TM 11-1053

RESTRICTED

WAR DEPARTMENT TECHNICAL MANUAL

TEST EQUIPMENT
RC-68 and RC-68-A

CONFIDENTIAL

WAR DEPARTMENT • 1 AUGUST 1944

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TEST EQUIPMENT
RC-68 and RC-68-A

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WAR DEPARTMENT,
WASHINGTON 25, D. C., 1 AUGUST 1944.

TM 11-1053, War Department Technical Manual, Test Equipment RC-68 and RC-68-A, 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.

DISTRIBUTION:
IC 11(5)

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

WARNING

HIGH VOLTAGE

is used in the operation of

this equipment.

DEATH ON CONTACT

may result if operating personnel

fail to observe safety precautions.

SAFETY NOTICE

HIGH VOLTAGES SUFFICIENT TO CAUSE DEATH EXIST IN THE TEST OSCILLOSCOPES AND IN TEST SET I-115. EXERCISE THE UTMOST CAUTION WHEN WORKING WITH THESE UNITS WHENEVER THE CHASSIS HAS BEEN REMOVED FROM THE CASE. BE SURE THAT THE POWER IS OFF AND THAT THE CAPACITORS IN THE HIGH-VOLTAGE CIRCUITS ARE COMPLETELY DISCHARGED BEFORE TOUCHING AND PARTS OF THE UNIT. DON'T RELY ALTOGETHER ON THE SAFETY SWITCH OR ON THE CAPACITORS DISCHARGING THRU THE RESISTANCE SHUNT, ESPECIALLY IF THE UNIT HAS BEEN DAMAGED. WHEN MEASURING VOLTAGES IN RADIO SETS OF THE SCR-268 SERIES DO NOT ATTEMPT TO MEASURE VOLTAGES IN EXCESS OF 500 VOLTS. CIRCUITS CONTAINING HIGHER VOLTAGES CAN BE EXAMINED BY RESISTANCE AND CONTINUITY CHECKS WITH THE POWER OFF.

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

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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LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (continued)

DESTRUCTION NOTICE

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

WHEN— When ordered by your commander.

HOW—

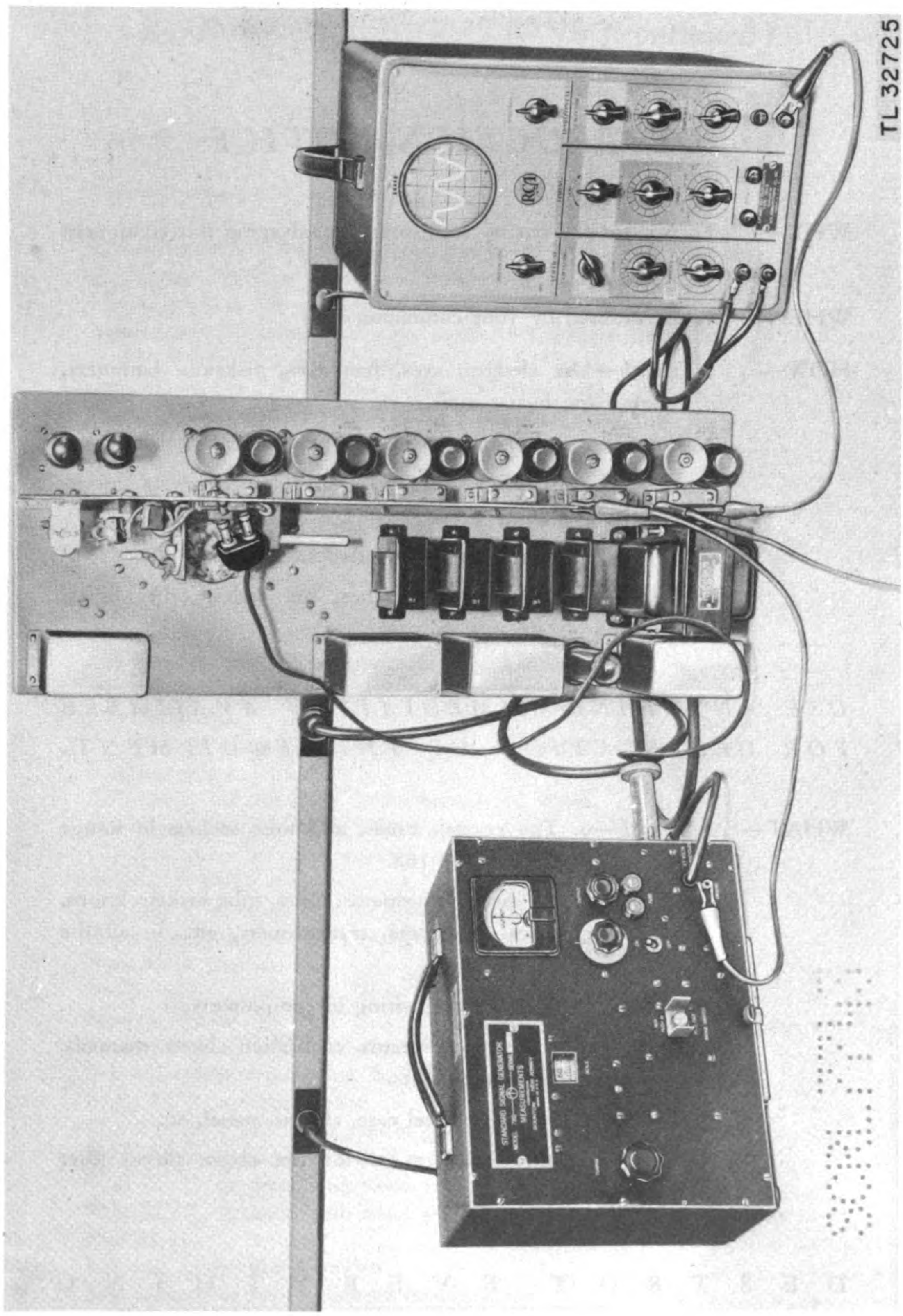
1. *Smash*—Use sledges, axes, handaxes, pickaxes, hammers, crowbars, heavy tools.
2. *Cut*—Use axes, handaxes, machetes.
3. *Burn*—Use gasoline, kerosene, oil, flame throwers, incendiary grenades.
4. *Explosives*—Use firearms, grenades, TNT.
5. *Disposal*—Bury in slit trenches, fox holes, other holes. Throw in streams. Scatter.

USE ANYTHING IMMEDIATELY AVAILABLE FOR DESTRUCTION OF THIS EQUIPMENT.

WHAT—

1. *Smash*—*a.* The crystal, tubes, and tube sockets in Range Calibrator I-168.
   b. All meter movements, tubes, tube sockets, knobs, fuses, capacitors, transformers, etc., in all the components.
2. *Cut*—Test cords, cables, wiring in components.
3. *Burn*—All schematic diagrams, calibration charts, manuals, wire, and all components.
4. *Bend and or break*—Steel case, chassis, panel, etc.
5. *Bury or scatter*—Any or all of the above pieces after breaking.

DESTROY EVERYTHING



Frontispiece. Alignment of Receiver BC-406-A.

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SECTION I
GENERAL DESCRIPTION

1. PURPOSE.

a. The nature of radio and electronic equipment is such that visual inspection is of little value in determining satisfactory performance. A wide variety of tests and of measuring apparatus, based on the same principles used in the equipment itself, has been devised to enable accurate evaluation of performance as well as to facilitate testing, adjustment, and efficient maintenance in the field.

b. The actual repair of radio apparatus is seldom difficult. A more difficult problem, however, is encountered in locating defects. It is therefore essential that the radio technician be familiar with the equipment to be repaired as well as with the test equipment with which the diagnosis is made.

c. With this in mind, the text of this manual is designed to explain the function and use of Test Equipment RC-68 and RC-68-A, supplied with Radio Sets SCR-268 and SCR-268-B respectively. In the text, the use of the symbol (*) with Test Equipment RC-68 will indicate both Test Equipment RC-68 and Test Equipment RC-68-A; and when used with Radio Set SCR-268, will indicate Radio Sets SCR-268, SCR-268-A, SCR-268-B, and SCR-268-C.

