# TM 11-2689

WAR DEPARTMENT TECHNICAL MANUAL

# OSCILLOSCOPE I-245-B





WAR DEPARTMENT 18 APRIL 1945

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WAR DEPARTMENT,

Washington, D. C., 18 April, 1945.

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[A. G. 300.7 (23 Jan 45).]

By Order of the Secretary of War:

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*Chief of Staff.*

Official:

J. A. ULIO,

*Major General,*

*The Adjutant General.*

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(For explanation of symbols see FM 21-6.)

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# LIST OF ILLUSTRATIONS

# DESTRUCTION NOTICE

**WHY** —To prevent the enemy from using or salvaging this equipment for his benefit.

**WHEN**—When ordered by your commander.

**HOW** —1. Smash—Use sledges, axes, handaxes, pickaxes, hammers, crowbars, heavy tools.

2. Cut —Use axes, handaxes, machetes.
3. Burn —Use gasoline, kerosene, oil, flame throwers, incendiary grenades.
4. Explosives—Use firearms, grenades, TNT.
5. Disposal —Bury in slit trenches, fox holes, other holes. Throw in streams. Scatter.

**USE ANYTHING IMMEDIATELY AVAILABLE FOR DESTRUCTION OF THIS EQUIPMENT.**

**WHAT**—1. Smash—Panels, switches, tubes, case. Be extremely careful when destroying cathode-ray tubes; use small arms fire from a shielded position.

2. Cut —Wiring, cables, transformer windings, choke windings.
3. Burn —Manuals, charts, schematics.
4. Bend —Framework, subpanels.
5. Bury or scatter—All of the above materials after destroying their usefulness.

## DESTROY EVERYTHING

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## WARNING
## HIGH VOLTAGE

**is used in the operation of this equipment.**

## DEATH ON CONTACT

**may result if personnel fail to observe safety precautions.**

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**OPERATION OF OSCILLOSCOPE I-245-B INVOLVES THE USE OF HIGH VOLTAGES WHICH ARE DANGEROUS TO LIFE. ANY MAINTENANCE TEST REQUIRING OPERATION OF THE OSCILLOSCOPE CHASSIS WITHOUT ITS PROTECTIVE CASE SHOULD BE UNDERTAKEN ONLY BY EXPERIENCED REPAIR PERSONNEL UNDER CONDITIONS OF ADEQUATE PRECAUTION AGAINST ELECTRIC SHOCK. BEFORE MAKING ANY SERVICE CHECKS ON THE OSCILLOSCOPE, MANUALLY DISCHARGE ALL HIGH-VOLTAGE CAPACITORS AFTER THE A-C POWER HAS BEEN REMOVED FROM THE INSTRUMENT.**

# FIRST AID TREATMENT FOR ELECTRIC SHOCK

I. **FREE THE VICTIM FROM THE CIRCUIT IMMEDIATELY.**

Shut off the current. If this is not immediately possible, use a dry nonconductor (rubber gloves, rope, board) to move either the victim or the wire. Avoid contact with the victim. If necessary to cut a live wire, use an axe with a dry wooden handle. Beware of the resulting flash.

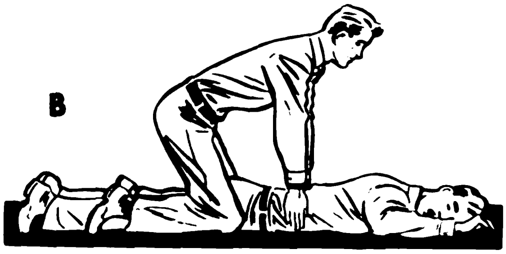
II. **ATTEND INSTANTLY TO THE VICTIM'S BREATHING.**

Begin resuscitation at once on the spot. Do not stop to loosen the victim's clothing. Every moment counts. Keep the patient warm. Wrap him in any covering available. Send for a doctor. Remove false teeth or other obstructions from the victim's mouth.

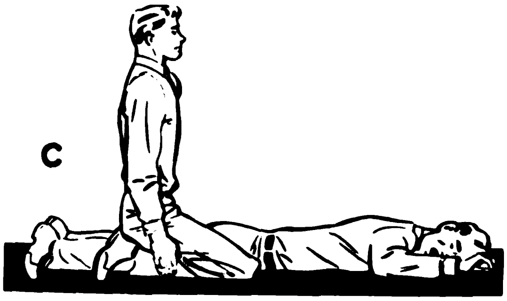
## Resuscitation

A

B



C



### POSITION

1. Lay the victim on his belly, one arm extended directly overhead, the other arm bent at the elbow, the face turned outward and resting on hand or forearm, so that the nose and mouth are free for breathing (fig. A).

2. Straddle the patient's thighs, or one leg, with your knees placed far enough from his hip bones to allow you to assume the position shown in figure A.

3. Place your hands, with thumbs and fingers in a natural position, so that your palms are on the small of his back, and your little fingers just touch his lowest ribs (fig. A).

### FIRST MOVEMENT

4. With arms held straight, swing forward slowly so that the weight of your body is gradually brought to bear upon the victim. Your shoulders should be directly over the heels of your hands at the end of the forward swing (fig. B). Do not bend your elbows. The first movement should take about 2 seconds.

### SECOND MOVEMENT

5. Now immediately swing backward, to remove the pressure completely (fig. C).

6. After 2 seconds, swing forward again. Repeat this pressure-and-release cycle 12 to 15 times a minute. A complete cycle should require 4 or 5 seconds.

### CONTINUED TREATMENT

7. Continue treatment until breathing is restored or until there is no hope of the victim's recovery. Do not give up easily. Remember that at times the process must be kept up for hours.

8. During artificial respiration, have someone loosen the victim's clothing. Wrap the victim warmly; apply hot bricks, stones, etc. Do not give the victim liquids until he is fully conscious. If the victim must be moved, keep up treatment while he is being moved.

9. At the first sign of breathing, withhold artificial respiration. If natural breathing does not continue, immediately resume artificial respiration.

10. If operators must be changed, the relief operator kneels behind the person giving artificial respiration. The relief takes the operator's place as the original operator releases the pressure.

11. Do not allow the revived patient to sit or stand. Keep him quiet. Give hot coffee or tea, or other internal stimulants.

## HOLD RESUSCITATION DRILLS REGULARLY

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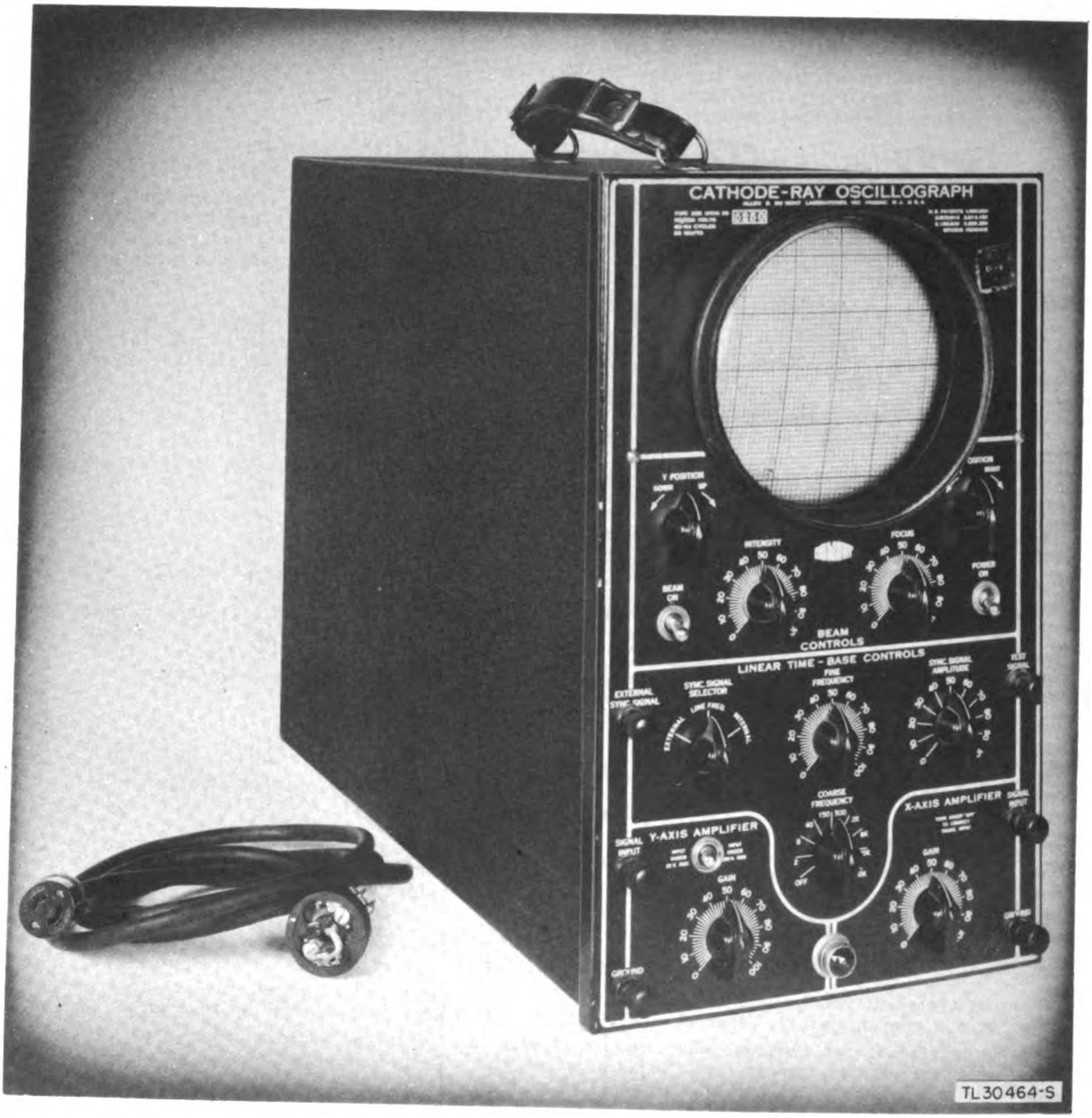


Figure 1. Oscilloscope I-245-B.

# PART ONE
# INTRODUCTION

## SECTION I
## DESCRIPTION

### 1. GENERAL.

Oscilloscope I-245-B is the Du Mont type 208-B cathode-ray oscilloscope (fig. 1). It is used for viewing waveforms and checking frequencies and phase relations at various test points in radio and radar sets. It consists of a cathode-ray tube using electrostatic focusing and deflection and connected in a conventional cathode-ray oscilloscope circuit. The instrument is mounted in a metal case with the operating controls located on the front panel. The screen of the cathode-ray tube is visible above the controls through an opening in the front panel. A linear sweep or timebase is generated internally. The amplitude and frequency of the sweep is variable. Different types of synchronizing signals with varying amplitudes may be applied. The signal to be viewed is applied to the vertical deflecting plates through an amplifier with variable gain. For special purposes external signals may be applied to the horizontal-deflecting plate through the X-axis amplifier, or to either pair of deflecting plates directly.

### 2. TECHNICAL CHARACTERISTICS.

Cathode-ray tube:
- Type .......... 5LP1 or 5LP5, high-vacuum, intensifier.
- Diameter .......... 5 inches.
- Deflection .......... Electrostatic.
- Focusing .......... Electrostatic.
- Persistence .......... Medium.
- Accelerating potential .......... 1,400 volts.

Input impedance:
- Y-axis .......... 2 megohms, 30 $\mu\mu$f.
- X-axis .......... .5 megohms, 25 $\mu\mu$f.

Maximum input potential:
- Y-axis .......... 250 rms volts maximum.
- X-axis .......... 25 rms volts maximum.

Amplifier frequency response:
- Y-axis .......... $\pm$10 percent of maximum from 2 to 100,000 sinusoidal cycles per second. 50 percent response at 325,000 cycles per second.
- X-axis .......... $\pm$10 percent of maximum from 2 to 100,000 sinusoidal cycles per second. 50 percent response at 250,000 cycles per second.

Voltage gain:
- Y-axis .......... 2,000
- X-axis .......... 43

Deflection factor:
- Through amplifier:
  - Y-axis .......... 0.010 rms volts per inch.
  - X-axis .......... 0.5 rms volts per inch.
- To deflection plates:
  - Y-axis .......... 21 rms volts per inch.
  - X-axis .......... 22 rms volts per inch.

| | |
|---|---|
| Sweep circuit: | |
| Sweep direction | Left to right. |
| Frequency (recurrent only) | 2 to 50,000 cycles per second. |
| Number of tubes: | 15 |
| Power input: | |
| Potential | 115/230 volts ac. |
| Frequency | 40 to 60 cycles per second. |
| Power consumption | 90 watts. |
| Fuse protection | 1.5 amperes. |

**3. PHYSICAL DESCRIPTION.**

The oscilloscope is mounted in a black wrinkle-finished steel cabinet supplied with a carrying handle (fig. 1). All of the controls and the input connection terminals for both amplifiers and the synchronizing circuit are available on the front panel (fig. 2). Direct connection to the deflecting plates may be made by means of terminals at the back of the case (fig. 3). Access to the inside of the instrument may be had by removing two screws at the back of the case and slipping the chassis and panel out. The line fuse and receptacle for the removable power cord are at the back of the unit. The cathode-ray tube screen is covered by a scale. Over-all dimensions excluding the carrying handle and feet are: height 14-1/4 inches, width 8-13/16 inches, and depth 19-1/2 inches. Net weight is 54 pounds.

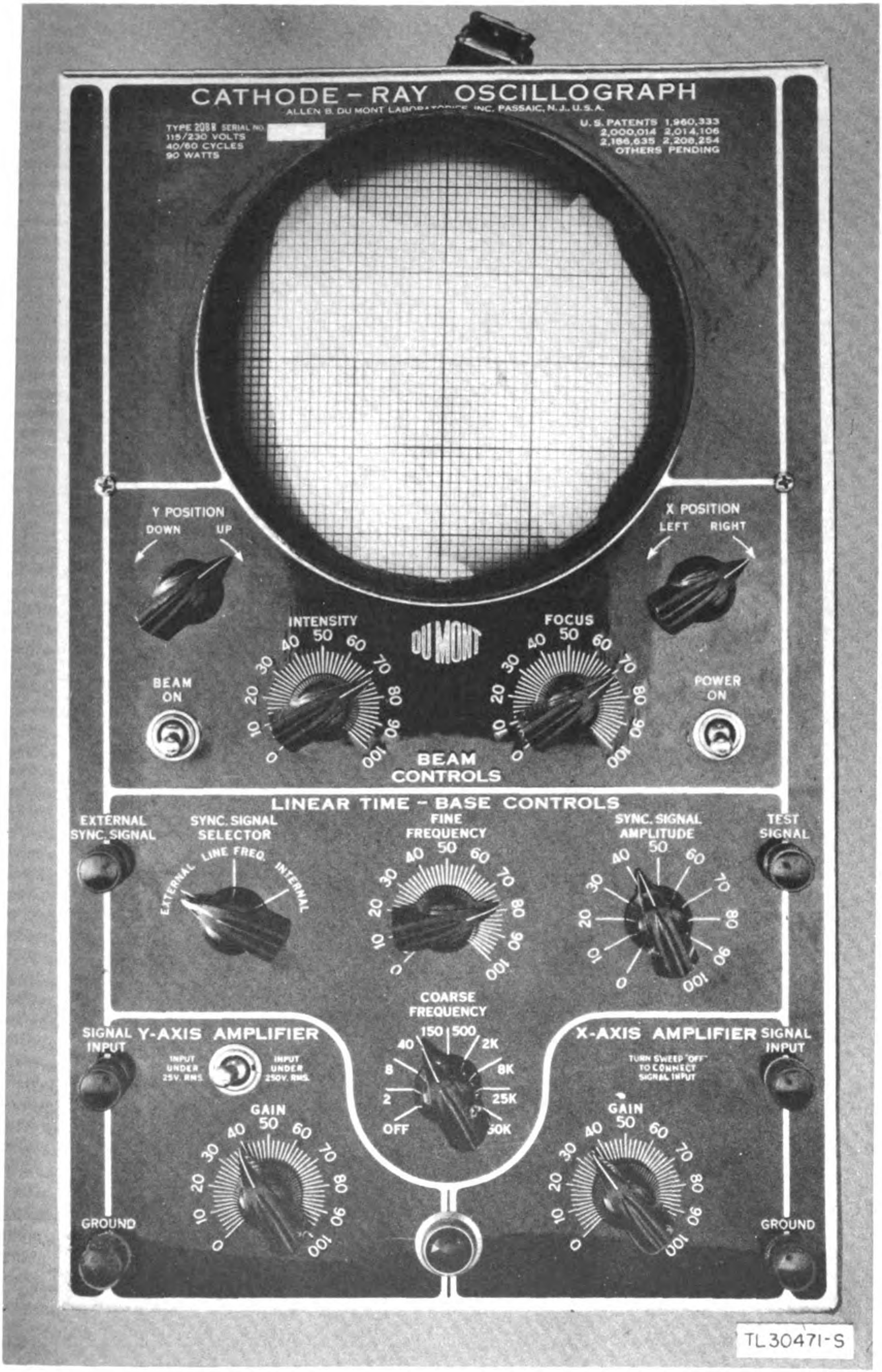


***Figure 2. Oscilloscope I-245-B, front view.***

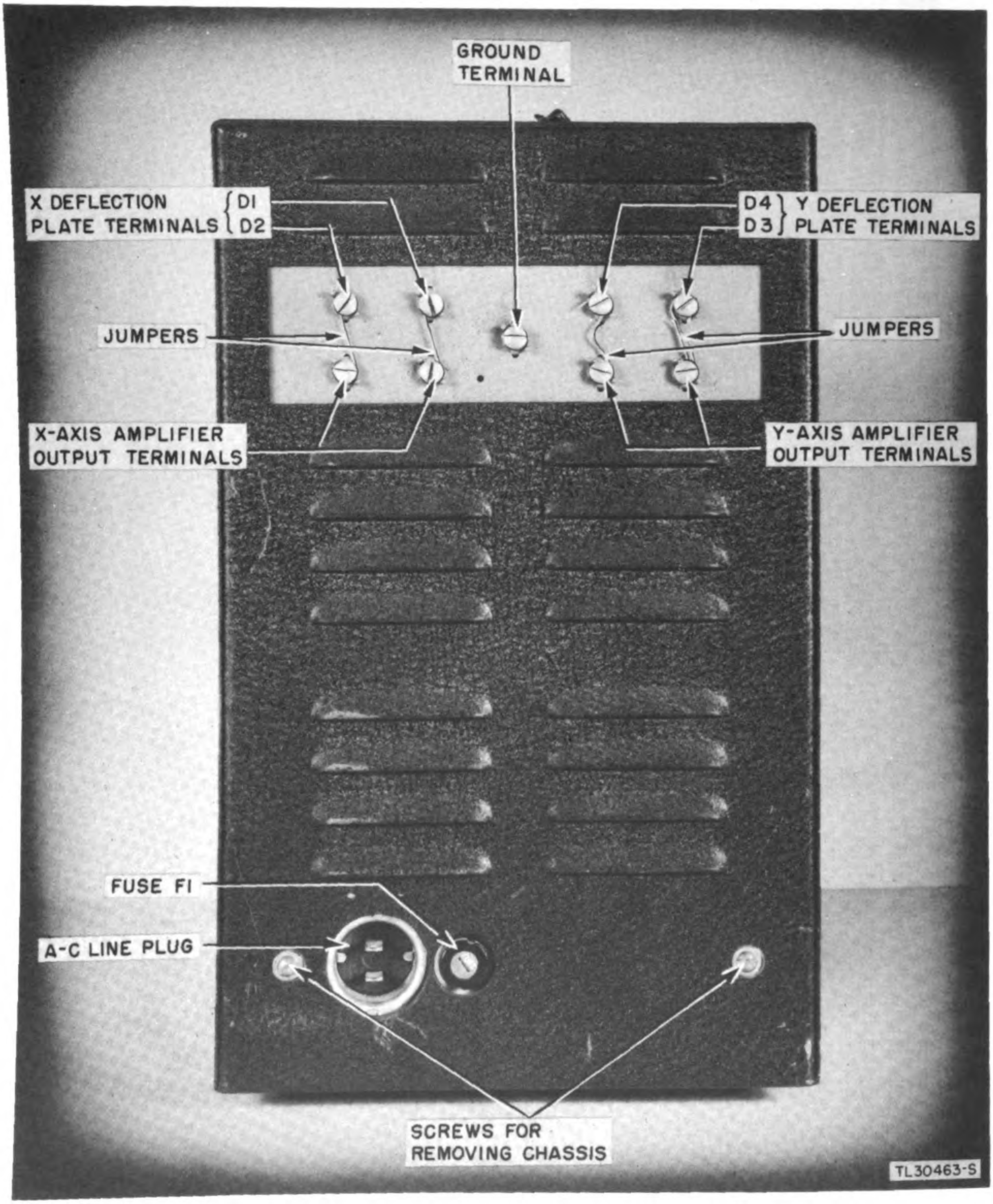


*Figure 3. Oscilloscope I-245-B, rear view.*

# SECTION II
# INSTALLATION

## 4. UNPACKING, UNCRATING, AND CHECKING.

Exercise particular care when unpacking or handling the equipment, because it may be damaged easily when it is not protected by the packing case. In unpacking the oscilloscope follow the steps outlined below.

**a.** Place the packing case in a convenient location where it can be opened easily.

**b.** If the instrument is packed in a wooden box, cut the steel straps which bind the box.

**c.** Remove the nails with a nail puller and remove the top of the packing case. *Prying the top off may result in damage to the equipment.*

**d.** Carefully lift the oscilloscope from the packing case and remove the waxed paper covering it.

**e.** Thoroughly inspect all parts of the case for possible damage during shipment.

**f.** Check the components against the master packing slip.

**CAUTION:** If the chassis has received moistureproofing and fungiproofing treatment, *do not remove* any of the protective coating.

## 5. INSTALLATION.

The equipment is shipped with a set of tubes installed in their respective sockets; check the tubes to see that each one is in the correct socket. Make sure that the tube clamps are seated firmly against the tube bases.

## 6. REMOVAL FROM SERVICE.

When the oscilloscope is not in use, always be sure that the switches are OFF. The power cord and leads should be removed, coiled, and stored.

# SECTION III
# INITIAL ADJUSTMENTS

## 7. LINE-VOLTAGE SELECTOR.

Remove the chassis from the cabinet and check the line-voltage selector switch (S7, fig. 28) to see that the power transformer is connected for the proper line voltage (115 or 230 volts).

## 8. CATHODE-RAY TUBE ADJUSTMENT.

**a.** Start the oscilloscope as explained in paragraph 10.

**b.** If the sweep line is not horizontal, rotate the cathode-ray tube until the sweep is horizontal. If the tube cannot be turned easily from the front, remove the chassis from the case and turn the tube base and socket (fig. 26).

# PART TWO
# OPERATING INSTRUCTIONS

**NOTE:** For information on destroying the equipment to prevent enemy use, refer to the destruction notice at the front of the manual.

## SECTION IV
## PREOPERATIONAL PROCEDURES

### 9. PREPARATION FOR USE.

Before handling Oscilloscope I-245-B, carefully read the instructions covering its use; it is a delicate electrical instrument and must be handled with care. *Pay particular attention to all cautions.* They are inserted to guide the user and to protect the equipment. Before turning on the oscilloscope, set the controls as follows (fig. 2):

**a.** POWER and BEAM switches OFF.

**b.** X and Y POSITION controls at midscale.

**c.** INTENSITY control completely counterclockwise.

**d.** FOCUS control at midscale.

**e.** COARSE FREQUENCY control at any position except OFF.

**f.** SYNC SIGNAL SELECTOR at INTERNAL.

**g.** SYNC SIGNAL AMPLITUDE control completely counterclockwise.

**h.** Attenuator switch to 250v or 25v position according to the amplitude of the Y signal input.

**i.** X GAIN control at midscale.

**j.** Y GAIN control completely counterclockwise.

**NOTE:** If direct-deflection tests are to be made, steps a through d apply.

### 10. STARTING THE OSCILLOSCOPE (fig. 2).

**CAUTION:** Do not leave the oscilloscope beam on indefinitely with no signals applied to either deflecting plates. The screen of the cathode-ray tube will be burned by the intense spot formed by the electron beam if the spot is left in one position too long. When observations are not being made, turn the BEAM switch OFF. This removes the spot or trace from the screen but keeps the instrument warmed up.

**a.** Set up the oscilloscope in the position where it is to be used.

**b.** Plug the line cord into the receptacle on the back of the oscilloscope and into the a-c line.

**c.** Turn the POWER switch ON.

**d.** Interconnect the oscilloscope and all other equipment used with a suitable ground wire.

**e.** Make the connections to the terminals of the instrument according to the test that is to be made (sec. V).

**f.** Turn the BEAM switch ON.

**g.** Adjust the INTENSITY and FOCUS controls until the line on the screen is sharp and well-defined.

**NOTE:** These two controls are interdependent: whenever the INTENSITY control is adjusted to change the brightness of the picture, the FOCUS control must be readjusted as well.

**h.** Adjust the Y POSITION control until the sweep line is centered vertically on the screen.

**i.** Adjust the X GAIN and X POSITION controls until the sweep line is the same length as the diameter of the screen and is centered horizontally.

# SECTION V
# OPERATION

## 11. GENERAL.

**a. Y-axis.** Y-axis deflection may be accomplished by applying the signal to be observed to the Y SIGNAL INPUT terminal or the Y direct deflection terminals (D3 and D4). This latter connection is especially valuable when observing pulses or square waves.

*(1) Y SIGNAL INPUT.* Signals for Y-deflection within the frequency and voltage range of the Y-amplifier (par. 2) are normally connected between the Y SIGNAL INPUT terminal and the GROUND terminal (fig. 2). The amplitude of deflection produced then depends upon the setting of the Y attenuator and Y GAIN controls, and these are adjusted until the desired deflection is produced.

*(2) Direct Deflection.* Signals may be connected directly to the Y-deflection plates of the cathode-ray tube by using the Y-deflection plate terminals (D3 and D4) on the terminal board at the back of the instrument (fig. 3). The jumper between the upper and lower terminal of each pair is disconnected, and the connections are made to the upper terminals. If the signal voltage is being measured with respect to ground, D4 should be grounded and the signal connected to D3. Connect a 5- to 10-megohm resistor from D3 to the ground terminal. If the signal is being measured between two points neither of which is at ground potential, each signal lead is connected to a deflection plate terminal, and a 5- to 10-megohm resistor is connected from each terminal to ground. If the signal is directly coupled to the deflection plate terminals, d-c voltages from the signal source will deflect the beam from its normal centered position. If this is undesirable, the signal may be capacitively coupled to the terminal by inserting a capacitor between the signal voltage and the terminal. Normally the Y POSITION control has no effect when the signal is directly connected, but it may be used when the signal source has high impedance by replacing the jumpers normally used with 5- to 10-megohm resistors. Small bypass capacitors should then be connected from the two lower terminals to ground.

**b. X-axis.** X-axis deflection may be accomplished by the following: the sweep generator or linear timebase; an external signal at the X SIGNAL INPUT posts; or an external signal at the direct deflection terminals. The use of the sweep generator is covered in subparagraph c below.

*(1) X SIGNAL INPUT.* When the COARSE FREQUENCY control is set to its extreme counterclockwise or OFF position, the X-axis amplifier is connected between the X SIGNAL INPUT terminal and the GROUND terminal (fig. 2). The amplitude of horizontal deflection produced then depends upon the X GAIN control; this control is adjusted until the desired deflection is produced. The range of signal voltage and frequency which may be used to give X-axis deflection is given in paragraph 2. *If these values are exceeded, the X-amplifier may be overloaded and the pattern distorted.*

*(2) Direct Deflection.* Signals may be connected directly to the X-deflection plates of the cathode-ray tube by using the X-deflection plate terminals (D1 and D2) on the terminal board at the back of the instrument (fig. 3). If the signal is unbalanced, D1 should be grounded. Otherwise the information given in subparagraph a (2) above for Y-axis direct deflection applies to the X-axis as well.

**c. Sweep Generator.** The sweep generator is connected to the X-axis amplifier when the COARSE FREQUENCY control is set in any position except OFF. It produces a horizontal deflection of the beam by applying a saw-tooth voltage to the X-deflection plates through the X-amplifier. The resulting horizontal deflection consists of a uniform motion of the beam from left to right on the face of the tube, followed by a rapid return of the beam to its starting point. This is repeated at a rate depending upon the setting of the COARSE and FINE FREQUENCY controls (fig. 2). When the sweep is used to provide a timebase, it is ordinarily adjusted by means of the frequency controls to the same frequency as that of the Y-axis signal, or a frequency which is some simple fraction of the signal frequency, such as one-half or one-third. This produces a stationary pattern on the screen.

**d. Synchronization.** To hold the pattern stationary on the screen, it is necessary to apply a small synchronizing signal to the sweep generator. This signal is usually of the same frequency as the signal being observed, but may be a multiple or submultiple of that frequency if external synchronization is being used. This is accomplished by means of the SYNC SIGNAL AMPLITUDE and SYNC SIGNAL SELECTOR controls and the EXTERNAL SYNC SIGNAL terminal (fig. 2).

*(1) SYNC SIGNAL SELECTOR.* The SYNC SIGNAL SELECTOR switch determines the source of the signal used for synchronizing.

*(a)* In the EXTERNAL position the switch permits synchronizing the timebase oscillations with a signal connected between ground and the EXTERNAL SYNC SIGNAL input post. The amount of signal necessary is discussed in subparagraph 31c.

*(b)* When the switch is turned to the LINE FREQ position, a synchronizing signal is supplied from the power line.

*(c)* When the selector is in the INTERNAL position, a signal is taken from a suitable point in the Y-amplifier and used to synchronize the sweep.

*(2) SYNC SIGNAL AMPLITUDE Control.* This control varies the amplitude of the synchronizing signal used. The minimum amount of synchronizing voltage which gives good synchronization should always be used. Excess synchronizing voltage may introduce nonlinearity in the sweep.

*(3) EXTERNAL SYNC SIGNAL Input.* When synchronization is desired from a signal other than the power line or that amplified by the Y-amplifier, that signal voltage is connected to the EXTERNAL SYNC SIGNAL terminal and the SYNC SIGNAL SELECTOR is set at EXTERNAL.

**CAUTION:** Excessive synchronizing voltage fed to this terminal may be coupled into the X- or Y-axis amplifier and cause distortion. One volt peak-to-peak should be the maximum external synchronizing signal used, though pulses of short duration might require somewhat greater amplitudes. If large values of external synchronizing voltage are available, a suitable series resistor should be connected to the external synchronizing signal input terminal to reduce this to the maximum value given above.

