R42	Same as R3	—
R43	Same as R4	—
R44	Same as R1	—
R45	Same as R6	—
R46	Same as R1	—
R47	Same as R9	—
R48	Same as R8	—
R49 R50	Same as R10	—
R51	Same as R11	—
R52	Same as R13	—
R53	Part of S2	—
R54	Same as R13	—

Symbol No.	Description	Stock No.
R55 R56	Same as R16	—
R57	Same as R18	—
R58	Same as R21	—
R59	Same as R20	—
R60	Variable: carbon, 2000 ohms ±10%, 2 w	93455
R61 R62	Same as R23	—
R63	Same as R25	—
R64	Same as R26	—
R65 R66 (b)	Carbon film: 24,000 ohms ±1%, 1 w	93473
R65A R65B R66A R66B (d)	Carbon film: 48,000 ohms ±1%, 1 w	96321
R67	Same as R33	—
R68 R69	Composition: 1 meg ±10%, ½ w	502510
R70	Composition: 10 meg ±10%, ½ w	502610
R71	Composition: 300 ohms ±5%, ½ w	502130
R72	Composition: 62 ohms ±5%, ½ w	502062
R73 (a)	Composition: 47,000 ohms ±5%, ½ w	502347
R73 (c)	Composition: 27,000 ohms ±5%, 1 w	71990
R74	Composition: 2700 ohms ±10%, ½ w	502227
R75	Variable: carbon, 1 meg ±10%	93447
R76	Composition: 47,000 ohms ±5%, ½ w	502347
R77	Same as R22	—
R78	Composition: 680,000 ohms ±5%, ½ w	502468
R79	Composition: 1200 ohms ±5%, ½ w	502212
R80	Same as R76	—
R81	Variable: carbon, dual type, 1 meg ±10%, ½ w and 8 meg ±10%, ½ w	93445
R82	Variable: carbon, 1 meg ± 10%	93447
R83	Variable: carbon, 250,000 ohms ±10%	93458
R84	Same as R81	—
R85	Composition: 1.5 meg ±10%, ½ w	502515
R86	Composition: 39,000 ohms ±5%, 2 w	502339
R87	Composition: 82 ohms ±10%, ½ w	502082
R88	Same as R22	—
R89	Composition: 27,000 ohms ±10%, 1 w	512322
R90	Wirewound: 0.68 ohm ±10%, ½ w	93468
R91	Variable: carbon, 100,000 ohms ±10%	93459
R92	Composition: 22,000 ohms ±5%, 1 w	512322
R93	Same as R76	—
R94	Same as R68	—
R95	Same as R34	—
R96	Composition: 5600 ohms ±10%, ½ w	502256
R97 R98 (n)	Composition: 3000 ohms ±10%, 1 w	47234
R99 (o)	Composition: 100,000 ohms ±10%, 2 w	522410
R100 (p)	Same as R73	
R101 (p)	Variable: carbon, 100,000 ohms	99312
R102 (p)	Composition: 150,000 ohms ±5%, 1 w	512415