2. TEST EQUIPMENT PROVIDED.

a. Modification of Official Component-parts List. Because of various circumstances, the test equipment actually provided with Radio Set SCR-268-(*) may depart widely from the official component-parts list for Test Equipment RC-68-(*). It is therefore impossible to determine in advance which piece of test equipment will be available. In order to cover all contingencies, a discussion of alternate units of test equipment has been included in this manual in addition to those on the official component-parts list. The parts list for Test Equipment RC-68-(*) is given at the rear of this book (pars. 200 to 206 inclusive). This list includes manufacturers and stock numbers.

b. Official and Alternate Units. A list of the test equipment covered in this book follows:

(1) Audio Oscillator I-151, Hickok model 198.
(2) Audio Oscillator, Supreme model 563.
(3) Analyzer I-167, Weston model 772.
(4) Analyzer I-153, Precision model 856.
(5) Analyzer, Supreme model 592.
(6) Calibrator I-168.
(7) Keyer load, Test Set I-115.
(8) Oscilloscopes, RCA models 155-A and 155-B.
(9) Oscilloscope I-134, Dumont model 224.
(10) Oscilloscope, Supreme model 546.
(11) Plug PL-217.
(12) Plug PL-218.
(13) Polarized Outlet Box BC-672-B.
(14) Range Calibrators I-108, I-158, and I-178.
(15) Receiver output boxes, Test Sets BC-671 and BC-708-A.
(16) Receiver remote control, Test Sets BC-670-A and BC-670-B.
(17) Remote Control Test Box BC-670-B.

(18) Screen M-352.
(19) Sight M-351.
(20) Signal Generator I-126, Measurements models 78-B and 78-C.
(21) Signal generator, Ferris microvolter 18-B.
(22) Syncronous repeater Test Set I-114.
(23) Thermocouples, Weston model 425 and Weston type D.
(24) Tube Checker I-180, Hickok model 540.
(25) Tube Checker I-157, Precision model 920.
(26) Tube checker, Supreme model 504-A.

c. *Test Cords.* Various test cords are provided with Test Equipment RC-68-(*). These cords are used for many purposes such as supplying power to the components of Radio Set SCR-268-(*) while in test position, connecting the output of Receiver BC-406 to the input of Oscilloscope BC-412, shorting out the interlock system while servicing the components, and as general utility cords. A detailed description of the test cords is given in paragraphs 200 and 203.

SECTION II
METERS

3. GENERAL.

a. Meters are used in radio repair work to obtain information necessary to locate and correct the various troubles that arise. There are three general types of meters, each designed to perform a specific operation: the *ammeter* (or *milliammeter*) which measures *current* in amperes (or milliamperes), the *voltmeter*, which measures *voltage*, and the *ohmmeter* which measures *resistance* in ohms. Perhaps the most frequently used instrument is the voltmeter. By taking voltage readings at various points throughout a radio circuit, trouble can be isolated to a single stage or circuit. The ohmmeter can then be used to locate the defective part or parts in that circuit. Resistors, volume controls, tuning coils, choke coils, transformer windings and capacitors can be checked with the ohmmeter to determine whether any of these parts contain open, short or grounded circuits. The ammeter (or milliammeter) is used less frequently in trouble shooting than other meters, but it is used extensively as a panel instrument on transmitters to indicate grid and plate currents.

b. All three general types of meters are simply galvanometers, current measuring devices with a scale calibrated in amperes (or milliamperes), volts, or ohms, as the case may be. The difference in function depends mainly upon how the galvanometer is connected to the circuit under test and on the units in which the instrument is calibrated. For convenience in trouble shooting, the functions of the ammeter, voltmeter, and ohmmeter are combined in one unit known as an *analyzer*. The desired function is selected by operating a button or switch.

4. THE GALVANOMETER.

a. The galvanometer is an instrument designed to detect the presence of direct current in a circuit. It consists principally of a permanent horseshoe magnet, between the two poles of which is suspended a movable coil. To the coil are attached a pointer and a spring which holds the pointer to its zero position when no current is being passed through the coil.

b. When a current is passed through the coil, it becomes an electromagnet with two poles of opposite polarity. The reaction between the energized coil and the permanent magnet causes the coil to rotate on its axis so as to facilitate the attraction of the unlike poles and the repulsion of the like poles of the two magnets. The amount of movement is determined by the resultant balance between the pull of the spring mechanism and the strength of the magnetic field set up around the coil. Since the strength of the magnetic field is determined by the amount of current flowing through the coil, the amount of rotation is a direct indication of the coil current. This may be read directly from the calibrated scale under the pointer.

5. AMMETERS AND MILLIAMMETERS.

a. General. The ammeter or milliammeter is inserted in *series* with a circuit to measure current flow. The circuit under test must be broken to allow the meter to be connected. The internal resistance of the moving coil is kept relatively low because, if the ammeter resistance were high, there would be an appreciable voltage drop across the ammeter. Because it is a low-resistance device, an ammeter should *never* be connected across a voltage source or line. If the ammeter were so connected, its low resistance would permit a large current through it, and the coil would be instantly burned out. An ammeter must, therefore, always be connected in *series* with the circuit.

b. Sensitivity. The sensitivity of a meter is determined by the amount of current necessary to cause full-scale deflection of the pointer. Thus, if a current of 1 milliampere through the moving coil causes full-scale deflection, the meter has a sensitivity of 1 milliampere. Meters of the moving-coil type are made with sensitivities varying from several milliamperes to a few microamperes, according to the sensitivity required. A galvanometer which is calibrated in microamperes is called a *microammeter;* one calibrated in milliamperes is called a *milliammeter;* one calibrated in amperes is an *ammeter.* The galvanometer movement can be designed to be calibrated in any one of the above units of current. In radio repair work the most commonly used meters are the milliammeter and microammeter. Since these two meters are very sensitive, full-scale deflection of the needle will be caused by a very small current.

c. Shunts. (1) To measure values of current greater than the scale calibration, it is necessary to shunt a definite portion of the current around the meter, and to take the shunt into consideration when reading the calibrated scale for the value of current. When $\frac{1}{10}$ of the current in a circuit is allowed to flow through the meter and $\frac{9}{10}$ of the current is shunted around it, the total current is 10 times the value of the meter reading. If the full amount of current were allowed to pass through the ammeter, the ammeter coil would of necessity have to be of heavier wire and thereby increase the size and cost, and also cut down the sensitivity of the entire moving element.

(2) A shunt will carry a portion of the total current which depends upon the ratio of its resistance to the resistance of the ammeter coil; this makes it possible to use an ammeter of the same sensitivity for different current ranges by merely shunting or bypassing a portion of the current. The size of the shunt desired is determined from the amount of current to be measured and from the existing resistance of the ammeter coil.

(3) For example, suppose a meter having a 990-ohm coil reads full scale with a current flowing through it of 1 milliampere and it is desired to extend the full scale reading to 10 milliamperes. The parallel or shunt resistor must be of such value that 9 milliamperes will flow through it, leaving 1 milliampere to flow through the meter for full-scale deflection. Using Ohm's law, this resistance is figured to be 110 ohms or $\frac{1}{9}$ of 990 ohms. This example is shown in figure 1 where R1 is the meter resistance and R2 is the shunting resistor, or the low-resistance path in parallel with the meter. All parts of the meter circuit are shown inside the broken line. Since E = IR:

$$E_{(meter)} = I_{(meter)} \times R_{(meter)}$$

$$E = 0.001 \times 990$$

$E = 0.99$ volts (voltage drop across meter).

