Replacement Parts List

Type WO-56A

Cathode-Ray Oscilloscope

When ordering Replacement Parts, please state Serial Number and Code Number of Instrument.

Symbol No.	Description	Stock No.
	Capacitors, Fixed and Variable	
C 1	Paper tubular, oil impregnated, .22 µf ± 20%, 400 volts	73794
C 2	Fixed mica, 160 µµf ± 2%, 500 volts	93464
C 3	Ceramic trimmer, 5-20 µµf	64689
C 4	Fixed mica, 1600 µµf ± 5%, 500 volts	39657
C 5	Same as C 3	—
C 6	Molded paper, 0.015 µf ± 10%, 200 volts	73797
C 7	Same as C 3	—
C 8, 9	Dry electrolytic, hermetically sealed, tubular, 15µf, + 100% − 10%, 150 volts	31323
C 10, 11, 12, 13	Variable trimmer, 0.5-5 µµf, 500 volts dc	93463
C 14	Paper tubular, oil impregnated, 0.1 µf ± 20%, 200 volts	73784
C 15	Dry electrolytic, hermetically sealed, tubular, 50 µf, + 100% − 10%, 50 volts	91392
C 16	Same as C 1	—
C 17	Same as C 2	—
C 18	Same as C 3	—
C 19	Same as C 4	—
C 20	Same as C 3	—
C 21	Same as C 6	—
C 22	Same as C 3	—
C 23	Paper tubular, oil impregnated, .01 µf ± 20%, 400 volts	73561
C 24, 25, 26, 27	Same as C 10	—
C 28	Same as C 14	—
C 29	Fixed mica, 220 µµf ± 10%, 500 volts	39636
C 30	Same as C 3	—
C 31, 32	Paper tubular, oil impregnated, 0.1 µf ± 20%, 400 volts	73551
C 33	Same as C 14	—
C 34	Fixed mica, 91 µµf ± 5%, 500 volts	39627
C 35	Fixed mica, 1000 µµf ± 2%, 500 volts	53537
C 36	Fixed mica, .01 µf ± 5%, 300 volts	92036
C 37	Paper tubular, oil impregnated, 0.1 µf ± 10%, 200 volts	73784
C 38	Special tubular, wax impregnated, wax coated, 1 µf ± 5%, 200 volts	54861
C 39	Special tubular, wax impregnated, wax coated, .5 µf ± 20%, 400 volts	56870
C 40, 41	Fixed paper, 0.1 µf ± 20%, 1500 volts	59325
C 42, 43	Dry electrolytic, 10 µf ± 10%, 525 volts	93465
C 44	Same as C 14	—
C 46	470 µµf, −10%	58243
C 47	Same as C 6	—
C 48	Same as C 29	—
	Socket	
I 1	Socket, pilot lamp	57760
	Jacks and Connectors	
J 1	Chassis connector	54695
J 2, 3, 4, 5, 6	Binding post	34085
	Inductor	
L 1	Reactor, filter	93442
	Resistors, Fixed and Variable	
R 1	Carbon film type, 1 meg. ± 1%, ½ watt	55658
R 2	Carbon film type, 100,000 ohms ± 1%, ½ watt	72893
R 3	Carbon film type, .91 meg. ± 1%, ½ watt	93471
R 4	Carbon film type, 10,000 ohms ± 1%, ½ watt	55665
R 5	Same as R 1	—
R 6	Carbon film type, 1000 ohms ± 1%, ½ watt	54198
R 7	Same as R 1	—
R 8	Carbon film type, 2200 ohms ± 1%, 1 watt	93472
R 9	Variable, wire wound, 3000 ohms ± 10%, 2 watts	93456
R 10	Fixed, wire wound, 56 ohms ± 10%, ½ watt	44095
R 11	Variable, wire wound, 10,000 ohms ± 10%, 2 watts	93457
R 12	Same as R 10	—
R 13	Fixed composition, 560 ohms ± 10%, ½ watt	19783
R 14	Variable, carbon type, 100,000 ohms ± 10%	93446
R 15	Same as R 13	—
R 16, 17	Carbon film type, 8200 ohms ± 1%, ½ watt	93469
R 18	Fixed, wire wound, 40,000 ohms ± 5%, 5 watts	93466
R 19	Variable, carbon, 1000 ohms ± 10%, 2 watts	93454
R 20	Fixed composition, 6800 ohms ± 5%, 1 watt	38887
R 21	Fixed composition, 7500 ohms ± 5%, 1 watt	46441
R 22	Fixed composition, 100,000 ohms ± 10%, ½ watt	3252
R 23, 24	Carbon film type, 12,000 ohms ± 1%, ½ watt	93470
R 25	Fixed composition, 25,000 ohms ± 5%, 5 watts	44964
R 26	Fixed composition, 15,000 ohms ± 5%, 5 watts	53658
R 27, 28	Carbon film type, 24,000 ohms ± 1%, 1 watt	93473
R 29	Fixed composition, 10 meg. ± 10%, ½ watt	30992
R 30	Fixed composition, 56,000 ohms ± 5%, ½ watt	30650
R 31	Same as R 29	—
R 32	Same as R 22	—
R 33	Fixed composition, 560,000 ohms ± 10%, ½ watt	30653
R 34	Fixed composition, 3300 ohms ± 10%, ½ watt	30733
R 35	Variable, carbon, 75,000 ohms	93461
R 36	Fixed composition, 620,000 ohms ± 5%, 1 watt	93467
R 37	Variable, carbon, high-voltage insulator, 500,000 ohms	93462