**e. Test Leads.**

*(1)* Avoid the use of a shielded test lead or twisted leads in taking waveforms since both of these shunt a high capacitance across the circuit under test and are apt to cause distortion, especially if the waveform is high-frequency or contains high-frequency components. The ground lead must be securely connected at all times.

*(2)* Keep the ungrounded test lead away from other circuits to avoid the possibility of picking up unwanted voltages. The test lead should be brought away from the test point in such a way as to introduce a minimum amount of coupling to other stages.

*(3)* Leads to the scope must be kept short when observing waveforms in grid circuits where the grid capacitance is small. The input of the oscilloscope has high impedance but it will cause loading on another high-impedance circuit and may distort the waveform. The smallest reaction on a waveform is introduced when measuring the voltage across the output (cathode) of a cathode follower or across low-impedance circuits in general.

*(4)* In measuring waveforms in high-impedance circuits, do not handle the *hot* test lead. If this precaution is not observed, the waveform will be distorted as a result of loading the circuit and picking up a 60-cycle voltage.

*(5)* A misleading indication may sometimes be obtained as the result of a signal voltage picked up by the test leads. For example a plate-to-grid coupling capacitor may be open, yet a signal appears at the grid. This effect can be recognized by distortion of the waveform due to the loss of low-frequency components.

**12. OBSERVATION OF WAVEFORMS.**

**a. Y SIGNAL INPUT.**

*(1)* Adjust all controls and connect the signal as explained in paragraphs 10 and 11a(1).

*(2)* Adjust the attenuator switch and Y GAIN control until a convenient amplitude of vertical deflection is obtained on the screen.

(3) Adjust the COARSE FREQUENCY and FINE FREQUENCY controls until one or more cycles of the waveform under test are seen. It is advisable to have two or three cycles of the waveform on the screen, especially if the waveform being tested is of a relatively high frequency; then disregard the cycle at the right end of the sweep (par. 31d).

(4) When the pattern has been adjusted as closely as possible with the FINE FREQUENCY control, advance the SYNC SIGNAL AMPLITUDE control just far enough to hold the pattern stationary.

**b. Direct Deflection.**

(1) Adjust the beam, linear timebase, and X-axis amplifier controls and connect the signal voltage to be viewed as explained in paragraphs 10 and 11a(2).

(2) Connect a jumper from the signal source to the EXTERNAL SYNC SIGNAL terminal.

(3) Set the SYNC SIGNAL SELECTOR to EXTERNAL.

(4) Adjust the COARSE FREQUENCY and FINE FREQUENCY controls until several cycles of the waveform under test are seen.

(5) When the pattern has been adjusted as closely as possible with the FINE FREQUENCY control, advance the SYNC SIGNAL AMPLITUDE control just enough to hold the pattern stationary.

**c. Waveforms with Special Timebase.** For some special purposes it is desirable to view waveforms on a circular, spiral, exponential or other nonlinear timebase, or on a linear timebase of higher frequency than that furnished by the internal timebase generator of the instrument. This timebase voltage may be applied through the X-axis amplifier (subpar. 11b(1) above) or directly to the horizontal deflecting plates (subpar. 11b(2) above). In either case the synchronizing circuit in the oscilloscope is inoperative. Circuits for generating special tyes of sweep voltages are given in TM 11-466, 29 June, 1944, paragraph 63.

**d. Comparison of Waveforms.** When reference waveforms are supplied with equipment, the actual waveform taken at a point with the oscilloscope should be quite similar to the reference waveform provided there is no fault in the equipment. Some differences in shape may occur for the following reasons, however, even though the circuit is normal:

(1) The test leads to the oscilloscope may not be placed in the same manner.

(2) A different oscilloscope may be used, having values of input resistance and capacitance which differ from those of Oscilloscope I-245-B.

(3) The various controls in the equipment may not be in the same positions as when the reference waveforms were taken. Note the conditions specified in the reference waveforms.

(4) The same number of cycles may not be present.

(5) The vertical or horizontal amplitudes of the reference waveforms and the test patterns may not be proportional. This will produce apparent differences in the shape of the two waveforms when there is no real difference.

(6) Whether or not a waveform is regarded as abnormal depends on the symptoms accompanying the fault which is being traced. If it is considered that the fault could be caused by a minor difference in waveform at the point under test, then this discrepancy should be considered significant. Otherwise time should not be spent in hunting down the cause for relatively minor differences between the shape of the reference waveform and the test waveform.

## 13. A-C VOLTAGE MEASUREMENT.

**a. Calibration of Oscilloscope.** The deflection sensitivity of the oscilloscope when used to measure a-c voltages may be varied over wide limits by adjustment of the Y GAIN control. Calibration consists in adjusting the Y amplifier gain to give a known deflection sensitivity. The deflection sensitivity desired depends on the amplitude of the voltage to be measured. For small voltages, the greater sensitivities (smaller number of volts per inch) will be used. The procedure for adjusting the sensitivity to the desired value is as follows:

(1) Apply a known sinusoidal a-c voltage to the Y SIGNAL INPUT terminal and adjust the controls to give a stationary picture on the screen with a convenient vertical deflection.

(2) Multiply the rms value of the known a-c voltage by 2.83 to obtain its peak-to-peak value.

*(3)* Multiply the result obtained in subparagraph (2) above by the factor indicated below for the deflection sensitivity desired:

| *Deflection sensitivity* | *Multiply by* |
|---|---|
| 0.1 volts per inch | 100 |
| 1 volt per inch | 10 |
| 10 volts per inch | 1 |
| 100 volts per inch | 1/10 |

*(4)* Adjust the attenuator switch (S1) and Y GAIN control until the peak-to-peak deflection of the signal on the screen is the sâme number of scale divisions as the result obtained in subparagraph (3) above.

**b. Measurement of Unknown Voltage.**

*(1)* When the scope has been calibrated as in subparagraph a above, the peak-to-peak value of any a-c voltage within the range for which the calibration has been made may be determined by applying the unknown voltage to the Y SIGNAL INPUT terminal and observing the deflection on the scale over the screen. The positioning and frequency controls may be adjusted to bring the picture into a better position for reading, but the Y GAIN control must not be moved once the calibration has been made. The deflection sensitivity may be changed in the ratio of 10:1, however, without affecting the calibration, by changing the attenuator switch.

*(2)* For a sinusoidal voltage the rms value may be determined by dividing the peak-to-peak value obtained from the oscilloscope measurement by 2.83.

## 14. D-C VOLTAGE MEASUREMENT.

D-c voltages are usually measured with a d-c voltmeter. In special cases, however, it is desirable to use the oscilloscope to reduce loading of the circuit in which the measurement is being made. The procedure is as follows:

**a.** Start the oscilloscope as explained in paragraph 10. Then turn the BEAM switch OFF.

**b.** Disconnect the jumpers for the vertical-deflecting plates, D3 and D4, on the terminal board at the back of the chassis (fig. 3) and ground both upper terminals.

**c.** Turn the BEAM switch ON, adjust the FOCUS control, and observe the position of the sweep line on the screen. Then turn the BEAM switch OFF.

**d.** To measure an unknown d-c voltage, disconnect the D3 terminal from the ground terminal and connect the unknown signal between D3 and D4.

**e.** Turn the BEAM switch ON and observe the position of the line on the screen.

**f.** Count the number of scale divisions between the two positions of the sweep line on the screen and multiply this number by 5.9 to obtain the reading in volts. An upward deflection indicates that the positive terminal is attached to D3. A downward deflection indicates the opposite polarity.

## 15. COMPARISON OF UNKNOWN FREQUENCY WITH A STANDARD.

Since the frequency controls of the oscilloscope are not precisely calibrated, the instrument may not be used as an absolute frequency measuring device. The only method by which a frequency may be measured is by comparison with a standard frequency such as the power line frequency or the output of a calibrated signal generator. Two methods are possible, one using Lissajous figures and the other using the internal linear timebase. The first method (subpar. a below) is applicable only to sine waves. The second method (subpar. b below) may be used for any type of voltage wave.

**a. Measurement by Means of Lissajous Figures.**

*(1)* Start the oscilloscope as explained in paragraph 10.

*(2)* Turn the BEAM switch and COARSE FREQUENCY control to OFF and connect the standard frequency source between the X SIGNAL INPUT and GROUND terminals.

*(3)* Turn the BEAM switch ON and adjust the X GAIN control until a convenient horizontal deflection is obtained on the screen.

*(4)* Connect the unknown signal between the Y SIGNAL INPUT and GROUND terminals.

*(5)* Adjust the attenuator switch and Y GAIN controls until a pattern of convenient shape is seen on the screen. This pattern is called a Lissajous figure. Typical patterns are shown in figure 4.

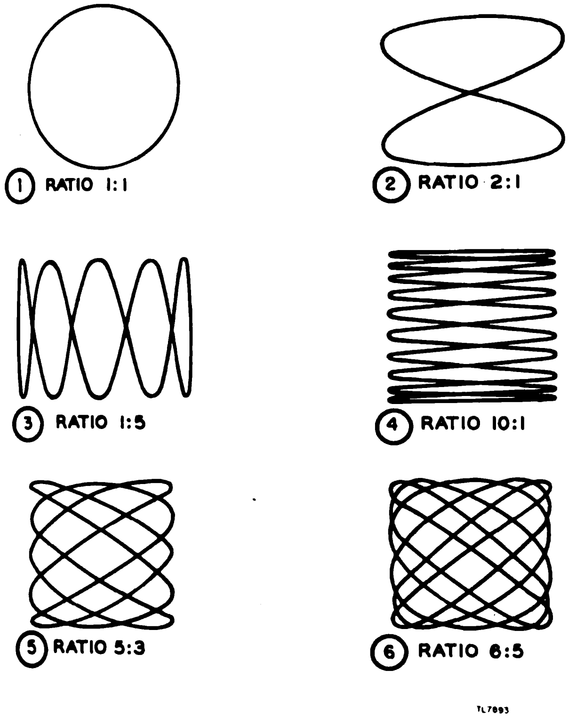


*Figure 4. Lissajous figures for various frequency ratios.*

*(6)* If the frequency ratio is large or not a simple ratio, the pattern is difficult to interpret. If the standard source of frequency is variable, it can be adjusted until a stationary pattern with a ratio of 1:1, 2:1, 3:2, or some other simple pattern is obtained.

*(7)* Inclose the pattern with an imaginary rectangle the sides of which are tangent to the pattern and parallel to the X and Y axes.

*(8)* At an instant when the pattern shows open loops, count the number of points at which the pattern is tangent to the vertical side and to the horizontal side of the rectangle.

*(9)* The ratio of the X to the Y frequency is equal to the ratio of the number of points of tangency on a vertical side to the number of points of tangency on a horizontal side or:

$$\text{Y frequency} = \frac{\text{Number of horizontal tangent points}}{\text{number of vertical tangent points}} \times \text{standard frequency.}$$

**b. Measurement by Calibration of Oscilloscope Linear Timebase.**

*(1)* Adjust the oscilloscope for observing waveforms as explained in paragraph 12a.

**CAUTION:** Use no synchronizing voltage in this test; set SYNC. SIGNAL SELECTOR switch to the EXTERNAL position.

*(2)* Remove the signal from the input terminal and connect the output of a calibrated signal generator to the Y SIGNAL INPUT.

*(3)* Adjust the signal generator until a steady pattern is obtained with the same number of cycles as was observed with the unknown signal or with some other integral number of cycles.

*(4)* The ratio between the unknown frequency and the signal generator frequency is the

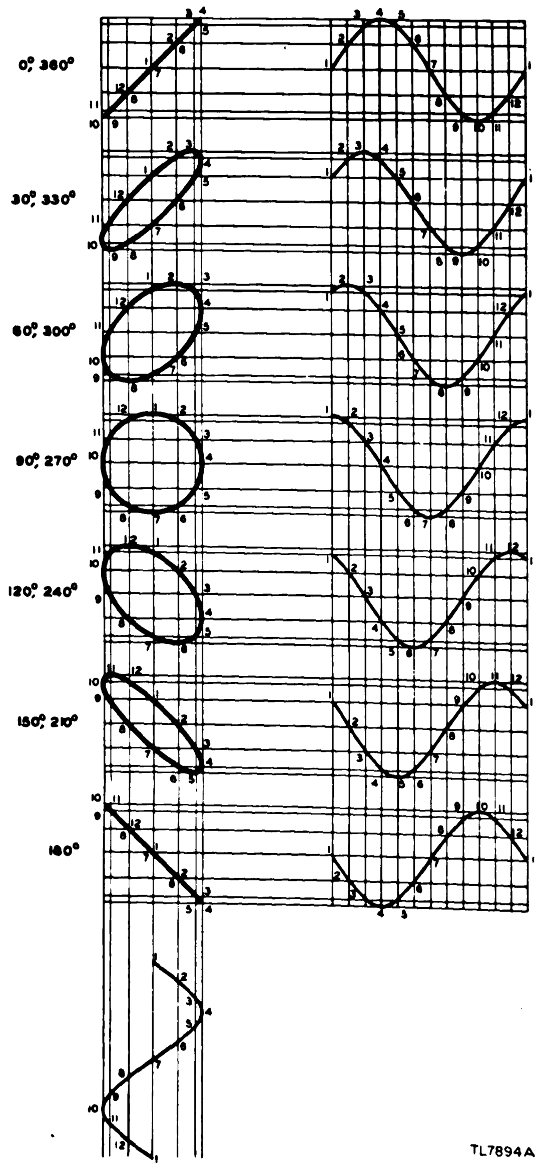


*Figure 5. Lissajous figures for various phase differences.*

same as the ratio of the number of cycles of signal frequency seen on the screen to the number of cycles of the signal generator frequency seen.

## 16. INDICATION OF PHASE ANGLE.

This method of indicating phase angle can be used only with sine waves of the same frequency and amplitude. For the measurement of phase angles between narrow pulses, use the procedure for measuring short time intervals given in paragraph 17.

**a.** Adjust the oscilloscope controls and connect the two signals to the input terminals in the same manner as explained in paragraph 15a.

**b.** The pattern obtained is a special type of Lissajous figure. The way in which phase difference is indicated is shown in figure 5. The phase angle cannot be read directly except at 0°, 90°, and 180°. This method of measurement is chiefly useful in adjusting a phase-shifting circuit so that the output is exactly in phase, or 90° or 180° out of phase, with a reference waveform.

## 17. MEASUREMENT OF SHORT TIME INTERVALS.

If a calibrated signal generator is available, time intervals between narrow pulses having the same recurrence frequency can be measured from approximately 1 microsecond to 0.5 second. The procedure is as follows:

**a.** Start the oscilloscope as explained in paragraph 10.

**b.** Connect one signal to the Y SIGNAL INPUT terminal and adjust the attenuator and Y GAIN controls until a convenient vertical deflection is obtained.

**c.** Adjust the X GAIN control until a horizontal deflection of four inches (40 scale divisions) is obtained.

**d.** Advance the frequency controls until a stationary picture with only one cycle of the wave is obtained.

**e.** Connect the other signal in parallel with the first at the Y SIGNAL INPUT and advance the frequency controls if necessary until a stationary pattern is obtained with the two pulses separated a convenient amount on the screen. Observe the number of scale divisions between the leading edges on the two pulses.

**f.** Disconnect the two signals and connect the signal generator output to the Y SIGNAL INPUT terminal.

**g.** Adjust the signal generator frequency control until one cycle of the sine wave output is seen on the screen.

**h.** The time interval between pulses is obtained from the following formula:

$$t = \frac{25{,}000d}{f}$$

where t = time interval in microseconds
d = number of scale divisions between pulses
f = frequency of the signal generator output in cycles per second.

**i.** If the difference in time is desired as a phase angle, use the following formula:

$$a = 9d$$

where a = the phase angle in degrees
d = the number of scale divisions between pulses.

## 18. CHECKING RADIO TRANSMITTERS.

**a. Neutralization of Radio Transmitters.** Neutralization of the radio-frequency (r-f) amplifier stages of a transmitter can be accomplished with the cathode-ray oscilloscope. The procedure for neutralization is essentially the same as any other method with the exception that the oscilloscope is used as the indicating instrument.

*(1)* Start the oscilloscope as explained in paragraph 10.

*(2)* Apply filament power, grid bias, and grid excitation to the stage to be neutralized, but ***apply no plate voltage.***

*(3)* With circuits utilizing link coupling between successive amplifier stages, the link winding coupled to the plate circuit of the amplifier to be neutralized can be connected directly to the terminals of the oscilloscope through a twisted pair of wires. If the frequency of operation of the r-f amplifier is below 3 megacycles, connect the link to the Y SIGNAL INPUT terminals as explained in paragraph 12a. If the frequency of operation is above 3 megacycles, connect the link coupling to the Y-axis direct deflection terminals D3 and D4 as explained in paragraph 12b.

*(4)* In general it will be impossible to synchronize the trace, and in this operation synchronization is not necessary. The amount of Y-axis deflection is the only indication of whether or not the r-f amplifier is neutralized.

*(5)* Assuming that the r-f amplifier is not neutralized, tune in the plate tank tuning capacitor for maximum Y-axis deflection on the oscilloscope.

*(6)* When the maximum is reached, tune the neutralizing capacitor for minimum Y-axis deflection. In using the Y-axis amplifier, adjust the attenuator and Y GAIN controls for maximum necessary sensitivity.

*(7)* Varying the plate tank tuning capacitor over its range now should produce no change in the Y-axis deflection if the r-f amplifier is properly neutralized.

*(8)* With amplifiers which do not have link couplings it is necessary to use an auxiliary link coil made of a few turns of wire and coupled to the tank coil of the r-f amplifier. Care must be taken when using an auxiliary link coil not to couple it so close as to alter the circuit conditions.

**b. Checking Phone Transmitter Operation.** The most reliable method of determining percentage of modulation of a transmitter is by means of the oscilloscope. Two types of oscilloscope patterns may be obtained: the ***wave envelope*** and the ***trapezoid***. The former shows the shape of the modulation envelope directly, while the latter in effect plots the modulation characteristic of the modulated stage on the cathode-ray tube screen.

*(1) **Wave Envelope Pattern.***

*(a)* Start the oscilloscope as explained in paragraph 10.

*(b)* Place a few turns of wire near the final tank circuit and connect the ends of the loop to the Y-axis direct deflection terminals D3 and D4 as explained in paragraph 12a.

*(c)* Synchronize the oscilloscope to the audio component of the r-f modulated wave by adjustment of the COARSE FREQUENCY and FINE FREQUENCY controls and the SYNC SIGNAL AMPLITUDE control.

*(d)* The picture seen is a reproduction of the modulation envelope filled in with the r-f cycles. The degree of modulation is obtained from the formula:

$$m = \frac{B - A}{B + A}$$

where m = degree of modulation
B = vertical height of pattern at its highest point
A = vertical height of pattern at its narrowest point.

*(2) **Trapezoidal Pattern.*** This pattern is more difficut to obtain than the wave envelope pattern but gives clearer information when non-sinusoidal waveforms are encountered.

*(a)* Couple the transmitter output to the Y-axis deflecting plates in the same manner as for the wave envelope pattern (subpar. (1) above).

*(b)* Connect a coupling capacitor to the modulation connection on the r-f amplifier and a voltage divider between the capacitor and ground.

*(c)* Adjust the tap on the voltage divider so as to tap off a few volts of the modulator audio output voltage, and connect it to the X SIGNAL INPUT terminal of the oscilloscope.

*(d)* Adjust the width of the pattern with the X GAIN control.

*(e)* The figure obtained should be a triangle for 100 percent modulation, a trapezoid for less than 100 percent modulation, and a triangle with a straight line extending from one vertex for more than 100 percent modulation. The degree of modulation is obtained from the formula:

$$m = \frac{B - A}{B + A}$$

where m = degree of modulation
B = length of longer vertical side of trapezoid
A = length of shorter vertical side of trapezoid.

**NOTE:** In order to obtain the trapezoidal pattern, the modulating voltage fed to the oscilloscope must be in phase with the modulation envelope. In some cases it may be necessary to connect a phase-shifting device between the modulator audio output and the X SIGNAL INPUT terminal and to adjust the phase shift until the trapezoidal or triangular pattern is obtained. (For phase-shifting circuits, see TM 11-466, 29 June, 1944, paragraph 52.)

## 19. SIGNAL TRACING.

**a. General.** Signal tracing is a trouble-shooting procedure which consists of checking the waveform of a signal at the input and output of successive stages through a circuit. By *signal* is meant any waveform which normally appears throughout the circuit or, in the case of a receiver, an audio signal supplied by a signal generator. Any departure from the normal wave form indicates a fault located between the point where the signal is last normal and the point where it is observed to be abnormal. For example, if a waveform is found to be normal at the grid of a stage and abnormal at the plate of the same stage, this indicates that the trouble lies in that stage.

**b. Procedure.**

*(1)* Start the oscilloscope as explained in paragraph 10 and connect a test prod to the Y SIGNAL INPUT terminal.

*(2)* If the circuit under test has its own signal waveform, check the waveform by placing the test prod at the following points in succession: input of the first stage, output of the first stage, input of the second stage, output of the second stage, etc.

*(3)* If an audio amplifier is being traced, connect the output of an audio signal generator to the input of the first stage and trace the signal in the same manner as explained in subparagraph (2) above.

*(4)* If a receiver or the intermediate-frequency (i-f) section of a receiver is being traced, connect the output of a modulated r-f signal generator of the proper frequency to the input of the first stage and trace the signal in the same manner as explained in subparagraph (2) above.

*(5)* In following the path of a signal through a circuit, the amplitude of the waveform will usually increase as the checking point progresses from the input to the output stages. This is not always true, however. For example, when going from the grid to the cathode of a cathode-follower stage, there is a loss of signal amplitude of about 10 percent or more. Another example is in wave-shaping circuits where a decrease in the width of a signal is accompanied by a decrease in amplitude (as in differentiating circuits).

**20. I-F ALIGNMENT.**

**a.** Start the oscilloscope as explained in paragraph 10.

**b.** Disconnect the local oscillator of the receiver from the mixer stage or make it inoperative by removing it, removing its plate voltage, grounding its grid, or by some other convenient means.

**c.** Connect the output of a modulated signal generator of proper frequency to the input of the first i-f stage.

**d.** Connect the output of the second detector or final audio or video stage to the Y SIGNAL INPUT terminal of the oscilloscope.

**e.** Keep the signal generator output at the lowest value which will give a satisfactory signal at the output of the i-f section.

**f.** Tune the i-f coils or transformers, in order, for maximum deflection on the oscilloscope, beginning with the last one and working back to the first.

NOTE: Some receivers have a stagger-tuned i-f section in order to give wide band pass. These receivers require a special tuning procedure. Before aligning the i-f section on any receiver, consult all information furnished with that receiver.

# PART THREE
# PREVENTIVE MAINTENANCE

## SECTION VI
## PREVENTIVE MAINTENANCE TECHNIQUES

### 21. MEANING OF PREVENTIVE MAINTENANCE.

Preventive maintenance is performed at regular intervals on test equipment when it is not in use to keep the equipment operating at top efficiency and to prevent break-downs. A distinction must be made between preventive maintenance, and trouble shooting and repair. The prime function of preventive maintenance is to *prevent* break-downs and, therefore, the need for repair. On the other hand, the prime function of trouble shooting and repair is to locate and correct existing defects as the importance of preventive maintenance cannot be overemphasized. The efficiency of a radio system depends upon the readiness and operating efficiency of each item of equipment when it is needed.

### 22. DESCRIPTION OF PREVENTIVE MAINTENANCE TECHNIQUES.

**a. General.** Because hit-or-miss maintenance techniques cannot be applied, definite and specific instructions are needed. The four basic maintenance operations required for this instrument are: Feel, Inspect, Tighten, and Clean. The first two operations establish the need for the other two. The selection of operations is based on a general knowledge of field needs. For example, the dust encountered on dirt roads during cross-country travel filters into the equipment no matter how much care is taken to prevent it. Rapid changes in weather (such as heavy rain followed by blistering heat), excessive dampness, snow, and ice tend to cause corrosion of exposed surfaces and parts. Without frequent inspections and the necessary performance of preventive maintenance, equipment soon becomes undependable and subject to break-down when it is most needed.

**b. Feel.** The feel operation is used most often to check transformers, chokes, and resistors for overheating, and to check electrical connections for looseness. The maintenance man must become familiar with the normal operating temperature of parts within the equipment in order to recognize signs of overheating.

NOTE: It is important that the feel operation be performed as soon as possible after the equipment is shut down and always before any other maintenance is done.

**c. Inspect.** Inspection is the most important operation in the preventive maintenance program. A careless observer will overlook the evidences of minor trouble. Valuable time and effort can be saved if defects are corrected before they lead to major break-downs. Make every effort to become familiar with the indications of normal functioning, in order to recognize the signs of a defective instrument. Inspection consists of carefully observing all parts of the equipment, noting state of cleanliness, placement of wires and cables, etc.

**d. Tighten.** This operation consists of tightening all loose connections, controls, terminals, and mounting screws.

**e. Clean.** The instrument must be kept thoroughly clean. All corrosion must be removed from metal parts and connections. Use crocus cloth if necessary. Dust, dirt, or other foreign matter can be removed with a small clean brush or a clean cloth moistened with a cleaning solvent.

### 23. COMMON MATERIALS NEEDED.

The following materials are needed in performing preventive maintenance on the equipment:

- Common hand tools (TE-41 or equivalent).
- Clean cloth.
- Sandpaper #0000.
- Crocus cloth.
- Paint brush, small.
- Solvent, Dry-cleaning, Federal Specification P-S-661a.

NOTE: Gasoline will not be used as a cleaning fluid for any purpose. Solvent, Dry-cleaning, Federal Specification P-S-661a, is available as a cleaning fluid through established supply channels. Oil, fuel, Diesel, U. S. Army Specification 2-102B, may be used for cleaning purposes when dry-cleaning solvent is not at hand. Carbon tetrachloride will be used, if necessary, ***only on contact parts of electronic equipment.***

## 24. APPLICATION TO OSCILLOSCOPE I-245-B.

General instructions are given below for the application of preventive maintenance techniques to Oscilloscope I-245-B. All work is to be performed with the instrument disconnected from the power line. Discharge all capacitors as soon as the chassis is removed from the case and before doing any work. After completion of the work, the oscilloscope should be put into operation and checked for satisfactory performance.

**a. Feel.** Feel transformer T1 and filter chokes L7 and L8 (fig. 28) for overheating as soon as possible after shutting down the oscilloscope.

**b. Inspect.** Observe all parts of the equipment carefully and note any signs of overheating as indicated by discoloration of the affected parts. Note the general condition of resistors, capacitors, potentiometers, chokes, coils, switches, terminal strips, and wiring. Look for loose or broken connections, loose mountings and parts, and cut or frayed insulation on the wiring. Examine all recesses for accumulation of dust and dirt, especially between connecting terminals. Parts, connections, and terminals must be free of rust and corrosion. In tropical and high-humidity locations, look for fungus growth and mildew. Examine all tubes to see that they are firm in their sockets, and all mounting screws for tightness. Inspect the a-c cord for worn or frayed insulation and broken wires or connections.

**c. Tighten.** All loose mountings must be securely tightened in place. If connections are dirty or corroded, clean them before tightening them. Tighten all loose terminals and resolder, or otherwise repair, any faulty or broken connections. If any clips on tube sockets are loose, compress them slightly with pliers.

**d. Clean.** All dirt and other foreign matter must be removed from the equipment. Clean all terminal boards, capacitors, resistors, potentiometers, tubes, tube sockets, transformers, and choke coils with a cleaning cloth. When it is necessary to use a cloth moistened with the dry-cleaning fluid, always wipe the surfaces thoroughly dry with a clean cloth. Do not displace any of the wiring when cleaning. Wipe the case clean inside and out.

## SECTION VII
## MOISTUREPROOFING AND FUNGIPROOFING

### 25. GENERAL.

When operated in tropical areas where temperature and relative humidity are extremely high, Signal Corps equipment requires special attention. These are some of the problems met:

**a.** Resistors, capacitors, coils, chokes, transformer windings, etc., fail because of the effects of fungus growth and excessive moisture.

**b.** Electrolytic action, often visible in the form of corrosion, takes place in resistors, coils, chokes, transformer windings, etc., causing eventual break-down.

**c.** Hook-up wire insulation and cable insulation break down. Fungus growth accelerates deterioration.

**d.** Moisture forms electrical leakage paths on terminal boards and insulating strips, causing flash-overs.

### 26. TREATMENT.

A moistureproofing and fungiproofing treatment has been devised which, if properly applied, provides a reasonable degree of protection against fungus growth, insects, corrosion, salt spray, and moisture. The treatment involves the use of a moisture-and fungi-resistant varnish applied with a spray gun or brush. Refer to TB SIG 13, Moistureproofing and Fungiproofing Signal Corps Equipment, for a detailed description of the varnish-spray method of moistureproofing and fungiproofing and the supplies and equipment required in this treatment.

**CAUTION:** Varnish spray may have poisonous effects if inhaled. To avoid inhaling spray, use respirator if available; otherwise, fasten cheesecloth or other cloth material over nose and mouth. Never spray varnish or lacquer near an open flame. Do not smoke in a room where varnish or lacquer is being sprayed. The spray may be highly explosive.

### 27. APPLICATION TO OSCILLOSCOPE I-245-B.

**a. Preparation.** Make all repairs and adjustments necessary for proper operation of the equipment.

**b. Disassembly.**

*(1)* Remove the two retaining screws from the rear of the case (fig. 3) and slide the chassis from the case.

*(2)* Remove one screw clamping the cathode-ray tube shield supporting bracket to the rear of the chassis (fig. 26).

*(3)* Remove the insulated connector cap from the intensifier terminal on the cathode-ray tube (fig. 26).

*(4)* Remove the cathode-ray tube from the socket and lift the tube and its shield from the chassis.

*(5)* Remove the four screws mounting the terminal board on the top side of the chassis and lift the board away from the chassis as far as the wiring will permit. Replace the screws in the chassis.

*(6)* Remove the screws mounting the three terminal strips on the rear of the chassis and pull the strips gently away from the chassis. Replace the screws in the chassis.

**c. Cleaning.** Clean all dirt, dust, rust, and fungus from the equipment to be processed. Clean all oil and grease from the surface to be varnished.

**d. Masking.**

*(1)* Mask the following parts on the top side of the chassis (fig. 6).

*(a)* Contacts and holes in the bases of the tube sockets (1).

*(b)* Opening in the front panel for the cathode-ray tube (2). Use a piece of cardboard and fasten it with tape.

*(c)* Cathode-ray tube socket (3).

*(d)* Holes in the cases of the four potentiometers mounted on the rear of the front panel (4).

*(e)* Contacts on the SYNC SIGNAL SELECTOR switch (5).

*(f)* Connector cap for the intensifier terminal on the cathode-ray tube (6).

*(g)* Holes in the ends of the two tuning coils (7).