Symbol No.	Description	Stock No.
	Switches	
S1 (h)	Rotary: 2 sections, 8 positions, 3 circuits	93443
S1 (j)	Rotary: 2 sections, 8 positions, 3 circuits	205312
S2 (h)	Rotary: 2 sections, 10 positions, 4 circuits (includes R53)	93449
S2 (j)	Rotary: 2 sections, 10 positions, 4 circuits (includes R53)	205313
S3 (h)	Rotary: 1 section, 4 positions, 1 circuit	93444
S3 (j)	Rotary: 1 section, 4 positions, 1 circuit	205314
S4 (b)	Rotary: 3 sections, 6 positions, 6 circuits	93448
S4 (d)	Rotary: 3 sections, 6 positions, 6 circuits	95546
S4 (j)	Rotary: 3 sections, 6 positions, 6 circuits	205315
S5	Part of R35	—
S6 (k)	Interlock: normally open	33885
T1	Transformer, power	96788
Y1 Y2	Crystal diode: type 1N34-A	59395
	Cable, ground: with phone tip and alligator clip	93407
	Clip, alligator	35262
	Cord, power: with male plug	70392
	Holder, fuse	54496
	Jewel, pilot lamp: red	54660
	Knob: blue, 1½″ dia. for 0.265 shaft	93451
	Knob: blue, 1″ dia. for ¼″ shaft	93452
	Knob: blue, 1″ dia. for 3/16″ shaft	93453
	Knob: blue, ¾″ dia. for ¼″ shaft	53689
	Ring, mounting: rubber, for CRT	93438
	Screen, graph	93440
	Socket, tube: 7-pin miniature	54684
	Socket, tube: 9-pin miniature	94926
	Socket, tube: for CRT	9952
	Socket: for pilot lamp	57760
	Shield, light: for CRT	93450
	WG-216A and WG-216B Low-Capacitance Probes	
C501 (f)	Capacitor: variable, 1-8 μμf, 500 v	93874
C501 (g)	Capacitor: variable, 1-8 μμf, 500 v	95548
R501 (f)	Resistor: fixed composition, 0.91 meg, ±5%, ½ watt	71667
R501 (g)	Resistor: carbon-film type, 9 meg, ±1%, 1 watt	59539
R502 (f)	Resistor: fixed composition, 0.11 meg, ±5%, ½ watt	2732
	Connector: female, 2 contact	59547
	Insert: for connector	98388
	Shell: probe housing	59549
	Shield: internal housing	59550
	Tip: probe	93876
	WG-218 Direct Probe and Cable	
	Cable: rf, coaxial, 38″	RG62U
	Connector: cable, and probe tip	48982
	Connector: cable, male	96318
	Shell: polystyrene, black	59529
	Sleeve: cable connector, black	59530

FOOTNOTES

(a) Used only in instruments with code number 650.
(b) Used only in instruments with code numbers 650 and 651.
(c) Used in all instruments except those with code number 650.
(d) Used in all instruments except those with code numbers 650 and 651.
(e) Used in all instruments except those with code number 651.
(f) Used only in WG-216A probe, supplied with instruments having code numbers 650 and 651.
(g) Used only in WG-216B probe, supplied with all instruments except those with code numbers 650 and 651.
(h) Used only in instruments with code numbers 650, 651, 751, and 951.
(j) Used in all instruments except those with code numbers 650, 651, 751, and 951.
(k) Used only in instruments with code numbers 650, 651, and 751.
(n) Installation optional on instruments with code number 951.
(o) Installation optional on instruments with code numbers 751 and 951.
(p) Used only in instruments with code number 355.

developed by a cylinder of an internal-combustion engine or any type of machine can be displayed on the oscilloscope screen. The oscilloscope has proven very useful in the development of internal-combustion engines when used with engine pressure-measuring devices.

The exceptional low-frequency response of the WO-56A enables it to portray graphically on its screen both static and dynamic pressures of engines, pumps, pneumatic and hydraulic systems. Transient pressures which are not recorded on conventional indicating devices can be observed on the oscilloscope screen. Abnormal pressures of extremely short duration can be viewed. The WO-56A will prove a valuable instrument for observing dangerous transient or peak pressures.

Vibration Measurements

The WO-56A can be used with a piezo-electric transducer for measuring vibration. Figure 22 illustrates a setup for obtaining vibration waveforms, indicating relative amplitudes and other characteristics of vibration, on the oscilloscope screen for observation or photographic recording. Compressing, warping, twisting strains and similar phenomena may be portrayed for study of their effects.

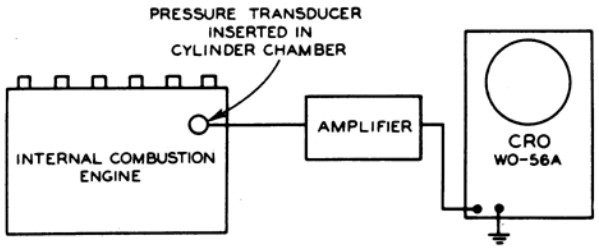


Figure 21. Engine-Pressure Analysis

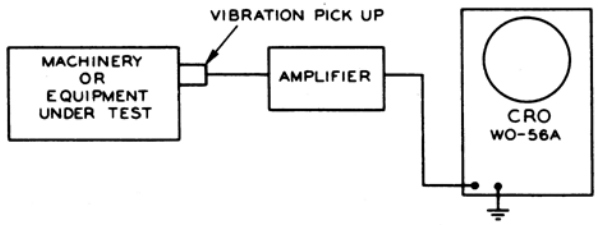


Figure 22. Vibration Analysis

Maintenance

CAUTION: Do not strike or subject the cathode-ray tube to excessive pressure as breakage of the tube may result in injury from flying glass.