Symbol No.	Description	Stock No.
R 38, 39	Fixed composition, 470,000 ohms ± 10%, 1 watt	72521
R 40	Same as R 1	—
R 41	Same as R 2	—
R 42	Same as R 3	—
R 43	Same as R 4	—
R 44	Same as R 1	—
R 45	Same as R 6	—
R 46	Same as R 1	—
R 47	Same as R 9	—
R 48	Same as R 8	—
R 49, 50	Same as R 10	—
R 51	Same as R 11	—
R 52	Same as R 13	—
R 53	Same as R 14	—
R 54	Same as R 13	—
R 55, 56	Same as R 16	—
R 57	Same as R 18	—
R 58	Same as R 21	—
R 59	Same as R 20	—
R 60	Variable, carbon, 2000 ohms ± 10%, 2 watts	93455
R 61, 62	Same as R 23	—
R 63	Same as R 25	—
R 64	Same as R 26	—
R 65, 66	Same as R 27	—
R 67	Same as R 33	—
R 68, 69	Fixed composition, 1 meg. ± 10%, ½ watt	30652
R 70	Same as R 29	—
R 71	Fixed composition, 300 ohms ± 5%, ½ watt	3792
R 72	Fixed composition, 62 ohms ± 5%, ½ watt	3579
R 73	Fixed composition, 47,000 ohms ± 5%, ½ watt	30797
R 74	Fixed composition, 2700 ohms ± 10%, ½ watt	30730
R 75	Variable, carbon type, 1 meg. ± 10%	93447
R 76	Same as R 73	—
R 77	Same as R 22	—
R 78	Fixed composition, 680,000 ohms ± 5%, ½ watt	30562
R 79	Fixed composition, 1200 ohms ± 5%, ½ watt	30731
R 80	Same as R 73	—
R 81	Variable, carbon dual type, 1 meg. ± 10%, ½ watt, and 8 meg. ± 10%	93445
R 82	Variable, carbon, 1 meg. ± 10%	93460
R 83	Variable, carbon, 250,000 ohms ± 10%	93458
R 84	Same as R 81	—
R 85	Fixed composition, 3.3 meg. ± 10%, ½ watt	31417
R 86	Fixed composition, 39,000 ohms ± 5%, 2 watts	30147
R 87	Fixed composition, 82 ohms ± 10%, ½ watt	13961
R 88	Same as R 22	—
R 89	Fixed composition, 27,000 ohms ± 10%, ½ watt	30409
R 90	Fixed wire, 0.68 ohms ± 10%, ½ watt	93468
R 91	Variable, carbon, 100,000 ohms ± 10%	93459
	Switches	
S 1	Rotary, 2 section, 8 position	93443
S 2	Rotary, 2 section, 10 position	93449
S 3	Rotary, 1 section, 4 position	93444
S 4	Rotary, 3 section, 8 position	93448
S 5	Part of R 35	—
S 6	Door, push button normally open, 0.75 amp., 125 volts	33885
	Transformer	
T 1	Power, 117 volts, 50/60 cycles	93441
	Miscellaneous	
	Cable, ground, 5/64 rubber 48 in. long, with alligator clip and phone tip	93407
	Clip, alligator	35262
	Connector, male, single contact	93474
	Knob, control, blue, round	93453
	Knob, control, blue, round	53689
	Knob, control, blue, round	93451
	Knob, control, blue, round	93452
	Holder, fuse mounting	54496
	Jewel pilot light, red	54660
	Ring for graph screen	93438
	Screen, graph, green	93440
	Shield, light	93450
	Socket, tube, miniature, 9 pin	59531
	Socket, tube, cathode-ray, 14 pin	9952C
	Socket, tube, miniature, 7 pin	54684

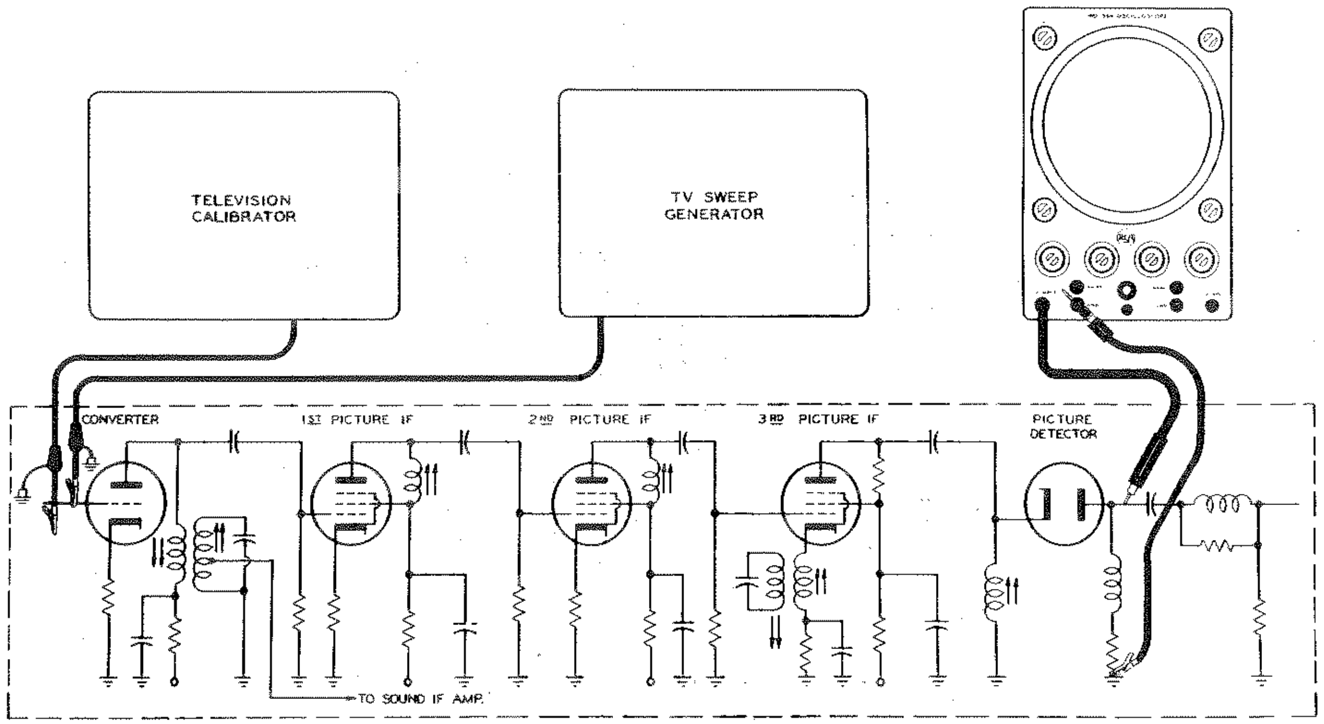


Figure 6. Setup for Alignment of Picture-IF Amplifier

positions of the picture and sound carriers and the traps.

CAUTION: Do not use too large a signal from the sweep generator when aligning the if amplifiers. Too large a signal may overdrive the amplifiers, thus producing a flat-top response curve even though the amplifier is incorrectly aligned. If the signal level is kept low enough so that a little noise is observed on the response curve, no difficulty of this type will be experienced.

