REPLACEMENT PARTS LIST
CATHODE RAY OSCILLOSCOPE
TYPE WO-55A

Symbol No.	Description	Stock No.
C-1	Capacitor—Paper, .25 mfd., 600 volts	70639
C-2,3,4,5	Capacitor—Paper, .25 mfd., 200 volts	70618
C-6	Same as C-1	
C-7	Capacitor—Mica, 120 mmf., ±10%	39630
C-8	Capacitor—Mica, 680 mmf., ±10%	39648
C-9	Capacitor — Mica., 3900 mmf., ±10%	39666
C-10	Capacitor—Paper, .02 mfd., 400 volts	70611
C-11	Capacitor—Paper, .1 mfd., 400 volts	70617
C-12	Capacitor—Paper, .5 mfd., 400 volts	70619
C-13,14	Capacitor—Tubular electrolytic, 8 mfd., 450 volts	56145
C-15	Capacitor — Tubular electrolytic, 10/10/10 mfd., 450 volts	56129
C-16,17	Capacitor—Paper, .01 mfd., 400 volts	70610
F-1	Fuse—1 amp., 250 volts	14133
J-1	Jack—Special, (Red) V INPUT, METER, SYNC, H INPUT	47228
J-2	Jack—Special, (Blue) GND	54494
J-3,4	Same as J-1	
J-5	Same as J-2	
J-6	Same as J-1	
J-7	Connector—A.C. connector, Male 2 contact	71448
R-1	Resistor — Carbon film, 350,000 ohms, ±1%, ½ watt	56482
R-2	Resistor — Carbon film, 150,000 ohms, ±1%, ½ watt	56483
R-3	Resistor — Carbon film, 17,650 ohms, ±1%, ½ watt	56484
R-4	Resistor — Carbon film, 118,000 ohms, ±1%, ½ watt	56485
R-5	Resistor—Carbon film, 5080 ohms, ±1%, ½ watt	56486
R-6	Resistor — Carbon film, 61,500 ohms, ±1%, ½ watt	56487
R-7	Resistor — Variable, V CALIBRATE, 500,000 ohms	56137
R-8,9	Resistor—Fixed composition, 560 ohms, ±10%, ¼ watt	
R-10	Resistor—Variable V & H CENTERING, 1000 ohms	56140
R-11	Resistor—Fixed composition, 6800 ohms, ±10%, ½ watt	
R-12	Resistor—Fixed composition, 1 meg., ±20%, ¼ watt	
R-13	Resistor—Fixed composition, 82 ohms, ±10%, ¼ watt	
R-14	Resistor — Fixed composition, 56,000 ohms, ±10%, ½ watt	
R-15	Resistor — Fixed composition, 100,000 ohms, ±10%, ½ watt	
R-16,17, 18,19	Same as R-14	
R-20	Same as R-12	
R-21,22	Same as R-8	
R-23	Same as R-10	
R-24	Same as R-13	
R-25	Same as R-11	
R-26	Same as R-12	
R-27	Resistor—Variable, H GAIN, 0.5 meg.	56138
R-28	Same as R-11	
R-29	Resistor—Carbon film, 195 ohms, ±1%, ½ watt	56488
R-30	Resistor—Carbon film, 250 ohms, ±1%, ½ watt	56489
R-31	Resistor — Fixed composition, 47,000 ohms, ±10%, 1 watt	
R-32	Resistor—Variable, SYNC ADJ, 0.1 meg.	56141
R-33	Resistor—Fixed composition, 470 ohms, ±10%, ¼ watt	
R-34	Resistor — Fixed composition, 27,000 ohms, ±10%, ¼ watt	
R-35	Resistor — Fixed composition, 68,000 ohms, ±10%, ¼ watt	
R-36A,36B	Resistor — Variable, SWEEP VERNIER, dual control, front section (A), 0.25 meg.; rear section (B), 1 meg.	56135
R-37,38, 39-40	Resistor—Fixed composition, 5.6 meg., ±20%, ¼ watt	
R-41	Resistor — Fixed composition, 68,000 ohms, ±10%, ½ watt	
R-42	Resistor—Variable, screw-driver type, 100,000 ohms	56144
R-43,44	Resistor — Fixed composition, 220,000 ohms, ±10%, ½ watt	
R-45	Resistor—Variable, FOCUS, 0.2 meg.	56143
R-46	Resistor — Fixed composition, 120,000 ohms, ±10%, ½ watt	
R-47	Resistor—Variable, INTENSITY, 50,000 ohms	56142
R-48	Resistor—Fixed composition, 5600 ohms, ±10%, 2 watts	
R-49	Resistor—Fixed composition, 2.2 meg., ±20%, ¼ watt	
R-50	Same as R-15	
R-51	Same as R-12	
R-52,53	Resistor—Fixed composition, 2.7 meg., ±20%, ¼ watt	
R-54	Resistor — Carbon film, 145,000 ohms, ±1%, ½ watt	56490
S-1	Switch—Rotary, V RANGE, 2 pole, 5 section	56136
S-2	Switch — Rotary, H SYNC/SWEEP SEL, 1 section, 5 Pos.	56134
S-3	Switch — Rotary, SWEEP RANGE, 2 sections, 5 positions	56133
S-4	Switch—Rotary, POWER, SPST, 3 amps., 125 volts	56139
T-1	Transformer—Power	56128
TB-1	Board—Terminal, 4 contact (upper rear)	56146
TB-2	Board — Terminal, 4 contact (lower rear)	56147
V-8	Tube—Cathode-ray, 3MP1	56186
X-1,2,3,4, 5,6,7	Socket—Tube, miniature, 7 pin	55733
X-8	Socket—Tube, molded, 12 pin	56130
	Cover—For terminal board	56151
	Cover—C-R Tube Cover (rear)	56149
	Escutcheon—Shield for tube	56131
	Holder—Fuse	54496
	Knob—Control (large)	54661
	Knob—Control (small)	53689
	Panel—Rear	56150
	Pointer—Knob	53684
	Screen—Tube screen assembly	56132
	Cable—Power cord, complete with male and female connections	53678

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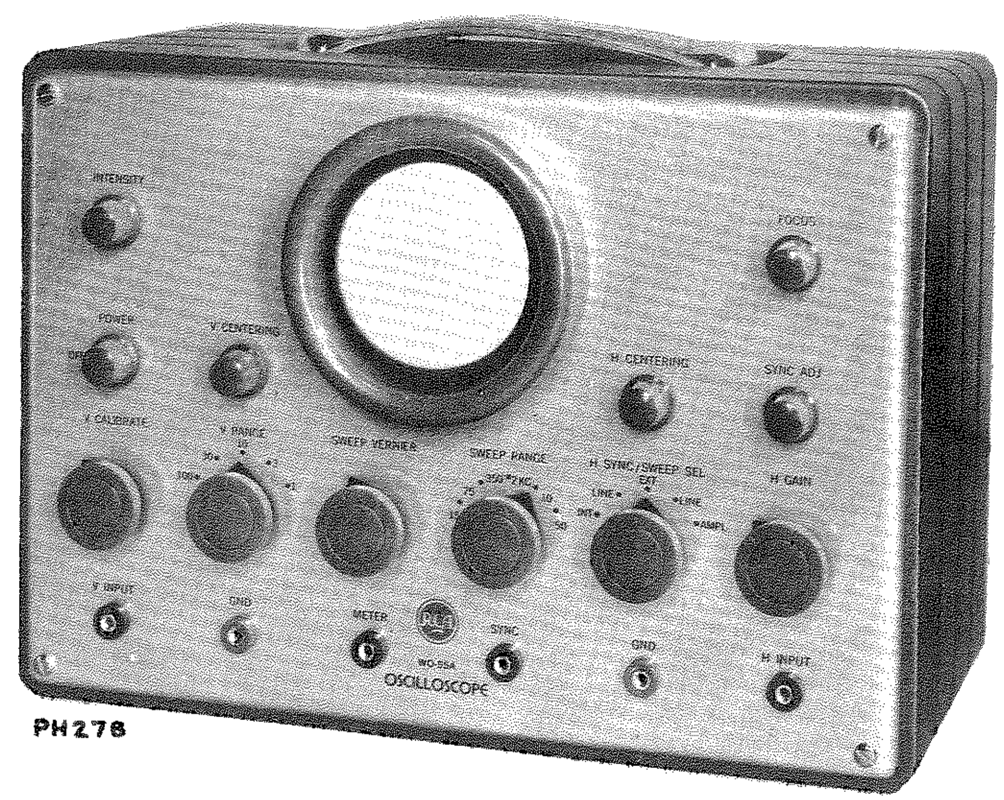
IB-4055-1

RCA

CATHODE RAY OSCILLOSCOPE
TYPE WO-55A



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TEST AND MEASURING EQUIPMENT SECTION

RADIO CORPORATION OF AMERICA

CAMDEN, NEW JERSEY, U.S.A.