# TM 11-2689

WAR DEPARTMENT TECHNICAL MANUAL

# OSCILLOSCOPE I-245-B





WAR DEPARTMENT

18 APRIL 1945

WAR DEPARTMENT TECHNICAL MANUAL

TM 11-2689

# OSCILLOSCOPE I-245-B

WAR DEPARTMENT 18 APRIL 1945

WAR DEPARTMENT,
Washington, D. C., 18 April, 1945.

TM 11-2689, Oscilloscope I-245-B, is published for the information and guidance of all concerned.
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By Order of the Secretary of War:

G. C. MARSHALL,
*Chief of Staff.*

Official:

J. A. ULIO,
*Major General,*
*The Adjutant General.*

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(For explanation of symbols see FM 21-6.)

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# LIST OF ILLUSTRATIONS

# DESTRUCTION NOTICE

**WHY** —To prevent the enemy from using or salvaging this equipment for his benefit.

**WHEN** —When ordered by your commander.

**HOW** —1. Smash—Use sledges, axes, handaxes, pickaxes, hammers, crowbars, heavy tools.

2. Cut —Use axes, handaxes, machetes.
3. Burn —Use gasoline, kerosene, oil, flame throwers, incendiary grenades.
4. Explosives—Use firearms, grenades, TNT.
5. Disposal —Bury in slit trenches, fox holes, other holes. Throw in streams. Scatter.

**USE ANYTHING IMMEDIATELY AVAILABLE FOR DESTRUCTION OF THIS EQUIPMENT.**

**WHAT** —1. Smash—Panels, switches, tubes, case. Be extremely careful when destroying cathode-ray tubes; use small arms fire from a shielded position.

2. Cut —Wiring, cables, transformer windings, choke windings.
3. Burn —Manuals, charts, schematics.
4. Bend —Framework, subpanels.
5. Bury or scatter—All of the above materials after destroying their usefulness.

## DESTROY EVERYTHING

---

## WARNING
## HIGH VOLTAGE

**is used in the operation of this equipment.**

## DEATH ON CONTACT

**may result if personnel fail to observe safety precautions.**

---

**OPERATION OF OSCILLOSCOPE I-245-B INVOLVES THE USE OF HIGH VOLTAGES WHICH ARE DANGEROUS TO LIFE. ANY MAINTENANCE TEST REQUIRING OPERATION OF THE OSCILLOSCOPE CHASSIS WITHOUT ITS PROTECTIVE CASE SHOULD BE UNDERTAKEN ONLY BY EXPERIENCED REPAIR PERSONNEL UNDER CONDITIONS OF ADEQUATE PRECAUTION AGAINST ELECTRIC SHOCK. BEFORE MAKING ANY SERVICE CHECKS ON THE OSCILLOSCOPE, MANUALLY DISCHARGE ALL HIGH-VOLTAGE CAPACITORS AFTER THE A-C POWER HAS BEEN REMOVED FROM THE INSTRUMENT.**

# FIRST AID TREATMENT FOR ELECTRIC SHOCK

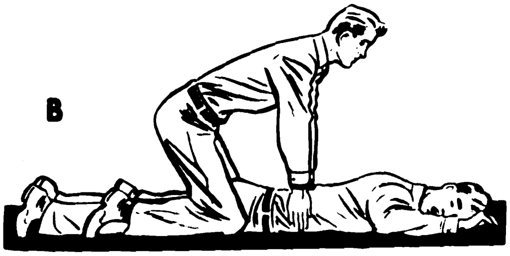
I. **FREE THE VICTIM FROM THE CIRCUIT IMMEDIATELY.**
Shut off the current. If this is not <u>immediately</u> possible, use a dry nonconductor (rubber gloves, rope, board) to move either <u>the victim or</u> the wire. Avoid contact with the victim. If necessary to cut a live wire, use an axe with a dry wooden handle. Beware of the resulting flash.

II. **ATTEND INSTANTLY TO THE VICTIM'S BREATHING.**
Begin resuscitation at once on the spot. Do not stop to loosen the victim's clothing. Every moment counts. Keep the patient warm. Wrap him in any covering available. Send for a doctor. Remove false teeth or other obstructions from the victim's mouth.

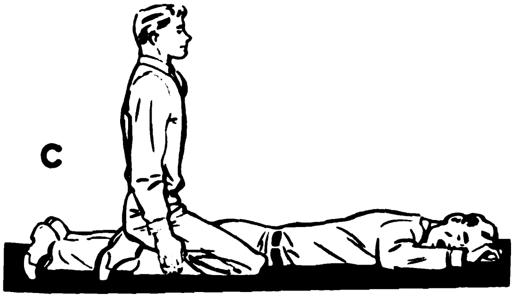
## *Resuscitation*

A

B



C



### POSITION

1. Lay the victim on his belly, one arm extended directly overhead, the other arm bent at the elbow, the face turned outward and resting on hand or forearm, so that the nose and mouth are free for breathing (fig. A).

2. Straddle the patient's thighs, or one leg, with your knees placed far enough from his hip bones to allow you to assume the position shown in figure A.

3. Place your hands, with thumbs and fingers in a natural position, so that your palms are on the small of his back, and your little fingers just touch his lowest ribs (fig. A).

### FIRST MOVEMENT

4. With arms held straight, swing forward slowly so that the weight of your body is gradually brought to bear upon the victim. Your shoulders should be directly over the heels of your hands at the end of the forward swing (fig. B). Do not bend your elbows. The first movement should take about 2 seconds.

### SECOND MOVEMENT

5. Now immediately swing backward, to remove the pressure completely (fig. C).

6. After 2 seconds, swing forward again. Repeat this pressure-and-release cycle 12 to 15 times a minute. A complete cycle should require 4 or 5 seconds.

### CONTINUED TREATMENT

7. Continue treatment until breathing is restored or until there is no hope of the victim's recovery. Do not give up easily. Remember that at times the process must be kept up <u>for hours</u>.

8. During artificial respiration, have someone loosen the victim's clothing. Wrap the victim warmly; apply hot bricks, stones, etc. Do not give the victim liquids until he is fully conscious. If the victim must be moved, keep up treatment while he is being moved.

9. At the first sign of breathing, withhold artificial respiration. If natural breathing does not continue, immediately resume artificial respiration.

10. If operators must be changed, the relief operator kneels behind the person giving artificial respiration. The relief takes the operator's place as the original operator releases the pressure.

11. Do not allow the revived patient to sit or stand. Keep him quiet. Give hot coffee or tea, or other internal stimulants.

## HOLD RESUSCITATION DRILLS REGULARLY

TL37451

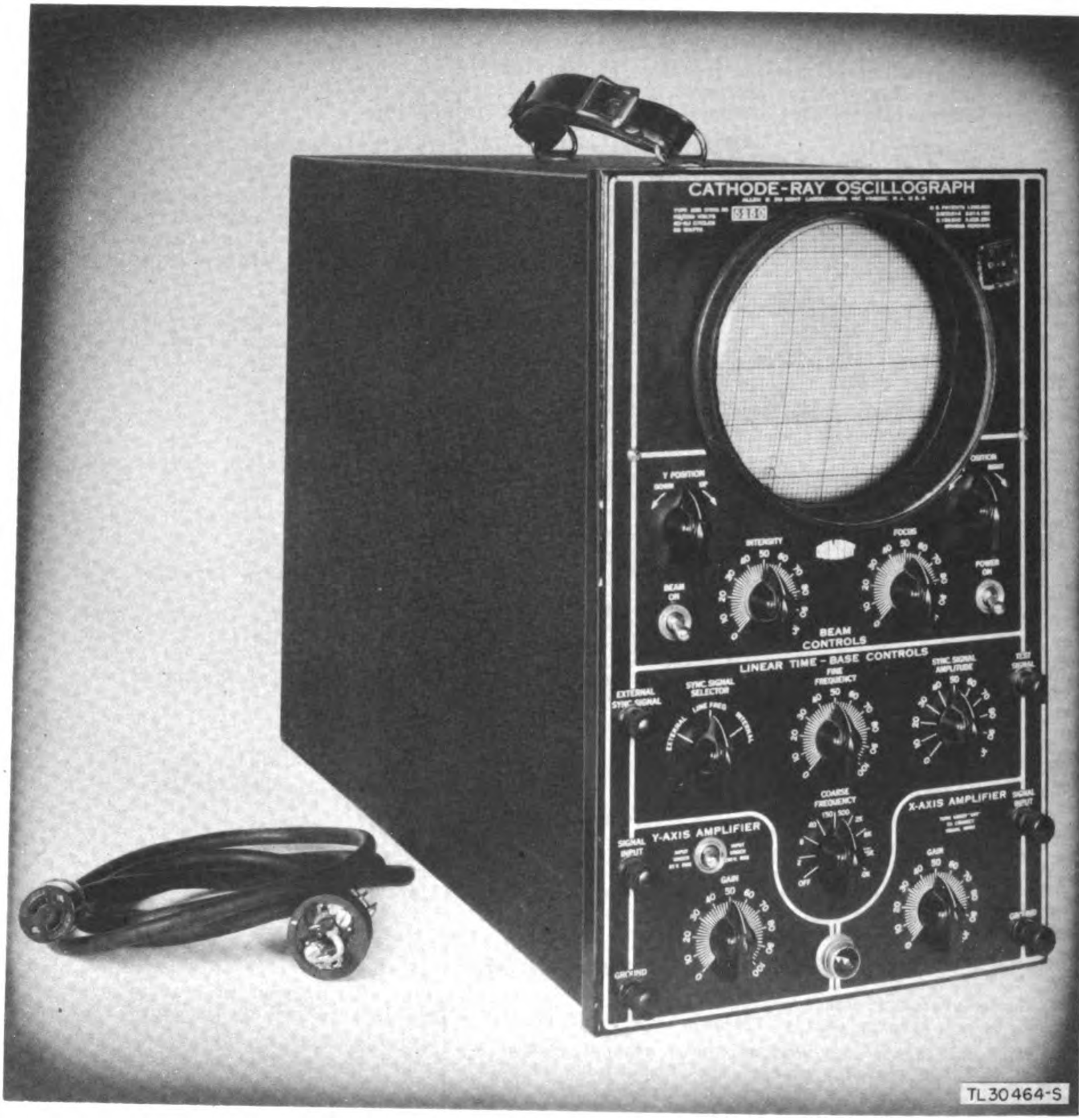



*Figure 1. Oscilloscope I-245-B.*

# PART ONE
# INTRODUCTION
## SECTION I
## DESCRIPTION

### 1. GENERAL.

Oscilloscope I-245-B is the Du Mont type 208-B cathode-ray oscilloscope (fig. 1). It is used for viewing waveforms and checking frequencies and phase relations at various test points in radio and radar sets. It consists of a cathode-ray tube using electrostatic focusing and deflection and connected in a conventional cathode-ray oscilloscope circuit. The instrument is mounted in a metal case with the operating controls located on the front panel. The screen of the cathode-ray tube is visible above the controls through an opening in the front panel. A linear sweep or timebase is generated internally. The amplitude and frequency of the sweep is variable. Different types of synchronizing signals with varying amplitudes may be applied. The signal to be viewed is applied to the vertical deflecting plates through an amplifier with variable gain. For special purposes external signals may be applied to the horizontal-deflecting plate through the X-axis amplifier, or to either pair of deflecting plates directly.

### 2. TECHNICAL CHARACTERISTICS.

Cathode-ray tube:
- Type ........ 5LP1 or 5LP5, high-vacuum, intensifier.
- Diameter ........ 5 inches.
- Deflection ........ Electrostatic.
- Focusing ........ Electrostatic.
- Persistence ........ Medium.
- Accelerating potential ........ 1,400 volts.

Input impedance:
- Y-axis ........ 2 megohms, 30 μμf.
- X-axis ........ .5 megohms, 25 μμf.

Maximum input potential:
- Y-axis ........ 250 rms volts maximum.
- X-axis ........ 25 rms volts maximum.

Amplifier frequency response:
- Y-axis ........ ±10 percent of maximum from 2 to 100,000 sinusoidal cycles per second. 50 percent response at 325,000 cycles per second.
- X-axis ........ ±10 percent of maximum from 2 to 100,000 sinusoidal cycles per second. 50 percent response at 250,000 cycles per second.

Voltage gain:
- Y-axis ........ 2,000
- X-axis ........ 43

Deflection factor:
- Through amplifier:
  - Y-axis ........ 0.010 rms volts per inch.
  - X-axis ........ 0.5 rms volts per inch.
- To deflection plates:
  - Y-axis ........ 21 rms volts per inch.
  - X-axis ........ 22 rms volts per inch.

Sweep circuit:
- Sweep direction .................. Left to right.
- Frequency (recurrent only) .. 2 to 50,000 cycles per second.

Number of tubes: 15

Power input:
- Potential ................................ 115/230 volts ac.
- Frequency ................................40 to 60 cycles per second.
- Power consumption ............ 90 watts.
- Fuse protection ....................1.5 amperes.

## 3. PHYSICAL DESCRIPTION.

The oscilloscope is mounted in a black wrinkle-finished steel cabinet supplied with a carrying handle (fig. 1). All of the controls and the input connection terminals for both amplifiers and the synchronizing circuit are available on the front panel (fig. 2). Direct connection to the deflecting plates may be made by means of terminals at the back of the case (fig. 3). Access to the inside of the instrument may be had by removing two screws at the back of the case and slipping the chassis and panel out. The line fuse and receptacle for the removable power cord are at the back of the unit. The cathode-ray tube screen is covered by a scale. Over-all dimensions excluding the carrying handle and feet are: height 14-1/4 inches, width 8-13/16 inches, and depth 19-1/2 inches. Net weight is 54 pounds.

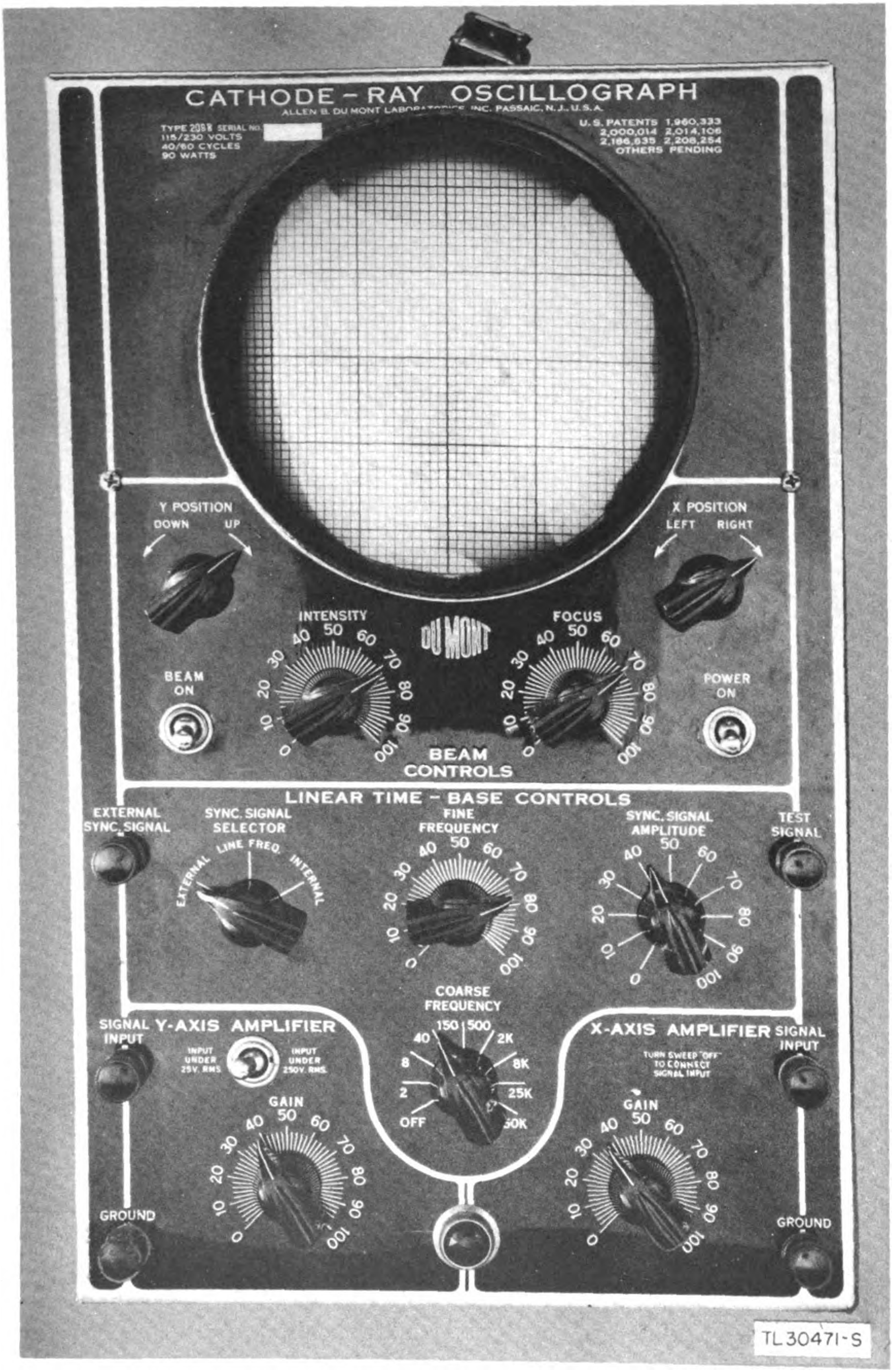



***Figure 2. Oscilloscope I-245-B, front view.***

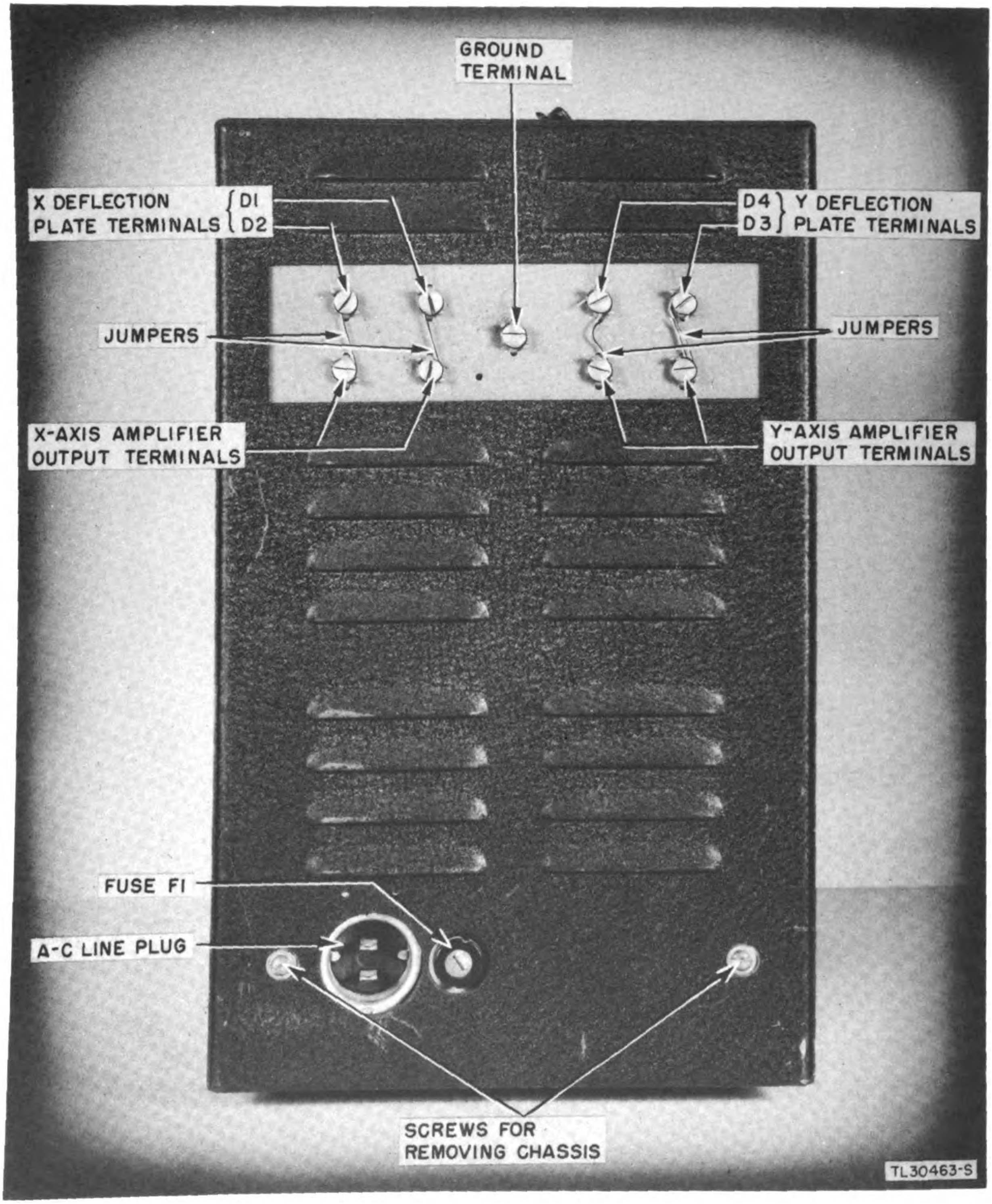



*Figure 3. Oscilloscope I-245-B, rear view.*

# SECTION II
# INSTALLATION

## 4. UNPACKING, UNCRATING, AND CHECKING.

Exercise particular care when unpacking or handling the equipment, because it may be damaged easily when it is not protected by the packing case. In unpacking the oscilloscope follow the steps outlined below.

a. Place the packing case in a convenient location where it can be opened easily.

b. If the instrument is packed in a wooden box, cut the steel straps which bind the box.

c. Remove the nails with a nail puller and remove the top of the packing case. *Prying the top off may result in damage to the equipment.*

d. Carefully lift the oscilloscope from the packing case and remove the waxed paper covering it.

e. Thoroughly inspect all parts of the case for possible damage during shipment.

f. Check the components against the master packing slip.

**CAUTION:** If the chassis has received moistureproofing and fungiproofing treatment, *do not remove* any of the protective coating.

## 5. INSTALLATION.

The equipment is shipped with a set of tubes installed in their respective sockets; check the tubes to see that each one is in the correct socket. Make sure that the tube clamps are seated firmly against the tube bases.

## 6. REMOVAL FROM SERVICE.

When the oscilloscope is not in use, always be sure that the switches are OFF. The power cord and leads should be removed, coiled, and stored.

# SECTION III
# INITIAL ADJUSTMENTS

## 7. LINE-VOLTAGE SELECTOR.

Remove the chassis from the cabinet and check the line-voltage selector switch (S7, fig. 28) to see that the power transformer is connected for the proper line voltage (115 or 230 volts).

## 8. CATHODE-RAY TUBE ADJUSTMENT.

a. Start the oscilloscope as explained in paragraph 10.

b. If the sweep line is not horizontal, rotate the cathode-ray tube until the sweep is horizontal. If the tube cannot be turned easily from the front, remove the chassis from the case and turn the tube base and socket (fig. 26).

# PART TWO
# OPERATING INSTRUCTIONS

**NOTE:** For information on destroying the equipment to prevent enemy use, refer to the destruction notice at the front of the manual.

## SECTION IV
## PREOPERATIONAL PROCEDURES

### 9. PREPARATION FOR USE.

Before handling Oscilloscope I-245-B, carefully read the instructions covering its use; it is a delicate electrical instrument and must be handled with care. *Pay particular attention to all cautions.* They are inserted to guide the user and to protect the equipment. Before turning on the oscilloscope, set the controls as follows (fig. 2):

**a.** POWER and BEAM switches OFF.

**b.** X and Y POSITION controls at midscale.

**c.** INTENSITY control completely counterclockwise.

**d.** FOCUS control at midscale.

**e.** COARSE FREQUENCY control at any position except OFF.

**f.** SYNC SIGNAL SELECTOR at INTERNAL.

**g.** SYNC SIGNAL AMPLITUDE control completely counterclockwise.

**h.** Attenuator switch to 250v or 25v position according to the amplitude of the Y signal input.

**i.** X GAIN control at midscale.

**j.** Y GAIN control completely counterclockwise.

**NOTE:** If direct-deflection tests are to be made, steps a through d apply.

### 10. STARTING THE OSCILLOSCOPE (fig. 2).

**CAUTION:** Do not leave the oscilloscope beam on indefinitely with no signals applied to either deflecting plates. The screen of the cathode-ray tube will be burned by the intense spot formed by the electron beam if the spot is left in one position too long. When observations are not being made, turn the BEAM switch OFF. This removes the spot or trace from the screen but keeps the instrument warmed up.

**a.** Set up the oscilloscope in the position where it is to be used.

**b.** Plug the line cord into the receptacle on the back of the oscilloscope and into the a-c line.

**c.** Turn the POWER switch ON.

**d.** Interconnect the oscilloscope and all other equipment used with a suitable ground wire.

**e.** Make the connections to the terminals of the instrument according to the test that is to be made (sec. V).

**f.** Turn the BEAM switch ON.

**g.** Adjust the INTENSITY and FOCUS controls until the line on the screen is sharp and well-defined.

**NOTE:** These two controls are interdependent: whenever the INTENSITY control is adjusted to change the brightness of the picture, the FOCUS control must be readjusted as well.

**h.** Adjust the Y POSITION control until the sweep line is centered vertically on the screen.

**i.** Adjust the X GAIN and X POSITION controls until the sweep line is the same length as the diameter of the screen and is centered horizontally.

# SECTION V

# OPERATION

## 11. GENERAL.

**a. Y-axis.** Y-axis deflection may be accomplished by applying the signal to be observed to the Y SIGNAL INPUT terminal or the Y direct deflection terminals (D3 and D4). This latter connection is especially valuable when observing pulses or square waves.

*(1) Y SIGNAL INPUT.* Signals for Y-deflection within the frequency and voltage range of the Y-amplifier (par. 2) are normally connected between the Y SIGNAL INPUT terminal and the GROUND terminal (fig. 2). The amplitude of deflection produced then depends upon the setting of the Y attenuator and Y GAIN controls, and these are adjusted until the desired deflection is produced.

*(2) Direct Deflection.* Signals may be connected directly to the Y-deflection plates of the cathode-ray tube by using the Y-deflection plate terminals (D3 and D4) on the terminal board at the back of the instrument (fig. 3). The jumper between the upper and lower terminal of each pair is disconnected, and the connections are made to the upper terminals. If the signal voltage is being measured with respect to ground, D4 should be grounded and the signal connected to D3. Connect a 5- to 10-megohm resistor from D3 to the ground terminal. If the signal is being measured between two points neither of which is at ground potential, each signal lead is connected to a deflection plate terminal, and a 5- to 10-megohm resistor is connected from each terminal to ground. If the signal is directly coupled to the deflection plate terminals, d-c voltages from the signal source will deflect the beam from its normal centered position. If this is undesirable, the signal may be capacitively coupled to the terminal by inserting a capacitor between the signal voltage and the terminal. Normally the Y POSITION control has no effect when the signal is directly connected, but it may be used when the signal source has high impedance by replacing the jumpers normally used with 5- to 10-megohm resistors. Small bypass capacitors should then be connected from the two lower terminals to ground.

**b. X-axis.** X-axis deflection may be accomplished by the following: the sweep generator or linear timebase; an external signal at the X SIGNAL INPUT posts; or an external signal at the direct deflection terminals. The use of the sweep generator is covered in subparagraph c below.

*(1) X SIGNAL INPUT.* When the COARSE FREQUENCY control is set to its extreme counterclockwise or OFF position, the X-axis amplifier is connected between the X SIGNAL INPUT terminal and the GROUND terminal (fig. 2). The amplitude of horizontal deflection produced then depends upon the X GAIN control; this control is adjusted until the desired deflection is produced. The range of signal voltage and frequency which may be used to give X-axis deflection is given in paragraph 2. ***If these values are exceeded, the X-amplifier may be overloaded and the pattern distorted.***

*(2) Direct Deflection.* Signals may be connected directly to the X-deflection plates of the cathode-ray tube by using the X-deflection plate terminals (D1 and D2) on the terminal board at the back of the instrument (fig. 3). If the signal is unbalanced, D1 should be grounded. Otherwise the information given in subparagraph a (2) above for Y-axis direct deflection applies to the X-axis as well.

**c. Sweep Generator.** The sweep generator is connected to the X-axis amplifier when the COARSE FREQUENCY control is set in any position except OFF. It produces a horizontal deflection of the beam by applying a saw-tooth voltage to the X-deflection plates through the X-amplifier. The resulting horizontal deflection consists of a uniform motion of the beam from left to right on the face of the tube, followed by a rapid return of the beam to its starting point. This is repeated at a rate depending upon the setting of the COARSE and FINE FREQUENCY controls (fig. 2). When the sweep is used to provide a timebase, it is ordinarily adjusted by means of the frequency controls to the same frequency as that of the Y-axis signal, or a frequency which is some simple fraction of the signal frequency, such as one-half or one-third. This produces a stationary pattern on the screen.

**d. Synchronization.** To hold the pattern stationary on the screen, it is necessary to apply a small synchronizing signal to the sweep generator. This signal is usually of the same frequency as the signal being observed, but may be a multiple or submultiple of that frequency if external synchronization is being used. This is accomplished by means of the SYNC SIGNAL AMPLITUDE and SYNC SIGNAL SELECTOR controls and the EXTERNAL SYNC SIGNAL terminal (fig. 2).

*(1) SYNC SIGNAL SELECTOR.* The SYNC SIGNAL SELECTOR switch determines the source of the signal used for synchronizing.

*(a)* In the EXTERNAL position the switch permits synchronizing the timebase oscillations with a signal connected between ground and the EXTERNAL SYNC SIGNAL input post. The amount of signal necessary is discussed in subparagraph 31c.

*(b)* When the switch is turned to the LINE FREQ position, a synchronizing signal is supplied from the power line.

*(c)* When the selector is in the INTERNAL position, a signal is taken from a suitable point in the Y-amplifier and used to synchronize the sweep.

*(2) SYNC SIGNAL AMPLITUDE Control.* This control varies the amplitude of the synchronizing signal used. The minimum amount of synchronizing voltage which gives good synchronization should always be used. Excess synchronizing voltage may introduce nonlinearity in the sweep.

*(3) EXTERNAL SYNC SIGNAL Input.* When synchronization is desired from a signal other than the power line or that amplified by the Y-amplifier, that signal voltage is connected to the EXTERNAL SYNC SIGNAL terminal and the SYNC SIGNAL SELECTOR is set at EXTERNAL.

**CAUTION:** Excessive synchronizing voltage fed to this terminal may be coupled into the X- or Y-axis amplifier and cause distortion. One volt peak-to-peak should be the maximum external synchronizing signal used, though pulses of short duration might require somewhat greater amplitudes. If large values of external synchronizing voltage are available, a suitable series resistor should be connected to the external synchronizing signal input terminal to reduce this to the maximum value given above.