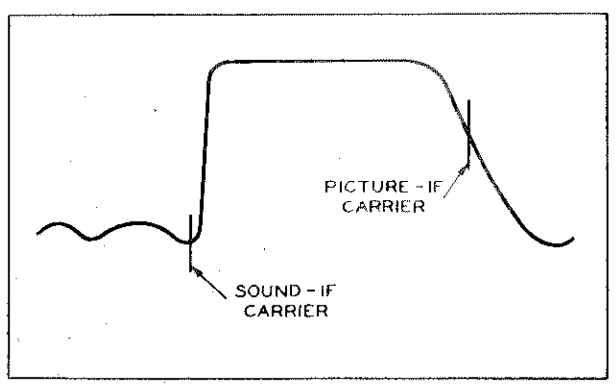


Figure 7. Picture-IF Response

Aligning Sound-IF Circuits

The procedure for visually aligning television sound-if circuits is the same as that used for visual alignment of the if system in a FM receiver. However, the reader is once again advised to consult the manufacturer's service notes before attempting alignment.

A suggested alignment procedure is outlined below. The setup for this procedure is illustrated in Figure 8.

1. Tune the sweep generator to the sound-if frequency.

2. Connect the Direct Probe and Cable across the limiter grid resistor and to the oscilloscope, as indicated in Figure 8. If the sweep generator uses a sinusoidal sweep of line frequency, set the H GAIN selector on "LINE", and adjust the PHASE control to give a single pattern on the oscilloscope screen. If the sweep generator uses a sawtooth sweep, feed the sweep-voltage output of the generator to the horizontal-deflection terminals on the oscilloscope and set the H GAIN selector to a position which will give a horizontal deflection of convenient length.

3. Feed the signal from the sweep generator to the grid of the stage preceeding the limiter, and adjust the transformer in the limiter grid circuit for

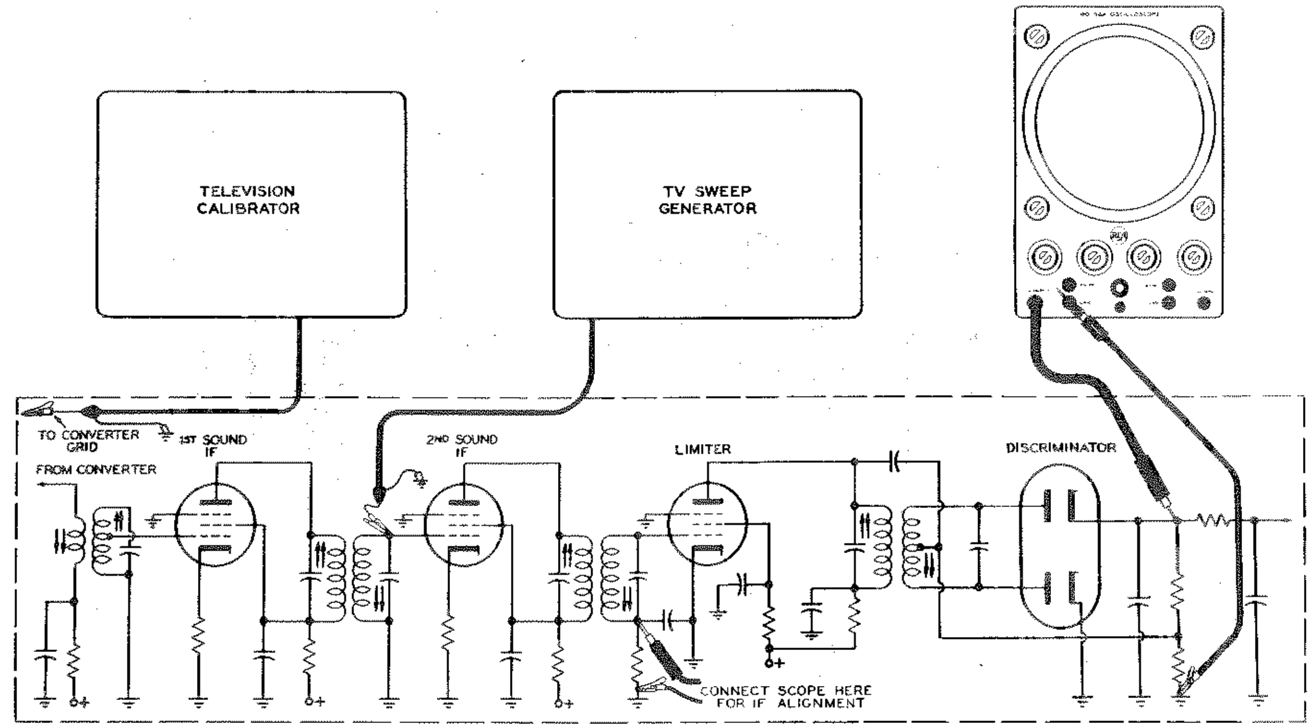


Figure 8. Setup for Alignment of Sound-IF Amplifier

a curve like that shown in Figure 9A. The WR-39B TV Calibrator should be set at the sound intermediate frequency, and the curve should be symmetrical about the marker from the signal generator.

4. Move the sweep-generator output cable back stage by stage, each time adjusting the proper transformer for the curve of Figure 9A.

Discriminator Alignment

Connect the output cable of the sweep generator to the if-amplifier input, and the Direct Probe and Cable and the Ground Cable of the WO-56A across the discriminator output. (See Figure 8.)

The discriminator response is illustrated in Figure 9B. Adjust the secondary of the discriminator transformer for maximum symmetry of the response curve, and adjust the primary for maximum linearity between points a and b, Figure 9B.

Aligning RF Circuits

Different manufacturers recommend different methods for the alignment of the rf sections of their receivers; therefore, the oscilloscope should be used as described in the manufacturer's service notes. A method of aligning the rf section will be given here, but in all cases where service notes are available, the rf-alignment instructions therein should be given preference.

For this method, the picture-if channel must first be properly aligned, and the oscillator in the rf section must be tuned to the correct frequency for each channel. The oscilloscope and the sweep generator should be set up as described for alignment of the picture-if amplifier, and the picture-if response curve made to approximate the curve shown in Figure 7.