General

The WO-56A has been properly aligned and adjusted at the factory and was in perfect operating condition before shipment. As the instrument incorporates high-gain direct-coupled push-pull amplifiers, however, it may require inspection upon receipt and periodic checks during its operating life.

To obtain maximum performance at all times, it is important that the few simple adjustments required to maintain maximum gain and stability be thoroughly understood. Complete alignment of the instrument should not be necessary under normal operating conditions. If complete alignment is necessary, however, an audio oscillator, a signal generator, and a square-wave generator are required.

The setting of the V BAL and H BAL adjustments on the front panel and the setting of the internal amplifier-gain con-

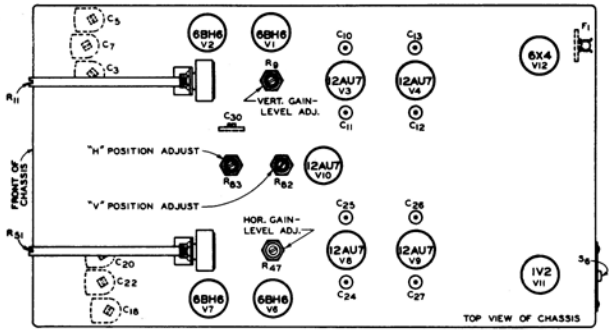


Figure 23A. Top-chassis view of instruments having code numbers 650, 651, 751, and 951.

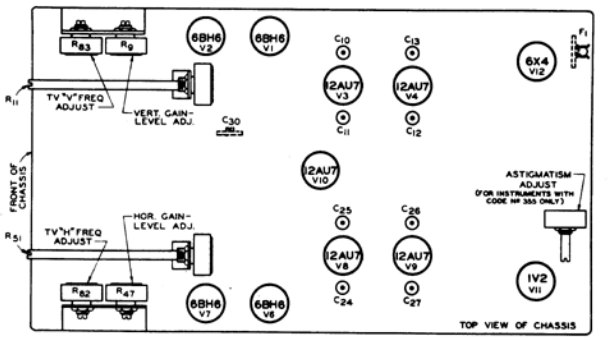


Figure 23B. Top-chassis view of all instruments except those with code numbers 650, 651, 751, and 951.

trols are important if maximum trace stability, best linearity, and freedom from effects of line-voltage variations are to be maintained.

When making gain adjustments, a minimum warm-up time of one hour should be allowed. The V BAL and H BAL controls, however, may be set for best balance during the warm-up period for immediate operation or after the warm-up period for extended operation.

For example, if the user desires to have best balance immediately upon applying power to the WO-56A, the V BAL and H BAL adjustments should be set within 5 minutes after turning on the instrument. If maximum stability is required over an extended period of operation, at least 20 minutes warm-up time should be allowed.

Performance of the WO-56A also depends upon the quality of the components employed. If it should become 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 three screws from the back of the instrument and applying pressure on the rear apron through the hole provided for the power cord.

Some models of the WO-56A are equipped with a power interlock switch. If the tube heaters or pilot lamp fail to light when the chassis is removed from the case, the interlock may be closed by strapping it down with a piece of tape when internal service or adjustment must be made. CAUTION: This oscilloscope uses high-voltage circuits.

Amplifier Operating Adjustments

Vertical displacement of the trace on the screen of the cathode-ray tube when the V GAIN vernier is varied indicates that the V BAL control R 11 is improperly adjusted. Horizontal displacement of the trace when the H GAIN vernier is varied indicates that the H BAL control R 51 is improperly adjusted. Both these controls are screw-driver adjustments which are marked on the front panel. They are accessible when the retractable light shield is pulled forward.

Internal gain-level adjustments for the oscilloscope are located inside the case. Their locations are shown in Figures 23A and 23B.

Vertical Amplifier Balance Adjustment—Proceed as follows:

1. Apply power to the instrument by turning the INTENSITY control clockwise.

2. Screw the Direct Probe cable connector to the V INPUT connector and connect the probe tip to the 3V P-P terminal.

3. Set the V GAIN selector to "3" on "AC", V GAIN vernier fully clockwise, H GAIN selector to "LINE", and the H GAIN vernier fully counterclockwise.

4. Adjust the PHASE control to obtain a circle. Center the circle in the graph screen with the V and H centering controls.