Since the voltage drop across the meter is also across the shunt, in order to make 9 milliamperes flow through the shunt:

$$R_{(shunt)} = \frac{E_{(shunt)}}{I_{(shunt)}}$$

$$R = \frac{0.99}{0.009} = 110 \text{ ohms (shunt)}$$

(4) By using values of shunt resistance which will increase the range of the meter in multiples of 10, the original calibrated scale of the meter may easily be used for a wide variety of ranges. Thus

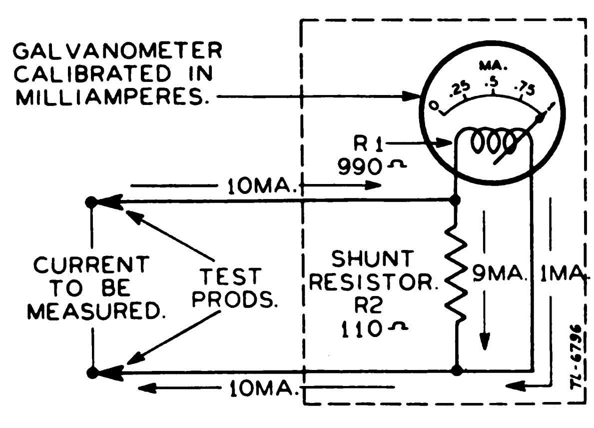


Figure 1. The galvanometer as a milliammeter, showing shunt.

with the arrangement shown in figure 1, the scale, although calibrated from zero to 1 milliampere, may be used to measure any current up to 10 milliamperes. The meter reading is multiplied by 10 to obtain the total current in the curcuit. To extend the range of the meter to read zero to 100 milliamperes the value of R2 must be changed to 10 ohms, or $\frac{1}{99}$ of the meter coil resistance. A current of 1 milliampere must still flow through the galvanometer for full-scale deflection, leaving 99 milliamperes to flow through R2. The meter reading is then multiplied by 100 for the actual current being measured.

(5) The value of the shunt resistor R2 may be changed by actually replacing R2 with a 10-ohm resistor, or by placing an 11-ohm resistor in parallel with the 110-ohm resistor used as a shunt for the 10-milliampere range (since 11 ohms in parallel with 110 ohms equals 10 ohms). Still another method is to short out 100 ohms of the 110-ohm resister, leaving 10 ohms for the shunt. Provisions for making these changes have been incorporated in the analyzer by the manufacturer. Either range switches or taps connected to pin jacks are generally used. It is not intended that the operator open up the analyzer and make these changes.

(6) For radio repair work, current ranges will vary from 100-microamperes full-scale deflection to 50-amperes full-scale deflection. The average meter, however, will not incorporate such extreme ranges. A range of 1 milliampere to 1-ampere full-scale deflection is sufficient for most needs in trouble shooting.

d. Correct Selection of Scale in Multiscale Meters. (1) The commonly used milliammeters are most accurate at the *top* (*maximum*) *portion of the scales.* For greatest accuracy, take current readings at the top of the scale by using the lowest available meter range for any given measurement. However to avoid damage to the meter always start by using the highest range and work down to the lowest usable range; that is, the range which will place the needle indication on the upper portion of the calibrated scale.

(2) Since a d-c meter will measure current flowing in only one direction, it is important to observe polarity when connecting the meter in a circuit. Current flowing through the meter in the wrong direction will damage the meter movement.

6. THE VOLTMETER.

a. General. (1) The voltage across a battery can be measured by a galvanometer arranged as a voltmeter (fig. 2). Voltmeters are used for measuring the electric pressure, or voltage, between two points in an electric circuit. While an ammeter is connected in *series* with the circuit in which current is being measured, a voltmeter is connected in *parallel* with (directly across) the voltage source. Because of its comparatively low resistance, the moving coil of the voltmeter cannot be connected directly across the voltage source, as it would ordinarily take an excessive current and be burnt out. Therefore, it is necessary to connect a high resistance in series with the coil.

(2) The galvanometer can then be connected across the voltage source in series with this resistance and used to measure voltage. By Ohm's law the current flowing through the meter is proportional to the voltage at its terminals. As explained previously, this current flows through the moving coil and develops a turning force proportional to the current intensity. Therefore, the voltage across the terminals of the voltmeter develops a turning force which moves the pointer attached to the moving coil across a scale calibrated in volts.

b. Multipliers. (1) Because of the low resistance of most meters only a very low voltage is required to cause full-scale deflection. The range of a voltmeter may be increased, however, by the use of additional resistances connected in series with the meter. These additional resistances are called multipliers. When the resistance of the meter circuit is increased by placing a resistor in series with it, the voltage necessary to cause full-scale deflection is increased proportionately.

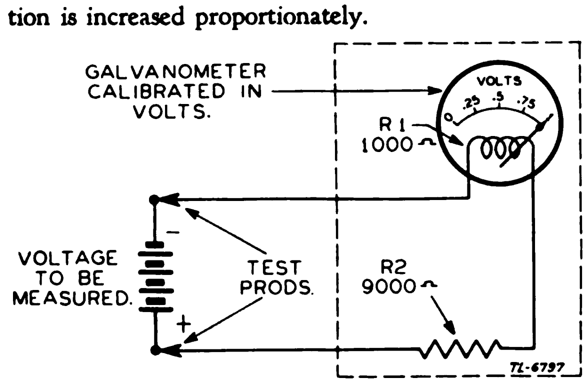


Figure 2. The galvanometer as a voltmeter.

(2) If a resistor equal in value to the meter resistance is placed in series with the meter across a battery, half as much current will flow, or twice the voltage will be required for full-scale deflection of the meter. If the meter is calibrated in units of current, and the values of the meter resistance R1 and the multiplier resistance R2 are known, the voltage across the battery may be calculated using Ohm's law. However, the calculations for such measurements may be eliminated entirely by calibrating the meter scale directly in volts and including the multiplier resistor R2 as a component part of the meter.

(3) A range switch may be included with the meter to switch various fixed values of R2 into the meter circuit, thereby permitting several voltage ranges to be used with one instrument. Usually one resistance is used and tapped at several points in order to provide several values of resistance. The values of R2 are generally chosen in multiples of 10 so that the resistance of the meter movement will be a fraction, such as $\frac{1}{10}$, $\frac{1}{100}$, or $\frac{1}{1000}$ of the total value of resistance in the meter circuit. This permits the original voltage-calibrated scale to be used on all ranges of the meter.

(4) As an example, suppose the meter movement in figure 2 has a resistance of 1,000 ohms and the scale of the meter is calibrated from zero to 1 volt. It is desired to extend the range of the meter to measure from zero to 10 volts. The multiplier resistor R2 must drop 9 volts, leaving 1 volt across the meter for full-scale deflection. By Ohm's law, the current through the meter with 1 volt across it is 1 milliampere. Since this same value of current must flow through R2, the resistance of R2 may be figured by Ohm's law to be 9,000 ohms. Any voltage between zero and 10 volts may now be measured by multiplying the reading on the meter scale by 10. If it is desired to extend the range of the meter to read from zero to 100 volts, a multiplier resistance of 99,000 ohms must be placed in series with the meter movement. Then the voltage reading on the meter scale will be multiplied by 100 for the correct value of voltage being measured. These figures may be verified by using Ohm's law.

c. Sensitivity. (1) The d-c voltmeters used in Test Equipment RC-68-(*) are rated at either 1,000 ohms per volt or 20,000 ohms per volt. This figure is based upon the current sensitivity of the meter movement, which means the amount of current which must flow through the moving coil of the meter for full-scale deflection. Thus, a meter rated at 1,000 ohms per volt uses a moving-coil system which, for full-scale deflection, requires 1 milliampere of current through the coil. A 20,000-ohm-per-volt instrument uses a moving-coil system which requires only 0.05 milliampere of current through the meter for full-scale deflection.

(2) It is not possible to change a low-resistance voltmeter to a high-resistance voltmeter of the same range by simply connecting a resistance in series with it, for this arrangement would reduce the current flowing through the meter and would therefore reduce the deflection of the pointer. High-resistance voltmeters are built especially for this purpose and are more sensitive than the ordinary low-resistance type. Usually more turns of wire are wound on the moving coil to obtain the same ampere-turn effect at a smaller value of amperes.