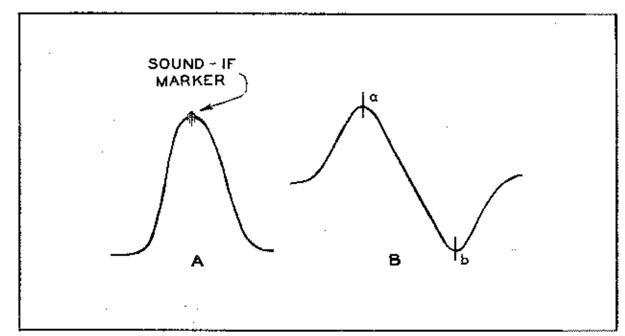


Figure 9. Sound-IF and Discriminator Response

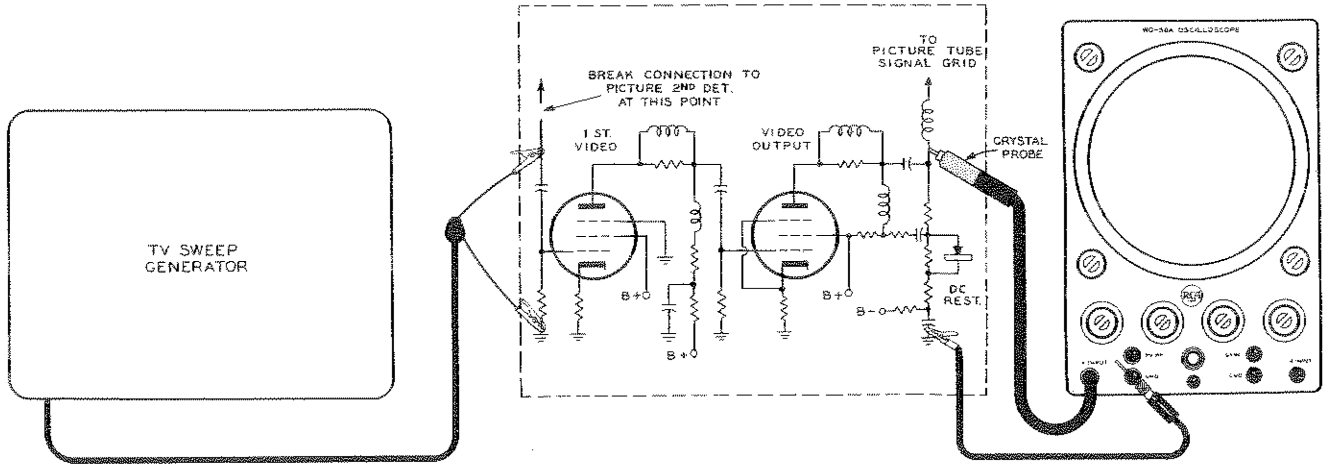


Figure 10. Setup for Checking Video-Amplifier Response

The sweep-generator output cable is then transferred to the antenna terminal of the receiver, and the generator is tuned to sweep channel 13. The receiver is also tuned to channel 13. Make all necessary circuit adjustments associated with channel 13 to produce on the oscilloscope screen an if response of maximum amplitude and one which closely approximates the response curve illustrated in Figure 7.

This procedure is repeated for the remainder of the rf channels. In each case, the receiver is tuned to the channel being adjusted, and the sweep generator is tuned to sweep the proper frequency band.

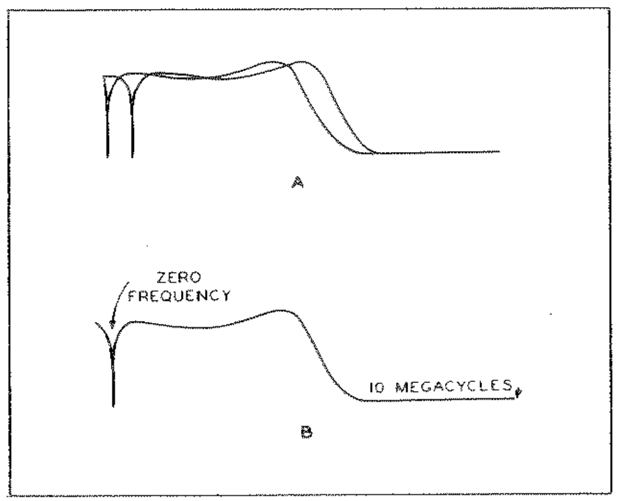


Figure 11. Video-Amplifier Response

Checking Video-Amplifier Frequency Response

A graphical representation of the response curve of a video amplifier may be obtained on the oscilloscope as follows:

1. Set up the equipment as shown in Figure 10. Set the H GAIN selector to "LINE" position. A pattern similar to that shown in Figure 11A should be obtained.

2. Adjust the PHASE control until the two patterns coincide so that a single pattern similar to that of Figure 11B is obtained.

3. Note that for this application a crystal probe is used. This probe should have approximately the same input capacitance as the input capacitance of the kinescope grid. The kinescope may be removed from its socket and the crystal probe connected to the grid terminal of the socket. The video-amplifier response may then be checked with a sweep generator and the oscilloscope, with the assurance that the capacitance loading on the output stage is essentially the same as would be obtained during normal operation of the television receiver.

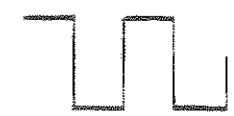
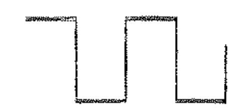
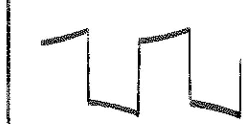
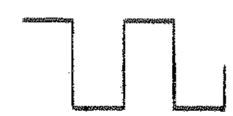
INPUT TO VIDEO AMPLIFIER	SHAPE OF OUTPUT WAVE SEEN ON C-R SCREEN	EFFECT ON TELEVISION PICTURE	DEFECT	CHECK THESE CIRCUIT COMPONENTS
SQUARE WAVE (ABOUT 60 CYCLES) 		PICTURE NORMAL	NO DEFECTS. GOOD LOW-FREQUENCY RESPONSE AND NEGLIGIBLE PHASE SHIFT.	
		GRADUAL CHANGE IN PICTURE SHADING FROM TOP TO BOTTOM OF PICTURE. (THIS EFFECT CAN BE MINIMIZED BY DC-RESTORER ACTION.)	LEADING LOW-FREQUENCY PHASE SHIFT. (USUALLY ACCOMPANIED BY A LOSS OF LOW-FREQUENCY GAIN.)	COUPLING CAPACITORS, SCREEN AND CATHODE BYPASS CAPACITORS, LOW-FREQUENCY COMPENSATION CIRCUITS, SCREEN AND GRID RESISTORS.
			LAGGING LOW-FREQUENCY PHASE SHIFT. (USUALLY CAUSED BY OVER-COMPENSATION.)	
SQUARE WAVE (ABOUT 25 KC) 		PICTURE NORMAL	NO DEFECTS. GOOD HIGH-FREQUENCY AND TRANSIENT RESPONSE.	
		PICTURE DETAIL IS POOR; SHARP CHANGES IN PICTURE SHADING ARE "FUZZY".	POOR HIGH-FREQUENCY RESPONSE.	PEAKING COILS, LOAD RESISTORS, LEAD DRESS OF PEAKING COILS AND COUPLING NETWORKS.
		FINE VERTICAL BLACK AND WHITE STRIATIONS FOLLOWING A SHARP CHANGE IN PICTURE SHADING.	EXCESSIVE HIGH-FREQUENCY RESPONSE AND NON-LINEAR TIME DELAY; ALSO HIGH-FREQUENCY CUTOFF MAY BE TOO SHARP.	PEAKING COILS, LOAD RESISTORS, DAMPING RESISTORS SHUNTING PEAKING COILS, LEAD DRESS.
		WHITE BORDER FOLLOWING A BLACK-TO-WHITE TRANSITION; BLACK BORDER FOLLOWING A WHITE-TO-BLACK TRANSITION.	EXCESSIVE OR NOT ENOUGH MID-FREQUENCY RESPONSE AND NON-LINEAR TIME DELAY.	PEAKING COILS, LOAD RESISTORS, DAMPING RESISTORS SHUNTING PEAKING COILS, LEAD DRESS.