**e. Test Leads.**

*(1)* Avoid the use of a shielded test lead or twisted leads in taking waveforms since both of these shunt a high capacitance across the circuit under test and are apt to cause distortion, especially if the waveform is high-frequency or contains high-frequency components. The ground lead must be securely connected at all times.

*(2)* Keep the ungrounded test lead away from other circuits to avoid the possibility of picking up unwanted voltages. The test lead should be brought away from the test point in such a way as to introduce a minimum amount of coupling to other stages.

*(3)* Leads to the scope must be kept short when observing waveforms in grid circuits where the grid capacitance is small. The input of the oscilloscope has high impedance but it will cause loading on another high-impedance circuit and may distort the waveform. The smallest reaction on a waveform is introduced when measuring the voltage across the output (cathode) of a cathode follower or across low-impedance circuits in general.

*(4)* In measuring waveforms in high-impedance circuits, do not handle the *hot* test lead. If this precaution is not observed, the waveform will be distorted as a result of loading the circuit and picking up a 60-cycle voltage.

*(5)* A misleading indication may sometimes be obtained as the result of a signal voltage picked up by the test leads. For example a plate-to-grid coupling capacitor may be open, yet a signal appears at the grid. This effect can be recognized by distortion of the waveform due to the loss of low-frequency components.

## 12. OBSERVATION OF WAVEFORMS.

**a. Y SIGNAL INPUT.**

*(1)* Adjust all controls and connect the signal as explained in paragraphs 10 and 11a(1).

*(2)* Adjust the attenuator switch and Y GAIN control until a convenient amplitude of vertical deflection is obtained on the screen.

*(3)* Adjust the COARSE FREQUENCY and FINE FREQUENCY controls until one or more cycles of the waveform under test are seen. It is advisable to have two or three cycles of the waveform on the screen, especially if the waveform being tested is of a relatively high frequency; then disregard the cycle at the right end of the sweep (par. 31d).

*(4)* When the pattern has been adjusted as closely as possible with the FINE FREQUENCY control, advance the SYNC SIGNAL AMPLITUDE control just far enough to hold the pattern stationary.

**b. Direct Deflection.**

*(1)* Adjust the beam, linear timebase, and X-axis amplifier controls and connect the signal voltage to be viewed as explained in paragraphs 10 and 11a(2).

*(2)* Connect a jumper from the signal source to the EXTERNAL SYNC SIGNAL terminal.

*(3)* Set the SYNC SIGNAL SELECTOR to EXTERNAL.

*(4)* Adjust the COARSE FREQUENCY and FINE FREQUENCY controls until several cycles of the waveform under test are seen.

*(5)* When the pattern has been adjusted as closely as possible with the FINE FREQUENCY control, advance the SYNC SIGNAL AMPLITUDE control just enough to hold the pattern stationary.

**c. Waveforms with Special Timebase.** For some special purposes it is desirable to view waveforms on a circular, spiral, exponential or other nonlinear timebase, or on a linear timebase of higher frequency than that furnished by the internal timebase generator of the instrument. This timebase voltage may be applied through the X-axis amplifier (subpar. 11b(1) above) or directly to the horizontal deflecting plates (subpar. 11b(2) above). In either case the synchronizing circuit in the oscilloscope is inoperative. Circuits for generating special tyes of sweep voltages are given in TM 11-466, 29 June, 1944, paragraph 63.

**d. Comparison of Waveforms.** When reference waveforms are supplied with equipment, the actual waveform taken at a point with the oscilloscope should be quite similar to the reference waveform provided there is no fault in the equipment. Some differences in shape may occur for the following reasons, however, even though the circuit is normal:

*(1)* The test leads to the oscilloscope may not be placed in the same manner.

*(2)* A different oscilloscope may be used, having values of input resistance and capacitance which differ from those of Oscilloscope I-245-B.

*(3)* The various controls in the equipment may not be in the same positions as when the reference waveforms were taken. Note the conditions specified in the reference waveforms.

*(4)* The same number of cycles may not be present.

*(5)* The vertical or horizontal amplitudes of the reference waveforms and the test patterns may not be proportional. This will produce apparent differences in the shape of the two waveforms when there is no real difference.

*(6)* Whether or not a waveform is regarded as abnormal depends on the symptoms accompanying the fault which is being traced. If it is considered that the fault could be caused by a minor difference in waveform at the point under test, then this discrepancy should be considered significant. Otherwise time should not be spent in hunting down the cause for relatively minor differences between the shape of the reference waveform and the test waveform.

## 13. A-C VOLTAGE MEASUREMENT.

**a. Calibration of Oscilloscope.** The deflection sensitivity of the oscilloscope when used to measure a-c voltages may be varied over wide limits by adjustment of the Y GAIN control. Calibration consists in adjusting the Y amplifier gain to give a known deflection sensitivity. The deflection sensitivity desired depends on the amplitude of the voltage to be measured. For small voltages, the greater sensitivities (smaller number of volts per inch) will be used. The procedure for adjusting the sensitivity to the desired value is as follows:

*(1)* Apply a known sinusoidal a-c voltage to the Y SIGNAL INPUT terminal and adjust the controls to give a stationary picture on the screen with a convenient vertical deflection.

*(2)* Multiply the rms value of the known a-c voltage by 2.83 to obtain its peak-to-peak value.

*(3)* Multiply the result obtained in subparagraph (2) above by the factor indicated below for the deflection sensitivity desired:

| *Deflection sensitivity* | *Multiply by* |
|---|---|
| 0.1 volts per inch | 100 |
| 1 volt per inch | 10 |
| 10 volts per inch | 1 |
| 100 volts per inch | 1/10 |

*(4)* Adjust the attenuator switch (S1) and Y GAIN control until the peak-to-peak deflection of the signal on the screen is the sâme number of scale divisions as the result obtained in subparagraph (3) above.

**b. Measurement of Unknown Voltage.**

*(1)* When the scope has been calibrated as in subparagraph a above, the peak-to-peak value of any a-c voltage within the range for which the calibration has been made may be determined by applying the unknown voltage to the Y SIGNAL INPUT terminal and observing the deflection on the scale over the screen. The positioning and frequency controls may be adjusted to bring the picture into a better position for reading, but the Y GAIN control must not be moved once the calibration has been made. The deflection sensitivity may be changed in the ratio of 10:1, however, without affecting the calibration, by changing the attenuator switch.

*(2)* For a sinusoidal voltage the rms value may be determined by dividing the peak-to-peak value obtained from the oscilloscope measurement by 2.83.

## 14. D-C VOLTAGE MEASUREMENT.

D-c voltages are usually measured with a d-c voltmeter. In special cases, however, it is desirable to use the oscilloscope to reduce loading of the circuit in which the measurement is being made. The procedure is as follows:

**a.** Start the oscilloscope as explained in paragraph 10. Then turn the BEAM switch OFF.

**b.** Disconnect the jumpers for the vertical-deflecting plates, D3 and D4, on the terminal board at the back of the chassis (fig. 3) and ground both upper terminals.

**c.** Turn the BEAM switch ON, adjust the FOCUS control, and observe the position of the sweep line on the screen. Then turn the BEAM switch OFF.

**d.** To measure an unknown d-c voltage, disconnect the D3 terminal from the ground terminal and connect the unknown signal between D3 and D4.

**e.** Turn the BEAM switch ON and observe the position of the line on the screen.

**f.** Count the number of scale divisions between the two positions of the sweep line on the screen and multiply this number by 5.9 to obtain the reading in volts. An upward deflection indicates that the positive terminal is attached to D3. A downward deflection indicates the opposite polarity.

## 15. COMPARISON OF UNKNOWN FREQUENCY WITH A STANDARD.

Since the frequency controls of the oscilloscope are not precisely calibrated, the instrument may not be used as an absolute frequency measuring device. The only method by which a frequency may be measured is by comparison with a standard frequency such as the power line frequency or the output of a calibrated signal generator. Two methods are possible, one using Lissajous figures and the other using the internal linear timebase. The first method (subpar. a below) is applicable only to sine waves. The second method (subpar. b below) may be used for any type of voltage wave.

**a. Measurement by Means of Lissajous Figures.**

*(1)* Start the oscilloscope as explained in paragraph 10.

*(2)* Turn the BEAM switch and COARSE FREQUENCY control to OFF and connect the standard frequency source between the X SIGNAL INPUT and GROUND terminals.

*(3)* Turn the BEAM switch ON and adjust the X GAIN control until a convenient horizontal deflection is obtained on the screen.

*(4)* Connect the unknown signal between the Y SIGNAL INPUT and GROUND terminals.

*(5)* Adjust the attenuator switch and Y GAIN controls until a pattern of convenient shape is seen on the screen. This pattern is called a Lissajous figure. Typical patterns are shown in figure 4.

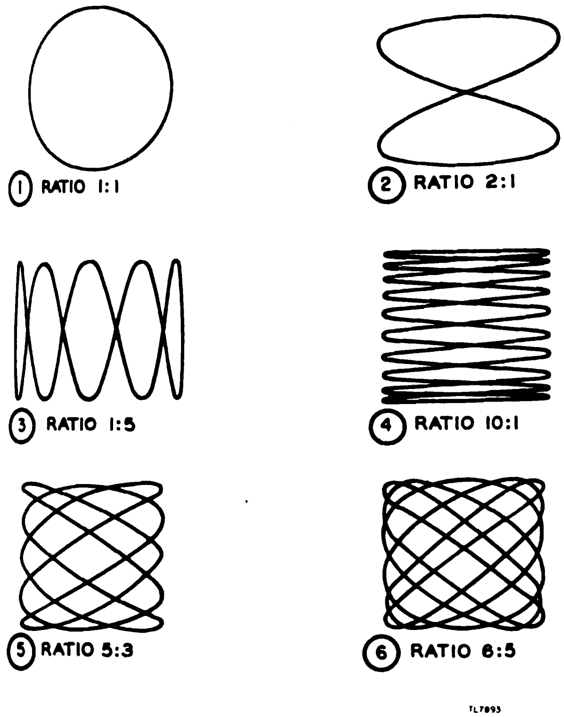



*Figure 4. Lissajous figures for various frequency ratios.*

*(6)* If the frequency ratio is large or not a simple ratio, the pattern is difficult to interpret. If the standard source of frequency is variable, it can be adjusted until a stationary pattern with a ratio of 1:1, 2:1, 3:2, or some other simple pattern is obtained.

*(7)* Inclose the pattern with an imaginary rectangle the sides of which are tangent to the pattern and parallel to the X and Y axes.

*(8)* At an instant when the pattern shows open loops, count the number of points at which the pattern is tangent to the vertical side and to the horizontal side of the rectangle.

*(9)* The ratio of the X to the Y frequency is equal to the ratio of the number of points of tangency on a vertical side to the number of points of tangency on a horizontal side or:

$$\text{Y frequency} = \frac{\text{Number of horizontal tangent points}}{\text{number of vertical tangent points}} \times \text{standard frequency.}$$

**b. Measurement by Calibration of Oscilloscope Linear Timebase.**

*(1)* Adjust the oscilloscope for observing waveforms as explained in paragraph 12a.

**CAUTION:** Use no synchronizing voltage in this test; set SYNC. SIGNAL SELECTOR switch to the EXTERNAL position.

*(2)* Remove the signal from the input terminal and connect the output of a calibrated signal generator to the Y SIGNAL INPUT.

*(3)* Adjust the signal generator until a steady pattern is obtained with the same number of cycles as was observed with the unknown signal or with some other integral number of cycles.

*(4)* The ratio between the unknown frequency and the signal generator frequency is the

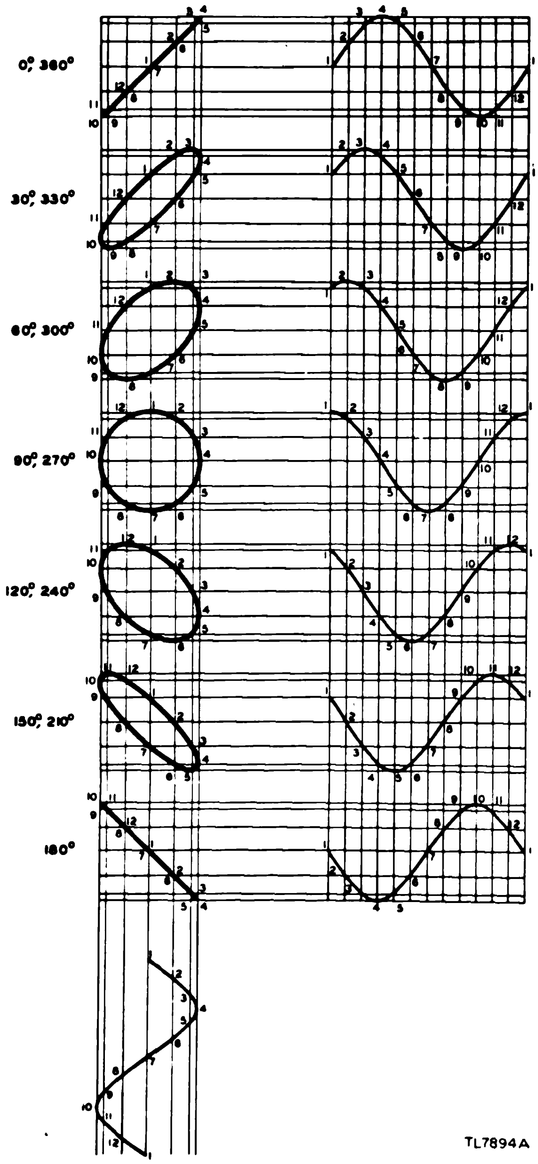



*Figure 5. Lissajous figures for various phase differences.*

same as the ratio of the number of cycles of signal frequency seen on the screen to the number of cycles of the signal generator frequency seen.

### 16. INDICATION OF PHASE ANGLE.

This method of indicating phase angle can be used only with sine waves of the same frequency and amplitude. For the measurement of phase angles between narrow pulses, use the procedure for measuring short time intervals given in paragraph 17.

**a.** Adjust the oscilloscope controls and connect the two signals to the input terminals in the same manner as explained in paragraph 15a.

**b.** The pattern obtained is a special type of Lissajous figure. The way in which phase difference is indicated is shown in figure 5. The phase angle cannot be read directly except at 0°, 90°, and 180°. This method of measurement is chiefly useful in adjusting a phase-shifting circuit so that the output is exactly in phase, or 90° or 180° out of phase, with a reference waveform.

### 17. MEASUREMENT OF SHORT TIME INTERVALS.

If a calibrated signal generator is available, time intervals between narrow pulses having the same recurrence frequency can be measured from approximately 1 microsecond to 0.5 second. The procedure is as follows:

**a.** Start the oscilloscope as explained in paragraph 10.

**b.** Connect one signal to the Y SIGNAL INPUT terminal and adjust the attenuator and Y GAIN controls until a convenient vertical deflection is obtained.

**c.** Adjust the X GAIN control until a horizontal deflection of four inches (40 scale divisions) is obtained.

**d.** Advance the frequency controls until a stationary picture with only one cycle of the wave is obtained.

**e.** Connect the other signal in parallel with the first at the Y SIGNAL INPUT and advance the frequency controls if necessary until a stationary pattern is obtained with the two pulses separated a convenient amount on the screen. Observe the number of scale divisions between the leading edges on the two pulses.

**f.** Disconnect the two signals and connect the signal generator output to the Y SIGNAL INPUT terminal.

**g.** Adjust the signal generator frequency control until one cycle of the sine wave output is seen on the screen.

**h.** The time interval between pulses is obtained from the following formula:

$$t = \frac{25{,}000d}{f}$$

where t = time interval in microseconds
d = number of scale divisions between pulses
f = frequency of the signal generator output in cycles per second.

**i.** If the difference in time is desired as a phase angle, use the following formula:

$$a = 9d$$

where a = the phase angle in degrees
d = the number of scale divisions between pulses.

### 18. CHECKING RADIO TRANSMITTERS.

**a. Neutralization of Radio Transmitters.** Neutralization of the radio-frequency (r-f) amplifier stages of a transmitter can be accomplished with the cathode-ray oscilloscope. The procedure for neutralization is essentially the same as any other method with the exception that the oscilloscope is used as the indicating instrument.

*(1)* Start the oscilloscope as explained in paragraph 10.

*(2)* Apply filament power, grid bias, and grid excitation to the stage to be neutralized, but *apply no plate voltage.*

*(3)* With circuits utilizing link coupling between successive amplifier stages, the link winding coupled to the plate circuit of the amplifier to be neutralized can be connected directly to the terminals of the oscilloscope through a twisted pair of wires. If the frequency of operation of the r-f amplifier is below 3 megacycles, connect the link to the Y SIGNAL INPUT terminals as explained in paragraph 12a. If the frequency of operation is above 3 megacycles, connect the link coupling to the Y-axis direct deflection terminals D3 and D4 as explained in paragraph 12b.

*(4)* In general it will be impossible to synchronize the trace, and in this operation synchronization is not necessary. The amount of Y-axis deflection is the only indication of whether or not the r-f amplifier is neutralized.

*(5)* Assuming that the r-f amplifier is not neutralized, tune in the plate tank tuning capacitor for maximum Y-axis deflection on the oscilloscope.

*(6)* When the maximum is reached, tune the neutralizing capacitor for minimum Y-axis deflection. In using the Y-axis amplifier, adjust the attenuator and Y GAIN controls for maximum necessary sensitivity.

*(7)* Varying the plate tank tuning capacitor over its range now should produce no change in the Y-axis deflection if the r-f amplifier is properly neutralized.

*(8)* With amplifiers which do not have link couplings it is necessary to use an auxiliary link coil made of a few turns of wire and coupled to the tank coil of the r-f amplifier. Care must be taken when using an auxiliary link coil not to couple it so close as to alter the circuit conditions.

**b. Checking Phone Transmitter Operation.** The most reliable method of determining percentage of modulation of a transmitter is by means of the oscilloscope. Two types of oscilloscope patterns may be obtained: the *wave envelope* and the *trapezoid.* The former shows the shape of the modulation envelope directly, while the latter in effect plots the modulation characteristic of the modulated stage on the cathode-ray tube screen.

*(1) Wave Envelope Pattern.*

*(a)* Start the oscilloscope as explained in paragraph 10.

*(b)* Place a few turns of wire near the final tank circuit and connect the ends of the loop to the Y-axis direct deflection terminals D3 and D4 as explained in paragraph 12a.

*(c)* Synchronize the oscilloscope to the audio component of the r-f modulated wave by adjustment of the COARSE FREQUENCY and FINE FREQUENCY controls and the SYNC SIGNAL AMPLITUDE control.

*(d)* The picture seen is a reproduction of the modulation envelope filled in with the r-f cycles. The degree of modulation is obtained from the formula:

$$m = \frac{B-A}{B+A}$$

where m = degree of modulation
B = vertical height of pattern at its highest point
A = vertical height of pattern at its narrowest point.

*(2) Trapezoidal Pattern.* This pattern is more difficut to obtain than the wave envelope pattern but gives clearer information when non-sinusoidal waveforms are encountered.

*(a)* Couple the transmitter output to the Y-axis deflecting plates in the same manner as for the wave envelope pattern (subpar. (1) above).

*(b)* Connect a coupling capacitor to the modulation connection on the r-f amplifier and a voltage divider between the capacitor and ground.

*(c)* Adjust the tap on the voltage divider so as to tap off a few volts of the modulator audio output voltage, and connect it to the X SIGNAL INPUT terminal of the oscilloscope.

*(d)* Adjust the width of the pattern with the X GAIN control.

*(e)* The figure obtained should be a triangle for 100 percent modulation, a trapezoid for less than 100 percent modulation, and a triangle with a straight line extending from one vertex for more than 100 percent modulation. The degree of modulation is obtained from the formula:

$$m = \frac{B-A}{B+A}$$

where m = degree of modulation
B = length of longer vertical side of trapezoid
A = length of shorter vertical side of trapezoid.

NOTE: In order to obtain the trapezoidal pattern, the modulating voltage fed to the oscilloscope must be in phase with the modulation envelope. In some cases it may be necessary to connect a phase-shifting device between the modulator audio output and the X SIGNAL INPUT terminal and to adjust the phase shift until the trapezoidal or triangular pattern is obtained. (For phase-shifting circuits, see TM 11-466, 29 June, 1944, paragraph 52.)

## 19. SIGNAL TRACING.

**a. General.** Signal tracing is a trouble-shooting procedure which consists of checking the waveform of a signal at the input and output of successive stages through a circuit. By *signal* is meant any waveform which normally appears throughout the circuit or, in the case of a receiver, an audio signal supplied by a signal generator. Any departure from the normal wave form indicates a fault located between the point where the signal is last normal and the point where it is observed to be abnormal. For example, if a waveform is found to be normal at the grid of a stage and abnormal at the plate of the same stage, this indicates that the trouble lies in that stage.

**b. Procedure.**

*(1)* Start the oscilloscope as explained in paragraph 10 and connect a test prod to the Y SIGNAL INPUT terminal.

*(2)* If the circuit under test has its own signal waveform, check the waveform by placing the test prod at the following points in succession: input of the first stage, output of the first stage, input of the second stage, output of the second stage, etc.

*(3)* If an audio amplifier is being traced, connect the output of an audio signal generator to the input of the first stage and trace the signal in the same manner as explained in subparagraph (2) above.

*(4)* If a receiver or the intermediate-frequency (i-f) section of a receiver is being traced, connect the output of a modulated r-f signal generator of the proper frequency to the input of the first stage and trace the signal in the same manner as explained in subparagraph (2) above.

*(5)* In following the path of a signal through a circuit, the amplitude of the waveform will usually increase as the checking point progresses from the input to the output stages. This is not always true, however. For example, when going from the grid to the cathode of a cathode-follower stage, there is a loss of signal amplitude of about 10 percent or more. Another example is in wave-shaping circuits where a decrease in the width of a signal is accompanied by a decrease in amplitude (as in differentiating circuits).

## 20. I-F ALIGNMENT.

**a.** Start the oscilloscope as explained in paragraph 10.

**b.** Disconnect the local oscillator of the receiver from the mixer stage or make it inoperative by removing it, removing its plate voltage, grounding its grid, or by some other convenient means.

**c.** Connect the output of a modulated signal generator of proper frequency to the input of the first i-f stage.

**d.** Connect the output of the second detector or final audio or video stage to the Y SIGNAL INPUT terminal of the oscilloscope.

**e.** Keep the signal generator output at the lowest value which will give a satisfactory signal at the output of the i-f section.

**f.** Tune the i-f coils or transformers, in order, for maximum deflection on the oscilloscope, beginning with the last one and working back to the first.

**NOTE:** Some receivers have a stagger-tuned i-f section in order to give wide band pass. These receivers require a special tuning procedure. Before aligning the i-f section on any receiver, consult all information furnished with that receiver.

# PART THREE
# PREVENTIVE MAINTENANCE

## SECTION VI
## PREVENTIVE MAINTENANCE TECHNIQUES

### 21. MEANING OF PREVENTIVE MAINTENANCE.

Preventive maintenance is performed at regular intervals on test equipment when it is not in use to keep the equipment operating at top efficiency and to prevent break-downs. A distinction must be made between preventive maintenance, and trouble shooting and repair. The prime function of preventive maintenance is to *prevent* break-downs and, therefore, the need for repair. On the other hand, the prime function of trouble shooting and repair is to locate and correct existing defects as the importance of preventive maintenance cannot be overemphasized. The efficiency of a radio system depends upon the readiness and operating efficiency of each item of equipment when it is needed.

### 22. DESCRIPTION OF PREVENTIVE MAINTENANCE TECHNIQUES.

**a. General.** Because hit-or-miss maintenance techniques cannot be applied, definite and specific instructions are needed. The four basic maintenance operations required for this instrument are: Feel, Inspect, Tighten, and Clean. The first two operations establish the need for the other two. The selection of operations is based on a general knowledge of field needs. For example, the dust encountered on dirt roads during cross-country travel filters into the equipment no matter how much care is taken to prevent it. Rapid changes in weather (such as heavy rain followed by blistering heat), excessive dampness, snow, and ice tend to cause corrosion of exposed surfaces and parts. Without frequent inspections and the necessary performance of preventive maintenance, equipment soon becomes undependable and subject to break-down when it is most needed.

**b. Feel.** The feel operation is used most often to check transformers, chokes, and resistors for overheating, and to check electrical connections for looseness. The maintenance man must become familiar with the normal operating temperature of parts within the equipment in order to recognize signs of overheating.

NOTE: It is important that the feel operation be performed as soon as possible after the equipment is shut down and always before any other maintenance is done.

**c. Inspect.** Inspection is the most important operation in the preventive maintenance program. A careless observer will overlook the evidences of minor trouble. Valuable time and effort can be saved if defects are corrected before they lead to major break-downs. Make every effort to become familiar with the indications of normal functioning, in order to recognize the signs of a defective instrument. Inspection consists of carefully observing all parts of the equipment, noting state of cleanliness, placement of wires and cables, etc.

**d. Tighten.** This operation consists of tightening all loose connections, controls, terminals, and mounting screws.

**e. Clean.** The instrument must be kept thoroughly clean. All corrosion must be removed from metal parts and connections. Use crocus cloth if necessary. Dust, dirt, or other foreign matter can be removed with a small clean brush or a clean cloth moistened with a cleaning solvent.

### 23. COMMON MATERIALS NEEDED.

The following materials are needed in performing preventive maintenance on the equipment:

Common hand tools (TE-41 or equivalent).
Clean cloth.
Sandpaper #0000.
Crocus cloth.
Paint brush, small.
Solvent, Dry-cleaning, Federal Specification P-S-661a.

NOTE: Gasoline will not be used as a cleaning fluid for any purpose. Solvent, Dry-cleaning, Federal Specification P-S-661a, is available as a cleaning fluid through established supply channels. Oil, fuel, Diesel, U. S. Army Specification 2-102B, may be used for cleaning purposes when

**dry-cleaning solvent is not at hand. Carbon tetrachloride will be used, if necessary, *only on contact parts of electronic equipment.***

## 24. APPLICATION TO OSCILLOSCOPE I-245-B.

General instructions are given below for the application of preventive maintenance techniques to Oscilloscope I-245-B. All work is to be performed with the instrument disconnected from the power line. Discharge all capacitors as soon as the chassis is removed from the case and before doing any work. After completion of the work, the oscilloscope should be put into operation and checked for satisfactory performance.

**a. Feel.** Feel transformer T1 and filter chokes L7 and L8 (fig. 28) for overheating as soon as possible after shutting down the oscilloscope.

**b. Inspect.** Observe all parts of the equipment carefully and note any signs of overheating as indicated by discoloration of the affected parts. Note the general condition of resistors, capacitors, potentiometers, chokes, coils, switches, terminal strips, and wiring. Look for loose or broken connections, loose mountings and parts, and cut or frayed insulation on the wiring. Examine all recesses for accumulation of dust and dirt, especially between connecting terminals. Parts, connections, and terminals must be free of rust and corrosion. In tropical and high-humidity locations, look for fungus growth and mildew. Examine all tubes to see that they are firm in their sockets, and all mounting screws for tightness. Inspect the a-c cord for worn or frayed insulation and broken wires or connections.

**c. Tighten.** All loose mountings must be securely tightened in place. If connections are dirty or corroded, clean them before tightening them. Tighten all loose terminals and resolder, or otherwise repair, any faulty or broken connections. If any clips on tube sockets are loose, compress them slightly with pliers.

**d. Clean.** All dirt and other foreign matter must be removed from the equipment. Clean all terminal boards, capacitors, resistors, potentiometers, tubes, tube sockets, transformers, and choke coils with a cleaning cloth. When it is necessary to use a cloth moistened with the dry-cleaning fluid, always wipe the surfaces thoroughly dry with a clean cloth. Do not displace any of the wiring when cleaning. Wipe the case clean inside and out.

# SECTION VII
# MOISTUREPROOFING AND FUNGIPROOFING

## 25. GENERAL.

When operated in tropical areas where temperature and relative humidity are extremely high, Signal Corps equipment requires special attention. These are some of the problems met:

**a.** Resistors, capacitors, coils, chokes, transformer windings, etc., fail because of the effects of fungus growth and excessive moisture.

**b.** Electrolytic action, often visible in the form of corrosion, takes place in resistors, coils, chokes, transformer windings, etc., causing eventual break-down.

**c.** Hook-up wire insulation and cable insulation break down. Fungus growth accelerates deterioration.

**d.** Moisture forms electrical leakage paths on terminal boards and insulating strips, causing flash-overs.

## 26. TREATMENT.

A moistureproofing and fungiproofing treatment has been devised which, if properly applied, provides a reasonable degree of protection against fungus growth, insects, corrosion, salt spray, and moisture. The treatment involves the use of a moisture-and fungi-resistant varnish applied with a spray gun or brush. Refer to TB SIG 13, Moistureproofing and Fungiproofing Signal Corps Equipment, for a detailed description of the varnish-spray method of moistureproofing and fungiproofing and the supplies and equipment required in this treatment.

**CAUTION:** Varnish spray may have poisonous effects if inhaled. To avoid inhaling spray, use respirator if available; otherwise, fasten cheesecloth or other cloth material over nose and mouth. Never spray varnish or lacquer near an open flame. Do not smoke in a room where varnish or lacquer is being sprayed. The spray may be highly explosive.

## 27. APPLICATION TO OSCILLOSCOPE I-245-B.

**a. Preparation.** Make all repairs and adjustments necessary for proper operation of the equipment.

**b. Disassembly.**

*(1)* Remove the two retaining screws from the rear of the case (fig. 3) and slide the chassis from the case.

*(2)* Remove one screw clamping the cathode-ray tube shield supporting bracket to the rear of the chassis (fig. 26).

*(3)* Remove the insulated connector cap from the intensifier terminal on the cathode-ray tube (fig. 26).

*(4)* Remove the cathode-ray tube from the socket and lift the tube and its shield from the chassis.

*(5)* Remove the four screws mounting the terminal board on the top side of the chassis and lift the board away from the chassis as far as the wiring will permit. Replace the screws in the chassis.

*(6)* Remove the screws mounting the three terminal strips on the rear of the chassis and pull the strips gently away from the chassis. Replace the screws in the chassis.

**c. Cleaning.** Clean all dirt, dust, rust, and fungus from the equipment to be processed. Clean all oil and grease from the surface to be varnished.

**d. Masking.**

*(1)* Mask the following parts on the top side of the chassis (fig. 6).

*(a)* Contacts and holes in the bases of the tube sockets (1).

*(b)* Opening in the front panel for the cathode-ray tube (2). Use a piece of cardboard and fasten it with tape.

*(c)* Cathode-ray tube socket (3).

*(d)* Holes in the cases of the four potentiometers mounted on the rear of the front panel (4).