CATHODE-RAY OSCILLOSCOPE

TYPE WO-55A

TECHNICAL SUMMARY

POWER REQUIREMENTS

Line Rating .... 105-125 volts; 50/60 cycles
Specifications are based on 117-volt, 60-cycle source.
Power Consumption .... 50 watts
Fuse Protection .... 1 ampere

DEFLECTION SENSITIVITY

Vertical Amplifier (at max. gain) .... Less than 1.33 volts peak-to-peak per inch deflection
Vertical Deflection Plates (direction connection) .... Less than 120 volts peak-to-peak per inch deflection
Horizontal Amplifier (at max. gain) .... Less than 1.5 volts peak-to-peak per inch deflection
Horizontal Deflection Plates (direct connection) .... Less than 135 volts peak-to-peak per inch deflection

The horizontal and vertical amplifiers are identical. The difference in sensitivity is due to the different deflection sensitivities of the horizontal and vertical plates in the cathode-ray tube.

INPUT IMPEDANCE

Vertical Amplifier .... 0.5 megohm shunted by 55 mmfd. (approx.)
Vertical Deflection Plates .... 5.6 megohms shunted by 15 mmfd. (approx.)
Horizontal Amplifier .... 0.5 megohm shunted by 37 mmfd. (approx.)
Horizontal Deflection Plates .... 5.6 megohms shunted by 12 mmfd. (approx.)

FREQUENCY RESPONSE (SINE WAVE)

Both Amplifiers .... Flat within ± 10% from 7 to 40,000 cps
Flat within ± 20% to 70,000 cps

DEFLECTION CAPABILITY

The beam may be deflected beyond full screen horizontally and vertically without noticeable overload.

MAXIMUM INPUT SIGNALS

Vertical Amplifier .... 750 volts peak-to-peak
Horizontal Amplifier .... 750 volts peak-to-peak
Vertical Deflection Plates .... 360 volts peak-to-peak
Horizontal Deflection Plates .... 360 volts peak-to-peak
D-C Voltage on Vertical Amplifier Input .... 600 volts
D-C Voltage on Horizontal Amplifier Input .... 600 volts

TIMING-AXIS OSCILLATOR

Range .... 15 to 50,000 cps in five overlapping ranges

TUBE COMPLEMENT

2 RCA-6AU6 Horizontal Amplifiers V-1, V-2
2 RCA-6AU6 Vertical Amplifiers V3, V4
1 RCA-6J6 Sweep Oscillator V-5
1 RCA-6X4 Low-Voltage Rectifier V-6
1 RCA-6X4 High-Voltage Rectifier V-7
1 3MP1 Cathode-Ray Tube V-8

MECHANICAL SPECIFICATIONS

Height .... 9¾ inches
Width .... 13½ inches
Depth .... 8½ inches
Weight .... 15 pounds (approx.)
Case .... Steel finished in blue-gray Hammeroid
Panel .... Anodized Satin Aluminum

GENERAL DESCRIPTION

The Type WO-55A Cathode-Ray Oscilloscope is a portable and compact 3" oscilloscope incorporating features of convenience, speed, and ease of operation. The utilization of an extremely short cathode-ray tube and miniature tubes throughout the design has made it possible to manufacture this oscilloscope in a small case matching other portable RCA Test Equipment. This instrument is designed primarily for use in the laboratory, school, and service shop

Provision for calibration of the vertical amplifier is incorporated into the WO-55A Oscilloscope. When so calibrated, the instrument is virtually a visual voltmeter. The three-to-one ranges of the vertical attenuator instead of the usual five- or ten-to-one ranges found in most oscilloscopes allow a generous overlap, which is standard with conventional voltmeters of good design. Peak-to-peak voltage measurements can be made with the same facility and accuracy that they are made with multi-range voltmeters. A feature of the instrument is the use of low-tolerance resistors in the range-control unit to insure accuracy of measurements.

The oscilloscope has a retractable light shield, which effectively increases the contrast obtainable by reducing the amount of incident light on the cathode-ray tube screen. Mounted in front of the cathode-ray tube is a removable, transparent screen with "graph paper" ruling to facilitate voltage measurement and calibration of the vertical amplifier. Removing the screen may enable a more detailed study of waveforms to be made.

The sensitivity of the instrument is adequate for all general purpose work in which the oscilloscope may be used.

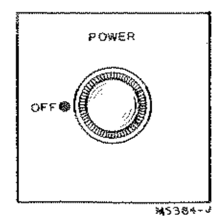
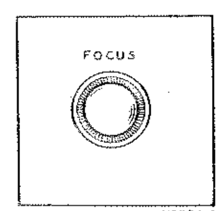
The sweep oscillator is a Potter type employing a high-vacuum tube, thus it is more reliable than some other circuits using gaseous-discharge tubes. The sweep oscillator is easily synchronized with phenomena to be observed and the waveform is exceptionally linear.

All input and output connections to the oscilloscope are terminated in jack bodies that will accommodate either binding-post pin plugs or RCA Stock No. 47089 locking-pin plugs. Use of these threaded plugs eliminates the annoyance caused by leads pulling out of jacks during tests. Binding-post pin plugs are supplied for the jacks.

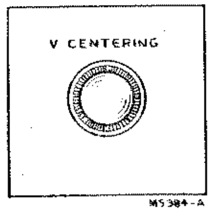
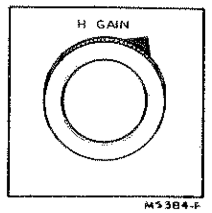
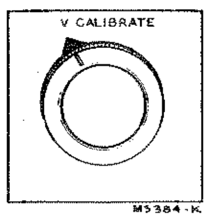
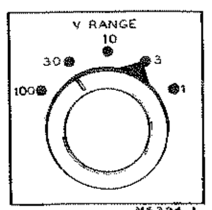
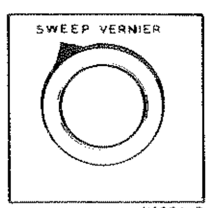
Direct connections to the deflection plates of the cathode-ray tube can be made to terminal boards located behind an access door on the rear panel of the WO-55A.

For a more comprehensive discussion of the fundamentals of cathode-ray tubes and an analysis of the figures which appear on the cathode-ray tube screen refer to RCA IB-26453, "A General Discussion of the Cathode-Ray Tube."

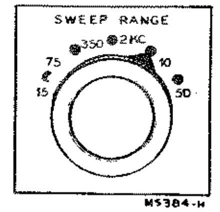
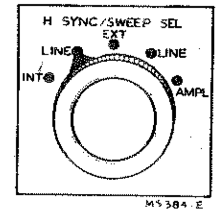
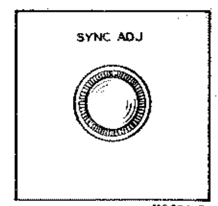
FUNCTION OF CONTROLS

Control	*Purpose*	*Setting*
	**Power switch.**	**Turn clockwise to apply power, counter-clockwise to remove power.**
	**Controls intensity of spot on c-r tube screen.**	**Adjust for desired brightness of pattern.**
	**Controls focus of spot on c-r tube screen.**	**Adjust to give pattern maximum sharpness. Normally requires adjustment when setting of intensity control has been changed.**

FUNCTION OF CONTROLS (Continued)

Control	*Purpose*	*Setting*
	Controls vertical position of trace.	Adjust to move trace to desired position in vertical plane.
	Controls horizontal position of trace.	Adjust to move trace to desired position in horizontal plane.
	Permits continuous adjustment of horizontal amplifier gain.	Use to adjust trace to desired width.
	Permits continuous adjustment of vertical-amplifier gain, and calibration of amplifier sensitivity to values marked on V RANGE switch.	Use with V RANGE control to adjust trace height to desired value. See APPLICATIONS section for calibration procedure.
	Position "1"—Transfers signal from V INPUT jack to vertical amplifier without attenuation. Position "3"—Attenuates signal voltage 3 to 1. Position "10"—Attenuates signal voltage 10 to 1. Position "30"—Attenuates signal voltage 30 to 1. Position "100" — Attenuates signal voltage 100 to 1.	Set to position that permits adjustment of trace height to desired value with V CALIBRATE control. The switch settings refer to the amplifier sensitivity in volts peak-to-peak per 10 minor spaces of deflection when the V CALIBRATE control is properly adjusted.
	Provides continuous control of sweep frequency over band selected by SWEEP RANGE control.	Adjust for desired sweep frequency.