Figure 12. Square-Wave Analysis Chart

General Applications

Circuit Analysis with Square Waves

Because of its ability to accurately reproduce wave forms which comprise a wide band of frequencies, the WO-56A Oscilloscope is useful in both low- and high-frequency square-wave analysis of amplifiers, filters, and other frequency-responsive devices.

The waveforms shown in the chart of Figure 12 are typical of those produced by circuit analysis with square waves. The chart illustrates various types of square-wave distortion in a video amplifier and indicates the circuit defect associated with the distortion.

Since a comprehensive discussion of the analysis of electronic circuits by means of square-wave signals is beyond the scope of this book, no attempt is made here to discuss the subject in detail. Square-wave analysis has been extensively discussed in the literature in papers such as:

1. T. J. Van Duyne and M. E. Clark, "Square-Wave Analysis in the AF Spectrum", AUDIO ENGINEERING, Vol. 31, No. 3, p. 27, May 1947.

2. G. P. Ohman, "Square-Wave Differentiating-Circuit Analysis", ELECTRONICS, Vol. 18, No. 8 pp. 132-135, August 1945.

3. W. L. Emery "ULTRA-HIGH FREQUENCY ENGINEERING", pp. 108-116, The MacMillan Co.

4. Frank Rockett, "Impedance Measurements with Square Waves", ELECTRONICS, Vol. 17, No. 9, pp. 138-140, September 1944.

5. F. E. Terman "RADIO ENGINEERS' HANDBOOK", pp. 968-971, McGraw-Hill Book Co.

6. R. D. Kell, A. V. Bedford, and H. N. Kozanowski, "A Portable High-Frequency Square-Wave Oscillograph for Television", PROC. I.R.E., Vol. 30, No. 10, pp. 458-464, October 1942.

7. E. H. B. Bartelink, "A Wide-Band Square-Wave Generator", Supplement to: ELECTRICAL ENGINEERING, Transactions Section, Vol. 60, No. 6, pp. 371-376, June 1941.

8. Donald L. Herr, "Square-Wave Harmonics", ELECTRONICS, Vol. 13, No. 5, p. 34, May 1940.

9. A. V. Bedford and G. L. Fredendall, "Transient Response of Multistage Video-Frequency Amplifiers", PROC. I.R.E., Vol. 27, No. 4, pp. 277-284, April 1939.

Phase-Shift Measurements

To measure the phase shift of an electrical network, apply a sine wave to the circuit under test. Then apply the signal as it appears at the input of the circuit under test across the H INPUT and GND terminals of the WO-56A, and the output from the test circuit to the V INPUT terminal. If no phase shift exists, a sloping straight-line image will appear. Phase shift is indicated as an elliptical or circular trace. Refer to Figure 13 for the method of calculating phase shift. The WO-56A is particularly useful in the measurement of phase shift at low frequencies because of its low-frequency response. In such applications, the dc input should be used.

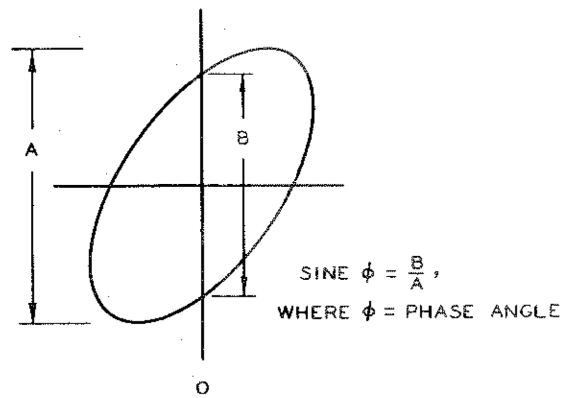


Figure 13. Measurement of Phase Shift

Frequency Measurements

Two methods may be employed in using the WO-56A for frequency measurements. In one method, a sine wave of known frequency is applied to the H INPUT terminal, and a sine wave of the frequency which is to be determined is applied to the V INPUT terminal. The pattern which appears on the oscilloscope screen, known as a Lissajou figure, indicates the ratio between the known and unknown frequency. Several typical Lissajou figures are illustrated in Figure 14.

In the other method of frequency measurement, the H GAIN selector is set at "SWEEP" position and the SYNC selector at "LINE", thus producing a linear sweep of line frequency. The signal of unknown frequency is 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.

AC-Voltage Measurements

After the instrument is calibrated as described in the "Operation" section, any ac voltage may be measured as follows:

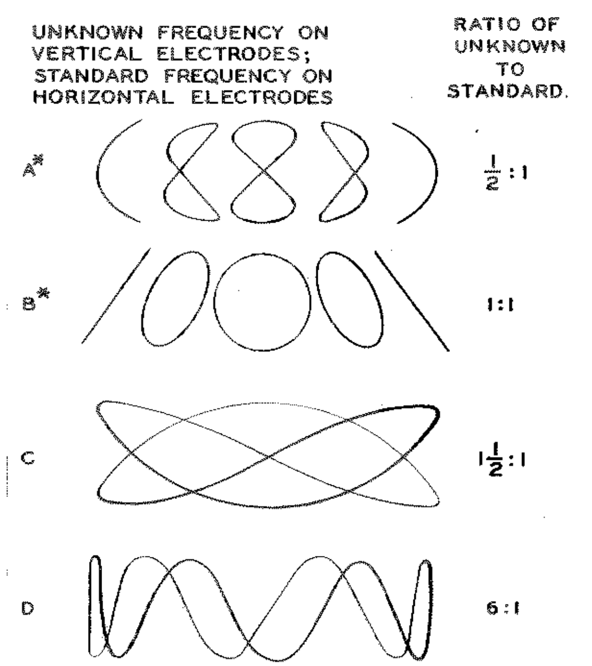
1. Connect the V INPUT terminal and a GND terminal across the voltage to be measured.