*(e)* Contacts on the SYNC SIGNAL SELECTOR switch (5).

*(f)* Connector cap for the intensifier terminal on the cathode-ray tube (6).

*(g)* Holes in the ends of the two tuning coils (7).

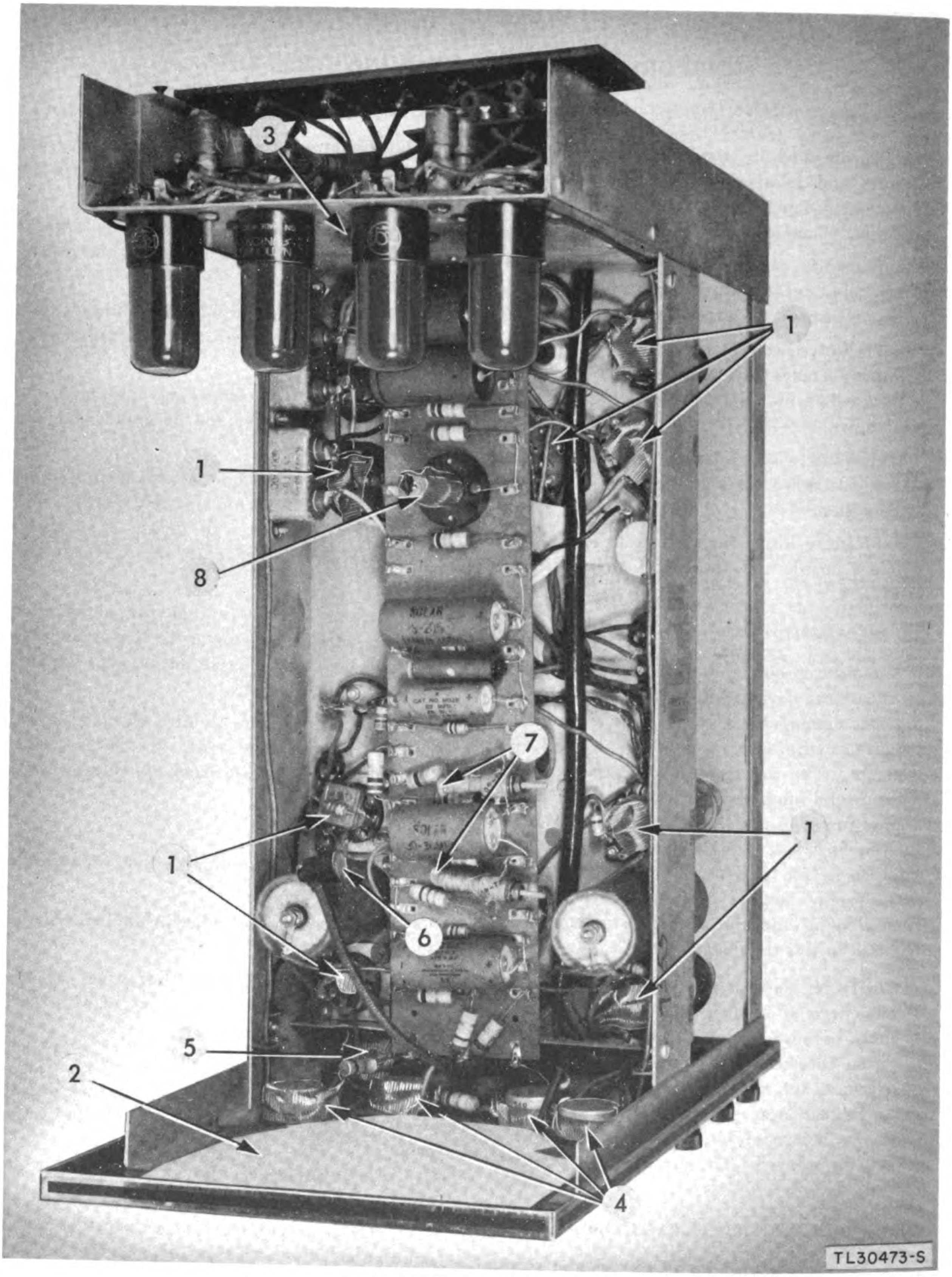



*Figure 6. Top of chassis masked.*

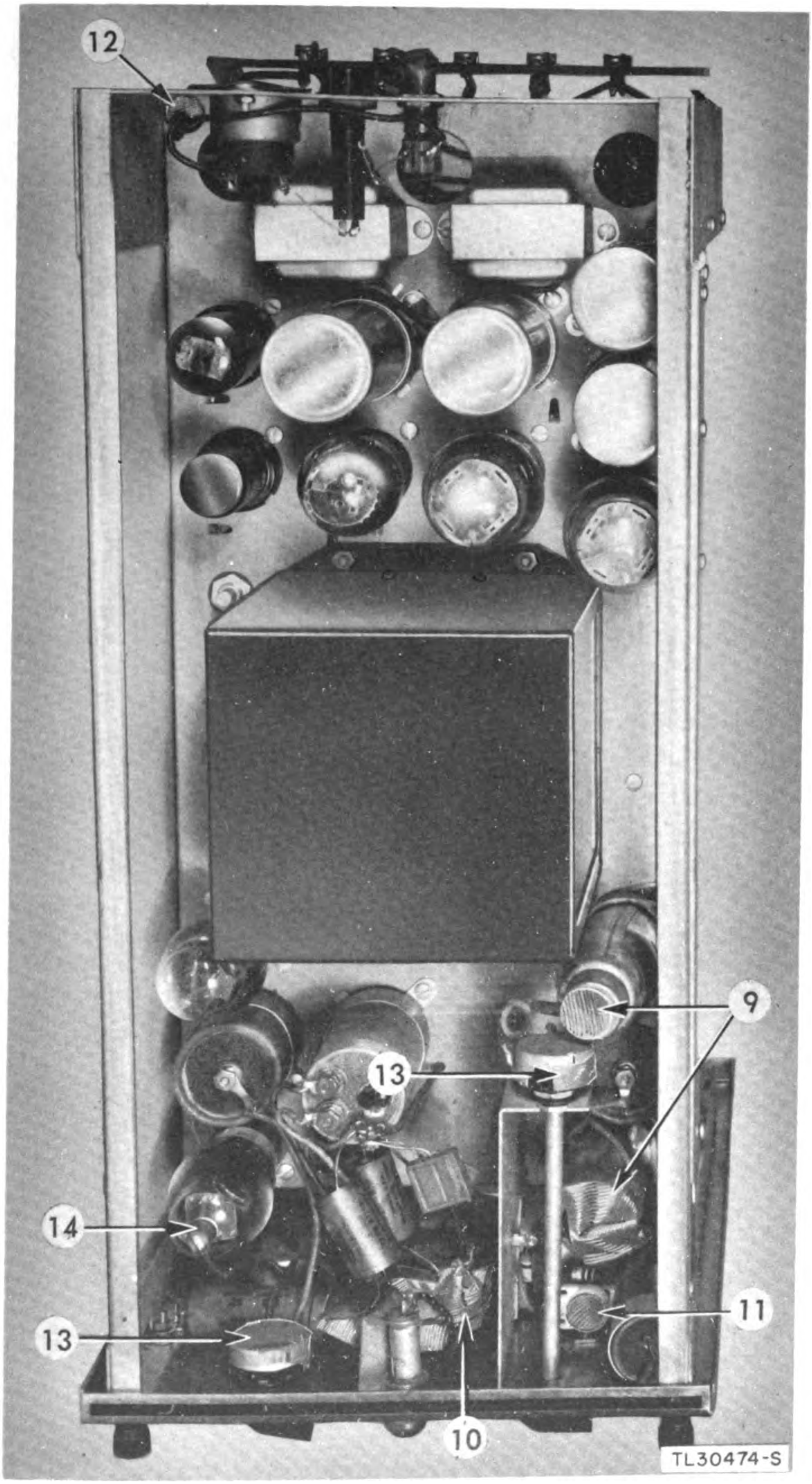



*Figure 7. Bottom of chassis masked.*

*(b)* Neon bulb (8).

*(2)* Mask the following parts on the under side of the chassis (fig. 7).

*(a)* Openings in the two tube shields (9).

*(b)* Contacts on the COARSE FREQUENCY selector switch (10).

*(c)* Trimmer capacitor C2 (11).

*(d)* Rubber grommet (12).

*(e)* Holes in the case of two potentiometers (13).

*(f)* Terminal clip on the type 6F8G tube (14) (on old units).

*(3)* Mask the following parts on the rear of the chassis (fig. 8).

*(a)* A-c power supply receptacle (15).

*(b)* Slot in the fuse holder (16).

*(c)* Contact on the interlock switch (17).

*(d)* Openings in the ends of the four tuning coils (18).

*(e)* Four rubber grommets (19).

*(f)* Contacts on five tube sockets (20).

**e. Drying.** Place the equipment in an oven or under heat lamps and dry for 6 hours at 140°F.

**f. Varnishing.**

*(1)* Apply three coats of moistureproofing and fungiproofing varnish (Lacquer, Fungus-Resistant, Spec No. 71-2202, stock No. 6G1005.3, or equal). Allow each coat to air-dry for 15 or 20 minutes before applying the next coat.

*(2)* Apply varnish immediately after the equipment is dried. If the varnish is not applied immediately, moisture condenses on the equipment. Varnish applied over the moisture peels off readily after the varnish has dried.

*(3)* Spray the top side, bottom, and rear of the chassis.

**g. Reassembly.**

*(1)* Remove all masking tape, being careful not to peel varnish from near-by areas.

*(2)* Touch up with a brush where necessary.

*(3)* Clean and burnish all contacts.

*(4)* Reassemble the oscilloscope and test its operation.

**h. Marking.** Mark the letters MFP and the date of treatment near the nameplate on the equipment and in such location that the marking will not become obliterated or rubbed off.

**Example:** MFP—20 Jan 45.

## 28. MOISTUREPROOFING AND FUNGIPROOFING AFTER REPAIRS.

If, during repair, the coating of protective varnish has been punctured or broken, and if complete treatment is not needed to reseal the equipment, apply a brush coat to the affected part. Be sure the break is completely sealed.

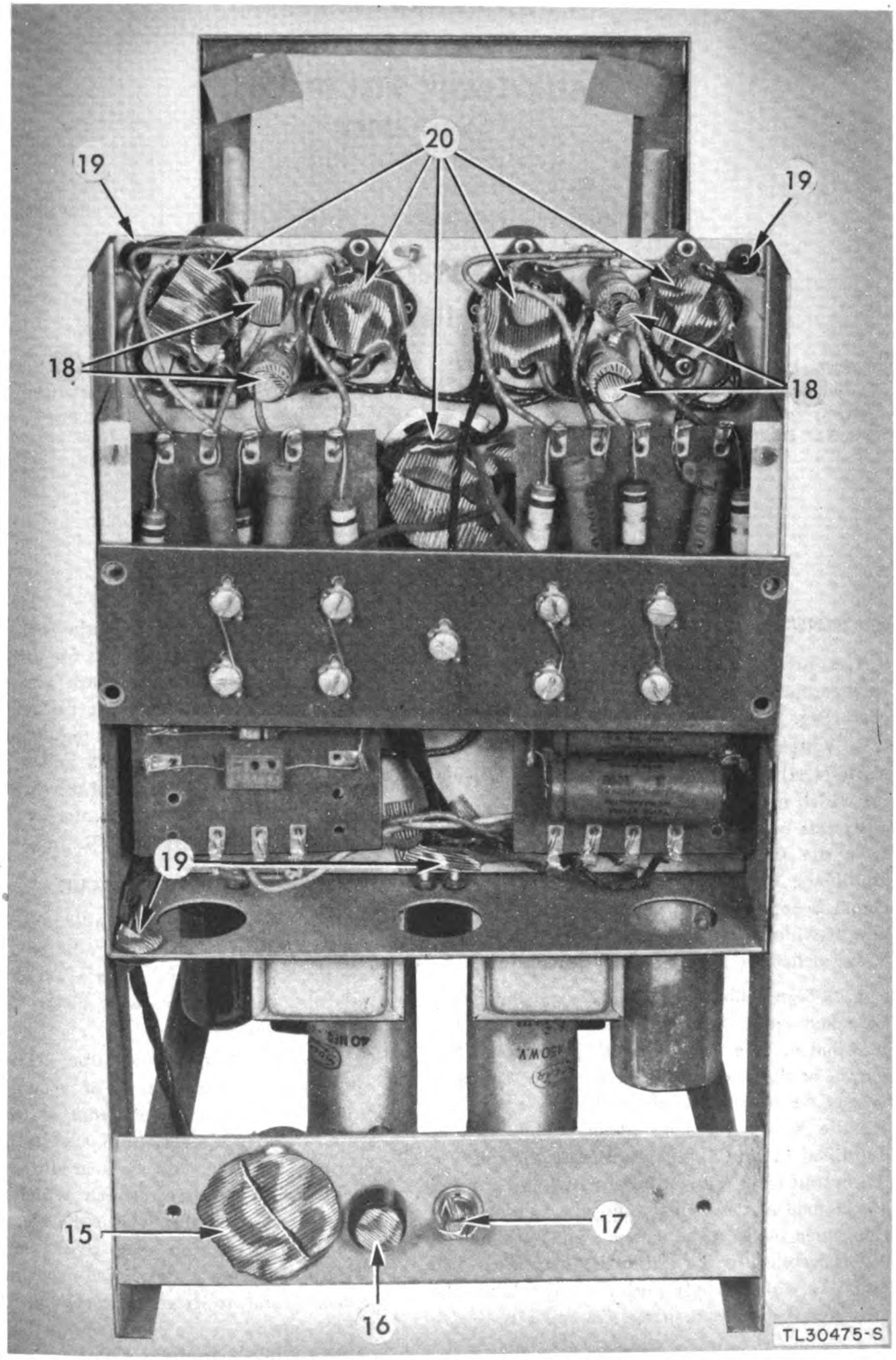



*Figure 8. Back of chassis masked.*

# PART FOUR
# AUXILIARY EQUIPMENT
## NOT USED

# PART FIVE
# REPAIR INSTRUCTIONS

**NOTE:** Failure or unsatisfactory performance of equipment used by Army Ground Forces and Army Service Forces will be reported on W.D., A.G.O. Form No. 468 (Unsatisfactory Equipment Report); by Army Air Forces, on Army Air Forces Form No. 54 (Unsatisfactory Report). If either form is not available, prepare the data according to the sample form reproduced in figure 29.

## SECTION VIII
## THEORY OF EQUIPMENT

### 29. GENERAL.

The interrelation of the various stages in the oscilloscope circuit is shown in the block diagram (fig. 9).

**a. Y-Signal Channel.** The Y signal from the Y SIGNAL INPUT terminal is fed to the attenuator which may be set for signal values under 25 volts rms or under 250 volts rms. The output from the attenuator is amplified in the Y-axis amplifiers, V1, V2, V3, and V4. The amplified signal is applied to the paraphase amplifiers V5 and V6 which supply push-pull signals for the two Y-axis deflection plates, D3 and D4.

**b. X-Signal Channel.** The X-axis signal may be taken either from the X SIGNAL INPUT terminal or from the saw-tooth generator. The output of the saw-tooth generator is a saw-tooth voltage wave which furnishes the linear timebase for the X-axis deflection plates. This wave is amplified in the X-axis amplifiers, V8 and V9. An output from V8 is differentiated and applied to the grid of the cathode-ray tube to blank out the return trace on the screen. The output from V9 is applied to the paraphase amplifiers V10 and V11 which supply push-pull signals for the two X-axis deflection plates, D2 and D1.

**c. Power Supplies.** Voltages needed for the circuits are supplied by three rectifiers and a three-tube voltage regulator. Rectifier V13 supplies —1,050 volts for the cathode-ray tube circuit; V14 supplies +280 volts for the four paraphase amplifiers, the saw-tooth generator, and the accelerating anode of the cathode-ray tube. Part of the output of V14 is regulated to +155 volts by V16, V17, and V18 and supplies the plates of the six amplifiers and the cathode of V7. Rectifier V15 supplies —280 volts for the cathode circuits of V1, V4, V8, and V9.

### 30. CATHODE-RAY TUBE CIRCUIT.

The cathode-ray tube supplied with Oscilloscope I-245-B is a type 5LP1 tube having a medium-persistence screen. It is a 5-inch diameter, intensifier-type, high-vacuum, electrostatic-deflection type tube.

**a. Typical Cathode-ray Tube.** The cathode-ray tube is a special type of vacuum tube in which electrons emitted from a cathode are caused to move at a very high velocity, are formed into a narrow beam, and are then allowed to strike a chemically prepared screen which fluoresces or glows at the point where the electron beam strikes. The electron beam passes between two pairs of deflecting plates which may cause it to be deflected and to trace patterns on the screen which depend on the properties of the deflecting voltage applied to the deflecting plates. A diagram of a cathode-ray tube of the type used in Oscilloscope I-245-B is shown in figure 10. A

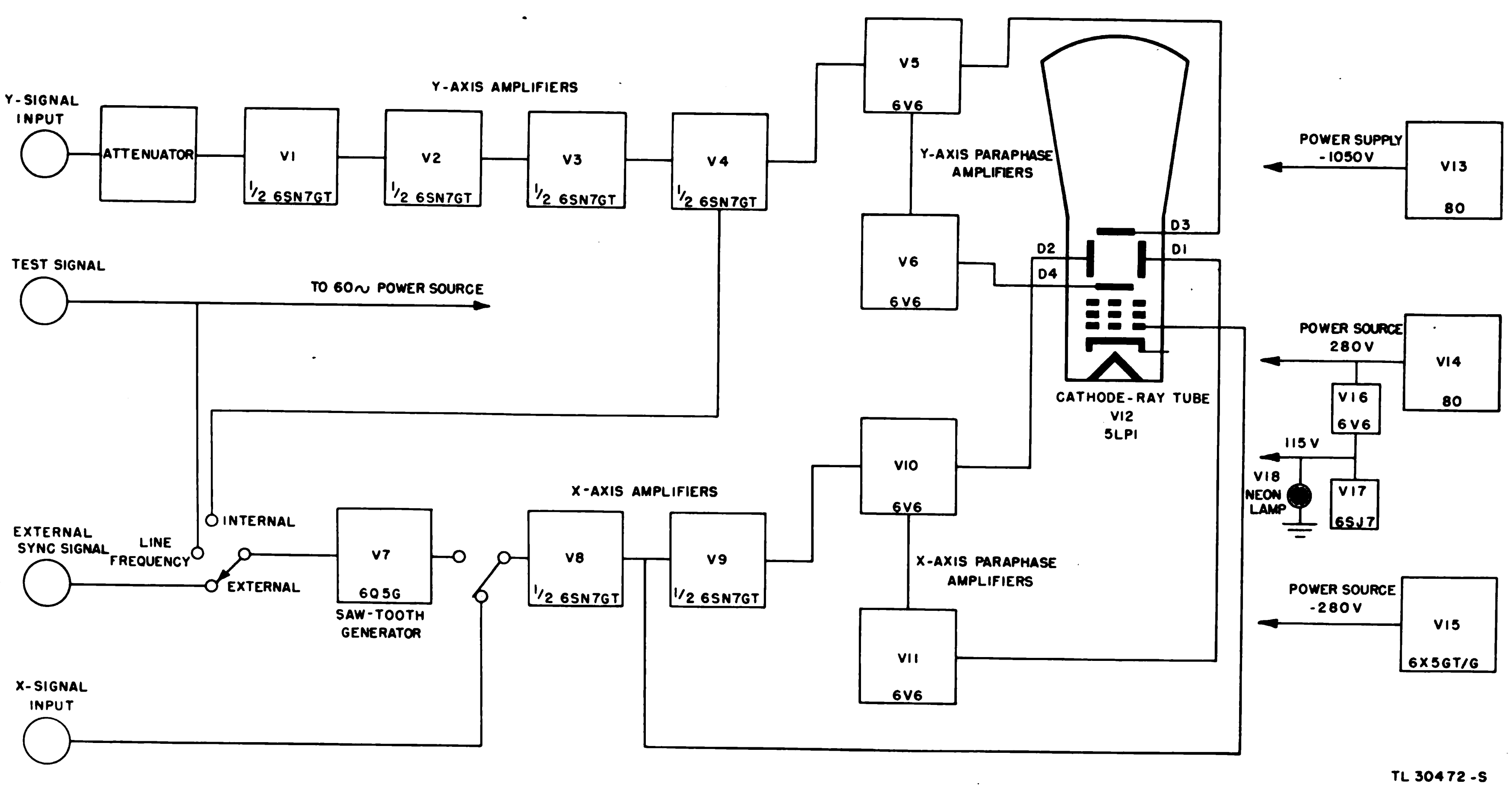



*Figure 9. Oscilloscope I-245-B, block diagram.*

more detailed description of the action of a cathode-ray tube may be found in TM 11-466, 29 June, 1944, section VIII.

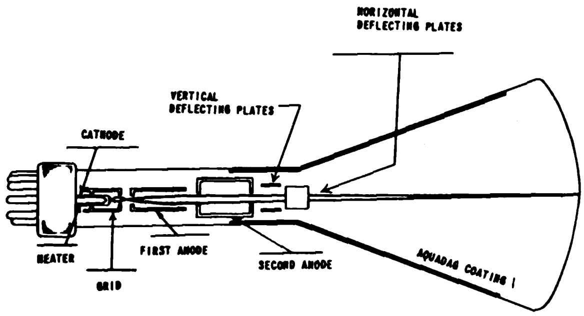



*Figure 10. Typical electrostatic cathode-ray tube.*

*(1)* The electron-emitting portion of the cathode-ray tube consists of a cylindrical cathode indirectly heated by a heater or filament mounted inside it. The end of the cathode is coated with an electron-emitting substance.

*(2)* The flow of electrons from the cathode is controlled by the grid. This is another cylinder which covers the cathode and has a hole in the end opposite the end of the cathode. The charge on this grid regulates the flow of electrons, and the electrostatic field between grid and cathode helps to form the stream of electrons into a beam.

*(3)* After leaving the grid, the beam of electrons passes through the first and second anodes. These are cylindrical elements open at both ends. The first anode is the focusing anode and is at a lower potential than the second anode which is the accelerating anode. The electrostatic field between these two anodes further focuses the electron stream into a beam, and the voltage on the focusing anode is variable so that the beam may be brought to a focus directly on the fluorescent screen.

*(4)* The deflecting plates are two pairs of parallel plates; each pair is at right angles to the other. When a difference of potential is applied across a pair of these plates, the beam (which is a stream of electrons with negative charge) is deflected toward the more positive plate, causing the spot on the fluorescent screen to move to one side or the other or up or down. By applying varying voltages to both pairs of plates, the beam may be made to trace various patterns on the screen.

*(5)* The deflecting plates are connected so that push-pull signals are applied to each pair of plates; that is, when one plate goes positive, the opposite plate goes negative.

*(6)* The aquadag coating on the inside of the glass envelope of the tube constitutes the final or intensifying anode. The electron stream is initially accelerated by the large difference in potential between the cathode and the second anode. After being deflected, the beam is further accelerated by the difference in potential between the second anode and the intensifying anode.

**b. Cathode-ray Tube Circuit of Oscilloscope I-245-B (fig. 11).**

*(1)* The accelerating voltage between cathode and second anode of the cathode-ray tube and the various intermediate voltages needed are supplied from the voltage divider consisting of R51 to R54.

*(2)* The grid is the most negative element in the tube. It is connected to —1,050 volts from the high-voltage power supply. Capacitor C29 and resistor R49 form a differentiating circuit which applies a cut-off voltage to the grid during the return trace of the saw-tooth sweep. The action of this circuit is explained in connection with the sweep circuit in paragraph 32d below.

*(3)* With the BEAM switch ON, the cathode is connected to the center arm of R51, the INTENSITY potentiometer. Varying this control varies the bias voltage between the grid and cathode. This varies the flow of electrons from the cathode and changes the intensity of the spot or line on the screen.

*(4)* When the BEAM switch is turned OFF, the cathode is connected to the junction of R52 and R53. This places a fixed bias of —150 volts between grid and cathode and cuts off the electron stream entirely.

*(5)* The focusing anode is connected to the center tap of R53, the FOCUS control. This control varies the voltage between the focusing and accelerating anodes. The accelerating anode and the positive side of the high-voltage power supply are grounded.

*(6)* The intensifying anode is connected to +280 volts. This voltage accelerates the electron beam further after it has been deflected. The total accelerating potential is thus approximately

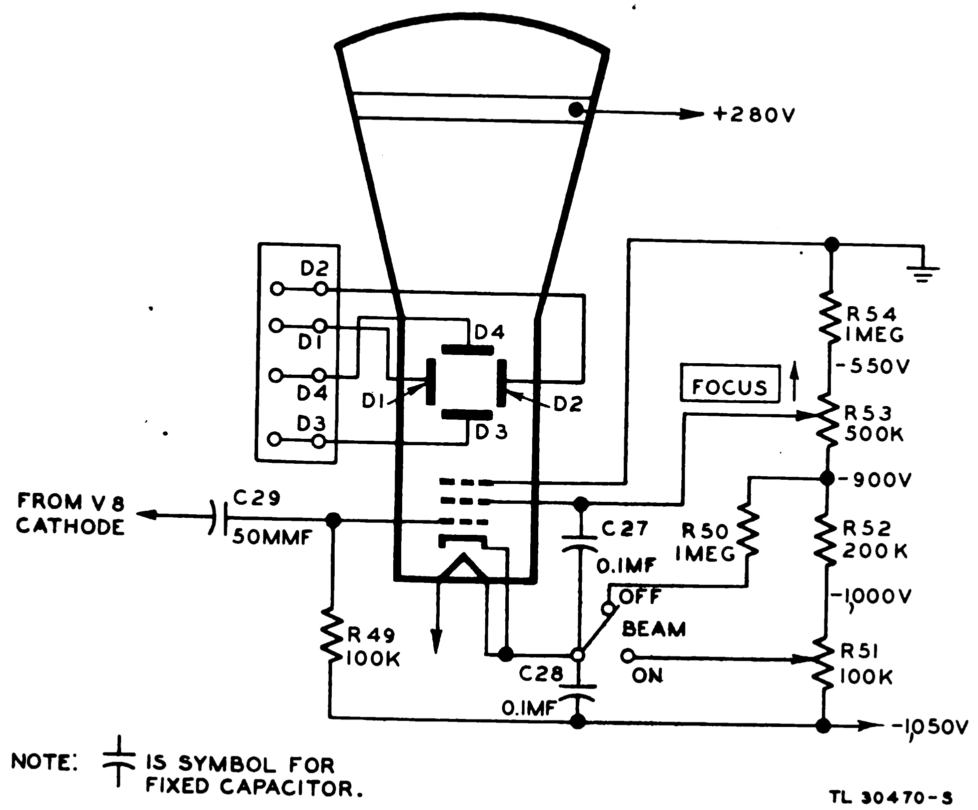



*Figure 11. Cathode-ray tube circuit, simplified schematic diagram.*

1,320 volts. The purpose of the intensifier is to provide greater deflection sensitivity than would be obtained if the total accelerating potential were applied between the cathode and accelerating anode. The voltage on the deflecting plates necessary to deflect the electron beam a given amount varies with the velocity of the electrons in the beam. By accelerating the beam partially and then deflecting it, a large deflection is obtained for a given deflecting voltage. The beam is then further accelerated in order to obtain proper intensity on the screen.

### 31. LINEAR TIMEBASE GENERATOR.

For most purposes a linear timebase generated internally is applied to the X-axis deflecting plates of the oscilloscope. The sweep voltage that will produce a linear timebase or uniform motion of the spot across the screen is a saw-tooth voltage. This voltage is produced by the saw-tooth generator.

**a. Simplified Saw-tooth Generator.** The saw-tooth generator is a relaxation oscillator using a thyratron or gas-filled triode tube as an electronic switch. A simplified thyratron saw-tooth genera-

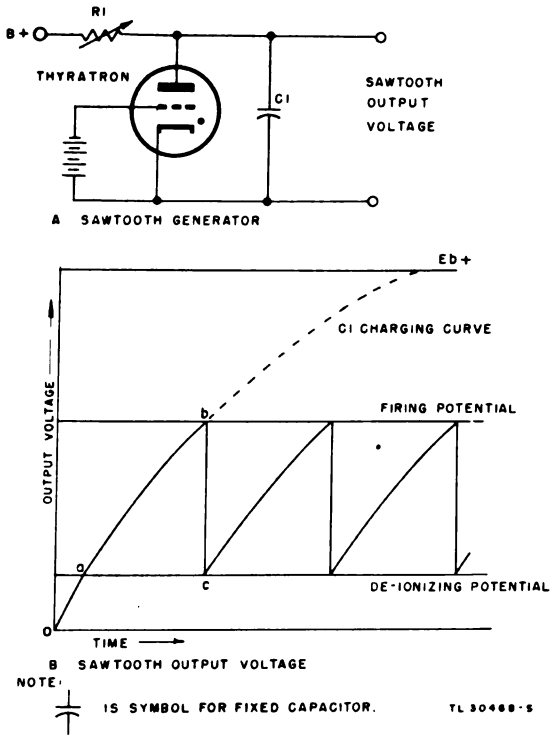



*Figure 12. Simple thyratron saw-tooth generator.*

tor is shown in figure 12-A. The waveform produced is shown in figure 12-B.

*(1)* When B+ voltage is applied, capacitor C1 begins to charge as shown by the curve *Oab*, The thyratron tube is initially nonconducting, but at a certain voltage called the firing or ionizing potential (point *b* on the curve) the gas in the tube ionizes and conducts, discharging C1 suddenly *(b* to *c)*. When the voltage across C1 drops to the point where the gas no longer is ionized (point *c)*, the tube ceases to conduct, and C1 again begins to charge. This action is repeated and produces the saw-tooth output voltage.

*(2)* The rise of the saw-tooth wave *(a* to *b)* is curved slightly because it is part of the C1 charging curve. If the B+ voltage is high enough so that only the lower portion of the charging curve is used, however, the rise of the saw-tooth is sufficiently linear for most purposes.

*(3)* The firing potential of a thyratron may be varied by changing the bias on the grid. This effect may be used to control the frequency of the saw-tooth wave as shown in figure 13-A. If the grid bias is reduced, the tube fires at point *d* instead of *b*. The potential drops from *d* to *e* and then begins to rise again. One cycle of the saw-tooth thus requires less time, and its frequency is increased. The amplitude is decreased at the same time.

*(4)* The frequency of the saw-tooth generator may be varied by changing the time constant of the charging circuit of C1 as shown in figure 13-B. If either R1 or C1 is decreased, the capacitor charges more rapidly and reaches the firing potential more quickly *(d* on fig. 13-B). When the frequency is varied in this manner, the amplitude remains unchanged.