(3) If the internal resistance-per-volt rating of the meter is known (such as 1,000 or 20,000 ohms-per-volt), it is simple to establish the total meter resistance for any voltage range selected for the measurement. Multiply the ohm-per-volt rating of the meter by the voltage range selected. Thus, a 1,000-ohm-per-volt meter set to the 5-volt range represents a total meter resistance of 1,000 x 5 (5,000 ohms). The same instrument set to the 250-volt range represents a total meter resistance of 1,000 x 250 (250,000 ohms). In the case of a 20,000-ohm-per-volt meter set to the 5-volt range, the meter resistance is 100,000 ohms; at the 250-volt range, the meter has a resistance of 5,000,000 ohms. These figures show that the increase in voltage range is caused by the increase in the total meter resistance which is placed in shunt with the resistance in the circuit being checked.

d. Errors in D-c Voltage Readings. If correct measurements are to be made and proper conclusions reached, it is imperative to understand the conditions which prevail in the components to be tested and also in the test equipment. The combination of both will materially influence the accuracy and interpretation of the measured values of voltage.

(1) An examination of the schematic diagrams of the components of Radio Set SCR-268-(*) will show that d-c operating potentials are applied to the vacuum-tube elements through resistances varying from several ohms to as high as 1 megohm. When one of the d-c voltmeters is connected across these resistances, the internal resistance of the voltmeter becomes a shunt path for the current normally flowing through the resistance and developing the voltage across that same resistance. This shunting effect is known as *loading*. Loading causes a voltmeter reading lower than the true value existing across the resistance, when no supplementary apparatus (such as the voltmeter) is connected across that resistance. The same is true when voltage measurement is made between any two points of a circuit containing such a resistance.

(2) The error which enters into the reading in high-resistance circuits, where the meter resistance is low compared to the resistance of the circuit being tested, is obvious in the following example. Suppose that two 1-megohm resistors are placed in series across a 100-volt battery (fig. 3). According to Ohm's law, a current of 0.05 milliampere will flow through each resistor, and a voltage drop of 50 volts will occur across each resistor. In attempting to measure this 50-volt drop with a 1,000-ohm-per-volt voltmeter using the 100-volt range, the comparatively low 100,000-ohm meter resistance will be in parallel with the 1-megohm circuit resistor (fig. 4). The value of the parallel combination is 90,909 ohms, or less than one tenth of the original 1-megohm resistor. The total resistance across the battery is now 1,090,909 ohms, and a current of about 0.09 milliampere will flow. This will cause a voltage drop of 90.9 volts across the remaining 1-megohm resistor, and a voltage drop of 9.1 volts across the combination of the meter and 1-megohm resistor under test. The voltmeter will indicate 9.1 volts, which is an error of 82 percent, much too great to be tolerated in repair work. *It is now evident that, for an accurate voltage reading across a high-resistance circuit, the resistance of the meter must be considerably higher than the resistance of the circuit.*

(3) The resistance of the meter circuit may be changed only by changing the value of the multiplier resistors. This is accomplished by the range

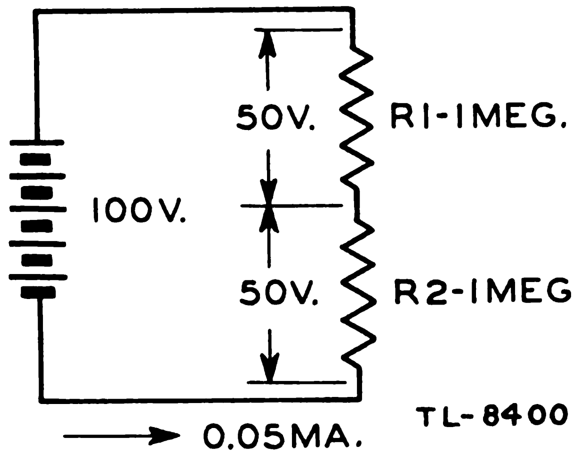


Figure 3. High-resistance series circuit.

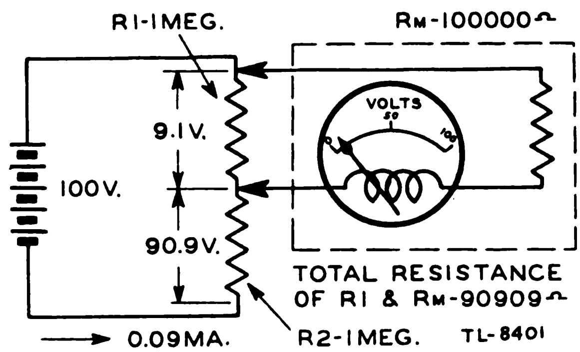


Figure 4. Circuit shown in figure 3 showing effect of voltmeter.

switch on the panel of the voltmeter. Since the voltmeter resistance increases as the voltage ranges are increased, the higher voltage ranges decrease the loading effect and therefore are more accurate. This seems to indicate that the meter-needle indication for a given voltage measurement should be at the *lower* end of the calibrated scale for best accuracy. However, it was shown that the *current* meter was most accurate when the needle indication was at the *top* (maximum) portion of the caibrated scale and, since the voltmeter is a current meter calibrated in volts, the same reasoning holds true for the voltmeter. This is in direct contrast to the discussion just finished on the voltmeter. Obviously a compromise must be made. When taking voltage readings across a *low-resistance* circuit such as a battery, power-supply voltage divider, or power line, the resistance of the meter is sufficiently greater than the resistance of the circuit under test to be disregarded as a source of error when placed in parallel with the circuit resistance. *The most accurate voltage reading across a low-resistance circuit is made when the needle indication is at the upper portion of the calibrated scale.* Consequently, the lowest available range of the voltmeter should be used for this measurement. Always take the precaution of starting with the highest range and working down to the proper low range in order to protect the meter from damage.

(4) Now, when taking voltage readings across a *high-resistance* circuit, such as a grid-leak bias resistor, the voltmeter resistance, even on the highest voltage range, is too small to be disregarded as a source of error when it is placed in parallel with the circuit resistance. *Therefore, the most accurate reading across a high-resistance circuit is made using the highest range that will give a readable indication. This means that the needle will be at the lower portion of the calibrated scale, and will indicate a reading which is only approximate.*

(5) *If the d-c voltmeter in use contains both a 1,000-ohm-per-volt and a 20,000-ohm-per-volt measuring system selected by means of a switch, the lower of the two can be used for all d-c voltage measurements across low values of resistance or low-resistance circuits. However, the 20,000-ohm-per-volt system should be used for all d-c measurements in high-resistance circuits, as well as for the measurement of low voltage in all circuits.* A good working rule to remember when using a voltmeter is that the resistance of the voltmeter (its resistance for the particular range used) should be at least ten times the resistance of the circuit across which it is connected when making the voltage measurement.

e. Effect of Variation in Voltage Range on Sensitivity. (1) Whenever a d-c voltage measurement is made across a circuit which contains a substantial value of resistance, the actual indication upon the voltmeter will vary in accordance with the voltage range selected as well as the meter resistance. For example, when measuring 100 volts across a 100,000-ohm resistor, the voltage indicated upon the meter will be different for the 1,000-ohm-per-volt system and the 20,000-ohm-per-volt system. Furthermore, it is different when the voltage range-selector switch of the meter is set to 100 volts, 250 volts, or 500 volts. The indication of voltage upon the meter increases with the increase in voltage range selected.

(2) The reason for this condition has already been mentioned, namely, that the higher the voltage range selected, the higher will be the internal resistance of the voltmeter, and the less the loading effect upon the circuit under test; consequently, the meter reading will approach more closely the true value of voltage across the circuit being checked. Conversely, the greater the loading of the voltmeter upon the circuit under test, the lower will be the voltmeter reading as compared with the true voltage across the circuit without any load. Correction factors for establishing true voltage cannot be stated because of the wide range of ohmic values of resistances used in the various tube circuits. Furthermore, the voltages to be measured vary over a wide range, and it is impossible to state exactly the particular voltmeter range which will be selected for voltage measurement.