2. Set the V GAIN selector so that a readable vertical deflection is obtained. The peak-to-peak value of the measured voltage is then equal to the V GAIN selector setting multiplied by the number of inches of vertical deflection as shown on the graph screen. If the voltage measured is a sine wave, then the rms value of the voltage can be computed by multiplying the peak-to-peak value by .354.

NOTE: Do not touch the V GAIN vernier after the instrument has been calibrated, or recalibration will be necessary.

Additional Applications of Voltmeter Feature

A few of the particular applications of the voltmeter feature of the oscilloscope are the determination of the effectiveness of a power-supply filter by measuring the ripple voltage at various places in the filter; the measurement of amplifier stage gain; the running of frequency-response curves on audio amplifiers, filters, and transformers; and the indication of resonance in audio and low supersonic frequency circuits.



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

Figure 14. Lissajou's Figures for Frequency Determination

Measurement of Impedance and Power Factor of Loudspeakers

A setup for measurement of the impedance and power factor of loudspeakers or other devices is shown in Figure 15.

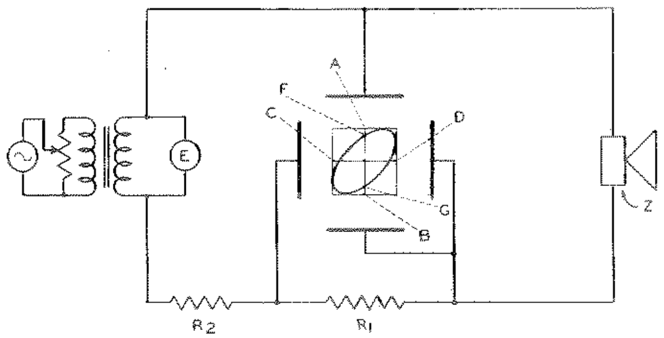


Figure 15. Measurement of Impedance and Power Factor

The sum of the resistances R_1 and R_2 is made equal to the plate resistance of the output tube used with the speaker. The voltage E is made equal to the μe_g of the output tube.

This method of measurement utilizes the relationship between the vertical and horizontal deflection factors of the cathode-ray tube; K is the ratio of the vertical deflection factor (in direction A to B) to the horizontal deflection factor (in direction C to D). The calculation of impedance magnitude "Z" and power factor "cos ϕ" are independent of the accelerating voltages applied to the anodes of the cathode-ray tube. The phase angle ϕ, and power factor cos ϕ, are obtained from sin ϕ = (FG/AB). The magnitude of the impedance vector is given by: $Z = K(AB/CD)R_1$.

If the frequency and magnitude of E are varied, resulting variations of impedance and power factor can be determined.

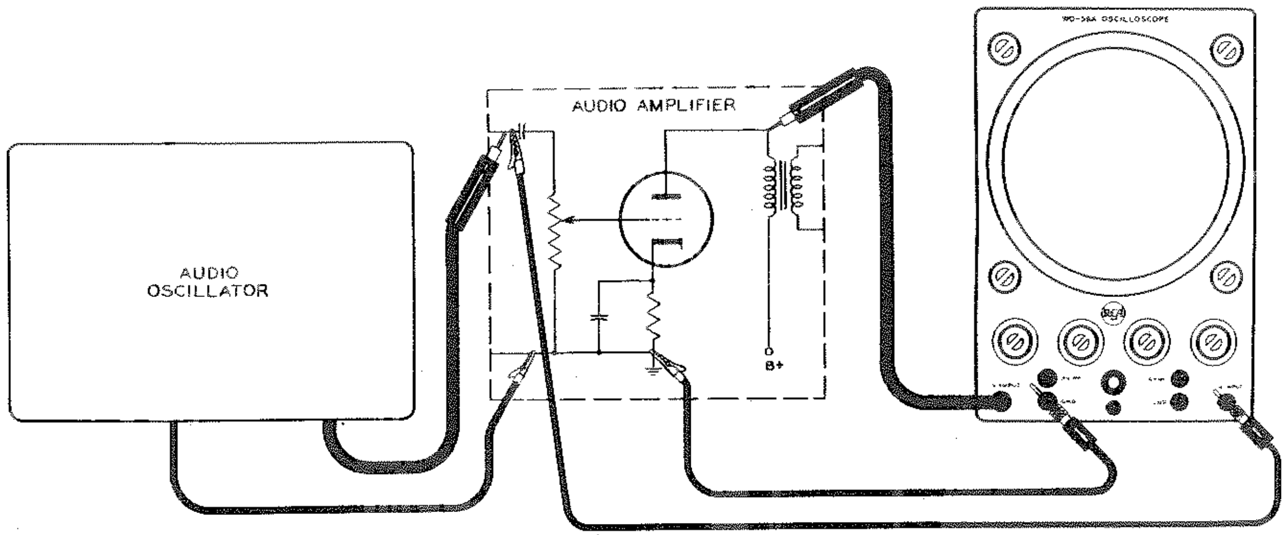


Figure 16. Audio-Amplifier Test Setup

Audio Quality Measurements

The WO-56A Oscilloscope is helpful in determining the quality of audio amplifiers, and in the qualitative analysis of amplifier distortion. A suggested test set up is shown in Figure 16, and the procedure is as follows:

1. Set the audio oscillator to the frequency at which the test is to be made.

2. Set the H GAIN selector and H GAIN vernier for a convenient horizontal deflection.

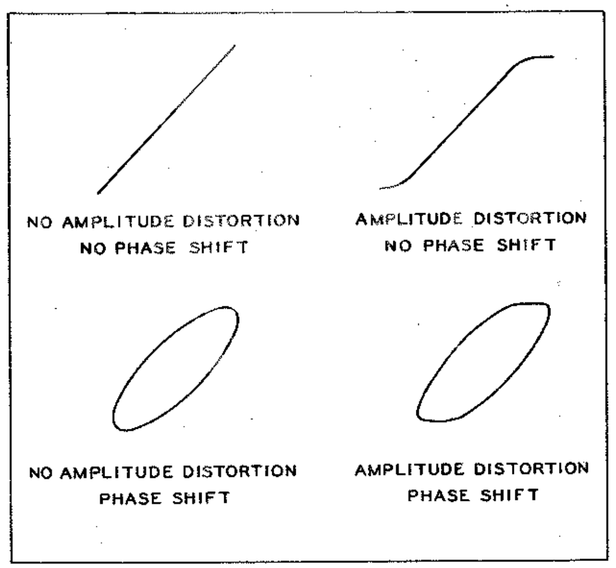


Figure 17. Distortion and Phase Shift in Audio Amplifier

3. Set the V GAIN selector and V GAIN vernier for a convenient vertical deflection.

Figure 17 shows some of the traces that may be seen, together with an explanation of the effects which produce them.