**b. Saw-tooth Generator Used with Oscilloscope I-245-B.** Figure 14 shows the circuit of the saw-tooth generator used with Oscilloscope I-245-B. Tube V7 is the thyratron tube, type 6Q5G.

*(1)* The voltage divider, consisting of R34, R31, and R61, maintains a fixed bias on the grid of the thyratron. The bias may be varied slightly by R61 in order to adjust the total frequency range of the generator. This is an internal adjustment and is set at the factory. Capacitor C15 by-passes the saw-tooth voltage wave around the biasing resistors R31 and R61.

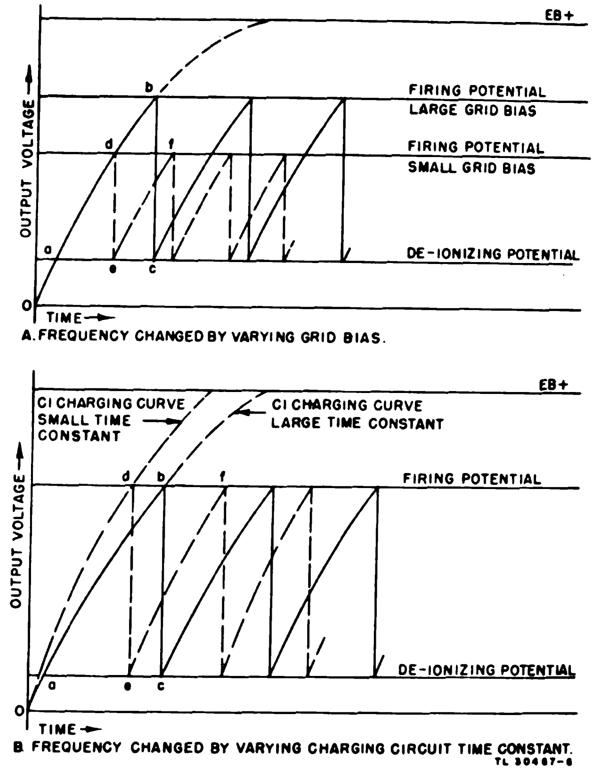



***Figure 13. Variation of saw-tooth generator frequency.***

*(2)* The frequency controls vary the frequency of the saw-tooth by varying the time constant of the charging circuit. The COARSE FREQUENCY control, S3, is a nine-position, two-gang switch which selects the proper capacitor (C16 to C23) for the frequency range desired. The FINE FREQUENCY control varies the charging rate of whatever capacitor is in the circuit by varying the resistance of R32.

*(3)* The only position in which the COARSE FREQUENCY switch has no capacitor is the OFF position. In this position the sweep generator is inoperative and the input of the X-axis amplifier is connected directly to the X SIGNAL INPUT terminal (fig. 24). In all other positions of the switch the saw-tooth output of the saw-tooth generator is applied to the X-axis amplifier.

**c. Synchronization.**

*(1)* In order to obtain a stationary pattern on the oscilloscope screen, the period of the sweep must be exactly equal to the period of the waveform to be observed or some whole multiple thereof. If the lengths of the two periods are almost the same, the pattern will drift across the

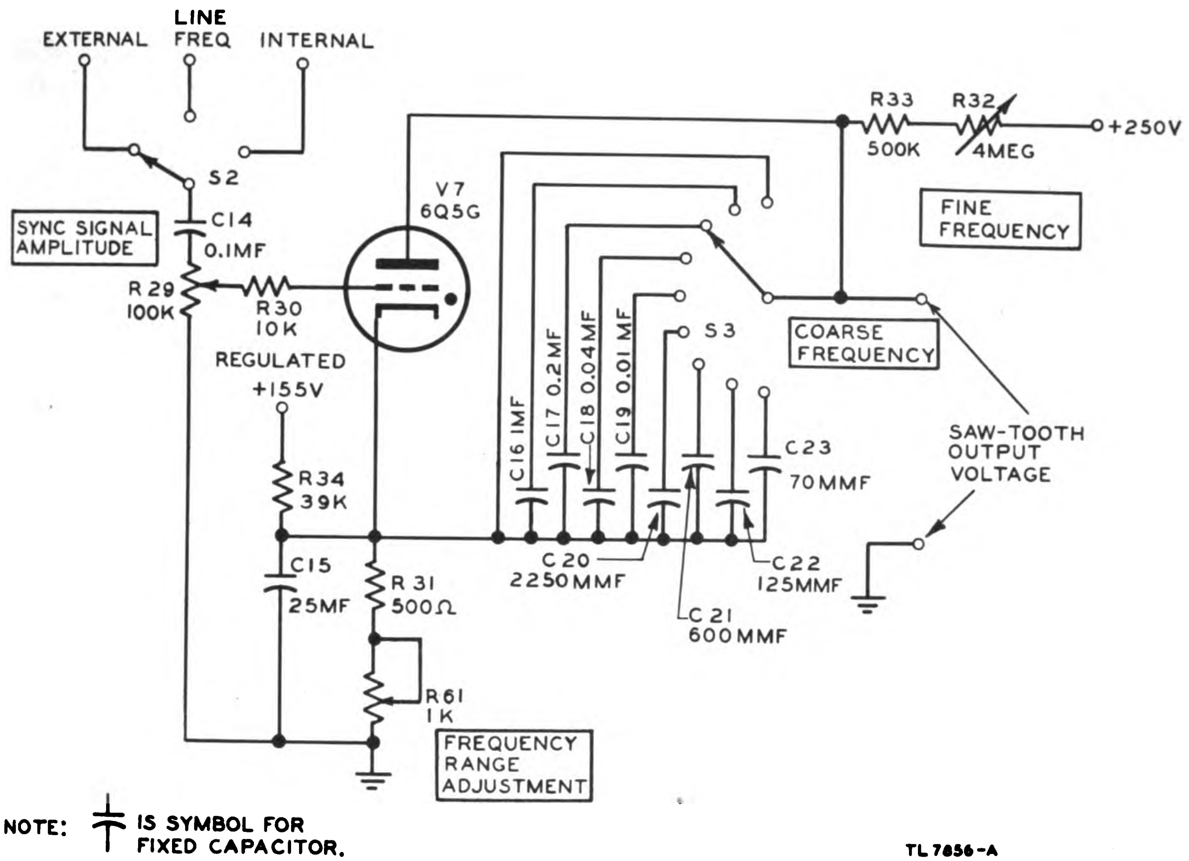



*Figure 14. Saw-tooth generator circuit, simplified schematic diagram.*

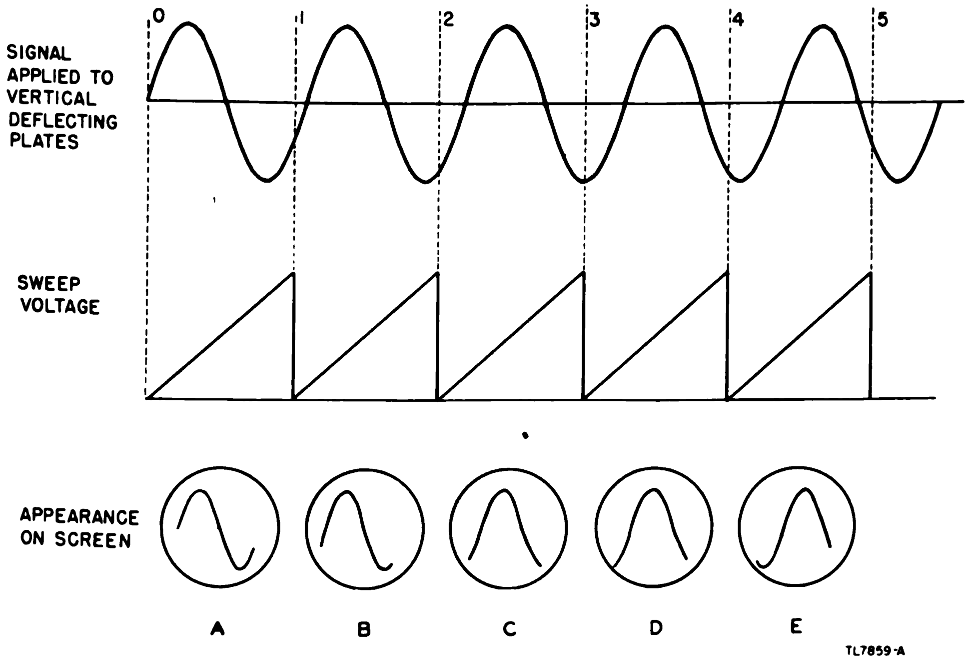



*Figure 15. Apparent motion of oscilloscope patterns on screen.*

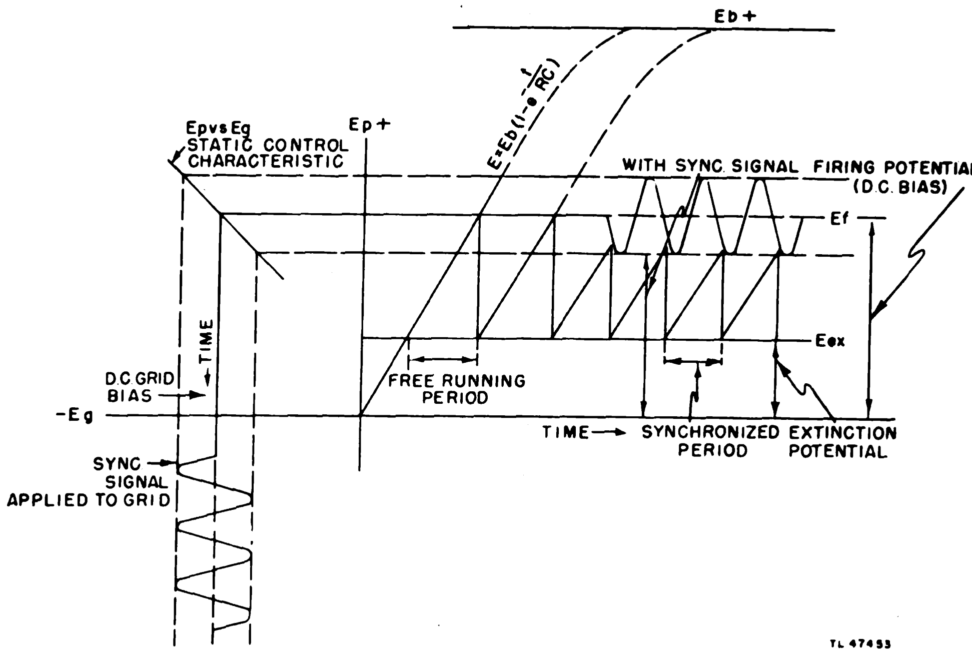



*Figure 16. Action of synchronizing voltage applied to grid of thyratron.*

screen as shown in figure 15. The signal voltage shown is a sine wave whose period is slightly longer than the period of the saw-tooth sweep. In the pattern shown at A only the part of the sine wave included between 0 and 1 will appear. On the second sweep the part between 1 and 2 will show, but it will differ slightly from the part shown in A. In the sweeps that follow, the picture continues to change and appears to travel across the screen from left to right.

*(2)* To synchronize the sweep so that it will have exactly the same frequency as the signal, a synchronizing signal is applied to the grid of the thyratron. The effect of this synchronizing voltage is shown in figure 16. The first two cycles of the saw-tooth show the condition when no synchronizing signal is applied. The line *Ef* represents the firing potential of the thyratron, and line *Eex* represents the extinction or deionizing potential. When a sine-wave synchronizing signal is applied to the grid, the firing potential varies with the synchronizing signal as shown by the sine-wave portion of the line *Ef*. The rising curve of voltage now reaches the firing potential on its downward cycle instead of at the d-c bias firing potential as before. A new cycle of the saw-tooth is started for each cycle of the synchronizing signal, and the sweep is thus exactly synchronized.

*(3)* In Oscilloscope I-245-B the synchronizing signal from the SYNC SIGNAL SELECTOR switch, S2, is applied through coupling capacitor C14 to the voltage divider, R29 (fig. 14). The amplitude of signal fed to the grid of the thyratron is determined by the setting of R29, the SYNC SIGNAL AMPLITUDE control.

*(4)* The synchronizing signal amplitude must be kept as low as possible during operation, because too much signal causes distortion. The reason for this is explained by figure 17. With a small value of synchronizing voltage the firing voltage is represented by the solid line *BDF*. The rise of the saw-tooth reaches the firing potential once for each synchronizing cycle, at *B*, *D*, and *F*, and the sweep is synchronized with the signal. If the synchronizing signal is increased so that the curve of the firing voltage is along the dotted curve *GIKM*, the rise of the saw-tooth reaches the firing potential three times for each cycle in the signal, at *G*, *I*, *K*, *M*, etc., and starts a new cycle each time. This causes distortion of the sweep and of the pattern on the screen.

*(5)* The synchronizing signal may be taken from any one of three sources depending on the setting of the SYNC SIGNAL SELECTOR switch (fig. 24).

(*a*) In the EXTERNAL position the signal is taken from the EXTERNAL SYNC SIGNAL terminal.

(*b*) In the LINE FREQ position the signal is taken internally from one of the low voltage secondaries of the power transformer. This applies a sinusoidal synchronizing signal of power line frequency.

(*c*) In the INTERNAL position the signal is taken from the output of the final stage of the Y-axis amplifier. Thus the sweep is synchronized to whatever signal is being applied to the Y SIGNAL INPUT.

**d. Distortion at High Sweep Frequency.** The time required for the spot on the oscilloscope screen to return to its starting point and to begin tracing another sweep is a finite time since it represents the time required for the charging capacitor (C1, fig. 12-A) to discharge through the thyratron tube. This time is called the ***fly-back*** time and is represented by ***bc*** on figure 12-B. The fly-back time is practically constant for all sweep frequencies and thus becomes a larger proportion of the time of one sweep cycle as the frequency of the sweep is increased. This causes a distortion at high sweep frequencies as shown by figure 18. Assume that the fly-back time is 10 microseconds. In (1) (fig. 18) the period of the 1,667-cycles-per-second sine wave

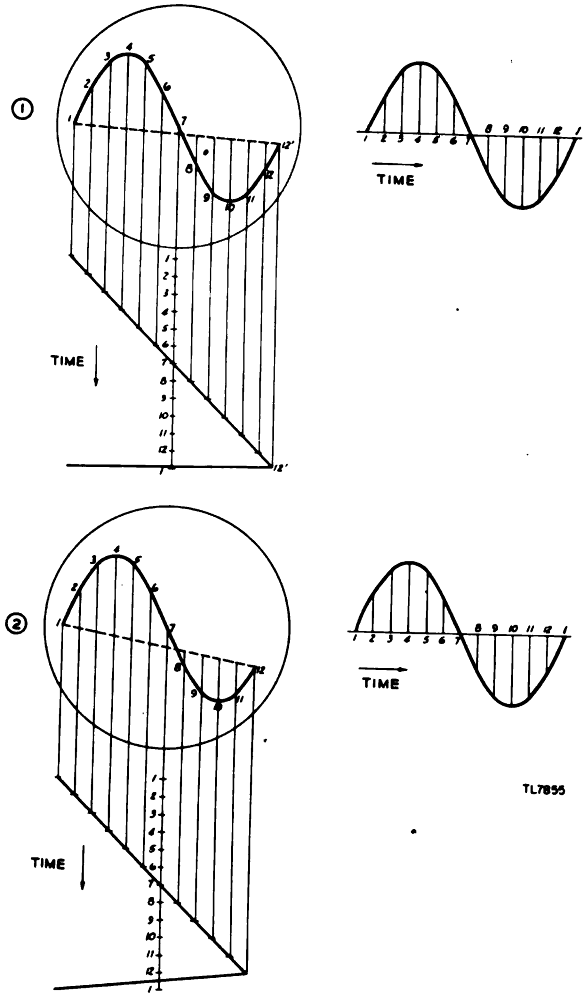



*Figure 18. Distortion of pattern at high screen frequencies.*

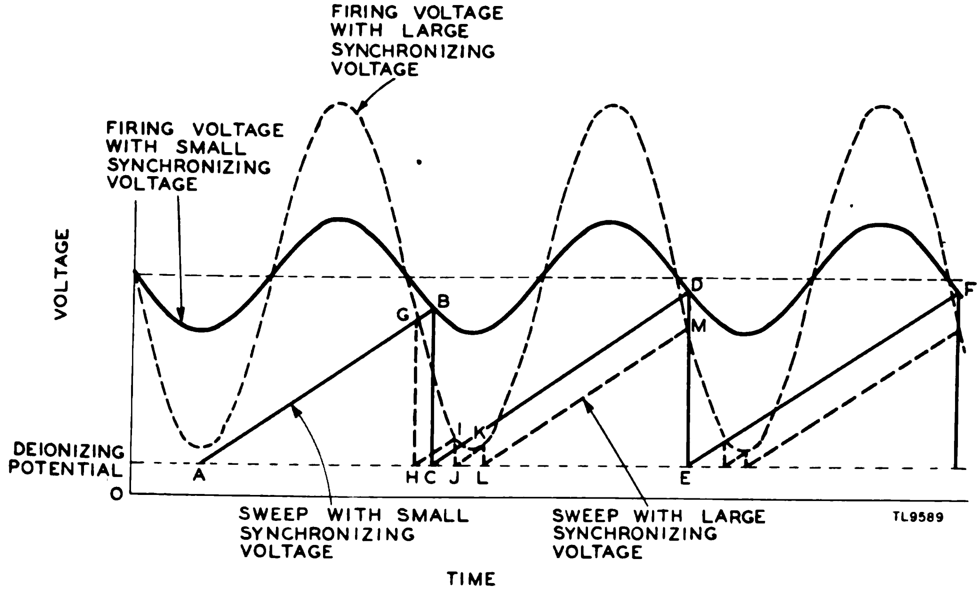



*Figure 17. Distortion of sweep resulting from too much synchronization.*

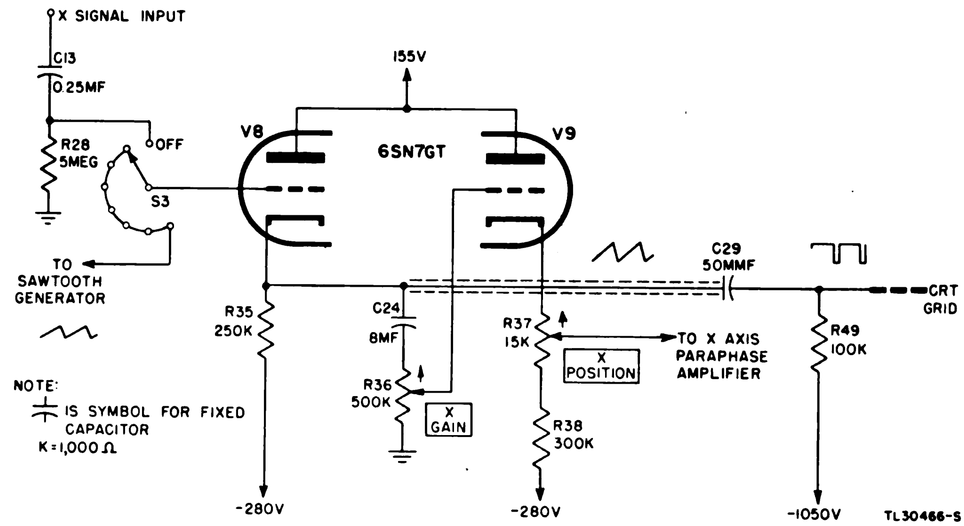



*Figure 19. X-axis amplifier, simplified schematic diagram.*

is 600 microseconds. The fly-back time is 10/600 or 1.6 percent of the period of the sine wave, so that 1.6 percent of the sine wave cycle will be distorted on the screen. If the frequency of both the sweep and the applied signal is multiplied by 5, the period of one cycle is 150 microseconds. Sinçe the fly-back time is still 10 microseconds, it now represents 10/150 or 6.6 percent of one cycle. In (2), 6.6 percent of the sine wave is distorted. To avoid this difficulty the sweep frequency is made a submultiple of the signal frequency so that several cycles of the signal appear on the screen. Only the last cycle is then distorted by the fly-back, and the others are accurately reproduced.

### 32. X-AXIS AMPLIFIER (fig. 19).

**a. Input.** The X-axis amplifier consists of two cathode followers, V8 and V9. The input to the amplifier is connected to the X SIGNAL INPUT terminal when S3 is in the OFF position and to the output of the saw-tooth generator when S3 is in any of the other positions.

**b. D-C Circuit.** The plates of both stages are connected to the regulated 155-volt supply. The cathode circuits are returned to —280 volts. The negative cathode return is provided so that a range of positive and negative voltages for positioning is available. The functioning of the positioning circuit is explained in paragraph 35.

**c. Output.** The signal output from V8 is applied through C24 to the voltage divider R36. Resistor R36 is the X GAIN control. It varies the amplitude of the signal applied to the grid of V9.

**d. Blanking Circuit.** A saw-tooth output from the cathode of V8 is taken through C29 to the grid of the cathode-ray tube for blanking out the sweep during the return trace. The operation of this circuit is illustrated in figure 20. Capacitor C29 and resistor R49 have a small time constant and constitute a differentiating circuit since the output is taken from across the resistor. Ca-

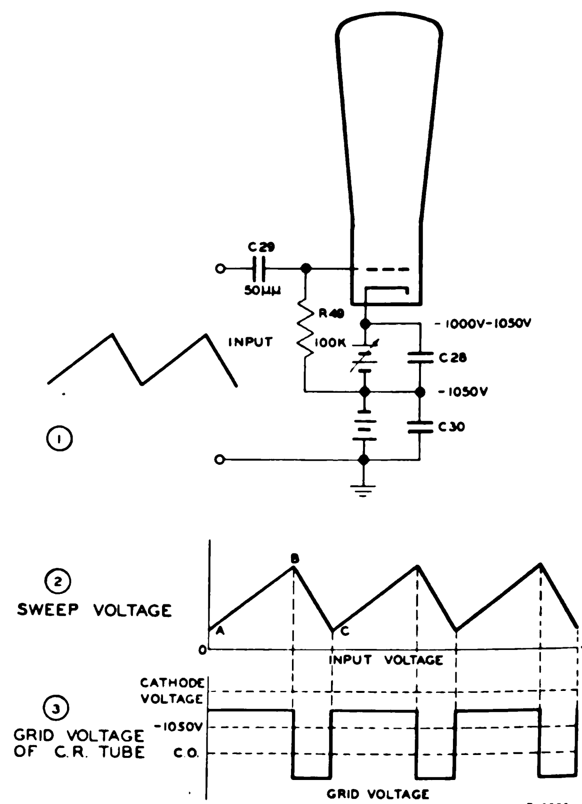



*Figure 20. Blanking circuit, simplified schematic diagram.*

pacitors C28 and C30 bypass the wave around the power supply and have no effect on its shape. A differentiated saw-tooth wave is a rectangular wave. The linear change of voltage of the saw-tooth makes C29 charge with a constant current. This current flowing through R49 produces a constant voltage drop. When the charging current reverses direction, a constant voltage drop in the opposite direction is produced. During the rapid fall of the saw-tooth, a large negative voltage appears across R49 and drives the grid below cut-off. Thus the spot is removed from the screen during the fly-back time.

### 33. Y-AXIS VIDEO AMPLIFIER (fig. 21).

**a. Attenuator.** When the attenuator switch, S1, is in the INPUT UNDER 250 V R.M.S. position, the input is applied to the attenuator circuit. This circuit is a frequency-compensated voltage divider; R1 and C2 form one section of the divider, and R2, R3, and C3 form the other section. The circuit is adjusted by variable capaci-

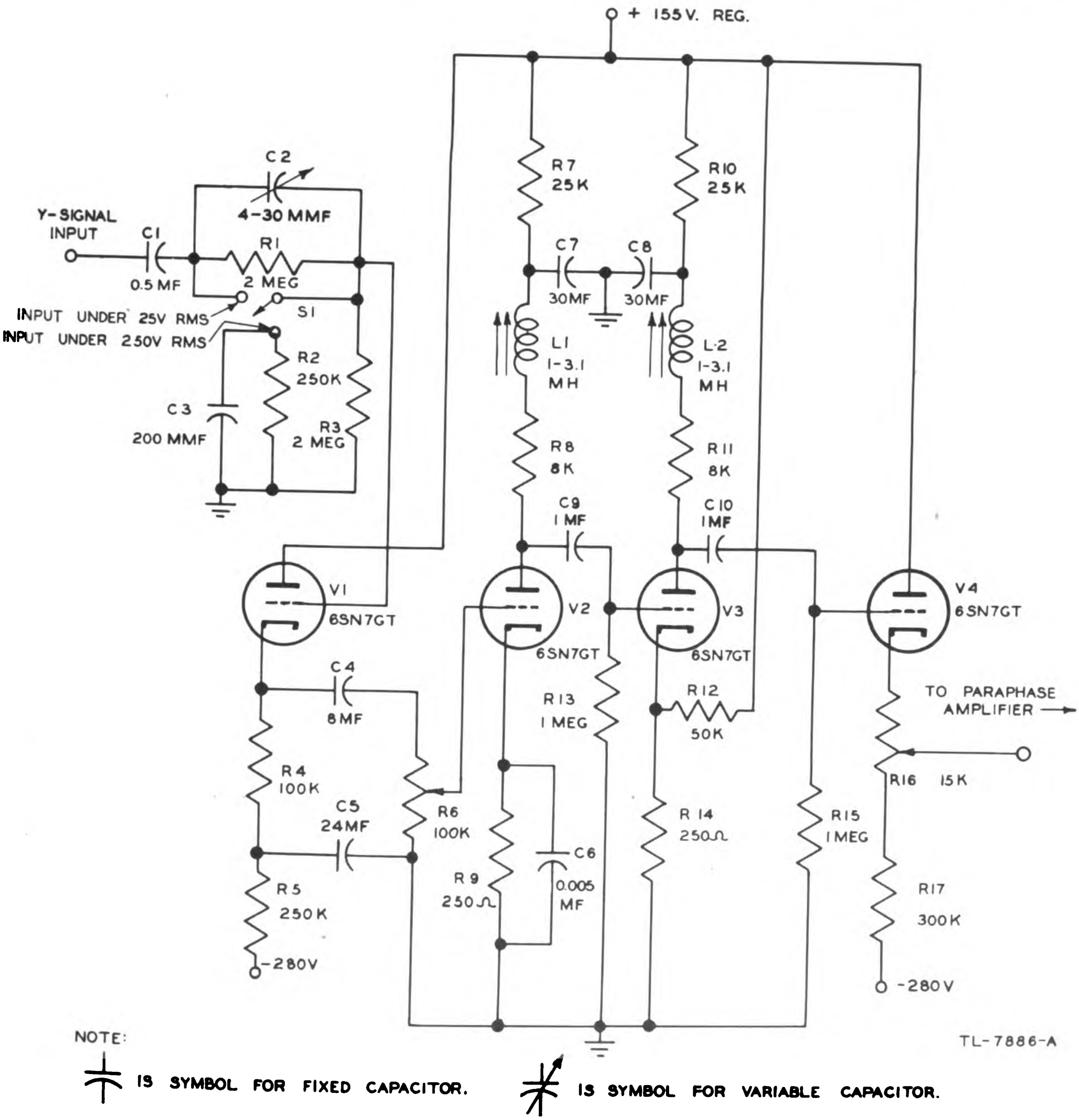



*Figure 21. Y-axis video amplifier, simplified schematic diagram.*

tor C2 so that the time constant of R1 and C2 equals the time constant of R2, R3, and C3. This makes the attenuation constant for all frequencies and prevents the distortion of non-sinusoidal waves. With S1 in the INPUT UNDER 25 V R.M.S. position, only R3 is in the circuit as a grid leak and the signal is not attenuated. The input resistance to the first stage, V1, is approximately 2 megohms in either position of the attenuator switch.

**b. Cathode Follower V1.** The first stage of the amplifier is the cathode follower V1. The cathode-follower input stage is used because the input impedance of this type of circuit is very high and because the danger of distortion, caused by drawing of current by the grid, is minimized. Since the gain of the cathode follower is less than 1, the applied signal appears across R4 with less amplitude than at the input but with the same waveshape. Since the cathode follower is normally conducting, there is a direct voltage at the cathode. The impressed signal causes this voltage to vary. Since all that is needed in the following stage is this varying voltage, capacitor C4 is used to block out the direct voltage. Capacitor C4 is large (8 mf) because it is desired to pass the very-low-frequency components of the signal. After the signal passes through C4, it is impressed on potentiometer R6. Since the slider on this potentiometer can select any desired fraction of the signal voltage, it serves as the gain control, although strictly speaking it does not alter at all the gain of the amplifier. Instead, it varies the amplitude of the input signal, and thereby controls the amplitude of the output. The advantage of this type of control is that the amplifier tubes may be operated at a fixed point and the most linear part of their characteristic may always be used.

**c. Video Amplifiers V2 and V3.** The second and third stages of the vertical deflection amplifier are compensated video amplifiers. In order to make the amplification more nearly uniform over a wide band, frequency-compensation networks are used.

*(1) High-frequency Compensation.* Plate-load resistors R8 and R11 are much smaller than normally would be used. Inductors L1 and L2 are used to compensate for the effect of stray capacitances at high frequencies. Since the reactance of an inductor increases as the frequency increases, the effective plate-load impedance tends to increase at the high frequencies. Therefore, as the frequency applied to V2 and V3 becomes higher, the shunting effect of stray capacitances, which tends to reduce the useful gain, is offset by the increasing magnitude of the plate-load impedance. When L1 and L2 are properly adjusted, the gain of the two stages will be nearly constant up to 1 megacycle.

*(2) Low-frequency Compensation.* At high frequencies, resistors R7 and R10 are bypassed by the low reactness of capacitors C7 and C8. At very low frequencies the gain of the amplifiers is reduced by the loss which occurs in the grid coupling circuit. The loss is compensated for in this amplifier, however, since at low frequencies the reactness of C7 and C8 is high. The plate-load resistors are thus effectively much larger, since a low-frequency voltage developed across R7 or R10 is not bypassed by the capacitors. The gain of the two stages is increased by making the effective plate-load resistance larger. Thus, the attenuation of very-low-frequency voltages in the input circuit is offset by the increased gain. In this manner the low-frequency response of the amplifier is extended down to nearly 2 cycles per second. Without C7, C8, R7, and R10, the lowest frequency that would be amplified with the midband gain would be approximately 30 cycles per second.

**d. Cathode Follower V4.** The output stage of the video amplifier is the cathode follower V4. The input impedance to a cathode follower is high, and the input capacitance is less than for a conventional amplifier. This low input capacitance makes it possible to extend the high-frequency response of the amplifier since the shunting effect of the capacitance is minimized. The signal appears across cathode resistors R16 and R17. In spite of the fact that R17 returns to —280 volts, the current through the cathode resistors is sufficient to make the cathode of V4 slightly positive with respect to ground, and the grid will not draw any current. The reason for returning R17 to —280 volts is to provide a voltage variation across R16. Thus, the lower end is negative with respect to ground, and the upper end is positive. Ground potential must be found somewhere in R16 if the position control in this particular circuit is to operate properly.