FUNCTION OF CONTROLS (Continued)

Control	*Purpose*	*Setting*
	Selects frequency band of sweep oscillator.	Set to position including desired sweep frequency.
	Position "INT" — Selects synchronizing voltage from vertical amplifier and applies sawtooth to horizontal amplifier. Position "LINE" (red)—Selects synchronizing voltage from filament supply and applies sawtooth to horizontal amplifier. Position "EXT"—Selects synchronizing voltage from SYNC terminal and applies sawtooth to horizontal amplifier. Position "LINE" (black)—Turns off sweep oscillator and applies sine wave of line frequency to horizontal amplifier. Position "AMPL" — Turns off sweep oscillator and supplies horizontal amplifier with external signal applied to H INPUT jack.	Set on "INT" to synchronize sweep oscillator with signal applied to vertical amplifier. Set on "LINE" to synchronize sweep oscillator with power-line frequency. Set on "EXT" to synchronize sweep oscillator with signal from external source. Set on "LINE" when a sinusoidal sweep of line frequency is desired. Set on "AMPL" when an external signal is being applied to the horizontal amplifier.
	Controls amplitude of synchronizing voltage fed to grid of sweep-oscillator tube.	Adjust to minimum setting necessary to lock pattern in a stationary position.

OPERATION

All controls and binding jacks associated with the vertical amplifier channel are located on the left side of the front panel. Similarly, the controls and binding jacks for the horizontal-amplifier circuits are on the right side of the panel. The sync-input terminal and the sweep-oscillator controls are located down the center of the panel.

FRONT-PANEL TERMINALS

All input and output connections to the oscilloscope are terminated with jack bodies that will accommodate either binding-post pin plugs or RCA Stock No. 47089 locking-pin plugs. Four binding-post pin plugs are supplied with the WO-55A.

Horizontal-Input Terminals—The H INPUT terminal (J-6) couples to the input of the horizontal amplifier when the H SYNC/SWEEP SEL switch is on "AMPL". The GND terminal (J-5) connects to the chassis.

Sync Terminal—The SYNC terminal (J-4) is connected through the "EXT" contact of the H SYNC/SWEEP SEL switch to the SYNC ADJ control.

Vertical-Input Terminals—The V INPUT terminal (J-1) couples to the input of the vertical amplifier through the vertical attenuator circuit (V RANGE control). The GND terminal (J-2) connects to the chassis.

Meter Terminal—A sinusoidal voltage of ten volts peak-to-peak (nominal) is available at the METER terminal (J-3) for calibration of the vertical amplifier.

PRELIMINARY ADJUSTMENTS

Before any measurements or applications are attempted, the operator is urged to go through the following procedure to familiarize himself with the location and operation of the controls:

1. Connect the power cable between the socket on the rear of the oscilloscope and a source of 105-125 volts, 50-60 cycles.
2. Turn the POWER switch clockwise and wait about 15 seconds for the instrument to warm up (counterclockwise rotation of the POWER switch turns the oscilloscope off).
3. Rotate the INTENSITY control clockwise until a spot or a horizontal line appears on the screen. The spot or line should increase in brilliancy as the INTENSITY control is turned clockwise.

CAUTION: DO NOT ALLOW A SMALL SPOT OF HIGH BRILLIANCY TO REMAIN STATIONARY ON THE SCREEN FOR AN APPRECIABLE LENGTH OF TIME, AS DISCOLORATION OR BURNING OF THE SCREEN MAY RESULT.

4. Position the spot or line in the center of the screen by adjusting the V CENTERING and the H CENTERING controls. Whether the image is a spot or a line will depend upon the setting of the H SYNC/SWEEP SEL switch.
5. Adjust the FOCUS control for an image of maximum sharpness.
6. Turn the H SYNC/SWEEP SEL switch to "AMPL". Unless an external signal is applied to the H INPUT jack, only a spot will show on the screen. For present purposes, apply no signal to the H INPUT jack.
7. Apply a voltage of power-line frequency between the V INPUT jack and the GND jack. A convenient voltage is the voltage present at the METER jack.
8. The cathode-ray tube screen should now display a vertical line, the length of which can be adjusted in steps by turning the V RANGE switch. Intermediate lengths of the trace may be obtained by adjustment of the V CALIBRATE control. By a combination of the adjustments of these two controls, the trace may be set to any desired height.
9. Turn the H SYNC/SWEEP SEL switch to any of the three extreme counterclockwise positions ("INT", "LINE", or "EXT"). The waveform of the signal at the V INPUT jack is now displayed on the cathode-ray tube screen upon a linear time base. The sweep frequency may be changed by means of the SWEEP RANGE switch, which determines the band of frequencies, and the SWEEP VERNIER control, which determines a specific frequency.
10. Rotate the SWEEP RANGE switch completely counterclockwise and adjust the SWEEP VERNIER control to obtain a single sine wave on the screen. The sweep oscillator is now oscillating at the frequency of the input signal.
11. The trace may move slowly to the right or left. To hold the trace steady, the sweep oscillator must be synchronized with the signal under observation. The source of the synchronizing signal may be selected by switching the H SYNC/SWEEP SEL switch to one of the three counterclockwise positions, "INT", "LINE", or "EXT".
12. For purposes of illustration turn the H SYNC/SWEEP SEL switch to "INT". Adjust the SYNC ADJUST control until the trace is still. A portion of the signal under observation has been used to synchronize the sweep oscillator.
13. Turn the H SYNC/SWEEP SEL switch to "LINE" and readjust the SYNC ADJUST control until the trace is still. A portion of the METER terminal voltage has been used to synchronize the sweep oscillator.
14. Turn the H SYNC/SWEEP SEL switch to the "EXT" position. Connect a source of power-line frequency, such as a filament transformer, between the SYNC terminal and a GND terminal. Readjust the SYNC ADJUST control to "hold" the trace. The power line, an external source of voltage, has synchronized the SWEEP OSCILLATOR.

NOTE: Always use the minimum setting of the SYNC ADJ control necessary to lock the trace in a stationary position. Too much synchronizing voltage will distort the pattern.

Further reference material covering general operation of oscilloscopes can be found in any text on Oscilloscopes or in "A General Discussion of the Cathode-Ray Tube", RCA IB-26453.

DIRECT CONNECTION TO DEFLECTION PLATES

At times it will be found advantageous to impress a signal directly on the deflection plates. Figure 1 shows the terminal board which provides connection to the deflection plates. The signal may be applied across a pair of plates, or from one plate to ground. Also, both sets of plates may be used directly, or only one set may be used, in which case the amplifier associated with the other set of plates may be used to provide a sweep voltage. In most cases, the signal to be studied will be applied to one or both vertical plates, and the horizontal plates will be left as for normal operation.

The following procedure is recommended when a direction connection, without the use of the amplifier, is needed:

1. Turn the POWER switch to "OFF". CAUTION: VOLTAGE IS PRESENT ON THE TERMINAL BOARDS WHEN THE INSTRUMENT IS TURNED ON.

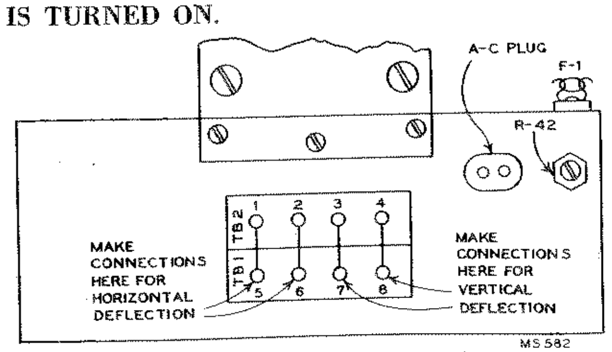


Figure 1—Terminal Board

2. Remove the access door on the rear panel, thus exposing the terminal boards TB1 and TB2.
3. Remove the jumper in the circuit of the deflection plate into which the external signal is to be fed. If both plates are to be used, remove both jumpers.
4. Feed the unknown signal to the terminals on TB1 through a blocking capacitor, or two blocking capacitors, if both plates are to be used. The size of the capacitor will be governed by the lowest frequency to be observed. DO NOT MAKE ANY CONNECTION TO TB2.
5. If the vertical plates are used, disconnect all leads to the V INPUT jack to prevent interference.
6. If the horizontal deflection plates are used, turn the H SYNC/SWEEP SEL switch to "AMPL", and disconnect any leads to the H INPUT terminal.
7. Turn the POWER switch on.