If it is necessary to study irregularities in waveshape on a linear time axis, proceed as follows:

1. Set the SWEEP selector on "INT+" or "INT—".

2. Adjust the SWEEP selector and SWEEP vernier controls until four or five cycles are observed on the screen.

3. Advance the SYNC vernier control until the pattern is stationary. NOTE: Do not advance this control any further than necessary.

4. Compare the waveform entering the amplifier with that leaving it to determine whether the amplifier is distorting.

The procedure for checking the overall fidelity of a receiver is similar to the foregoing method, except that the audio oscillator is used to modulate an rf signal generator. The modulated rf output of the signal generator is connected to the antenna terminals of the receiver, and the V INPUT and GND terminals of the oscilloscope are connected across the loudspeaker voice coil.

Industrial Applications

Use of the cathode-ray oscilloscope with a few pieces of auxiliary apparatus has solved many perplexing problems both in the laboratory and in the shop. Obviously, it is impractical to attempt to describe in this book all the important applications of the oscilloscope. However, a few of its uses which are considered to be of current interest or which are particularly adaptable to the WO-56A are briefly described.

Resistance-Welding Applications

Because of its low-frequency response and the identical phase-shift characteristics of its vertical and horizontal amplifiers, the WO-56A is uniquely suited to the operational analysis and servicing of resistance-welding devices. The oscilloscope can be used to check the waveforms and phase relationship of the control and supply voltages. A typical test set-up with associated waveforms are shown in Figure 18. The time-consuming process of readjusting the welding instrument for correct operation can be eliminated with the WO-56A Oscilloscope. It is merely necessary to record the waveforms at the time of initial adjustment (for any particular operation), and later quickly resetting the instrument by adjusting it for the same pattern on the oscilloscope screen. The oscilloscope can also be used to insure that the correct settings are maintained throughout the welding operation.

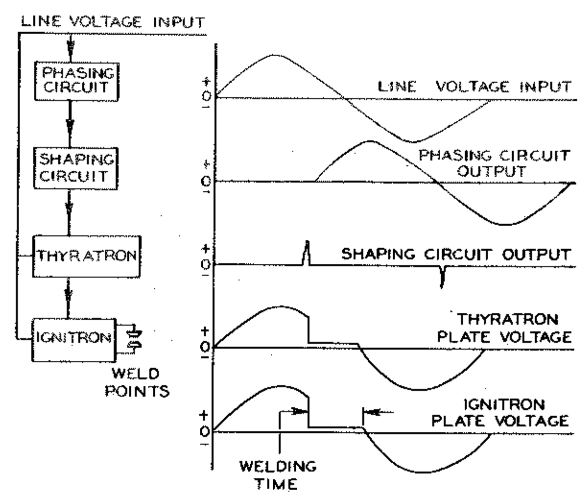


Figure 18. Waveforms in Resistance Welder

Engine Pressure Analysis

When the WO-56A is used with auxiliary equipment such as is shown in Figure 19, variations in pressure 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.

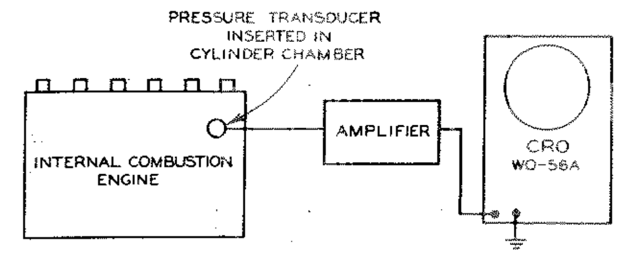


Figure 19. Engine-Pressure Analysis

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 20 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.

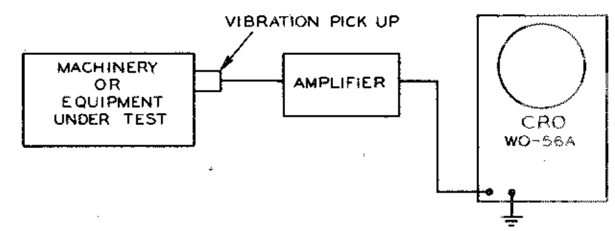


Figure 20. Vibration Analysis

Maintenance

Caution: See "Safety Precautions".

General

The WO-56A has been properly aligned and adjusted at the factory; no further servicing is normally required. However, after long continued use the instrument may require servicing. For the proper adjustment and alignment of the instrument, an audio oscillator, a signal generator, and a square-wave generator are required. Refer to Figure 21 for the physical location of all adjustable parts in the WO-56A.

To gain access to the chassis for replacement of tubes or servicing, remove the three screws at the rear of the case. The chassis should never be removed from the case by pulling the front panel of the instrument, or the panel will be damaged. Pressure should be applied to the rear apron of the chassis through the hole provided for the power cord at the rear of the case.

The safety interlock switch S-6, located on the rear apron of the chassis (Figure 21), opens as the chassis is withdrawn and removes power from the oscilloscope. Short this interlock switch if it is necessary to apply power to the instrument when the chassis is removed from the case. CAUTION: See "Safety Precautions".

The performance of the WO-56A, like that of any other precision instrument is dependent upon the rating and quality of its components. If it should become necessary to replace a component part, find the stock number of the part in the Replacement Parts List in this book. Only RCA replacement parts, or parts having equivalent specifications, should be used.

Amplifier-Balance Adjustment

Vertical movement of the spot on the face of the cathode-ray tube when the V GAIN vernier is rotated indicates that the vertical balance control R-11 is improperly adjusted. Horizontal movement of the spot when the H GAIN vernier is rotated indicates that the horizontal balance control R-51 is improperly adjusted.

Adjust R-11 and R-51 for minimum vertical and horizontal movement of the spot when the associated gain verniers are rotated through their range. R-11 and R-51 are located behind the rim of the retractable light shield; they are accessible when the light shield is withdrawn. NOTE: It is not necessary to remove the chassis from the case for this adjustment.

Adjustment of WG-216A 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-216A 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, adjust the Low-Capacitance Probe as indicated below. (See schematic diagram for the schematic of this probe.)

1. Unscrew the probe tip.
2. Place a small screw driver to fit in the slot of the capacitor tuning stud C-45.
3. Rotate the stud for the best square wave on the screen of the cathode-ray tube.
4. Replace probe tip.