7. THE A-C VOLTMETER.

a. General. (1) The direct current operated voltmeter may be used to measure a-c voltages provided the meter is used in conjunction with a rectifier. The a-c voltage must be rectified before it is applied to the meter circuit for measurement. The rectifier used for this purpose is usually of the full-wave, copper-oxide type, consisting of four copper-oxide rectifier disks connected in a bridge circuit. The rectification is caused by the oxide film formed on the copper disks. Current flows readily from the oxide to the copper and much less readily in the reverse direction. The disks are usually arranged in a stack, with suitable terminals between adjacent disks for connection to the instrument and to the external circuit. Contact to the oxide coating is made by the use of lead washers, graphite, or various metals applied to the surface, the main requirement being low-resistance contact over an extended period of time.

(2) Since the output of the rectifier is a pulsating direct current, the movement of the meter needle follows the average value of the measured voltage. However, most a-c voltmeters are calibrated in

terms of the root-mean-square (rms), or effective, value of voltage.

(3) The a-c voltmeters used in the voltage-measuring units of Test Equipment RC-68-(*) consist of 1-milliampere d-c meters operated in conjunction with copper-oxide rectifiers to become 1,000-ohm-per-volt a-c voltmeters. The 20,000-ohm-per-volt instrument in Analyzer I-167 (Weston model 772) is converted into a 1,000-ohm-per-volt meter by means of an external shunt.

b. Errors in A-c Voltage Readings. (1) In voltage measurements taken with a current-operated a-c meter, the copper-oxide rectifier is an outstanding source of error. The rectifier varies in efficiency with the amount of current passing through it. As the current flow increases, the resistance of the rectifier decreases. Thus the total of the multiplier and meter resistances is changed with the variation of current flow. This introduces error in reading an evenly calibrated scale. If the scale is calibrated to compensate for this error, it is so crowded at the lower end that accurate readings at that end are difficult.

(2) The a-c meters are suitable for measurement of a-c voltages only up to about 10,000 cycles, because the accuracy of the rectifier-meter combination decreases about 0.5 percent per thousand cycles. The frequencies of most of the signal voltages in Receiver BC-406 are so high as to be beyond the range of the analyzers included in Test Equipment RC-68-(*). These signal voltages are of the order of 205 megacycles in the radio-frequency (r-f) and miexr systems; 185 megacycles in the oscillator, oscillator-buffer, and mixer systems; and approximately 20 megacycles in the intermediate-frequency (i-f) system. Other signal voltages in the receiver, keyer, range unit, and oscilloscope are in the audio-frequency (a-f) band which permits the application of the a-c voltmeters contained in the analyzers, provided these signals are sinusoidal.

(3) The signal voltages in some of the components of Radio Set SCR-268-(*) are essentially of pulse, saw-tooth, and rectangular waveshape, and as such cannot be accurately measured by means of the meter-type a-c voltmeters contained in the test equipment. These nonsinusoidal signal voltages decrease the accuracy of the meter.

(4) Another factor which may cause errors in a-c voltage readings is the previously discussed loading effect of the analyzer system upon the a-c circuit which is being measured (par. 6d(1)).

c. The Output Meter. (1) This instrument is an a-c voltmeter, usually calibrated in volts. When used as an output meter it indicates comparative voltage readings. An application of this would be in the alignment procedure of a radio set, where it is merely used to indicate a maximum swing of the needle for a given condition, such as resonance in a tuned circuit through which a signal is passing.

(2) A series capacitor self-contained in the instrument is supplied for taking output readings directly from the plate circuit of any vacuum tube. The capacitor isolates the instrument so that d-c potential will not cause damage. When taking a-c readings, never use the series capacitor if actual voltages are to be measured, as the impedance of the capacitor will vary with frequency and therefore will materially upset the calibration of the instrument. Where comparisons are made in output, the capacitor may be used provided the variations in audio frequency are not a factor.

8. THE OHMMETER.

a. General. (1) The galvanometer may be used to measure resistance if it is connected as shown in figure 5. It has been shown that if a galvanometer is placed across a source of voltage, the amount of current flowing through the meter depends upon the resistance of the meter circuit. In the case of the voltmeter, the *resistance* was fixed so that the voltage could be measured. In the case of the ohmmeter, the *voltage* is fixed so that

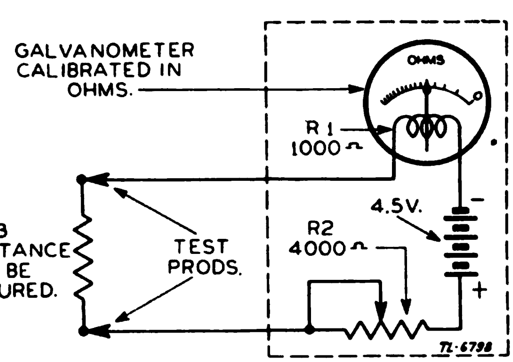


Figure 5. The galvanometer as an ohmmeter.

resistance may be measured. The fixed voltage is supplied by a battery which is included as a part of the ohmmeter.

(2) Suppose the same galvanometer that was used as a voltmeter is to be used as an ohmmeter. The meter-coil resistance R1 will then be 1,000 ohms, and a current of 1 milliampere flowing through the coil will cause full-scale deflection. If the battery used with the ohmmeter has a terminal voltage of 4.5 volts as in figure 5, the resistance in the meter circuit for a current flow of 1 milliampere must be 4,500 ohms. If 1,000 ohms of the resistance is in the coil of the meter, 3,500 ohms must be added to the circuit. This is accomplished by R2, a variable resistor with a maximum resistance of 4,000 ohms. R2 is then adjusted to a value of 3,500 ohms. But R3, the resistance to be measured, is also in the circuit. If R3 is shorted out and R2 is adjusted to exactly 3,500 ohms, the meter will indicate full-scale deflection. This corresponds to a reading of zero ohms since the value of R3 when it is shorted out is zero ohms. Full-scale deflection on the scale may then be calibrated as zero ohms. If the short across R3 is removed, resistance will be added to the meter circuit and cause less current to flow through the meter. This means that there will be less deflection of the needle on the calibrated scale. If R3 has a value of 4,500 ohms, the total resistance in the meter circuit will be 9,000 ohms, exactly twice the previous value for full-scale or zero-ohms deflection. Therefore the current will be one half of what it was before, and the meter will read half scale. The half-scale mark on the meter will then correspond to 4,500 ohms and may be calibrated as such. Various values of R3 will then cause various deflections on the meter scale which, if calibrated in ohms, will indicate the value of the resistance under test.

b. *Zeroing the Meter.* The process of adjusting R2 for full-scale deflection on the meter scale with R3 shorted out (or, what amounts to the same thing, with the test prods shorted together) is called *zeroing* the meter. THE METER MUST BE ZEROED EVERY TIME AN UNKNOWN RESISTANCE IS MEASURED. R2 is variable instead of fixed because the battery voltage does not remain constant over a period of time. As the battery ages, its terminal voltage drops and thus reduces the current flow through the meter. In a situation involving lower battery voltage, R3 shorted out, and R2 still adjusted to 3,500 ohms, the meter deflection will no longer be full scale. However, if R2 is readjusted to a value less than 3,500 ohms, the current may be increased to cause full-scale deflection again for zero ohms.

c. *Range.* The average ohmmeter scale is calibrated from zero to 1,000 ohms, with zero ohms corresponding to full-scale deflection and 1,000 ohms corresponding to only a very slight deflection. To read values of resistance higher than 1,000 ohms, the range of the ohmmeter must be increased. This is done in a manner similar to the method used for the voltmeter. A single calibrated scale is used, and all ranges are increased in multiples of 10. Thus the single scale may be used to read all resistances simply by multiplying the meter reading by the appropriate figure such as 10, 100, 1,000. In order to increase the range of the ohmmeter, the battery voltage must be increased. Because the resistance under test is added to the meter circuit and limits the current flow through the meter movement, the meter movement resistance must be sufficiently low to allow adequate current to flow through and cause deflection on the meter. If resistance R3 under test is so high in value that the current flow through the meter is insufficient to cause needle deflection, the battery voltage must be increased in order to cause greater current flow through the meter. The battery voltage may be made variable by placing a voltage divider across a battery with high-terminal voltage and tapping the divider at various points.

d. *Testing of Capacitors.* Instructions explaining the use of the ohmmeter in testing capacitors is given in paragraph 197.