5. Rotate the V GAIN vernier and notice whether the vertical position of the trace changes. If the position shifts vertically, adjust the V BAL control with a screw driver for a minimum vertical displacement with variation of the V GAIN vernier. Exact adjustment of the V BAL control is indicated when no displacement occurs as the V GAIN vernier is varied.

Horizontal Amplifier Balance Adjustment—Proceed as follows:

1. Follow steps 1 through 4 as described above.

2. Rotate the H GAIN vernier and notice whether the horizontal position of the trace changes. If the trace shifts horizontally as the H GAIN vernier is rotated, adjust the H BAL control for minimum horizontal displacement with variation of the H GAIN vernier. Exact adjustment of the H BAL control is indicated when no displacement occurs as the H GAIN vernier is rotated.

Vertical Gain-Level Adjustment—The vertical gain level may be adjusted as follows:

1. Turn on the instrument and allow one hour for the WO-56A to thoroughly warm up. Instruments with code numbers 650, 651, 751, and 951 will require removal of the chassis from the case to provide access to the vertical-gain adjustments. Locations of adjustments for all instruments are shown in Figures 23A and 23B.

2. Connect the WG-218 Direct Probe to the V INPUT connector and connect the probe tip to the 3V P-P terminal.

3. Set the V GAIN selector to "3" on "AC", V GAIN vernier fully clockwise, H GAIN control at "LINE", and the H GAIN vernier fully counterclockwise.

4. With a screw driver, adjust the vertical gain potentiometer R 9 for maximum waveform height. Readjust the V BAL control as described under "Vertical Amplifier Balance Adjustment", if necessary.

5. Remove the calibrating voltage and reinstall the instrument.

Horizontal Gain-level Adjustment—The horizontal gain level may be adjusted as follows:

1. Follow steps 1 through 3 described under "Vertical Gain-level Adjustment".

2. With a screw driver, adjust the horizontal gain potentiometer R 47 for maximum waveform width. Readjust the H BAL control as described under "Horizontal Amplifier Balance Adjustment", if necessary.

3. Remove the calibrating voltage and reinstall the instrument.

Tube or Component Replacement—The amplifier balance and gain adjustments described above should be made whenever required during the life of the instrument and should always be made when a tube or component is replaced. If a tube or component is replaced, however, the instrument should be run for at least 24 hours before attempting adjustments. This pre-aging of a tube or component aids in stabilizing the electrical performance of the new unit in relation to the rest of the circuitry.

Amplifier Alignment

For complete alignment of the vertical and horizontal amplifiers, a signal generator and a square-wave generator are required.

Vertical Amplifier Alignment—1. Remove the chassis from the case and apply power. Allow the instrument to warm up for at least 15 minutes.

2. Set the V GAIN and H GAIN selectors to "30" on "AC". Set the V GAIN and H GAIN verniers to their extreme counterclockwise positions. A spot should appear on the oscilloscope screen. NOTE: Do not allow a small spot of high brilliance to remain on the oscilloscope screen for an appreciable length of time because damage to the screen may result.

3. Center the spot with the H CENTER and V CENTER controls.

4. Rotate the adjustable screws of the neutralizing capacitors C-10, C-11, C-12, and C-13 completely counterclockwise. CAUTION: These screw adjustments carry high voltage when power is applied to the instrument.

5. Set the V GAIN selector to "3" on "AC", turn the V GAIN vernier fully clockwise, and set the H GAIN selector to "LINE." Connect the WG-218 Direct Probe to the V INPUT connector and the probe tip to the 3V P-P terminal. Adjust the PHASE control to obtain a circle. Center in the graph screen by adjusting the V and H CENTER controls.

6. With a screw driver, adjust the vertical amplifier gain potentiometer R-9 for maximum height of the waveform. Remove the calibrating voltage.

7. Readjust the V BAL control if necessary (see "Vertical Amplifier Balance Adjustment" above).

8. Set the H GAIN selector to "SWEEP".

9. Set up the external square-wave generator for approximately 1.0 peak-to-peak volt at a frequency of 100 Kc. Apply the square-wave signal to the V INPUT terminal.

10. Set up the external signal generator for a frequency of 100 Kc. Connect the output to the H INPUT connector.

11. Adjust the V GAIN selector and vernier controls to obtain a pattern of suitable height. The number of waveforms on the screen may be determined by adjustment of the SWEEP controls. Adjust the H GAIN vernier for a horizontal trace of approximately four inches. Synchronize the external generators by adjusting the frequency of the signal generator until the pattern remains steady.