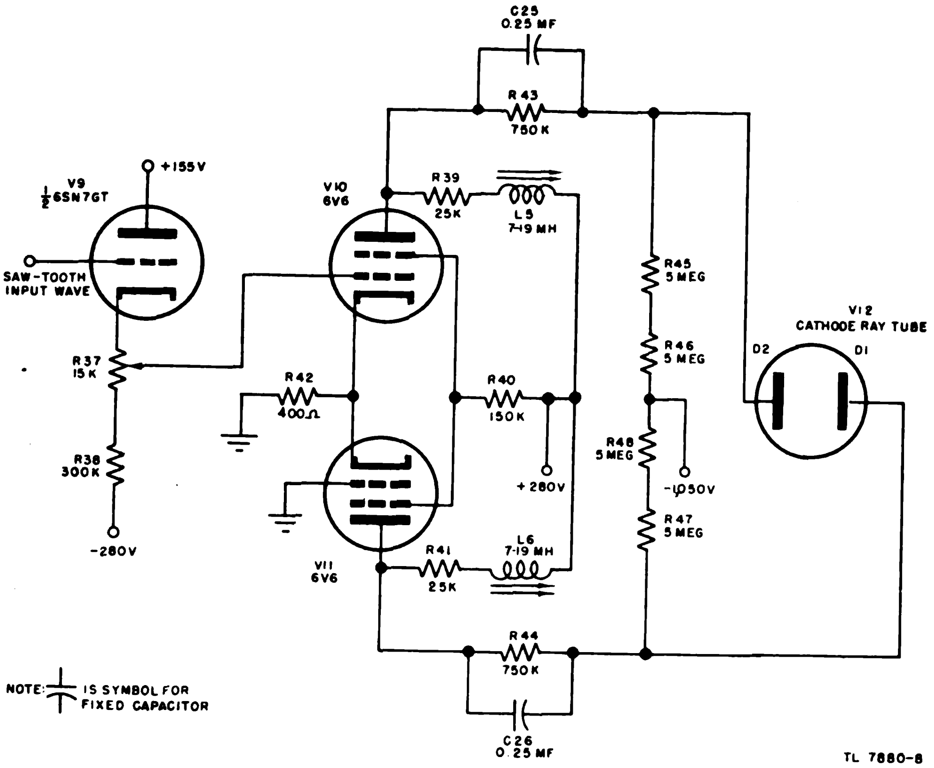



*Figure 22. X-axis paraphase amplifier, simplified schematic diagram.*

**34. PARAPHASE AMPLIFIERS.**

The two paraphase amplifiers are identical in circuit arrangement and operation. The action will be explained in relation to the X-axis amplifier (fig. 22).

**a. Inputs.** The saw-tooth voltage wave applied to the grid of V10 produces across R42 a voltage wave of the same shape and polarity but of approximately half the amplitude of the input. This voltage is used to drive V11, and, since it is a degenerative voltage for V10, the voltage effective between grid and cathode of this tube is approximately half of the input voltage. Thus the input voltages to the two tubes are nearly equal, but of opposite polarity with respect to the grids, so that the outputs of the circuit are two voltages of approximately the same amplitude but of opposite polarity.

**b. Outputs.** The plates of the two amplifiers are directly coupled to the deflecting plates of the cathode-ray tube to prevent attenuation of the low-frequency signals. In order to maintain the deflecting plates at approximately d-c ground potential, the two resistor networks, R46, R45, R43, and R39 in the circuit of V10, and R48, R47, R44, and R41 in the circuit of V11, are connected between —1,050 volts and +280 volts. Capacitors C25 and C26 and chokes L5 and L6 compensate for low-frequency and high-frequency losses, respectively, in the same manner as C7, C8, L1, and L2 in the Y-axis video amplifier (par. 33). The wide frequency band pass obtained in the video amplifier is thus maintained in the paraphase amplifier.

**35. POSITION CONTROLS.**

Since the deflecting plates are directly coupled to the plates of the paraphase amplifiers, the average d-c voltage on the amplifier plates acts as a positioning voltage. The X POSITION control is R37 and the Y POSITION control is R16 (fig. 24). Since the operation of both circuits is identical, it will be explained in relation to the X-axis paraphase amplifier circuit (fig. 22).

**a.** As explained above (par. 32b), the cathode follower V9 is designed so that there will be a point at about the middle of potentiometer R37 at which the voltage to ground is zero. When R37 is set at the ground potential point, the bias on V10 must be exactly the same as the bias on V11. If no signal is applied, both tubes will conduct the same amount of current, and the voltage at the plate of V10 will be the same as the voltage at the plate of V11. The spot will then be in the center of the screen if the electron gun is aimed accurately.

b. If it is desired to move the spot to the right, the slider on R37 is moved up so that the grid of V10 becomes more positive. When the cathode of V11 becomes more positive, however, the bias on this tube is increased and it passes a smaller current. This tends to reduce the voltage drop across the common cathode resistor R42, but the result is that the voltage across R42 is larger than it was when the grid of V10 was at ground potential. Therefore, since V10 is passing a larger current than before and V11 is passing a smaller current, the average voltage at the plate of V11 is more positive than the voltage at the plate of V10, and the spot is attracted to the right toward deflecting plate D1. In a similar way it can be shown that the spot will move to the left, or toward deflecting plate D2, if position control R37 makes the grid of V10 negative with respect to ground.

c. Movement of the position control potentiometer has very little effect on the gain of tubes V10 and V11, since the actual shift of bias is so small that the tubes will work on the linear part of their characteristics. The over-all gain is affected slightly because the amplitude of the input signal to V10 varies somewhat as the slider on R37 is moved. Since R38 is large compared to R37, however, most of the signal voltage is developed across R38. Thus the over-all gain is decreased or increased only approximately 1 percent.

d. In the Y-axis circuit the spot is moved toward D4 when R16 is moved toward the more positive direction and toward D3 when R16 is moved toward the more negative direction.

### 36. POWER SUPPLIES (fig. 24).

a. Negative 1,050 volts is furnished by V13, a type 80 rectifier tube connected as a half-wave rectifier. The output is taken from the two plates connected in parallel and is filtered by the resistance-capacitance filter R55, C31, C30. The plate winding for this rectifier is the portion of the high-voltage secondary (on transformer TI) included between the filament circuit of V13 and the grounded terminal of the winding.

b. Positive 280 volts is furnished by V14, a type 80 rectifier tube connected as a full-wave rectifier. The output is taken from the center tap of the filament winding for V14 and filtered in the two-section pi filter consisting of L8, L7, C32, C33, and C34. The plate winding for this rectifier is the center-tapped portion of the high-voltage secondary winding, to each end of which one of the rectifier plates is connected.

c. Negative 280 volts is furnished by V15, a type 6X5GT/G rectifier tube connected as a half-wave rectifier. The output is taken from the two plates connected in parallel and is filtered by the resistance-capacitance filter consisting of R56, C35, and C36. This rectifier has a separate center-tapped filament winding with the center tap grounded. The d-c return is to the two cathodes connected in parallel. The plate winding for this circuit is the last section of the high-voltage winding, with one end grounded and the other connected to the cathodes of the rectifier.

### 37. VOLTAGE REGULATOR (fig. 23).

Part of the output of the positive 280-volt power supply is regulated by the voltage regulator consisting of V16, V17, and V18 and is supplied to the plates of the amplifiers (fig. 24). The purpose of the regulated voltage is to prevent movement of the picture on the oscilloscope screen such as would be caused by power-line fluctuations. The circuit is shown in figure 23, and its operation is as follows:

a. The output voltage of the regulator is developed across the bleeder resistors R62 and R59 in parallel with the resistance of the load. These resistors make up the resistance of one part of the total voltage divider. The other resistance, through which all of the load current must flow, is the plate-to-cathode resistance of tube V16. The other elements in the circuit are used to control the resistance of V16 and by this means to maintain a constant voltage across the load.

b. The plate voltage of V17 is the regulated voltage output of the regulator. The potential of the cathode of V17 is held at a constant positive value by the glow tube V18. The grid potential of V17 is a voltage selected by potentiometer R59. This potentiometer is set so that the grid voltage is less positive than the cathode by an amount (the bias) which causes V17 to pass a certain plate current. This plate current flows through the plate-load resistance R57 and causes a drop across it. The magnitude of the voltage across R57 is the bias on tube V16. Therefore, the adjustment of potentiometer R59 establishes the normal resistance of V16. This adjustment is used to set the value of load voltage which the regulator is to maintain.

c. If the load voltage tends to rise, whether from a decrease in the load current or from an increase in the input voltage, the voltage on the grid of V17 also tends to rise (become less negative), the cathode voltage remaining practically constant. Tube V17 then conducts more current because the bias is smaller. A greater current flows through R57 which causes a greater voltage drop across this resistor. This voltage, which is the bias voltage for V16, causes the plate resistance of V16 to increase. A larger portion of the available voltage appears across the higher resistance of V16, and the load voltage remains practically constant. The action is similar if the load voltage tends to fall.

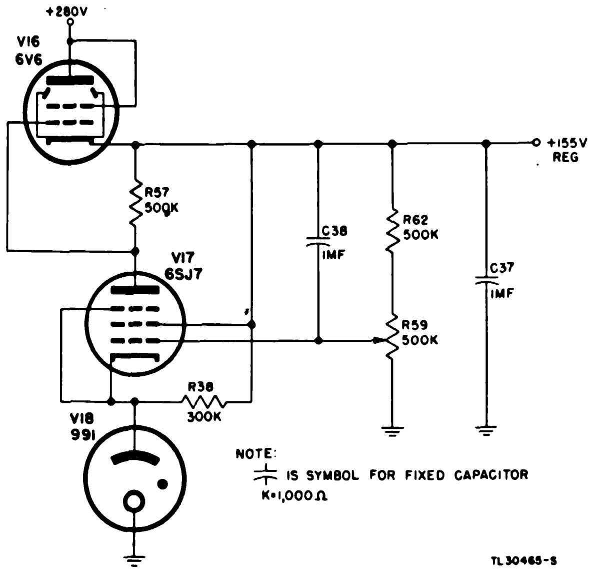



*Figure 23. Voltage regulator simplified schematic diagram.*

d. A pentode (6SJ7) is used for V17 because of the high amplification possible with this type of tube. The use of such a tube makes the output voltage much more constant since small variations of load voltage are amplified sufficiently to cause operation of the circuit.

e. The anode of the neon glow tube, V18, is connected to the cathode of V17 and to the regulated voltage output through resistor R58. It is necessary to connect the glow tube to the B+ voltage in this way in order to cause the gas in this tube to ionize when the power supply is first turned on.

## 38. PRIMARY POWER CIRCUIT (fig. 24).

a. Power from the input plug passes through a 1.5-ampere fuse, F1, interlock switch S6, POWER ON switch S5, and line voltage selector switch S7 to the primary circuit of power transformer T1. Switch S6 is mounted on the rear of the chassis and opens, breaking the circuit, when the chassis is removed from the case. Transformer T1 has two primary windings. Switch S7 connects the two windings in series for 230-volt operation or in parallel for 115-volt operation.

b. Transformer T1 has five secondary windings which supply all the voltages needed for filaments and rectifiers throughout the circuit.

*(1)* One 6.3-volt winding, insulated for high voltage, supplies the filament of the cathode-ray tube (Z-Z, fig. 24).

*(2)* One 6.3-volt winding supplies the filaments of the voltage regulator tubes V16 and V17 (Y-Y).

*(3)* One 5-volt winding supplies the filament of rectifier V14 and is center-tapped to provide an output connection for the dc from V14.

*(4)* One 6.3-volt winding supplies the filaments of all remaining tubes in the circuit except V13 (X-X). This winding has a grounded center tap, and the pilot light, V19, is connected across it.

*(5)* The fifth winding is a high-voltage winding with five taps. It supplies the following:

*(a)* 5 volts for the filament of V13.

*(b)* 800 volts for the high-voltage power supply.

*(c)* 700 volts center-tapped for the 280-volt power supply.

*(d)* 385 volts for the —280-volt power supply.

# SECTION IX
# TROUBLE-SHOOTING PROCEDURES

**CAUTION:** Dangerously high voltages are present in the chassis when the oscilloscope is turned on. Operate the oscilloscope out of its case only when absolutely necessary, and then be extremely careful.

## 39. INTRODUCTION.

**a. Trouble-shooting Data.** Figures 25, 26, 27, and 28 at the end of this section show the physical location of the components on the chassis. In addition the block diagram (fig. 9), the complete schematic diagram (fig. 24), and the various partial schematic diagrams (figs. 11, 12, 19, 20, 21, and 22) will be helpful in trouble shooting. Figure 24 shows the d-c voltages which should be present at various points in the circuit.

**b. Obtaining Trouble-shooting Information.** When trouble occurs in the oscilloscope, all possible symptoms of the trouble should be observed before removing the chassis from the case. The various controls should be adjusted and the effect noticed. By this means a general idea of the location of the trouble may be obtained before more detailed examination of the circuit is begun. The following things should be observed:

*(1)* If no spot appears when the oscilloscope is turned on, turn both position controls over their whole range before concluding that no spot is present. Some troubles unbalance the positioning circuits and cause the spot to be deflected clear off the screen. In some cases, however, the range of the position controls may not be sufficient to bring the spot onto the screen.

*(2)* If no sweep appears on one range setting of the COARSE FREQUENCY control, try all other ranges.

*(3)* If no sweep appears on any of the frequency ranges, turn the COARSE FREQUENCY control OFF and apply a signal to the X SIGNAL INPUT to see if a horizontal line appears.

**c. Trouble-shooting Chart.** The trouble-shooting chart given in paragraph 40 gives a systematic procedure for sectionalizing trouble in the oscilloscope. A systematic step-by-step procedure for turning on the unit is given together with the normal indications which should appear at each step. Abnormal indications and probable causes of trouble are also given.

## 40. START-STOP PROCEDURE ANALYSIS.

**a. Preparation.** Set up the oscilloscope and adjust the controls as follows:

*(1)* Turn the POWER and BEAM switches OFF.

*(2)* Set X and Y POSITION controls at midscale.

*(3)* Turn INTENSITY control completely counterclockwise.

*(4)* Turn COARSE FREQUENCY control to OFF.

*(5)* Set X-AXIS AMPLIFIER GAIN control at midscale.

*(6)* Connect no signals to any terminals.

*(7)* Plug the line cord into the oscilloscope and into the a-c line.

**b. Analysis.**

**NOTE:** Where a defective tube is indicated in the chart as the probable cause of trouble, the tube itself is most likely at fault. Check the tube by replacing it with a new one or one known to be good. If the fault is still present, replace the original tube and check the circuit elements in the stage of the tube.

*(1)* **STEP 1.** Turn POWER switch ON.

| Normal indication |
|---|
| Pilot light glows. |

| Abnormal indication | Probable causes of trouble |
|---|---|
| Pilot light does not glow. | Defective line cord.<br>Defective fuse F1.<br>Defective POWER switch S5.<br>Defective transformer T1.<br>Defective pilot light V19. |

(2) **STEP 2.** Turn BEAM switch ON.

| Normal indication |
|---|
| None. |

(3) **STEP 3.** Turn INTENSITY control clockwise until spot can be seen on screen.

**CAUTION:** Do not increase the intensity more than necessary to make the spot visible. Do not leave the spot on the screen any longer than necessary to make observations.

If spot does not appear, adjust X and Y POSITION controls to bring it onto the screen.

| Normal indications |
|---|
| *(a)* A spot appears on the screen increasing in intensity as the INTENSITY control is turned clockwise.<br>*(b)* Spot is centered on the screen with the X and Y POSITION controls at approximately midscale.<br>*(c)* Spot moves up, down, right, and left when the X and Y POSITION controls are turned as indicated on the panel. |

| Abnormal indications | Probable causes of trouble |
|---|---|
| *(a)* No spot appears. | *(a)* Defective transformer T1.<br>Defective rectifier V13 or V15.<br>Defective tube V4, V5, V9, V10, or V16.<br>Defective high-voltage bleeder circuit.<br>Defective cathode-ray tube. |
| *(b)* Spot is centered but neither position control has any effect. | *(b)* Defective rectifier V14. |
| *(c)* X POSITION control must be turned clockwise farther than normal to bring spot on screen. | *(c)* Defective tube V11. |
| *(d)* Y POSITION control must be turned counterclockwise farther than normal to bring spot on screen. | *(d)* Defective tube V6. |

(4) **STEP 4.** Turn COARSE FREQUENCY control over entire range.

| Normal indications |
|---|
| Horizontal line appears on screen for each frequency-range setting. |

| Abnormal indications | Probable causes of trouble |
|---|---|
| *(a)* No line appears on all ranges. | *(a)* Defective tube V7 or V8. |
| *(b)* No line appears on one range. | *(b)* Defective capacitor on range affected. |
| | *(c)* Defective switch S3. |

(5) **STEP 5.** Adjust FOCUS control until line is sharply defined on screen.

| Normal indications |
|---|
| Sweep line may be brought to a sharp focus over its entire length for any setting of INTENSITY control. |

| Abnormal indications | Probable causes of trouble |
|---|---|

| | |
|---|---|
| Line does not focus properly. | Defective focus control.<br>Defective cathode-ray tube. |

*(6)* **STEP 6.** Turn COARSE FREQUENCY control to OFF and attenuator switch to INPUT UNDER 25 V RMS, and connect a jumper between the TEST SIGNAL and Y SIGNAL INPUT terminals. Turn the Y GAIN control over its entire range.

| Normal indication |
|---|
| Vertical line appears at the center of the screen and extends off the screen at both ends as GAIN control is turned up. |

| Abnormal indications | Probable causes of trouble |
|---|---|
| No line appears. | Defective tube V1, V2, or V3. |

*(7)* **STEP 7.** Turn COARSE FREQUENCY control to 40 position, SYNC SIGNAL SELECTOR switch to INTERNAL, and SYNC SIGNAL AMPLITUDE control counterclockwise. Adjust the FINE FREQUENCY control until one sine wave appears on the screen.

| Normal indication |
|---|
| One undistorted sine wave appears on the screen with no return trace visible. Sine wave may move across the screen, but it should be possible to hold it almost stationary by adjusting the FINE FREQUENCY control. |

| Abnormal indications | Probable causes of trouble |
|---|---|
| *(a)* More than one cycle appears on screen, or a stationary pattern may not be obtained. | *(a)* Defect in saw-tooth generator circuit. |
| *(b)* Sine wave is distorted. | *(b)* Defective tube V1, V2, V3, V4, V5, V6, V8, V9, V10, or V11. |
| *(c)* Return trace is visible. | *(c)* Defective blanking circuit. |

*(8)* **STEP 8.** Turn SYNC SIGNAL AMPLITUDE control clockwise until pattern is stationary on screen.

| Normal indication |
|---|
| Pattern becomes and remains stationary with a very small clockwise turn of the control. |

| Abnormal indications | Probable causes of trouble |
|---|---|
| *(a)* Pattern continues to move across the screen. | *(a)* Defective SYNC SIGNAL AMPLITUDE control.<br>Defective SYNC SIGNAL SELECTOR switch. |
| *(b)* Pattern moves or jumps with changes in line voltage. | *(b)* Defective voltage regulators V17 or V18. |

*(9)* **STEP 9.** Turn attenuator switch to INPUT UNDER 250 V RMS and turn up Y GAIN control.

| Normal indication |
|---|
| Signal is reduced in amplitude. |

| Abnormal indications | Probable causes of trouble |
|---|---|
| *(a)* Signal is not reduced in amplitude. | *(a)* Defective attenuator switch S1. |
| *(b)* Signal changes shape or becomes distorted. | *(b)* Defective attenuator circuit. |