9. PRECAUTIONS WHEN HANDLING METERS.

Since the meters contained in Test Equipment RC-68-(*) are sensitive instruments, precautionary measures must be taken when handling each piece of equipment.

a. *Connecting and Setting Voltmeters.* When a voltmeter is applied to a circuit for voltage measurement, whether a-c or d-c, always set the range-selector switch to the highest voltage range before taking any measurements. Then, with the instrument connected, reset the voltage-range-selector switch to give the most readable indication. This simple precaution may save the instrument from serious damage. Meter pointers should not be *banged* across the scale. Furthermore, an excessive overload will burn out the meter coil or the copper-oxide rectifier. Even if the meter coil or the rectifier are not burnt-out, careless handling will bend the pointer and spoil the accuracy of the reading.

b. Polarity. Always observe correct polarity, when the test leads are applied to the component being measured. All d-c voltages are usually measured with respect to ground. When measuring positive d-c voltages, connect the positive lead to the voltage source and the negative lead to the chassis or ground. When measuring negative d-c voltages, connect the negative lead to the voltage source and the positive lead to the chassis or ground. If this polarity is not observed, the analyzer will be damaged. If the polarity cannot be determined, merely touch the test leads to the source of voltage, using a range of 500 volts or higher. If the meter kicks to the left, off scale, the test leads are reversed. Reverse the leads and continue with the measurement.

c. Connecting Ammeters. Always connect an ammeter or milliammeter in series with either side of the line. When connecting an ammeter in a circuit, open one side of the line and connect the ammeter so that the current flows through it. Never connect an ammeter across the line, since its very low resistance would allow a heavy rush of current to burn out the meter.

d. A-c and D-c Measurements. Make certain when changing from a-c to d-c measurement that the selector switch has been properly set to adapt the instrument for d-c measurement. Be sure that similar precautions are observed when changing from d-c to a-c measurements. A few seconds of thought may save hours of work.

e. Tube Sockets. Take care before attempting to measure voltages at any tube socket. Modern octal sockets look alike but tube elements do not always terminate upon the same terminals on the sockets. It is easy to make a mistake. If the tube-pin connections are not familiar, consult a reference manual.

f. High Voltages. Operating voltages in the radio set range from a fraction of a volt to approximately 11,000 volts. Since high voltages are dangerous and require extreme care in making measurements, *do not* attempt to measure voltages in excess of 500 volts. Whenever it is necessary to examine circuits containing higher voltages, such as the keyer or oscilloscope high-voltage circuits, make resistance and continuity tests with the power OFF.

g. Live Circuits. Never connect an ohmmeter to a live circuit. Do not touch the metal portion of the test prods while in use.

h. Battery Drainage. Do not allow the ohmmeter test leads to be shorted for an excessive period of time, such as when the meter is not in use, in order to preserve the battery.

SECTION III

ANALYZER I-167, WESTON MODEL 772

10. GENERAL. Analyzer I-167 is one of the combination a-c d-c voltage-measuring and d-c resistance-measuring devices contained in the test equipment. A front view of the panel with identification of the functions of the various connectors and switches is given in figure 6 and a complete schematic diagram is presented in figure 7. This unit is equipped to measure d-c volts between zero and 1,000 in five ranges, d-c current from zero to 250 milliamperes in three ranges, and from zero to 1 and from zero to 10 amperes in two ranges. The instrument will measure d-c resistance from zero to 30 megohms and a-c volts from zero to 1,000 in five ranges. Individual scales are provided for resistance measurement, d-c volts, and a-c volts. The d-c-volt scale is also the d-c-current scale. All the d-c-volt ranges are available at a sensitivity of 20,000 ohms per volt. All the a-c ranges operate at 1,000 ohms per volt.

11. APPLICATIONS OF ANALYZER TO RADIO SET SCR-268-(*).

a. Limitations. (1) Operating voltages in Radio Set SCR-268-(*) cover a range from a fraction of a volt to about 11,000 volts. Voltages in parts of certain components cannot be measured by the analyzer because they exceed the voltage ranges of the analyzer. Such voltages appear in the transmitter, the rectifier, the modulator, the high-voltage power supply (to the cathode-ray tube) in the oscilloscope, and the final amplifier and high-voltage power supply circuits of the keyer.

(2) The high frequency of most of the signal voltages in the receiver limits the use of the analyzer. These signal voltages are approximately 205 megacycles in the r-f and mixer circuits; 185 megacycles in the oscillator, buffer, and mixer circuits, and 20 megacycles in the i-f circuits. The analyzer is suitable for measuring a-c voltages up to 10,000 cycles only.

(3) The pulse and rectangularly shaped signal voltages in the oscilloscope and keyer cannot be measured accurately by the analyzer.

(4) A further limitation in the use of the analyzer is imposed by the high resistance of receiver-grid circuits. This resistance may result in loading, a condition explained in paragraph 6d.

b. D-c Voltages. The analyzer will measure safely all d-c operating potentials in the receiver and range units and can be used also in all the low-voltage circuits of the oscilloscope and keyer.

c. A-c Voltages. The voltage-measuring device included in the analyzer may be applied to all audio-frequency voltages within its range such as the audio output of the receiver and oscilloscope. However, the meter accuracy decreases when it is applied to the nonsinusoidal waveshaped pulses at different points in both the oscilloscope and keyer.

d. Resistance Measurements. The analyzer can be used to make continuity tests and take resistance measurements in all components of the set. These operations always are performed with no voltage applied to the circuit. The ohmmeter is particularly