The characteristics of the instrument when used in this manner can be found in the TECHNICAL SUMMARY.

APPLICATIONS

A-C VOLTMETER WITH AMPLIFIER

Since the oscilloscope measures peak-to-peak voltages, its use as a voltmeter covers a much greater range of applications than does a conventional voltmeter.

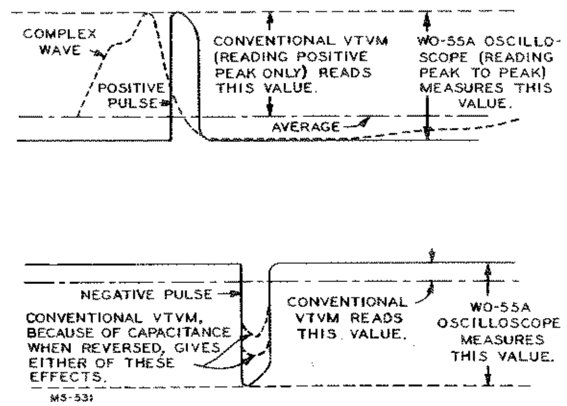


Figure 2—Measurement of Pulses

The peak-to-peak values of complex waves and pulses are measured just as easily with the oscilloscope as are the values of sine waves. Figure 2 shows the advantage of the oscilloscope over the conventional vacuum-tube voltmeter when the amplitudes of complex waves are being measured.

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

1. Fasten the ruled screen to the face of the cathode-ray tube.
2. Turn the H SYNC/SWEEP SEL switch to "AMPL" (the horizontal amplifier channel is not ordinarily used when voltage measurements are made).
3. Set the V RANGE switch on "10".
4. Connect the METER jack to the V INPUT jack. A vertical line should appear on the screen.
5. Adjust the V CALIBRATE control until the trace height is exactly ten spaces (¾ inch). It may be convenient to adjust the V CENTERING control also so that the ends of the trace just coincide with the major divisions of the graph. Since the voltage at the meter jack is nominally ten volts peak-to-peak, and since the V RANGE switch is set on "10", the vertical amplifier sensitivity is now one volt peak-to-peak per minor division, or ten volts peak-to-peak per two major divisions.
6. Disconnect the V INPUT and METER jacks. Do not again touch the V CALIBRATE control while voltage measurements are being made. To do so will necessitate recalibration of the vertical amplifier.

While the foregoing calibration procedure will give results sufficiently accurate for most purposes, the fact that the voltage at the METER jack will not always be exactly ten volts, peak-to-peak, due to line-voltage variations, introduces an error in the procedure. Higher accuracy will be obtained by metering the voltage at the METER jack during the calibration procedure. This will yield a more accurate figure for the peak-to-peak volts per space of deflection. Since the meter will read rms voltage, the meter reading must be multiplied by 2.83 to obtain the peak-to-peak voltage.

The graph shown in Figure 3 will be of value when a precise calibration of the amplifier is desired. An example of its use follows:

1. Repeat steps 1 to 4 inclusive of the foregoing calibration procedure.
2. Connect an accurate voltmeter between the METER jack and a G terminal and note the voltmeter reading. Suppose the meter reading is 3.7 volts. From the graph, the corresponding vertical deflection is 10.45 minor spaces.
3. Set the V RANGE control so that 10.45 minor spaces of vertical deflection (obtained from the graph) are obtained. The amplifier will then be precisely calibrated for 1 volt peak-to-peak per two major divisions when the V RANGE switch is on "1", 3 volts peak-to-peak per major division when the switch is on "3", etc.
4. Disconnect the voltmeter and the V INPUT and METER jacks.

After the instrument is calibrated, any a-c voltage may be measured as follows:

1. Connect the V INPUT jack and a GND jack across the voltage to be measured.
2. Set the V RANGE switch so that a readable vertical deflection is obtained. The peak-to-peak value of the measured voltage is then equal to the V RANGE switch setting multiplied by the number of major spaces of deflection. Refer to Figure 4 for some examples. 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