12. With a screw driver, adjust C-12 and C-13 until the square wave just begins an overshoot condition. These controls should be adjusted alternately, taking care to keep the slugs even.

13. Rotate the V GAIN vernier clockwise and reduce the output from the square-wave generator until a vertical deflection of approximately four inches is obtained. Adjust C-10 and C-11 by equal amounts until the leading edge of the square wave just begins to round off.

14. Set the square-wave generator and the signal generator for 10 Kc. Set the V GAIN control to ".3" and adjust the output of the square-wave generator for a waveform deflection of approximately three inches on the screen. With a screw driver, adjust C-3 in the vertical attenuator section for best square-wave response. Adjust the remaining vertical-attenuator trimmers, C-5 and C-7, for best square-wave response by setting the V GAIN selector to positions "3" and "30" respectively.

Horizontal Amplifier Alignment—

1. Follow the procedure given in steps 1 through 3 of the above section "Vertical Amplifier Alignment".

2. Rotate the adjustable screws of the neutralizing capacitors C-24, C-25, C-26, and C-27 fully counterclockwise. CAUTION: These screw adjustments carry high voltage when power is applied to the instrument.

3. Set the V GAIN selector to "3" on "AC", turn the V GAIN vernier fully counterclockwise, and set the H GAIN selector to "LINE". Connect the WG-218 Direct Probe to the V INPUT connector and the probe tip to the 3V P-P terminal. Adjust PHASE control to obtain a circle. Center in graph screen by adjusting the V and H CENTER controls.

4. With a screw driver, adjust the horizontal amplifier gain potentiometer R-47 for maximum width of the waveform. Remove the calibrating voltage.

5. Readjust the H BAL control if necessary (see "Horizontal Amplifier Balance Adjustment" above).

6. Set the H GAIN selector to ".03" on "DC" and turn the H GAIN vernier fully counterclockwise.

7. Set up the square-wave generator to deliver a frequency of 100 Kc at approximately 1.0 peak-to-peak volts. Connect the output to the H INPUT terminal and GND terminal.

8. Set up the signal generator for a frequency of 100 Kc and connect the output to the V INPUT connector.

9. Adjust the V GAIN selector and vernier controls to obtain a pattern of suitable height. The number of waveforms on the screen may be determined by adjustment of the SWEEP controls. Adjust the H GAIN vernier for a horizontal trace of approximately four inches. Synchronize the external generators by adjusting the frequency of the signal generator until the pattern remains steady.

10. With a screw driver, adjust C-26 and C-27 until the square wave just begins an overshoot condition. These controls should be adjusted alternately, taking care to keep the slugs even.

11. Set the H GAIN vernier to its maximum clockwise position and reduce the output voltage of the square-wave generator to produce a convenient deflection.

12. Adjust C-24 and C-25 by equal amounts until the corner of the square wave just begins to round off.

13. Tune the square-wave generator and the signal generator to deliver a frequency of 10 Kc. Set the H GAIN to ".3". Increase the output voltages, if necessary, to produce sufficient deflection. Adjust C-18 in the horizontal attenuator section for best square-wave response. Adjust the remaining horizontal-attenuator trimmers, C-20 and C-22, for best square-wave response by setting the H GAIN selector to positions "3" and "30", respectively.

Sweep-Oscillator Adjustments

The procedure for adjusting the sweep oscillator is outlined below.

1. Remove the chassis from the case, plug in the power cord to an ac outlet, and short the interlock switch S-6. CAUTION: See "Safety Precautions".

2. Rotate the INTENSITY control to turn the instrument on, and set the V GAIN selector to position "30" on the AC range.

3. Tune an audio oscillator to approximately 10 kc and apply the oscillator output across the V INPUT and GND terminals using the Direct Probe and Cable and the Ground Cable.

4. Set the V GAIN vernier for a convenient vertical deflection, the H GAIN selector to "SWEEP" position, and the H GAIN vernier for a convenient horizontal deflection.

5. Set the SWEEP selector to position "300-3K" and the SWEEP vernier counterclockwise. Set the SYNC selector to "INT+" or "INT—" position and the SYNC vernier for a stationary pattern.

6. Adjust C-30 for an undistorted sine wave on the face of the cathode-ray tube. This adjustment controls the linearity of the sawtooth output of the sweep oscillator.