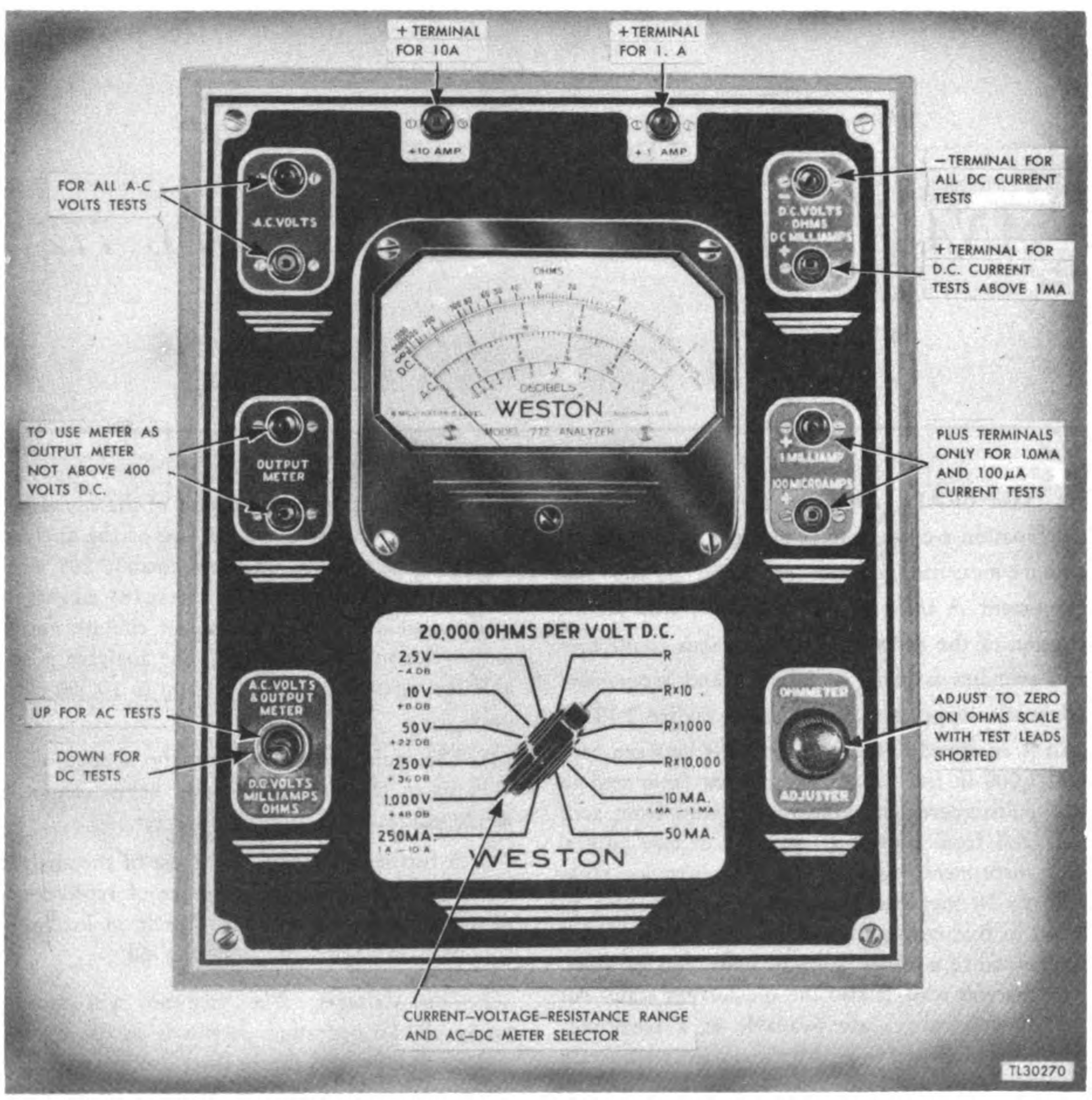


Figure 6. Analyzer I-167, Weston model 772, panel view.

useful in making continuity tests of cords and cables.

e. Precautions. Refer to paragraph 9 for precautions to be taken when handling meters.

12. D-C VOLTAGE MEASUREMENTS. The following procedure is given for measuring d-c voltages:

> **CAUTION:** Do not attempt to measure voltage in excess of 500 volts.

a. Plug the red test lead into the jack marked D.C. VOLTS, OHMS, D.C. MILLIAMPS. Plug the black test lead into the —jack.

b. Set the toggle switch to the D.C. position.

c. Rotate the range switch to any one of the four ranges required. If the approximate voltage is not known, always use the highest voltage range and reset the range after the instrument is connected.

d. Apply the test leads to the circuit being measured, observing polarity. For d-c positive voltages, connect the red test lead to the voltage source and the black test lead to the chassis or ground. For d-c negative voltages, reverse the leads.

e. Take the reading on the black VOLTS MA. AMPS scale using the associated numbering. Multiply by 1, 10, or 100 in accordance with the switch range being used. All ranges are 20,000 ohms per volt. The current that the voltmeter draws may be calculated on any measurement in terms of a full-scale deflection of 50 microamperes.

f. The resistances of the volt ranges are as follows:

Volt ranges	*Resistances*
2.5-volt range	50,000 ohms
10-volt range	200,000 ohms
50-volt range	1 megohm
250-volt range	5 megohms
1,000-volt range	20 megohms

13. D-C CURRENT MEASUREMENTS. All current measurements are made with the test leads in series with the load. Following are instructions for taking d-c current measurements.

> **CAUTION:** Do not attempt to measure current in the presence of voltage greater than 500 volts.

a. For 250, 50, or 10 Milliamperes. (1) Plug the red test lead into the +jack marked D.C. VOLTS OHMS D.C. MILLIAMPS. Plug the black test lead into the —jack.

(2) Set the toggle switch in the D.C. position.

(3) Rotate the range switch to the desired milliampere range (250ma, 50ma, or 10ma).

(4) Apply the test leads in *series* with the load, making sure that proper polarity is observed. Always apply the positive lead in the direction of the higher-potential source and connect the negative lead in the direction of the lower-potential source.

(5) Take the reading on the black VOLTS MA. AMPS scale.

b. For 1 Milliampere or 100 Microamperes. (1) Plug the black test lead into the —jack marked D.C. VOLTS OHMS D.C. MILLIAMPS.

(2) Plug the red lead into the jack marked +1 MILLIAMP or +100 MICROAMPS as required.

(3) Set the range switch in the 10 MA — 1 MA — .1 MA position.

(4) Apply the test leads in *series* with the load, observing proper polarity.

(5) Take the reading on the black VOLTS MA. AMPS scale.

c. For 50 Microamperes. (1) Plug the red test lead into the +jack marked D.C. VOLTS OHMS D.C. MILLIAMPS. Plug the black test lead into the —jack.

(2) Set the toggle switch to the D.C. position.

(3) Rotate the range switch to the 2.5 V position.

(4) Apply the test leads in *series* with the load, observing proper polarity.

(5) Take the reading on the black VOLTS MA. AMPS scale. The full scale is 50 microamperes.

d. For 1 or 10 Amperes. (1) Plug the black test lead into the —jack marked D.C. VOLTS OHMS D.C. MILLIAMPS.

(2) Plug the red test lead into the +1 AMP. or +10 AMP. jack as required.

(3) Set the range switch to the 250 MA. — 1 A. — 10 A. position.

(4) Apply the test leads in *series* with the load, observing proper polarity.

(5) Take the reading on the black VOLTS MA. AMPS scale.

14. RESISTANCE MEASUREMENTS. Take all resistance measurements with the power in the circuit *off*.

a. Plug the test leads into the D.C. VOLTS OHMS D.C. MILLIAMPS jacks.

b. Set the toggle switch to the D.C. position.

c. Rotate the range switch to the ohm range desired.

Range	*Ohms*
R	0 to 3,000
R x 10	0 to 30,000
R x 1,000	0 to 3 megohms
R x 10,000	0 to 30 megohms

d. Short-circuit the test leads and set the pointer to full scale by rotating the OHMMETER ADJUSTER knob.

e. Apply the free ends of the test leads across the circuit being measured, and take the ohm-resistance reading on the top scale using the multiplying factor in accordance with the switch position.

f. When ranges are changed, short-circuit the test leads and readjust the OHMMETER ADJUSTER until the pointer indicates exactly full scale.

15. A-C VOLTAGE MEASUREMENTS.

a. Plug the test leads into the A.C. VOLTS jacks.

b. Set the toggle switch in the A.C. VOLTS & OUTPUT METER position.

c. Rotate the range-selector switch to the correct voltage range. If the correct range is not known, use the highest voltage range and readjust the range after the instrument is connected.

d. Apply the test leads to the circuit being measured.

e. Read the red arc for all a-c volt ranges.

16. USE AS AN OUTPUT METER.

a. General. An output meter is a device used for measuring the output power of amplifiers, radio receivers, etc. The method of measurement is to feed the output of the set to a load resistance in the meter and measure the voltage drop produced across this resistor. The scale is calibrated in volts. For the purpose of measuring the signal voltage in a circuit that also contains d-c, a capacitor has been incorporated in the analyzer circuit used to measure a-c (fig. 7).

b. Operation. (1) Plug the test leads into the OUTPUT METER jacks.

(2) Set the toggle switch to the A.C. VOLTS & OUTPUT METER position.

(3) Rotate the range switch to any one of the five voltage ranges desired.

(4) Apply the free ends of the test leads to the circuit being measured.

(5) The readings will be relative as the 0.2-mfd capacitor in the circuit will cause an error on low ranges. This capacitor (which is built into the analyzer to protect the instrument against direct current) is limited to 400 volts direct current and must not be used in circuits which exceed this d-c voltage.

17. MAINTENANCE.

a. General. (1) Analyzer I-167 is a precision instrument and no maintenance will be attempted by inexperienced personnel. Analyzers contain many parts which are more delicate than parts of a fine watch. Mechanical shocks or electrical overloads will damage the meter or affect its accuracy. Maintenance of this analyzer will consist chiefly of battery replacement and, to a limited extent, replacing of component parts. Locate faults by continuity tests, by resistance measurements, and by visual inspection.

> **CAUTION:** Do not attempt any adjustment or repair on the meter movement.

(2) The schematic diagram (fig. 7) shows the values of component parts.

(3) Replace batteries which are part of the meter when necessary. Need for replacement may be indicated by faulty meter operation or by periodic checks. When opening test equipment for inspection of batteries, visually inspect the wiring and component parts for loose connections, obviously overloaded components, dirty switch contacts, or other likely sources of trouble.