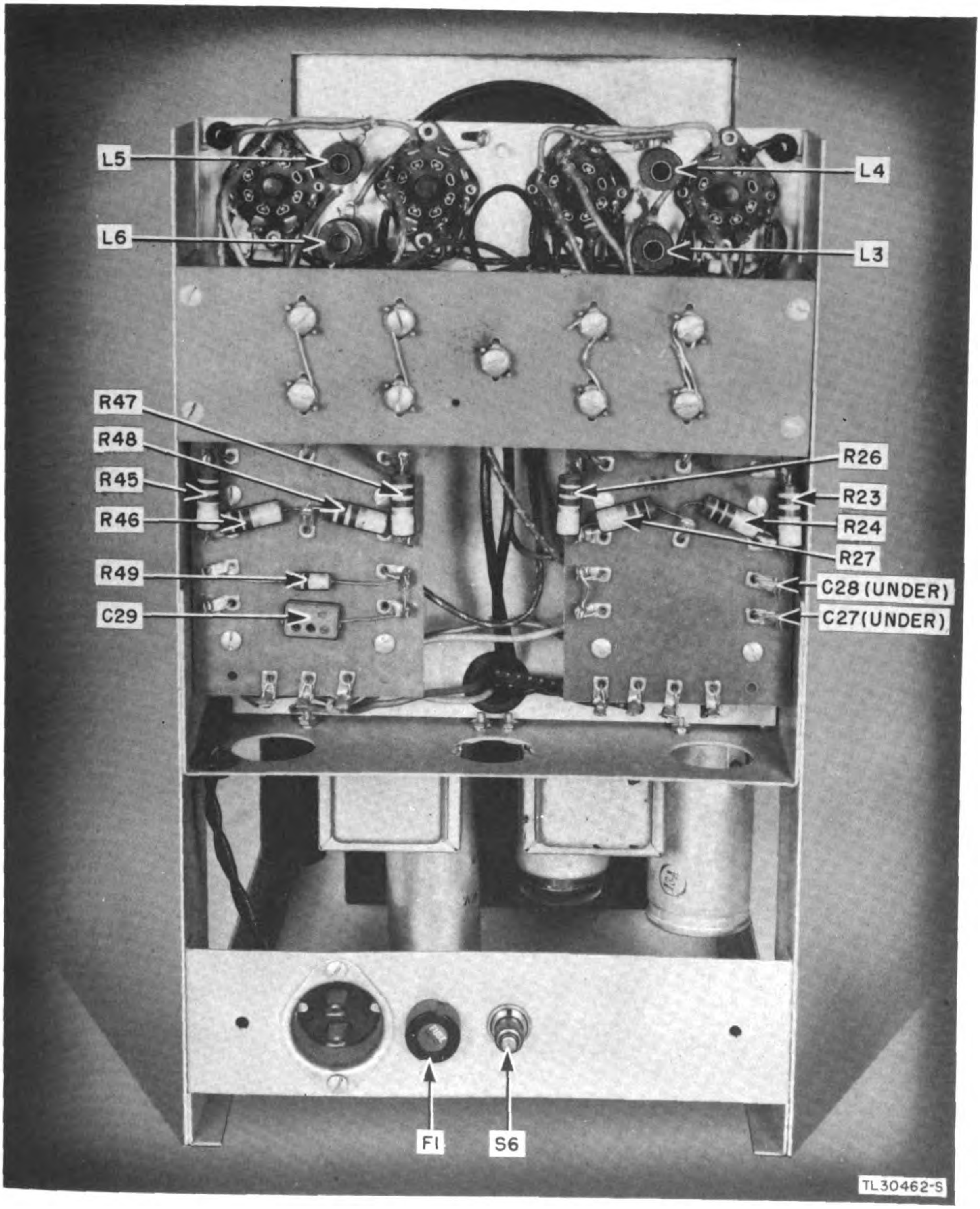



*Figure 25. Rear of chassis.*

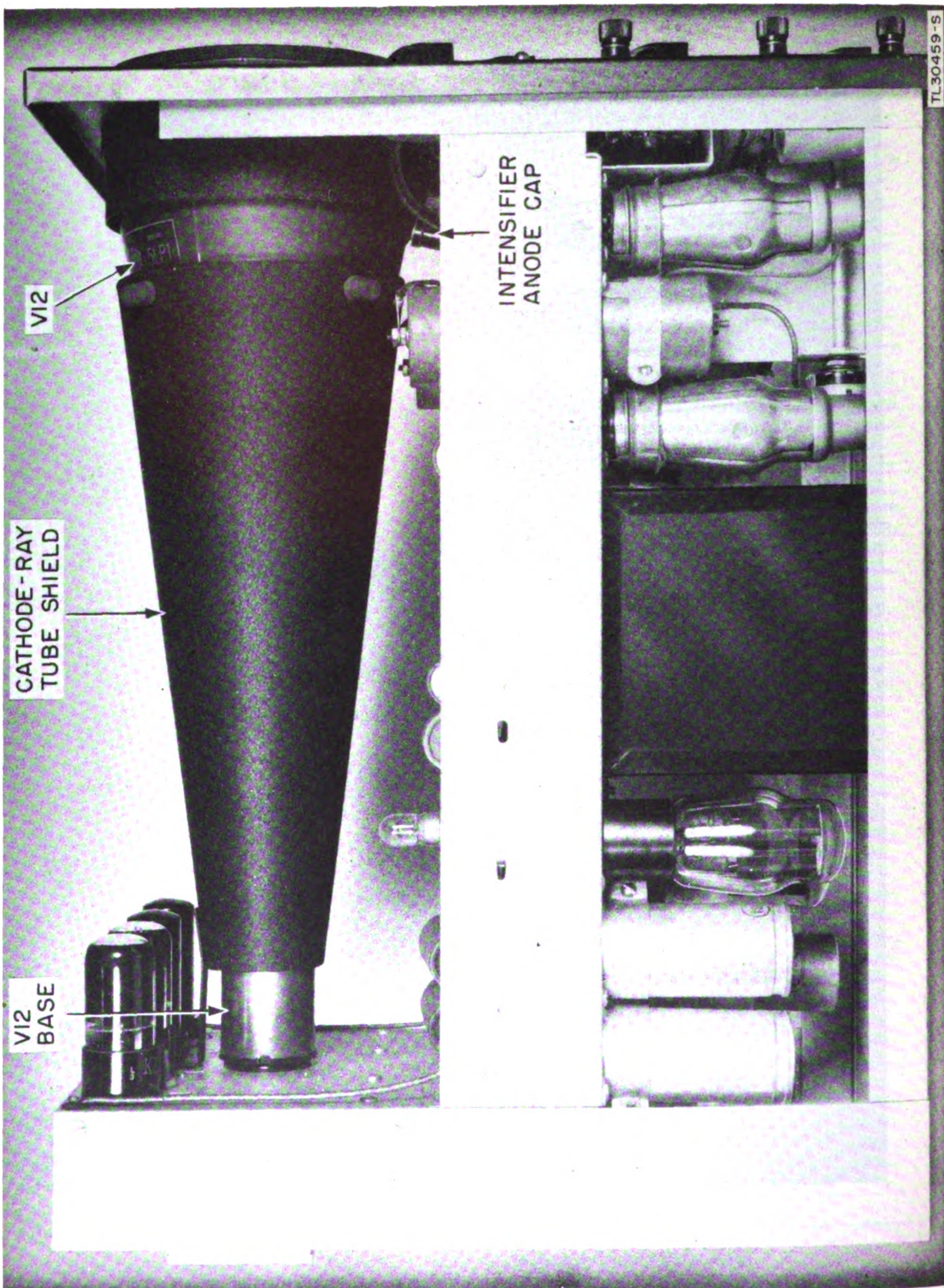



*Figure 26. Side of chassis.*

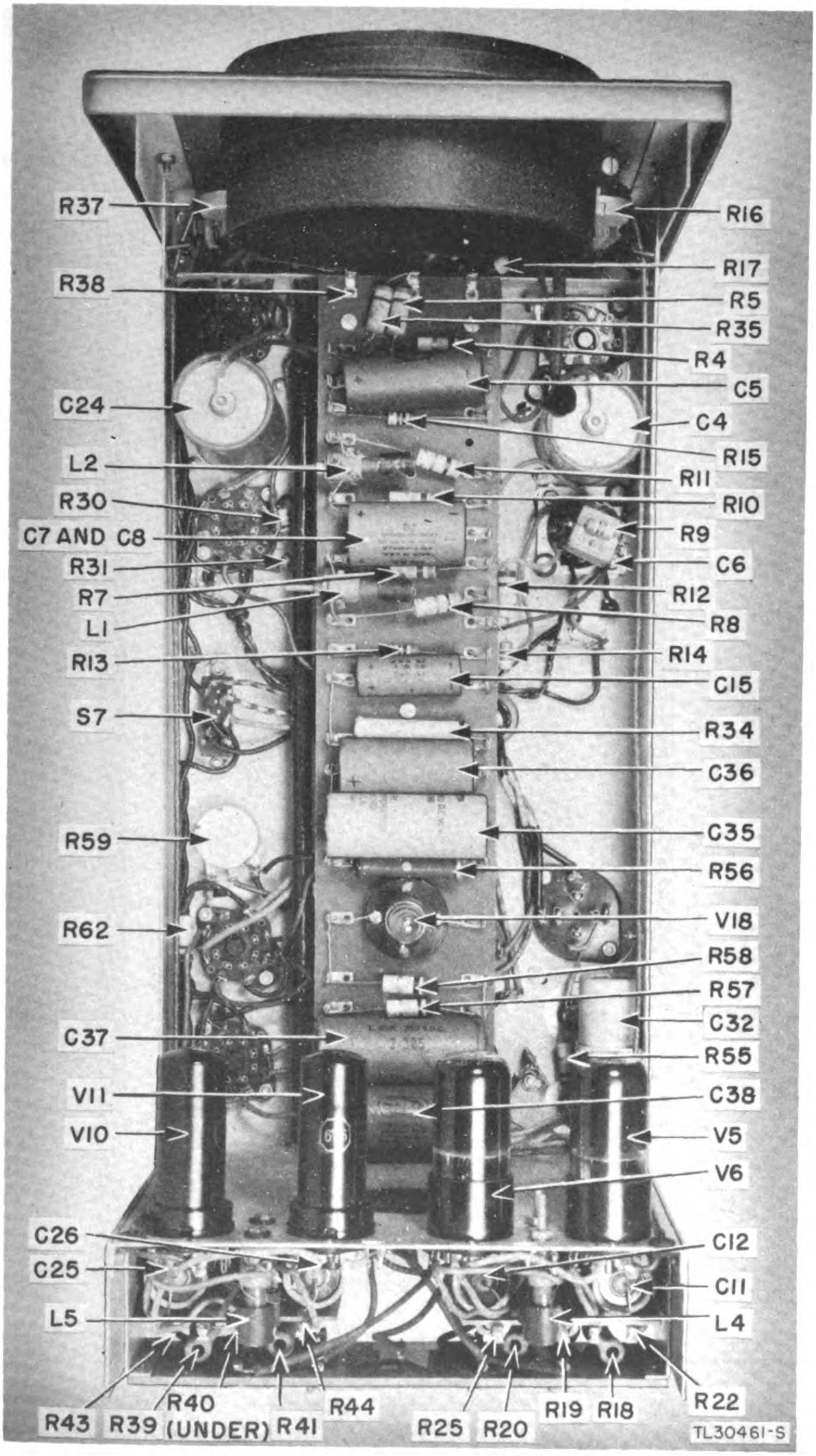



*Figure 27. Top of chassis, cathode-ray tube removed.*

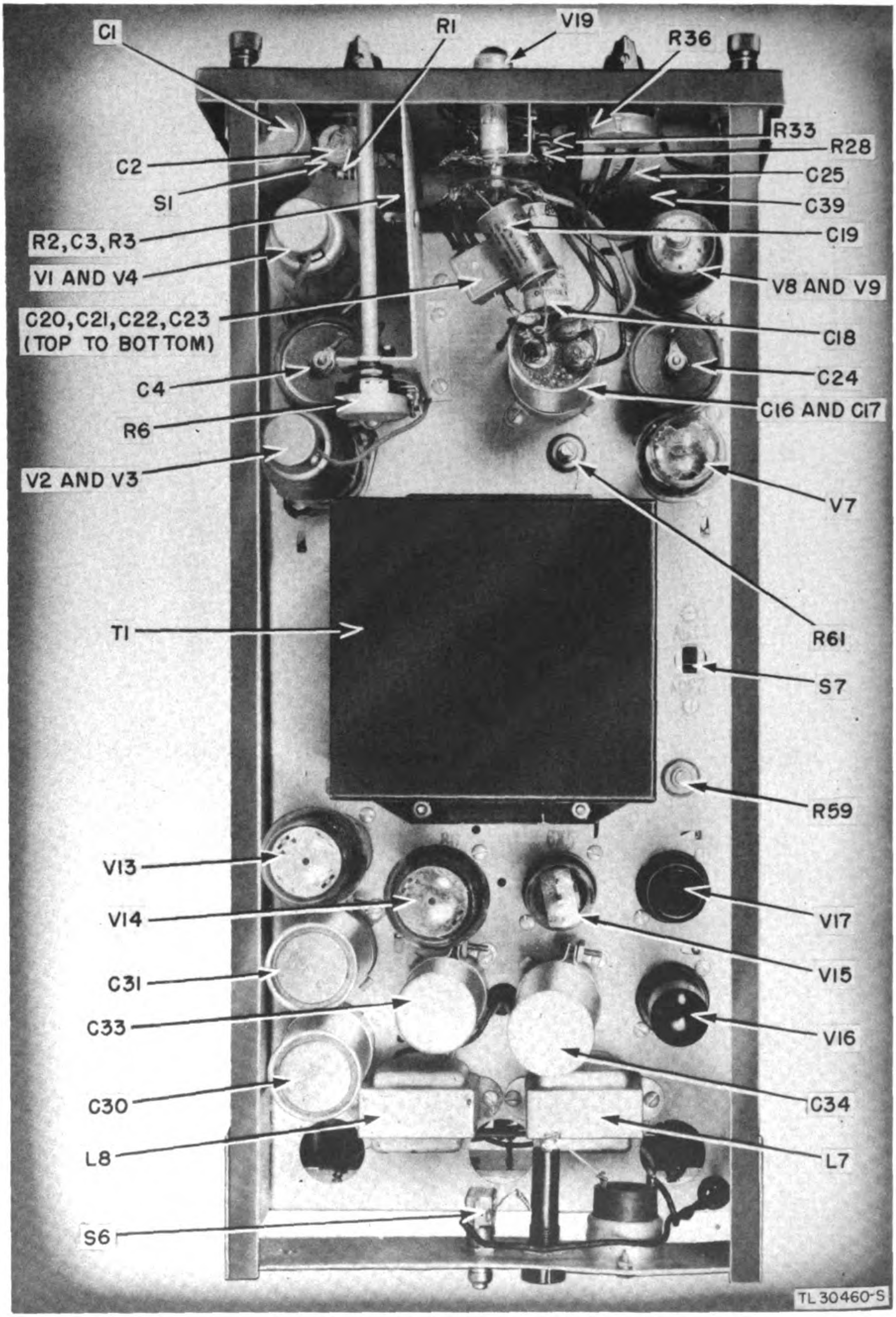



*Figure 28. Bottom of chassis.*

# SECTION X

# REPAIRS

## 41. SERVICING.

Be careful in maintaining and servicing this equipment. Servicing and repair other than the replacement of tubes should be performed only by competent personnel supplied with adequate tools and instruments. An inexperienced operator attempting to locate and repair troubles may damage the equipment to such an extent that shipment to a higher repair echelon is necessary.

## 42. GENERAL REPAIR.

Removal and replacement of defective parts or circuit elements in this equipment are difficult in some cases, and great care must be taken to avoid further damage to the equipment or to the part being replaced. Before attempting repairs, make every effort to obtain the proper tools for the job.

**a. Identification of Leads.** Often it may be necessary to remove other circuit elements to gain access to the defective part. To insure proper reinstallation, make a record of the connections to each removed element and of the position of the element in the equipment.

**b. Electrical Connections.** When replacing leads, clip them as short as possible for satisfactory connection and avoid using more solder than necessary to make a secure connection. A very slight amount of excess solder dropped accidentally inside the equipment may cause other circuits or circuit elements to be short-circuited. Some clearances are very small, and extreme care must be exercised in soldering. Do not heat the lug or connection more than is absolutely necessary because of possible damage to near-by elements such as chokes, capacitors, resistors, and wiring. When a wire is connected to a tube socket, the connecting wire should be long enough to prevent pull on the socket. Save time and trouble by making a thorough electrical check of any part that appears to be defective *before* removing it from the equipment.

**CAUTION:** Never change the location of parts or wiring leads, particularly in the video amplifier circuit. Such a change may affect the performance of the entire circuit. Never change the length of wiring leads.

## 43. MECHANICAL REPAIRS.

**a. General.** When replacing mechanical parts in the equipment, use extreme care in disassembling and reassembling any mechanical units. Use screwdrivers and other tools that fit the job at hand. Secure bolts and screws snugly but do not overtighten them.

**b. Removing Cathode-ray Tube.**

**CAUTION:** Use extreme care when working around, removing, or replacing the cathode-ray tube. Do not strike the tube or allow strains to be placed on it. The tube is highly evacuated, and injury from flying glass may result if it is broken.

*(1)* Remove the two screws at the back of the instrument which hold the chassis in the cabinet (fig. 3) and remove the chassis.

*(2)* Remove tubes V6 and V11 (fig. 27) from their sockets.

*(3)* Remove the intensifying anode cap from the terminal under the cathode-ray tube (fig. 26).

*(4)* Force the cathode-ray tube out of its socket by pulling on the tube base or by pressing on the alignment key with the thumb.

*(5)* Remove the screw which holds the tube shield support bracket to the back of the chassis.

*(6)* Remove the tube and shield together by lifting them out toward the rear of the chassis.

*(7)* In order to replace the tube and shield, replace all parts in reverse order.

*(8)* Turn on the oscilloscope and turn the cathode-ray tube and its socket until the sweep line is horizontal.

# SECTION XI

# ALIGNMENT AND ADJUSTMENT

## 44. VOLTAGE—REGULATOR ADJUSTMENT.

The voltage regulator must be readjusted whenever tubes are changed in the voltage-regulator circuit. The procedure is as follows:

a. Remove the chassis from the cabinet and connect the power cord to the back of the chassis and to the a-c line.

b. Turn the BEAM switch OFF and the POWER switch ON.

> **CAUTION:** Use extreme care when working on the inside of the chassis with the voltage on. Dangerously high voltages are present. Avoid especially the high-voltage rectifier, V13, and the cathode-ray tube socket and circuits.

c. Hold the interlock switch S6 (fig. 25) closed manually; after about 30 seconds, measure the voltage between pin 8 on tube V16 and the chassis with a d-c voltmeter.

d. If the voltage is not 155 volts, adjust the voltage regulator adjustment on the bottom of the chassis (R59, fig. 28) until a reading of 155 volts is obtained.

## 45. FREQUENCY—RANGE ADJUSTMENT.

The sweep frequency range must be readjusted when V7 or one of the resistors in the saw-tooth generator circuit is changed. The procedure is as follows:

a. Start the oscilloscope as explained in paragraph 10.

b. Turn the COARSE FREQUENCY control to 2, the FINE FREQUENCY control completely counterclockwise, and the SYNC SIGNAL SELECTOR switch to EXTERNAL.

c. Adjust the X GAIN control until a sweep line of convenient length is obtained.

d. Turn the POWER switch OFF and remove the chassis from the case without moving the controls.

e. Plug the a-c cord into the chassis again, turn the POWER switch ON, and hold the interlock switch down manually. Wait 30 seconds.

f. Time the horizontal sweeps and adjust the FREQUENCY RANGE ADJUSTMENT (R61, fig. 28) until approximately 2 sweeps per second or 120 sweeps per minute occur.

g. Turn the POWER switch OFF and replace the chassis in the case.

## 46. ADJUSTMENT OF FREQUENCY—COMPENSATION COILS AND ATTENUATOR CIRCUIT.

> **NOTE:** These circuits are adjusted at the factory. They should be adjusted only when it is certain that they are out of alignment and are causing distortion of signal waves.

a. Remove the chassis from the case and short out the interlock switch, S6, with a short wire jumper.

b. Adjust the oscilloscope as explained in subparagraph 12a.

c. Connect a good square-wave signal of about 10,000 cycles-per-second repetition frequency or higher and approximately 100 volts peak-to-peak amplitude to the Y SIGNAL INPUT terminal.

d. Set the attenuator switch at INPUT UNDER 250 V R.M.S.

e. Adjust the frequency controls to obtain at least 2 cycles of the signal on the screen.

f. Adjust the coils and attenuator capacitor in the following order for least distortion of the square wave on the screen: C2, L4, L3, L2, L1, (figs. 25 and 27).

g. Check the adjustment of all the coils and the capacitor in the same order once more.

h. Turn up the intensity until the return trace is visible on the screen. If this is impossible, disconnect one end of the capacitor C29 from the terminal board on the rear of the chassis (fig. 25).

i. Adjust coils L6 and L5 (figs. 25 and 27) for least distortion at the end of the pattern on the screen where the return trace starts.

j. Remove the signal and shut off the power. If C29 has been disconnected, replace it. Be sure to remove the jumper from the interlock switch before putting the chassis back in the case.

## WAR DEPARTMENT
## UNSATISFACTORY EQUIPMENT REPORT

| | | | |
|---|---|---|---|
| FOR | TECHNICAL SERVICE: Signal Corps | MATERIEL | DATE: 20 Feb. 1945 |
| FROM | ORGANIZATION: 885 Signal Repair Co. | | STATION: APO 258, New York |
| TO | NEXT SUPERIOR HEADQUARTERS: Signal Officer | STATION: Army | TECHNICAL SERVICE |

**COMPLETE MAJOR ITEM**

| | | | |
|---|---|---|---|
| NOMENCLATURE: Oscilloscope I-245 | TYPE | | MODEL: Dumont 208-B |
| MANUFACTURER: Dumont | U. S. A. REG. NO.: Order No. 817-MPD-44 | SERIAL NO.: 6428 | DATE RECEIVED: 15 Dec. 1944 |
| EQUIPMENT WITH WHICH USED (If applicable): Radio Set SCR-584 | | | |

**DEFECTIVE COMPONENT—DESCRIPTION AND CAUSE OF TROUBLE**

| | | | |
|---|---|---|---|
| PART NO.: (R-59) 3Z8701-71 | TYPE: Potentiometer | MANUFACTURER: Centralab | DATE INSTALLED: 20 Dec. 1944 |
| DESCRIPTION OF FAILURE AND PROBABLE CAUSE (If additional space is required, use back of form): Potentiometer burned out - too low wattage rating. | | | |

| DATE OF INITIAL TROUBLE | TOTAL TIME INSTALLED | | | TOTAL PERIOD OF OPERATION BEFORE FAILURE | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | YEARS | MONTHS | DAYS | YEARS | MONTHS | DAYS | HOURS | MILES | ROUNDS |
| 26 Jan. 1945 | | 1 | 6 | | | 5 | 15 | | |

BRIEF DESCRIPTION OF UNUSUAL SERVICE CONDITIONS AND ANY REMEDIAL ACTION TAKEN: High operating temperature.

| TRAINING OR SKILL OF USING PERSONNEL | | | RECOMMENDATIONS (If additional space is required, use back of form) |
|---|---|---|---|
| POOR | FAIR | GOOD | |
| | | ✓ | Potentiometer R59 should have a higher power rating. |

**ORIGINATING OFFICER**

| | |
|---|---|
| TYPED NAME, GRADE, AND ORGANIZATION: HAROLD T. MASON, CAPT., SIG.C., 885 SIG. REPAIR Co. | SIGNATURE: Harold T. Mason |

**FIRST ENDORSEMENT**

| | | | |
|---|---|---|---|
| TO CHIEF | TECHNICAL SERVICE | OFFICE | |
| NAME, GRADE, AND STATION | | STATION | DATE |

***Instructions***

1. It is imperative that the chief of technical service concerned be advised at the earliest practical moment of any constructional, design, or operational defect in matériel. This form is designed to facilitate such reports and to provide a uniform method of submitting the required data.
2. This form will be used for reporting manufacturing, design, or operational defects in materiel, petroleum fuels, lubricants, and preserving materials with a view to improving and correcting such defects, and for use in recommending modifications of materiel.
3. This form will not be used for reporting failures, isolated material defects or malfunctions of matériel resulting from fair-wear-and-tear or accidental damage nor for the replacement, repair or the issue of parts and equipment. It does not replace currently authorized operational or performance records.
4. Reports of malfunctions and accidents involving ammunition will continue to be submitted as directed in the manner described in AR 750-10 (change No. 3).
5. It will not be practicable or desirable in all cases to fill all blank spaces of the report. However, the report should be as complete as possible in order to expedite necessary corrective action. Additional pertinent information not provided for in the blank spaces should be submitted as inclosures to the form. Photographs, sketches, or other illustrative material are highly desirable.
6. When cases arise where it is necessary to communicate with a chief of service in order to assure safety to personnel, more expeditious means of communication are authorized. This form should be used to confirm reports made by more expeditious means.
7. This form will be made out in triplicate by using or service organization. Two copies will be forwarded direct to the technical service; one copy will be forwarded through command channels.
8. Necessity for using this form will be determined by the using or service troops.

W. D., A. G. O. Form No. 468
30 August 1944

This form supersedes W. D., A. G. O. Form No. 468, 1 December 1943, which may be used until existing stocks are exhausted.

TL14114-A

U. S. GOVERNMENT PRINTING OFFICE 16—41546-1

*Figure 29. Unsatisfactory Equipment Report.*

## 47. UNSATISFACTORY EQUIPMENT REPORT.

a. When trouble in equipment used by Army Ground Forces or Army Service Forces occurs more often than repair personnel feel is normal, War Department Unsatisfactory Equipment Report, W.D., A.G.O. Form No. 468, should be filled out and forwarded through channels to the Office of the Chief Signal Officer, Washington 25, D. C.

b. When trouble in equipment used by Army Air Forces occurs more often than repair personnel feel is normal, Army Air Forces Form No. 54 should be filled out and forwarded through channels.

c. If either form is not available, Form No. 468 (fig. 29) may be reproduced, filled out, and forwarded through channels. When Army Air Forces No. 54 is required but unavailable, reproduce Form No. 468 and forward it through channels in accordance with directions on Form No. 468.

## 48. MAINTENANCE PARTS FOR OSCILLOSCOPE I-245-B.

| Major component | Ref symbol | Signal Corps stock No. | Name of part and description | Mfr's part and code No. |
|---|---|---|---|---|
| | C-2 | 3D9030V-6 | CAPACITOR, fixed: ceramicon; 4-30 mmf; 500 vdcw; Erie type #N500-TS2A. | |
| | C-29 | 3D9050-10 | CAPACITOR, fixed: mica; 50 mmf ±10%; 1,200 vdcw; Solar type MOB. | |
| | C-23 | 3D9070-2.1 | CAPACITOR, fixed: mica; 70 mmf ±20%; 500 vdcw; Solar type #MO-1413. | |
| | C-22 | 3D9125-2 | CAPACITOR, fixed: mica; 125 mmf ±10%; 500 vdcw; Solar type MOB. | |
| | C-3 | 3D9200-23.3 | CAPACITOR, fixed: mica; 200 mmf ±20%; 500 vdcw; Solar type #MOB-1418. | |
| | C-21 | 3D9600-25 | CAPACITOR, fixed: mica; 600 mmf ±10%; 500 vdcw; Solar type #MWB-1223-10. | |
| | C-20 | 3DA2.500-10 | CAPACITOR, fixed: mica; 2,500 mmf ±10%; 500 vdcw; Solar type #MWB-1234-10. | |
| | C-6 | 3DA5-9.2 | CAPACITOR, fixed: mica; 5,000 mmf ±20%; 500 vdcw; Solar type #MWB-1239. | |
| | C-19 | 3DA10-30.3 | CAPACITOR, fixed: paper; 10,000 mmf ±10%; 400 vdcw; Solar type #XT1M4-.01-10. | |
| | C-18 | 3DA40-12.1 | CAPACITOR, fixed: paper; 40,000 mmf ±10%; 400 vdcw; Solar type #XT1M4-04-10. | |
| | C-14<br>C-27<br>C-28<br>C-39 | 3DA100-161.1 | CAPACITOR, fixed: paper; 100,000 mmf +20% —10%; 100 vdcw; Solar type #XT1M10-.1. | |
| | C-11<br>C-12<br>C-13<br>C-25<br>C-26 | 3DA250-69.2 | CAPACITOR, fixed: paper; 250,000 mmf; 400 vdcw; Solar type #XT1M4. | |
| | C-30<br>C-31 | 3DA500-120 | CAPACITOR, fixed: paper; 500,000 mmf +20% —10%; 1,500 vdcw; Solar type #SJ-266. | |
| | C-1 | 3DA500-121 | CAPACITOR, fixed: paper; 500,000 mmf +20% — 10%; 600 vdcw; Solar Type #XT1M6-.5. | |
| | C-16<br>C-17 | 3DB1.268 | CAPACITOR, fixed: paper; dual sect; 1-1 mf ±10%; 400 vdcw; Solar type #SJ-268. | |

## 48. MAINTENANCE PARTS FOR OSCILLOSCOPE I-245-B (contd).

| Major component | Ref symbol | Signal Corps stock No. | Name of part and description | Mfr's part and code No. |
|---|---|---|---|---|
| | C-9<br>C-10<br>C-37<br>C-38 | 3DB1.263 | CAPACITOR, fixed: paper; 1 mf +20% —30%; Solar type #SJ-263. | |
| | C-32<br>C-35 | 3DB1.10-2 | CAPACITOR, fixed: paper; 1 mf ±10%; 1,000 vdcw; Solar type #KLMR10-1. | |
| | C-4<br>C-24 | 3DB8-75 | CAPACITOR, fixed: paper; 8 mf ±20%; 200 vdcw; Solar type #SJ-262. | |
| | C-33<br>C-36 | 3DB16-11.2 | CAPACITOR, fixed: electrolytic; 16 mf +50% —25%; 450 vdcw; Solar type #DF-416. | |
| | C-5 | 3DB24-1 | CAPACITOR, fixed: paper; electrolytic; 24 mf +50% —10%; 350 vdcw; Solar type #Minacap M-324. | |
| | C-15 | 3DB25-24 | CAPACITOR, fixed: electrolytic; 25 mf +50% —25%; 25 vdcw; Solar type #Minacap M-5025. | |
| | C-7<br>C-8 | 3DB30-12 | CAPACITOR, fixed: electrolytic; dual sect 30-30 mf; 150 vdcw; Solar type Minacap Dual. | |
| | C-34 | 3DB40-49 | CAPACITOR, fixed: electrolytic; 40 mf; 450 vdcw; in 1-3/8" d clamp type can with term lugs; Solar. | |
| | L-3<br>L-4<br>L-5<br>L-6 | 2C2788/C2 | COIL, radio, i-f: peaking; 7-9 mh; Meisner type #S-23865. | |
| | L-1<br>L-2 | 2C2728/C1 | COIL, radio, i-f: peaking; 1 to 3.1 mh; Meisner type #S-23866. | |
| | L-7<br>L-8 | 3C317-15 | COIL, radio, r-f: filter choke; 10.5 hy; 35 ma; 310 ohms; d-c; Chi Trans type #6772. | |
| | | 2Z3063-11 | CONNECTOR, plug: female cont; C-H type #7862-K-7. | |

## 48. MAINTENANCE PARTS FOR OSCILLOSCOPE I-245-B (contd).

| Major component | Ref symbol | Signal Corps stock No. | Name of part and description | Mfr's part and code No. |
|---|---|---|---|---|
| | | 6Z7816-1 | CONNECTOR, receptacle: male cont; C-H type #7868-K-7. | |
| | 8 | 2Z5786.33 | KNOB, bar: bakelite; Crowe Name Plate. | |
| | | 3ZK741-1 | POST, binding: Amer Rad Hdwe type #138VD. | |
| | | 3Z3275 | POST, extractor fuse: screwdriver operated; Littelfuse type #1075. | |
| | R-14 | 3Z6025-21 | RESISTOR, fixed: composition; 250 ohms; 1/2w; Erie type #504. | |
| | R-21<br>R-42 | 3Z6040-27 | RESISTOR, fixed: composition; 400 ohms; 1w; Erie type #504. | |
| | R-31 | 3Z6050-65 | RESISTOR, fixed: composition; 500 ohms; 1/2w; Erie type #504. | |
| | R-8<br>R-11 | 3Z6580-17 | RESISTOR, fixed: composition; 8,000 ohms; 1w; Erie type #518. | |
| | R-30<br>R-60 | 3RC20AE103K | RESISTOR, fixed: composition; 10,000 ohms; 1/2w; Erie type #504. | |
| | R-18<br>R-20<br>R-39<br>R-41 | 3Z6625-73 | RESISTOR, fixed: wire wound; 25,000 ohms ±5%; 10w; Clarostat type "Greenohm"-C10F. | |
| | R-7<br>R-10 | 3Z6625-120 | RESISTOR, fixed: composition; 25,000 ohms ±20%; 1w; Erie type #518. | |
| | R-34 | 3Z6640-38 | RESISTOR, fixed: composition; 40,000 ohms; 3w; Carborund type #792-A. | |
| | R-56 | 3Z6650-102 | RESISTOR, fixed: composition; 50,000 ohms; 3w; Carborund type #792-A. | |
| | R-12<br>R-55 | 3Z6650-51 | RESISTOR, fixed: composition; 50,000 ohms; 1w; Erie type #518. | |
| | R-4<br>R-58 | 3ZK6700-100 | RESISTOR, fixed: composition; 100,000 ohms; 1w; Erie type #518. | |

## 48. MAINTENANCE PARTS FOR OSCILLOSCOPE I-245-B (contd).

| Major component | Ref symbol | Signal Corps stock No. | Name of part and description | Mfr's part and code No. |
|---|---|---|---|---|
| | R-49 | 3RC20AE104K | RESISTOR, fixed: composition; 100,000 ohms; 1/2w; Erie type #504. | |
| | R-19<br>R-40 | 3Z6715-41 | RESISTOR, fixed: composition; 150,000 ohms; 1w; Erie type #518. | |
| | R-52 | 3Z6720-25 | RESISTOR, fixed: composition; 200,000 ohms; 1w; Erie type #518. | |
| | R-2 | 3Z6725-38 | RESISTOR, fixed: composition; 250,000 ohms ±5%; 1/2w; Erie type #504. | |
| | R-5<br>R-35 | 3Z6725-26 | RESISTOR, fixed: composition; 250,000 ohms; 1w; Erie type #518. | |
| | R-17<br>R-38 | 3Z6730-20 | RESISTOR, fixed: composition; 300,000 ohms; 1w; Erie type #518. | |
| | R-33<br>R-57<br>R-62 | 3Z6750-36 | RESISTOR, fixed: composition; 500,000 ohms; 1w; Erie type #518. | |
| | R-22<br>R-25<br>R-43<br>R-44 | 3Z6775-6 | RESISTOR, fixed: composition; 750,000 ohms; 1w; Erie type #518. | |
| | R-54 | 3Z6801-56 | RESISTOR, fixed: composition; 1 meg; 1w; Erie type #518. | |
| | R-13<br>R-15<br>R-50 | 3ZK6801-59 | RESISTOR, fixed: composition; 1 meg; 1/2w; Erie type #504. | |
| | R-3 | 3Z6802-21 | RESISTOR, fixed: composition; 2 meg; 1/2w; Erie type #504. | |
| | R-1 | 3Z6802-10 | RESISTOR, fixed: composition; 2 meg ±5%; 1/2w; Erie type #504. | |
| | R-23<br>thru<br>R-27<br>R-45<br>thru<br>R-48 | 3Z6805-12 | RESISTOR, fixed: composition; 5 meg; 1w; Erie type #518. | |

## 48. MAINTENANCE PARTS FOR OSCILLOSCOPE I-245-B (contd).

| Major component | Ref symbol | Signal Corps stock No. | Name of part and description | Mfr's part and code No. |
|---|---|---|---|---|
| | R-28 | 3Z6805-9 | RESISTOR, fixed: composition; 5 meg; 1/2w; Erie type #504. | |
| | R-61 | 2Z7268.16 | RESISTOR, variable: carbon; 1,000 ohms; 1w; Clarostat type #37 (Potentiometer). | |
| | R-16<br>R-37 | 2Z7270.25 | RESISTOR, variable: carbon; 15,000 ohms; 1w; Clarostat type #37 (Potentiometer). | |
| | R-29<br>R-51 | 2Z7271.28 | RESISTOR, variable: carbon; 100,000 ohms; 1w; Clarostat type #37 (Potentiometer). | |
| | R-6 | 2Z7271-28 | RESISTOR, variable: 100,000 ohms; 270° rotation; shaft 4-3/8" lg; S taper; Clarostat type #37 (Potentiometer). | |
| | R-36<br>R-53<br>R-59 | 2Z7272-28 | RESISTOR, variable: 500,000 ohms; 270° rotation; shaft 3/8" lg; S taper; Clarostat type #37 (Potentiometer). | |
| | R-32 | 2Z7274-8 | RESISTOR, variable: 4 meg ±10%; 270° rotation; shaft 3/8"; S taper; Clarostat type #37 (Potentiometer). | |
| | | 2Z8681.3 | SOCKET: 11-prong magnal w/one retainer ring; Eby type #S-20-11. | |
| | | 2Z8678.42 | SOCKET: octal wafer; 1-1/2" between mtg; Friedman type #39M-1E. | |
| | | 2Z8674.37 | SOCKET: 4-prong wafer; insulator 1-11/16" between mtg centers; Friedman type #34-11-AA. | |
| | | 2Z8678.41 | SOCKET: octal; w/1/4" slotted holes; Amphenol type #M1P-8F. | |
| | | 2Z8672.26 | SOCKET: bayonet base; 2 cont; Graybar type Morse Eureka #20. | |
| | | 2Z5883-81 | SOCKET: miniature bayonet; Dialco type #810. | |
| | S-1<br>S-4 | 3Z9846.2 | SWITCH, toggle: SPDT; AH & H type #21350. | |
| | S-2 | 3Z9825-62.33 | SWITCH: SP3T; Oak type #18597-H-1. | |
| | S-3 | 3Z9825-62.32 | SWITCH, rotary: DP9T; Oak type #18596-QH-2. | |

## 48. MAINTENANCE PARTS FOR OSCILLOSCOPE I-245-B (contd).

| Major compo-nent | Ref symbol | Signal Corps stock No. | Name of part and description | Mfr's part and code No. |
|---|---|---|---|---|
| | S-5 | 3Z9692.1 | SWITCH, toggle: SPST; AH & H type #20992. | |
| | S-6 | 3Z9559 | SWITCH, safety: normally open; AH & H type #3592. | |
| | S-7 | 3Z9835 | SWITCH, slide: DPDT; Stackpole type #SS3. | |
| | T-1 | 2Z9608-8 | TRANSFORMER, power: Chi Trans type #6164A. | |
| | | 2J6F8G | TUBE, electron: JAN-6F8G (VT-99). | |
| | | 2J6SJ7GT | TUBE, electron: JAN-6SJ8GT (VT-116A). | |
| | | 2J6V6GT/G | TUBE, electron: JAN-6V6GT/G (VT-107A). | |
| | | 2J6X5GT/G | TUBE, electron: JAN-6X5GT/G (VT-126B). | |
| | | 2J80 | TUBE, electron: JAN-80 (VT-80). | |
| | | 2J6Q5G | TUBE, electron: JAN-6Q5G. | |
| | | 2J5LP1 | TUBE, electron: JAN-5LP1. | |

Order No. 1352-MPD-44; 11,500 copies; 18 April, 1945.

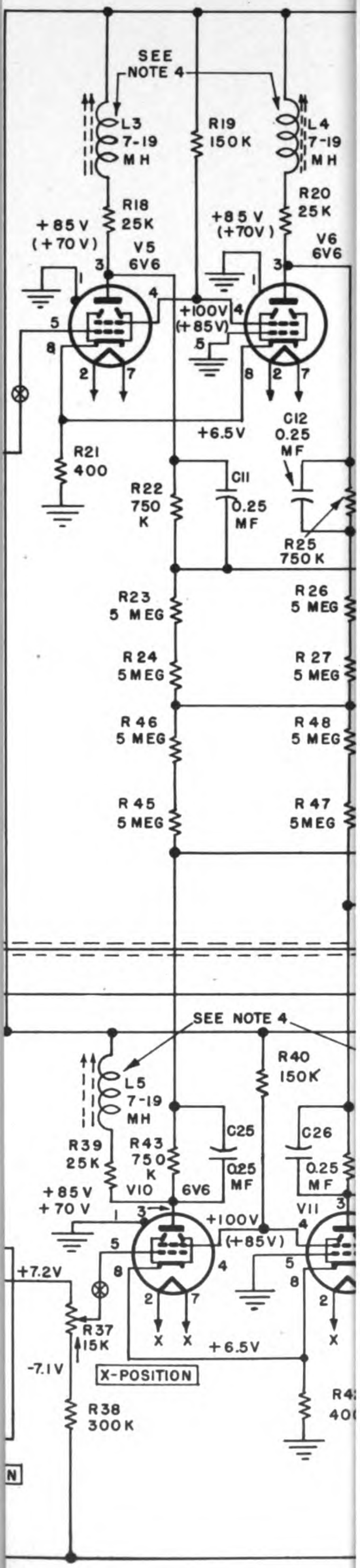



*Figure 24. Oscilloscope I-245-B*