If the prefixed sync positions marked "TV V" and "TV H" fail to give a locked-in pattern on the screen, the potentiometers R-82 and R-83 may need adjustment in order to bring the preset sync frequencies to their proper settings. They may be adjusted as follows:

1. Connect an audio oscillator set up to give an output frequency of exactly 25 cps to the "V INPUT" terminals.
2. Set the H GAIN selector to "SWEEP."
3. Set the SYNC selector control at either the "—INT" or "+INT" position and the SYNC vernier control to its maximum counterclockwise position.
4. Set the SWEEP switch to the "TV V" position and adjust R-83 until exactly two waveforms appear on the oscilloscope screen.
5. Turn the SWEEP switch to the "TV H" position, set the audio oscillator to deliver a frequency of exactly 6500 cps, and adjust R-82 until exactly two waveforms appear on the oscilloscope screen.

The 25 and 6500 cps lock-in frequencies are set low in order to insure lock-in over a range of frequencies should drift or voltage changes affect the circuit.

If an audio oscillator is not immediately available, temporary readjustment may be made. The procedure is as follows:

1. Connect the oscilloscope to a television receiver as described on page 10 in the section "Applications".
2. With the instrument set up to measure the vertical sync pulse, set the SYNC vernier control to mid position, and adjust R-83 until exactly two pulses are locked in on the oscilloscope screen.
3. With the instrument set up to measure the horizontal sync pulse, set the SYNC vernier control to mid position, and adjust R-82 until exactly two pulses are locked in on the oscilloscope screen.

Adjustment of the WG-216B Low-Capacitance Probe

Apply the output of a square-wave generator which has been tuned to 10 kc across the V INPUT terminal and the GND terminal of the oscilloscope, using the Direct Probe and Cable and the Ground Cable, and adjust the proper controls to give a square wave of convenient amplitude on the oscilloscope screen. Attach the WG-216B Low-Capacitance Probe to the Direct Probe and Cable, and connect this probe to the output of a square-wave generator. If the square wave now obtained is distorted as compared to the square wave previously viewed, the response of the probe may be corrected by adjusting C-501 until the square waveform is satisfactory. C-501 is accessible when the hexagonal nut and the probe tip are removed from the front of the probe.

If it should become necessary to replace any of the parts in the WG-216B, disassemble the probe as follows:

1. Unscrew and remove the probe tip.
2. Scrape the wax from the set screw on the probe housing and remove the set screw. CAUTION: When reassembling the probe, replace the wax or otherwise insulate the exposed portion of the set screw.
3. Remove the hexagonal nut.
4. Remove the internal assembly from the probe housing by applying pressure at point A. See Figures 24 and 25.
5. Remove the electrical tape from the internal assembly.

Astigmatism Adjustment

Astigmatism, or a trace that does not have the same degree of focus at all points may be adjusted by means of the Astigmatism control, R101, on instruments having the code number 355. This control is accessible through a hole at the rear of the right side-panel. To make this adjustment proceed as follows:

1. Apply power to the instrument by turning the INTENSITY control clockwise.
2. Screw the Direct Probe cable connector to the V INPUT connector and connect the probe tip to the 3V P-P terminal.
3. Set the V GAIN selector to "3" on "AC", and set the H GAIN to "LINE".
4. Adjust the V GAIN vernier, the H GAIN vernier and the PHASE control to obtain a circle about two inches in diameter.
5. Adjust R101 for best focus over the entire circumference of the trace.