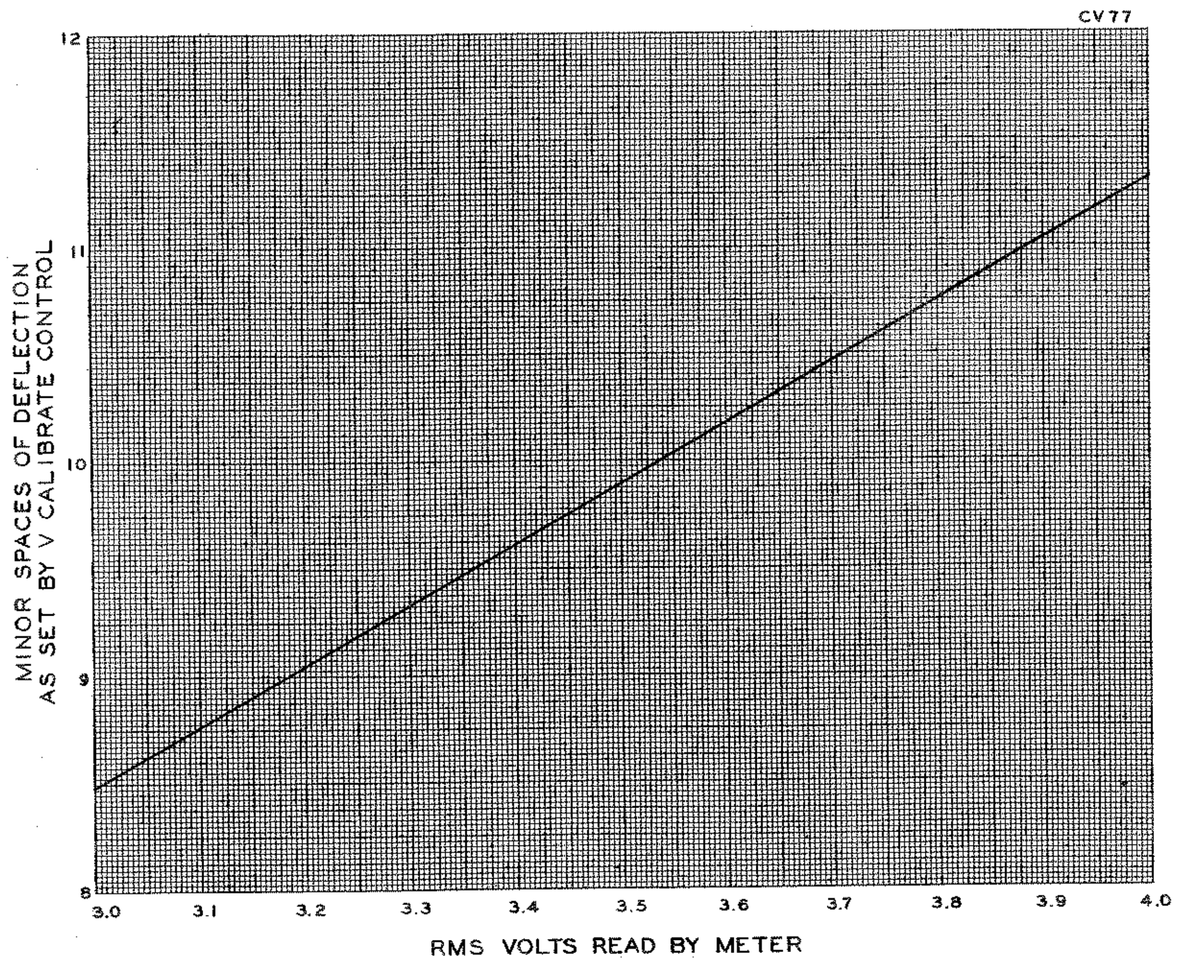


Figure 3—Calibration Curve

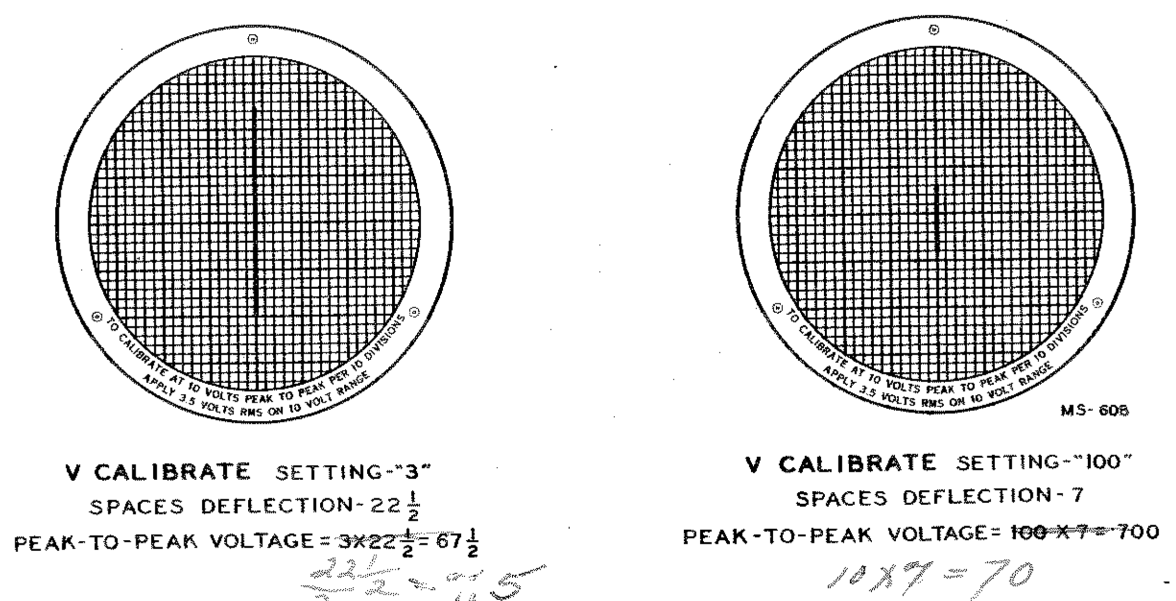


Figure 4—Examples of Voltage Measurements

by .354. A curve of rms voltage vs peak-to-peak voltage is given in Figure 5 to eliminate the need for this computation.

NOTE—DO NOT TOUCH THE V CALIBRATE CONTROL AFTER THE INSTRUMENT HAS BEEN CALIBRATED, OTHERWISE RECALIBRATION WILL BE NECESSARY.

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 super-sonic frequency circuits.

A-C VOLTMETER WITHOUT AMPLIFIER

Make connections to the vertical deflection plates as described under "Direct Connect to Deflection Plates," page 6. Measure or estimate the trace length in minor spaces appearing on the screen (depending upon accuracy desired) and multiply by nine. This gives the approximate peak-to-peak value of the unknown voltage. For the approximate rms value if the voltage measured is sinusoidal, multiply the peak-to-peak value by 0.354 or refer to Figure 5.

Should higher accuracy be desired the operator should first find the exact sensitivity of his particular oscilloscope. This can be done by impressing a voltage of known peak-to-peak value on the deflection plates and measuring the resulting trace in spaces on the "clip-on" screen accurately. Dividing the known voltage by the number of spaces measured will determine the sensitivity of the deflection plates in peak-to-peak volts per space. The accuracy of this determination will depend, of course, upon the care used in making the measurements.

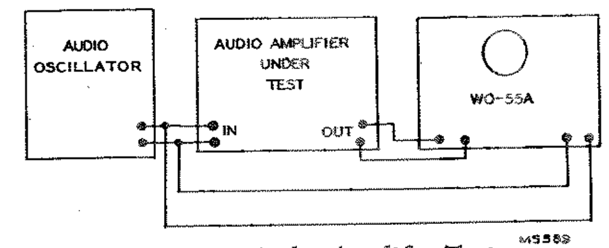


Figure 6—Audio Amplifier Test

AUDIO QUALITY MEASUREMENTS

The WO-55A Oscilloscope is helpful in the determination of the quality of audio amplifiers, and in the qualitative analysis of amplifier distortion. A suggested test setup is shown in Figure 6, 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 SYNC/SWEEP SEL switch on "AMPL", and adjust the H GAIN Control for a

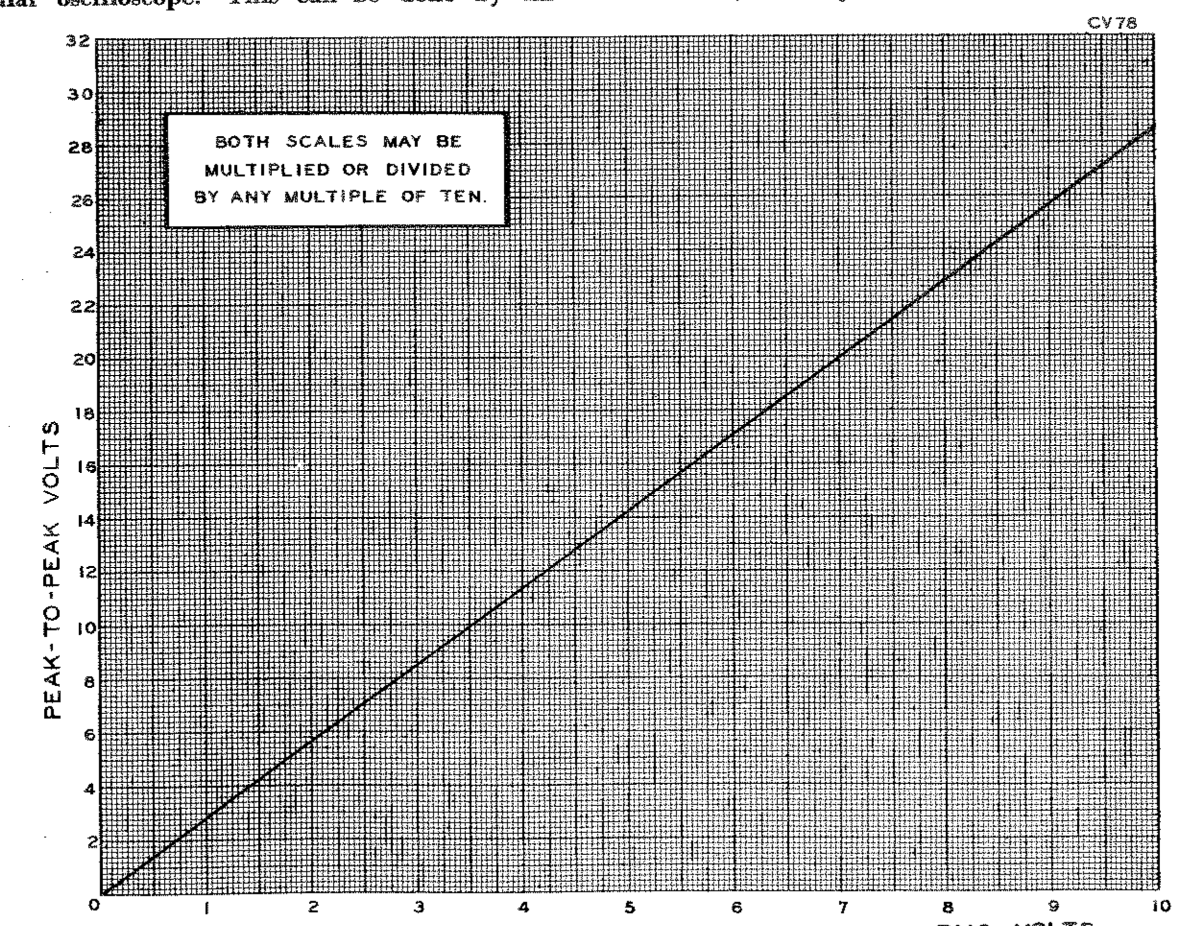


Figure 5—RMS vs Peak-to-Peak Voltage Curve

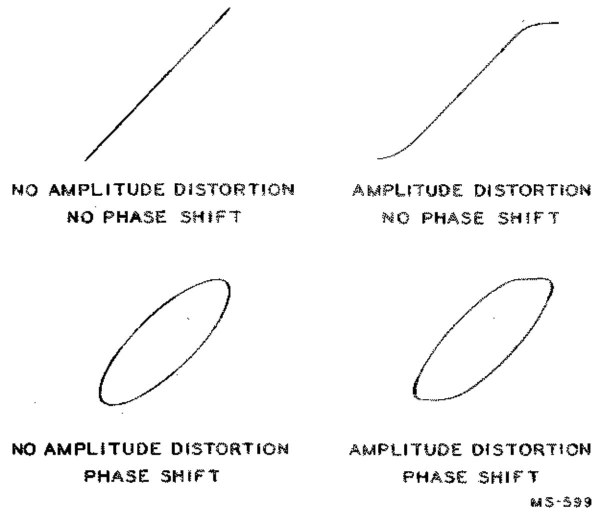


Figure 7—Distortion and Phase Shift

convenient horizontal deflection.