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.

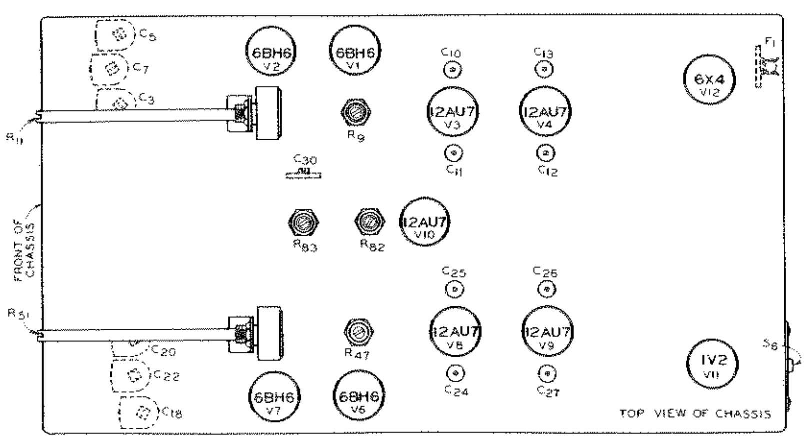


Figure 21. Location of Tubes and Adjustable Parts in the WO-56A

Vertical-Amplifier Adjustments

The general procedure for adjusting the vertical amplifier is outlined below. See Figure 21 for the physical locations of the adjustable parts involved.

If any of the adjustable parts is replaced, it is necessary only to make the adjustments associated with the replaced part; it is not necessary to follow the entire procedure for readjusting the vertical amplifier.

1. Remove the chassis from the case as indicated above in the "General" section.
2. Connect the power cord to an ac outlet supply 105-125 volts at 50/60 cycles, and short the interlock switch S-6 located on the rear apron of the chassis. CAUTION: See "Safety Precautions".
3. Rotate the INTENSITY control to turn the instrument on, and allow at least fifteen minutes for the instrument to warm up.
4. Set the V GAIN selector and H GAIN selector to position "30" on the AC range, and rotate the V GAIN and H GAIN verniers to their extreme counterclockwise position. A spot should appear on the oscilloscope screen. CAUTION: Do not allow a small spot of high brilliancy to remain on the screen for an appreciable length of time because discoloration and burning of the screen may result. The spot may be weakened in intensity by means of the INTENSITY control.
5. Center the spot with the H CENTER and V CENTER controls.
6. Rotate the adjustable screws of capacitors C-10, C-11, C-12, and C-13 completely counterclockwise. CAUTION: High voltages are present at the adjustable screws C-10, C-11, C-12, and C-13 when the power is applied to the instrument.
7. Set the V GAIN selector to ".3" on the AC range, and apply the voltage available at the 3V P-P terminal to the V INPUT terminal.
8. Adjust R-9 for maximum vertical gain. Remove the voltage applied to the V INPUT terminal.
9. Readjust R-11 and R-51, if necessary. (See "Amplifier-Balance Adjustment" above.)
10. Set the H GAIN selector to "SWEEP" position, and adjust the H GAIN vernier for a horizontal-sweep width of approximately four inches.
11. Tune the square-wave generator for a 100-kc output of approximately 1.0 volts peak-to-peak. Apply this output to the oscilloscope with the Direct Probe and Cable and the Ground Cable.
12. Set the SWEEP selector and the SWEEP vernier for a square-wave pattern of a convenient number of cycles on the oscilloscope screen, and adjust the V GAIN vernier to its extreme counterclockwise position. Set the V GAIN selector to position ".03" on either the AC or DC range.
13. Adjust C-12 and C-13 by equal amounts until the square wave on the oscilloscope screen just begins an overshoot condition.
14. Rotate the V GAIN vernier clockwise and lower the output from the square-wave generator to give a vertical deflection of approximately four inches on the screen.
15. Adjust C-10 and C-11 by equal amounts until the corner of the square wave just begins to round off.
16. Tune the square-wave generator for a 10-kc output; set the V GAIN selector to ".3" position on the AC range; and adjust the output of the square-wave generator to provide approximately three inches of vertical deflection on the face of the cathode-ray tube.
17. Adjust C-3 for the best square wave.
18. Repeat steps 16 and 17, setting the V GAIN selector first to position "3" and then to position "30", and adjusting C-5 and C-7, respectively.

Horizontal-Amplifier Adjustments

The general procedure for adjusting the horizontal amplifier is outlined below. See Figure 21 for the physical locations of the adjustable parts involved.

If any of the adjustable parts is replaced, it is necessary only to make the adjustments associated with the replaced part; it is not necessary to follow the entire procedure for readjusting the horizontal amplifier.

1. Follow the procedure outlined in steps 1 through 5 under "Vertical-Amplifier Adjustments" above.
2. Rotate the adjustable screws of capacitors C-24, C-25, C-26, and C-27 completely counterclockwise. CAUTION: High voltages are present at the adjustable screws C-24, C-25, C-26, and C-27 when the power is applied to the instrument.
3. Set the H GAIN selector to "LINE" position and the H GAIN vernier completely counterclockwise. Adjust R-47 for maximum horizontal gain.
4. Set the H GAIN selector to ".03" position on the DC range and the H GAIN vernier fully counterclockwise.
5. Apply a 100-kc square wave from a square-wave generator to the H INPUT terminal, using the WG-218 Direct Probe and Cable, and apply a 100-kc, 10-volts-rms signal from a signal generator to the V INPUT terminal. These two inputs may be synchronized by applying a sync voltage to the sync terminal of the square-wave generator from the output terminal of the signal generator.
6. Adjust C-26 and C-27 by equal amounts until the square-wave pattern just begins an overshoot condition.
7. Set the H GAIN vernier to its maximum clockwise position, and reduce the output voltage of the square-wave generator, to produce a convenient horizontal deflection.
8. Adjust C-24 and C-25 by equal amounts until the corner of the square wave just begins to round off.
9. Replace the signal generator with the audio oscillator and tune the square-wave generator and the audio oscillator to 10 kc, synchronizing the two outputs for a stationary square wave on the oscilloscope screen.
10. Set the H GAIN selector to ".3" on the AC range.
11. Adjust C-18 for the best square-wave response.

NOTE: It may be necessary to increase the output voltage of either the square-wave generator or the audio oscillator for this adjustment.

12. Repeat steps 10 and 11, setting the H GAIN selector first to position "3" and then to position "30" on the AC range, and adjusting C-20 and C-22, respectively, for the best square-wave response.