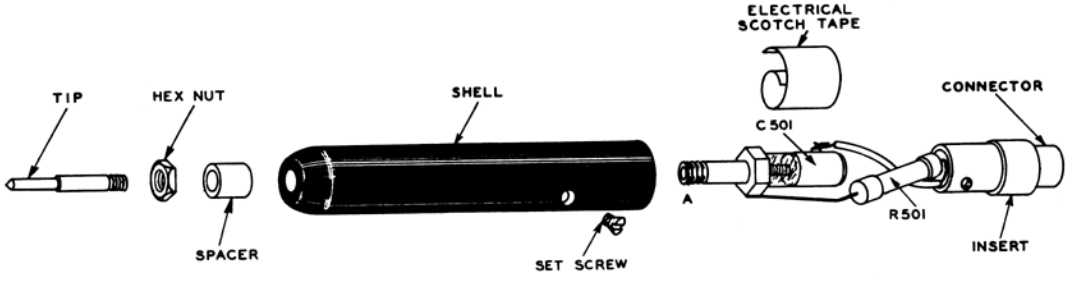


Figure 24. Exploded View of WG-216B Low-Capacitance Probe

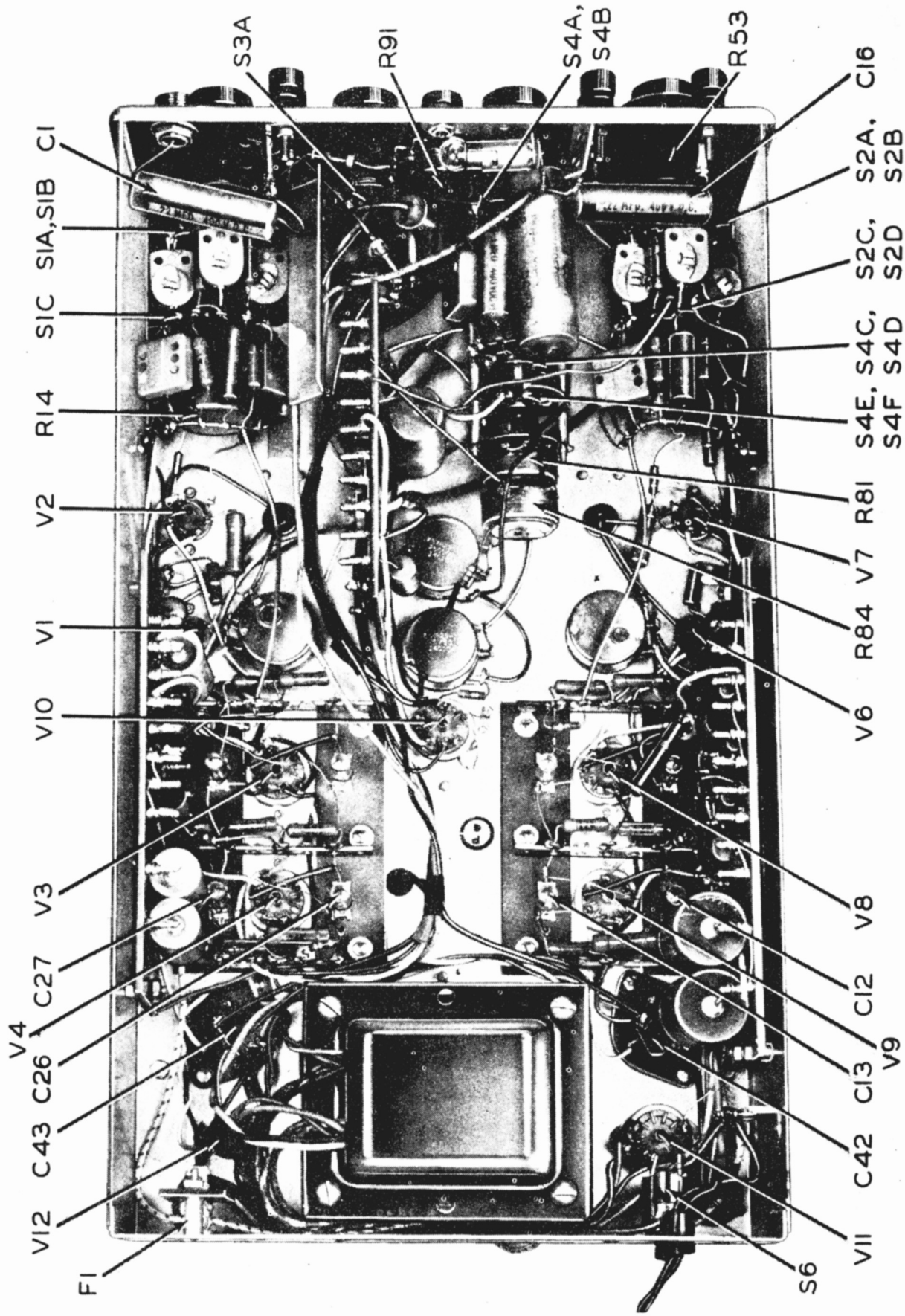


Figure 25. Under-chassis view of WO-56A. NOTE: On all instruments other than those having code numbers 650, 651, 751, and 951, potentiometers R9, R47, R82, and R83 have been relocated. See Figure 23B.