3. Set the V RANGE and V CALIBRATE controls for a convenient vertical deflection.

Figure 7 shows some of the traces that may be seen, together with an explanation of the effects which produce them.

If it should be desirable to study irregularities in wave shape on a linear time axis, proceed as follows:

1. Set the H SYNC/SWEEP SEL on "INT."

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

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

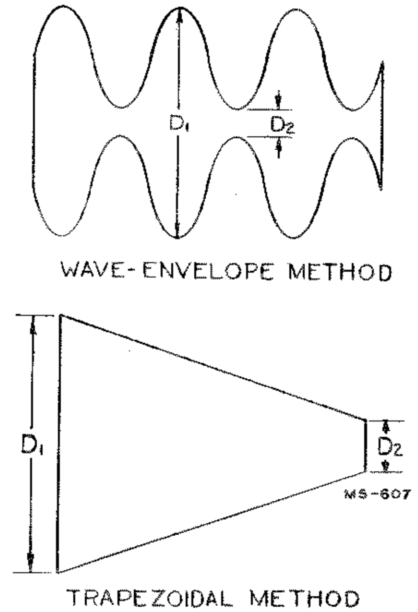
4. Compare the wave form entering the amplifier with that leaving it to determine whether the amplifier is distorting.

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 r-f signal generator, such as the RCA Test Oscillator.

The modulated r-f 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.

MODULATION MEASUREMENT

This instrument can be used for measuring the modulation percentage of a transmitter by either the wave-envelope or the trapezoidal method. For both methods, a small portion of the modulated r-f output of the transmitter is coupled through a small pickup coil directly to the vertical deflection plates of the oscilloscope. An untuned pickup coil consisting of two or three turns of wire, in most cases, provides adequate deflection voltage. The position of the coil can be varied until a pattern of the desired height is obtained. A twisted pair line can be used to connect the pickup coil to the vertical deflection plates of the oscilloscope. When making connections to these plates, observe the



$$\% \text{ MODULATION} = \frac{D_1 - D_2}{D_1 + D_2} \times 100$$

Figure 8—Modulation Patterns

precautions given under the section on Direct Connection to Deflection Plates, page 6. The output of the modulator is coupled through a voltage divider to the horizontal deflection plates for the trapezoidal method or to the SYNC jack for the wave envelope method.

Figure 8 shows the patterns that will be obtained, and the method of determining the modulation percentage from the patterns.

FREQUENCY MEASUREMENTS

The measurement of unknown low frequencies can be accomplished with a high degree of accuracy by using the oscilloscope and a calibrated frequency standard. The unknown-frequency voltage is normally applied to the vertical amplifier (or deflection plates), and the standard frequency signal to the horizontal amplifier (or deflection plates). The frequency is then determined by comparing Lissajou's figures with the patterns obtained. Minor frequency deviation between the unknown signal and standard signal can be determined by direction and rate of rotation of the pattern. Lissajou's figures for several frequency ratios are shown in Figure 9. This method is satisfactory for measurement of frequencies ranging from approximately one-tenth to ten times the standard frequency.

MEASURING PHASE SHIFT

To check phase shift of electrical equipment with the oscilloscope, observe the screen pattern with the input to the equipment connected to the H INPUT terminals and the output from the equipment connected to the V INPUT terminals. If no phase shift exists, a sloping straight-line image will appear. Phase shift will manifest itself as an elliptical or circular trace. Refer to Figure 10 for the method of calculating phase shift.

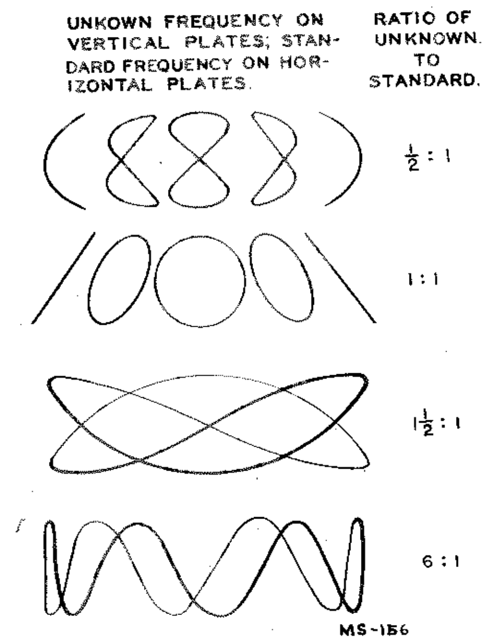


Figure 9—Lissajou's Figures

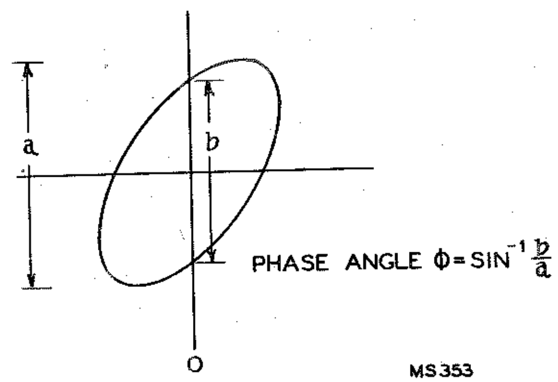


Figure 10—Phase-Shift Measurement

VISUAL ALIGNMENT OF RECEIVER I-F STAGES

For this application, there must be available a frequency-modulated oscillator to sweep through the receiver intermediate-frequency band. The test setup shown in Figure 11 requires a sweep signal obtained from the frequency-modulated oscillator to be applied between the H INPUT AND GND terminals of the oscilloscope. In this case, the H SYNC/SWEEP SEL switch is set on "AMPL", and the sweep-signal generator furnishes the horizontal deflection. Another method is to utilize the sawtooth generator in the WO-55A to furnish horizontal deflection. In this case, the sweep generator must furnish a synchronizing voltage. The method used will depend upon the particular sweep generator available.

The sweep-generator output should be coupled to the grid of the tube preceding the tuned circuit under alignment. It is essential that this connection be made without altering any of the operating characteristics of the stage. If the grid of the tube to which connection is to be made is at zero d-c

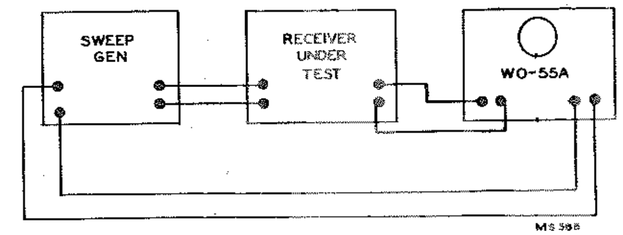


Figure 11—Alignment Setup

potential with respect to ground, connect the sweep generator to the grid of the tube, disconnect the lead normally on the grid, and connect the low side of the sweep generator output to chassis ground. If the grid is not at zero d-c potential with respect to ground, connect the high side of the oscillator to the grid (disconnect the lead normally on the grid) and the other side to the "—C" lead for this grid. Or, in either case, couple the test oscillator to the grid through a small capacitor without disconnecting the lead normally on the grid, and connect the low side of the test oscillator to chassis ground.

The V INPUT binding-jack of the oscilloscope should be connected to the audio output of the second detector. For a diode detector, this connection should be across the diode load resistor. When the second detector is a triode, tetrode or pentode, resistance-coupled to the first audio stage, the H INPUT binding-jack may be connected to the plate of the tube. The GND post is connected to the receiver chassis. In the case of a triode, tetrode or pentode, transformer- or impedance-coupled to the first audio stage, connect a resistor of approximately 20,000 ohms in series with the plate of the tube and by-pass the inductance in the plate circuit with a 1.0 mfd. or larger capacitor. This changes the impedance of the plate circuit to resistance rather than inductive reactance.

Figure 12 shows typical patterns which may be obtained when aligning i-f stages. Diagram "a" shows the picture obtained when the sweep frequency of the horizontal trace is twice the sweep-generator modulation frequency. The i-f trimmers are adjusted for maximum amplitude and coincidence of patterns. The sweep generator is slightly detuned in this pattern to show how the traces should overlap. Diagram "b" shows the picture obtained when the sweep frequency of the horizontal trace is equal to the sweep-generator modulation frequency. The adjustments for this case are made to effect maximum amplitude and symmetry of pattern.

A marker can be inserted at any point on the trace by applying an additional unmodulated

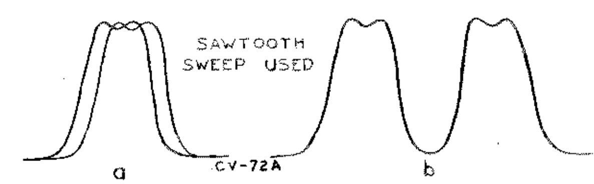


Figure 12—Alignment Curves

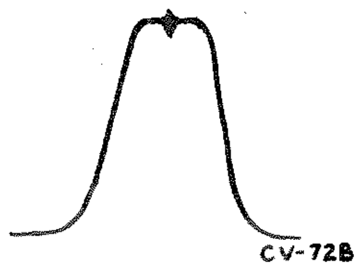


Figure 13—Marker "Pip"

signal to the i-f circuits of the receiver. By varying the frequency of this signal, the point at which the marker appears can be moved to any point on the oscilloscope trace, thus serving to identify or mark that point on the curve. The frequency corresponding to that point on the trace is the frequency of the oscillator providing the marker signal. This permits a very accurate check to be made of band width, peaks, and important points on the response curve. See Figure 13.

ALIGNMENT OF RADIO-FREQUENCY STAGES

The equipment used for r-f alignment is identical to that for i-f alignment, except that the test oscillator output is connected to the antenna lead of the receiver, and the sweep generator is set to sweep through the frequency to which the receiver is tuned.

THE FLUORESCENT SCREEN

The fluorescent screen used in the type-3MP1 cathode-ray tube has very good visual and photographic properties, as well as high luminous efficiency. The phosphorescent effect is of medium persistence; this is an aid in visual work and has no undesirable effect on the photographing of cathode-ray tube patterns. With the retractible light shield extended, the pattern appearing on the screen may be observed with lower spot intensity.

To aid further in viewing the pattern, a light filter, such as the Wratten No. 61N made by the Eastman Kodak Co., may be used. This green filter transmits light of approximately the same wave-length as that of the trace, allowing the pattern to be viewed with greater contrast.

If it is desired to photograph the image, the following hints may be helpful:

The screen of the tube is made of No. 1 phosphor, which emits light peaking at a wave-length of approximately 525 millimicrons. Therefore, the photographic emulsion used should be sensitive to blue and green light. Film of the panchromatic type "B" or "C" is recommended.

The camera should be sharply focused on the fluorescent pattern and have a lens speed of f 4.5 or better. Exposure time will, of course, depend upon the lens and photographic emulsion speeds, and the brilliance and steadiness of the pattern.

CIRCUIT DESCRIPTION

The schematic diagram of the WO-55A is shown in Figure 16.

VERTICAL & HORIZONTAL AMPLIFIERS

Since the vertical and horizontal amplifier circuits are identical, it will be sufficient to describe only the vertical amplifier circuit in detail. Two 6AU6 pentode amplifiers are combined to form a cathode-coupled push-pull amplifier. A replica of the signal applied to the grid of V4 is developed across the common cathode resistors R8, R9, R10, R11 and R13. Since the grid of V3 is at a-c ground potential, the cathode-to-ground voltage is impressed between the cathode and grid of V3. The signal applied to the grid of V4 is therefore amplified by both tubes and appears in push-pull at the plates of V3 and V4. The outputs of these tubes drive the vertical-deflection plates of the cathode-ray tube.

R10 is the V CENTERING control, which is used to vary the d-c potential on the grid of V3. A change of d-c potential on this grid appears amplified and in push-pull at the plates of V3 and V4. Shifting of the cathode-ray tube trace is thereby accomplished.

The V RANGE control network is featured by the low-tolerance resistors used, making it possible to attenuate the input to the vertical amplifier in precise steps. The V CALIBRATE control adjusts the sensitivity of the vertical amplifier stage.

SWEEP OSCILLATOR

The sweep circuit employs an RCA 6J6 twin triode (V5) in a Potter Oscillator circuit. As shown by the simplified schematic, Fig. 14, the common cathode of V5 is connected through a cathode-resistor (R-33) to ground. The plate of the first section of the tube A is capacity-coupled to the grid of the second section (B). The plate of the second section is connected to ground through a capacitor (C12).

The circuit is self-oscillating, and produces a sawtooth voltage that rises practically uniformly with time, insuring a sweep with good linearity.

During the time that the cathode-ray spot is sweeping across the screen from left to right, B

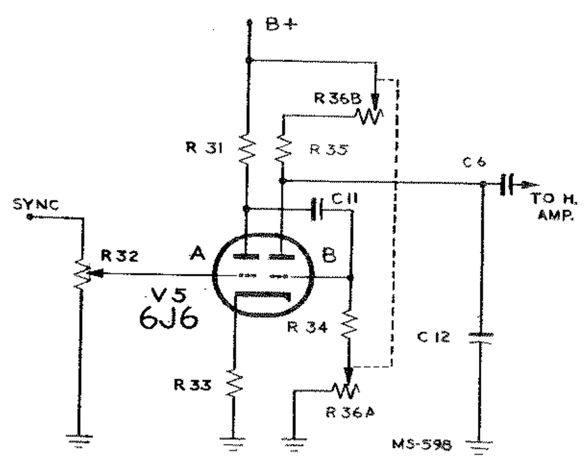


Figure 14—WO-55A Sweep Oscillator

is cut off by a large negative charge on C11. This charge was placed on C11 previously; just how it got there will be explained later. Since B is cut off, C12 charges through R35 and R36B toward the supply voltage, B+. The voltage across C12, which rises practically uniformly with time as C12 charges, is the voltage which, when amplified, causes the spot to sweep from left to right.

At the same time that C12 charges, the negative charge on C11 leaks off through R34 and R36A, thus the grid voltage of B changes in a positive direction. When this grid voltage reaches the cut-off voltage, B starts to conduct, and C12 discharges through B. The discharge current flows through R33, and the resultant higher drop across this resistor biases A past cutoff. The plate voltage of A therefore rises sharply, and this rise is coupled to the grid of B through C11. The positive voltage thus coupled to the grid of B increases its conduction, which hastens the discharge of C12. Since C12 discharges through B much faster than it charges through R35 and R36B, the voltage across C12 falls rapidly, therefore the cathode-ray spot returns to the left-hand side of the screen in much less time than it took to traverse the screen from left to right. When C12 has almost completely discharged, the voltage across the cathode resistor, R33, drops owing to the decrease of current through it. Since the bias on A decreases, A starts to conduct again. When A conducts, its plate voltage drops, and the charge on C11 that was placed there by the supply voltage, B+, while A was cut off, now biases B past cutoff. The entire cycle is then repeated. The sweep oscillator can be synchronized with a synchronizing voltage applied to the grid of the first triode section of the sweep tube. The H SYNC/SWEEP SEL control permits selection of the synchronizing voltage from the vertical amplifier, power line or SYNC terminal. A SYNC ADJ control makes it possible to adjust the sync-voltage amplitude to the desired value.

POWER SUPPLY

Two RCA-6X4 rectifier tubes and their associated circuits provide the plate voltages for the amplifiers, the sweep oscillator, and the cathode-ray tube. Plate voltage for all tubes except the cathode-ray tube is furnished by V6. Second anode voltage for the cathode-ray tube is obtained from the output of V7.

MAINTENANCE

All components of the WO-55A become accessible for maintenance, repair, or inspection when the chassis is withdrawn from the case. To remove the chassis it is necessary to remove four screws from the bottom and four screws from the front panel. The chassis-and-panel assembly can then be withdrawn from the case. It is not necessary to remove the knobs or controls from the front panel.

RESISTANCE AND CONTINUITY TESTS

Resistance and capacitance values are shown on the schematic diagram, Figure 16, to facilitate circuit checks.

Because of the high voltages present on the chassis, it is advisable to limit trouble shooting to resistance and continuity checks whenever possible. BE SURE THAT POWER HAS BEEN REMOVED BY DISCONNECTING THE POWER CABLE BEFORE ATTEMPTING THESE CHECKS.

VOLTAGE MEASUREMENTS

If it should become necessary to check voltages as a means of isolating and eliminating trouble, the following precautions should be taken to prevent possible injury:

1. Familiarize yourself with the equipment to ascertain where high voltages exist. Take care to avoid bodily contact with such points.
2. Do not attempt voltage measurements while standing on a damp or metal floor, or while leaning or resting any part of the body against any object at ground potential.
3. When possible attach leads while the power is off, and turn the power on only while observing a meter deflection.
4. If measurements are to be made without turning the power off, always keep the ground lead securely attached to the equipment ground and keep fingers well away from the probe tip. Also make sure that the insulation on the voltmeter probe and leads has not deteriorated to a point where it is ineffective.

To measure voltage values accurately, the input resistance of the voltmeter used should be much higher than the resistance of the circuit in which the voltage is being measured. The correct voltage readings for various parts of the circuit are shown on the schematic diagram, Figure 16. These values were obtained with an RCA VoltOhmyst while the equipment was being operated from a power source delivering 117 volts.

REPLACING PARTS

Should it become necessary to replace any part in the oscilloscope circuit several precautions should be observed. The replacement part used should be an exact duplicate of the original part or should have equally good characteristics. Care should be taken to position the part and leads to correspond to the original assembly. In some circuits where facilities for adjustment are provided, the adjustment procedure applying to that section of the circuit should be carried out after replacement of any of the components.

FUSE REPLACEMENT

The circuits of the oscilloscope are protected by a one-ampere fuse. Since the value of this fuse is selected to give maximum protection, it should never be replaced with one having a higher rating. If a fuse failure should occur, the cause should be carefully investigated and corrected before replacement is made.

Occasional failure may result from surges in power-line voltage or from heat generated by contact resistance between the fuse and the holder contacts. To avoid failure from the latter cause, the contacts of the fuse holder should be kept clean and in secure contact with the fuse.

REPLACING THE CATHODE-RAY TUBE

The approach to the limit of life of the 3MP1 cathode-ray tube is indicated by low spot intensity, a streaked or spotted screen, or inability to obtain good focus. The tube may be replaced without removing the instrument from its case. Merely remove the clip-on graph screen, pull the retractible light shield out, twist it counterclockwise, and remove it by pulling forward again. Remove the cathode-ray tube by pulling it forward while at the same time rocking it from side to side.

The new tube can be inserted by reversing the foregoing procedure. Some rotation of the new tube may be necessary to bring the axes of deflection into their proper horizontal and vertical planes. To accomplish this, loosen the screws on each side of the cathode-ray tube shield clamps, rotate the shield and socket to its proper position, then tighten the screws.

CORRECTION FOR ASTIGMATISM

If the trace on the cathode-ray tube screen is sharper in the center of the screen than at the edges, it is suggested that the following procedure be followed to equalize the sharpness of the trace:

1. Ground both the V INPUT and the H INPUT binding posts.
2. Turn the H SYNC/SWEEP SEL switch to "AMPL".
3. Turn "ON" the POWER switch.
4. Advance the INTENSITY control until a spot is seen on the screen.
5. Center the spot on the screen using the V and H CENTERING controls.
6. Operate the FOCUS control throughout its range, while observing the shape of the spot.
7. The screw-driver adjustment (R-42) should be made so that, as the FOCUS control is varied, the spot will be round at all settings. See Figure 15 for the location of R-42.
8. After making this adjustment, it will be possible to focus the beam to a small round spot at any point on the screen.

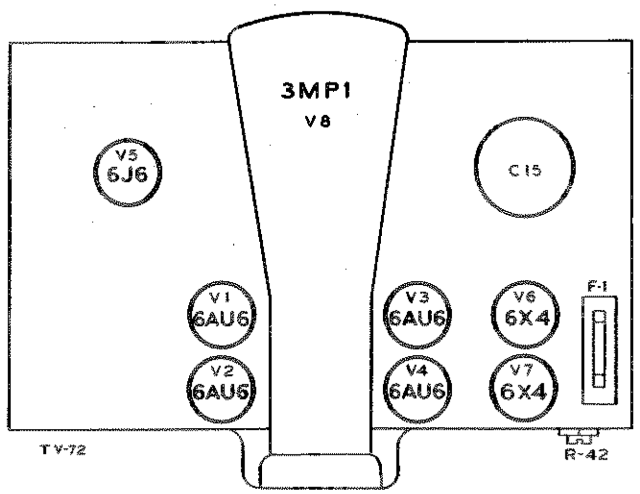


Figure 15—Tube and Adjustment Locations

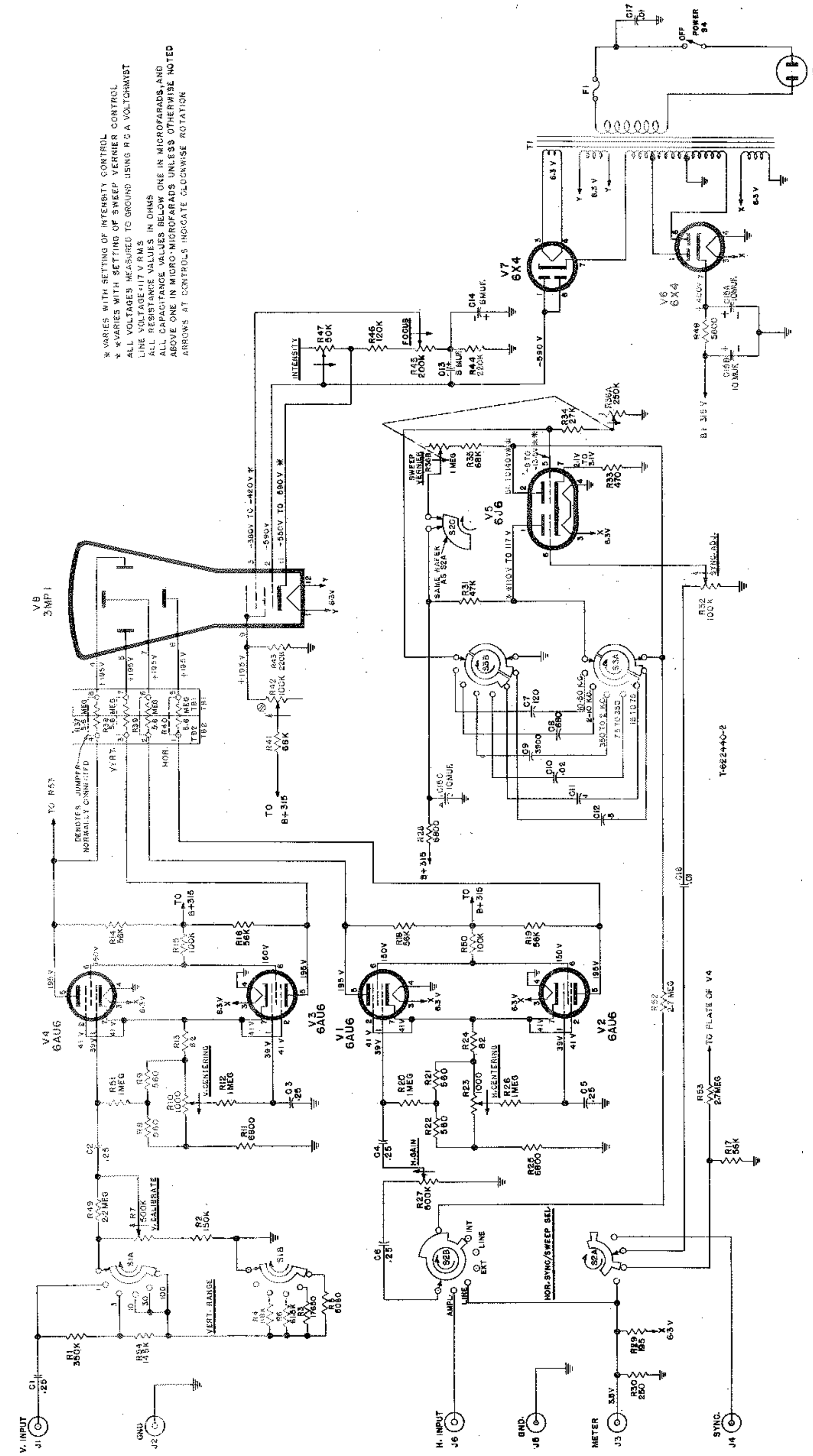


Figure 16—Schematic Diagram