(4) In testing meter circuits with an ohmmeter, the sensitive indicating-meter movement of a piece of test apparatus should be disconnected first from the circuit.

b. Battery Testing and Replacement. (1) The Weston model 772 analyzer utilizes two Burgess No. 5540 batteries of 7.5 volts each, connected in series with a tap-off of 1.5 volts for the three lowest ranges (R, Rx10, Rx1,000). These batteries are located in the bottom of the case and held in place by clamps. The batteries may be reached for replacement or test by removing the four corner screws on the panel and lifting the complete analyzer from its case.

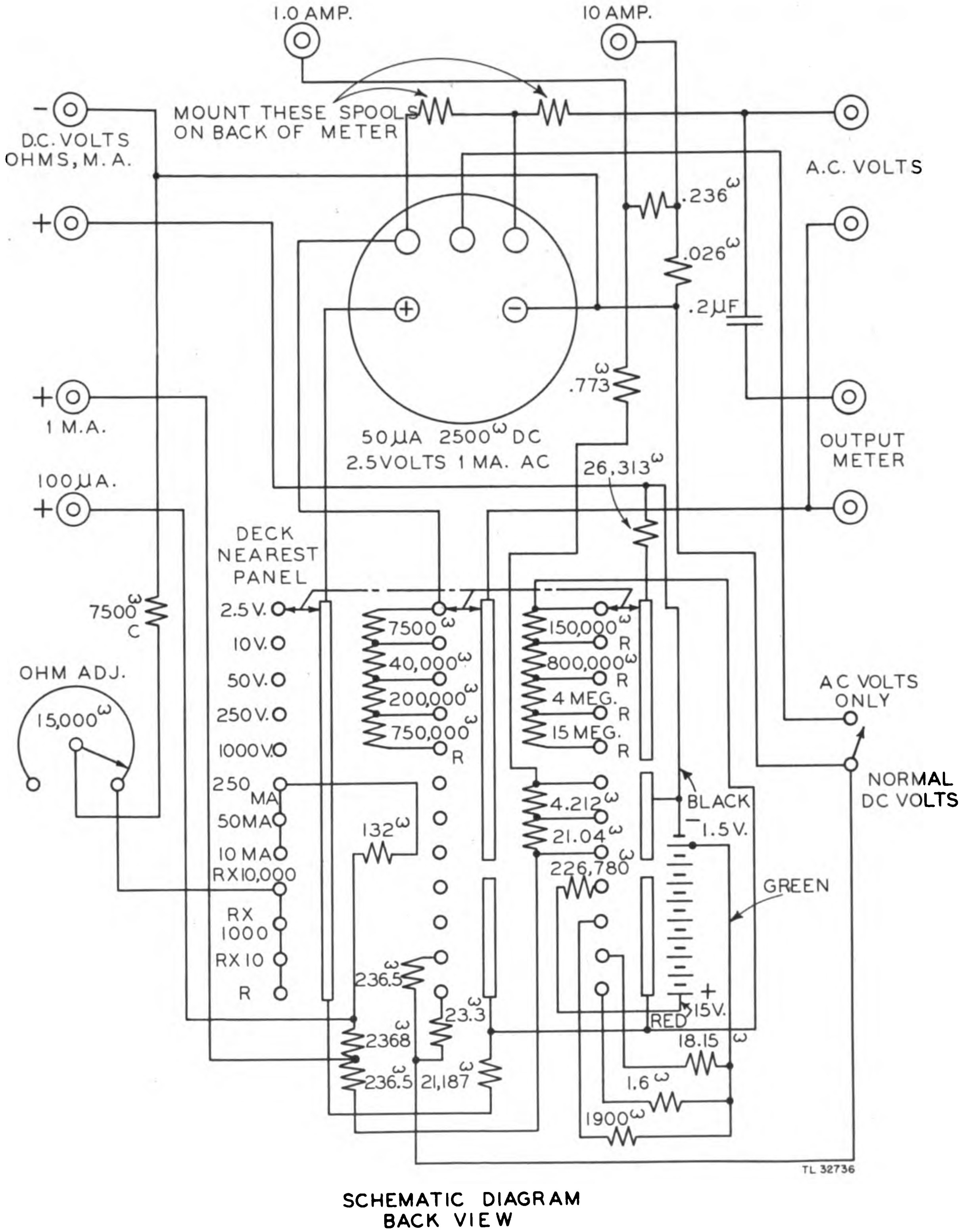


Figure 7. Analyzer I-167, Weston model 772, schematic diagram.

(2) With the test leads inserted in the jacks labeled OHMS and the toggle switch set at OHMS, short the two leads together. If the pointer does not reach full-scale deflection on *any* of the four ranges, and the ohmmeter adjuster will not correct this, the batteries should be checked and replaced in the same positions and polarity.

(3) If the pointer reaches full-scale deflection on the Rx10,000 range but does not on the three lowest ranges (R, Rx10, Rx1,000), the batteries are still good but the single cell used to supply 1.5 volts to the three low ranges has weakened. It is not necessary in this case to replace the batteries. Merely interchange the respective connections to the two batteries so that, in effect, the two batteries have changed position and the green lead is now connected to the —6 post of the other battery. Observe proper polarity when making these changes in the battery connections.

c. *Meter Zero Adjustment.* The meter needle should point to zero on the a-c volt scale before making any measurements with this analyzer. If the meter is not indicating zero when in normal position (no measurements being made), adjust it by turning the screw directly below the scale on the meter case.

SECTION IV
ANALYZER I-153, PRECISION SERIES 856

18. GENERAL. Analyzer I-153 is another unit that may be supplied with the test equipment. The front view of the panel is shown in figure 8. The schematic of this tester is shown in figure 9. This unit is a multirange instrument equipped to measure d-c volts between zero and 6,000 in seven ranges, at sensitivities of 20,000 and 1,000 ohms per volt; a-c volts between zero and 6,000 in seven ranges, at a sensitivity of 1,000 ohms per volt; and resistances from zero to 60 megohms in three ranges. The analyzer can measure d-c current from zero to 300 microamperes in two ranges, from zero to 600 milliamperes in four ranges, and from zero to 12 amperes in one range.

19. APPLICATIONS OF ANALYZER TO RADIO SET SCR-268-(*).

a. Limitations. (1) Operating voltages in Radio Set SCR-268-(*) cover a range from a fraction of a volt to about 11,000 volts. Voltages in parts of certain components cannot be measured by the analyzer because they exceed the range of the analyzer. Such voltages appear in the transmitter, the rectifier, the modulator, the high-voltage power supply (to the cathode-ray tube), the oscilloscope, and the final amplifier and high-voltage power-supply circuits of the keyer.

(2) The high frequency of most of the signal voltages in the receiver limits the use of the analyzer. These signal voltages are approximately 205 megacycles in the r-f and mixer circuits; 185 megacycles in the oscillator, buffer, and mixer circuits, and 20 megacycles in the i-f circuits. The analyzer is suitable for measuring a-c voltages up to 10,000 cycles only.

(3) The pulse and rectangularly shaped signal voltages in the oscilloscope and keyer cannot be measured accurately by the analyzer.

(4) A further limitation in use of the analyzer is imposed by the high resistance of the receiver grid circuits. This resistance may result in loading, a condition which is explained in paragraph 6d.

b. D-c Voltages. The analyzer will measure safely all d-c operating potentials in the receiver and range units and can be used also in all the low-voltage circuits of the oscilloscope and keyer.

c. A-c Voltages. The voltage-measuring device included in the analyzer may be applied to all audio-frequency voltages within its range, such as the audio output of the receiver and the range unit and the various audio pulses present in the keyer and oscilloscope. However, the accuracy of the meter decreases when it is applied to the nonsinusoidal waveshape of the pulses at different points in both the oscilloscope and the keyer.

d. Resistance Measurements. The analyzer can be used to make continuity tests and resistance measurements in all components of the set, as these operations always are performed with no voltage applied to the circuit. The ohmmeter is particularly useful in making continuity tests of cords and cables.

e. Precautions. Refer to paragraph 9 for precautions to be observed when handling meters.

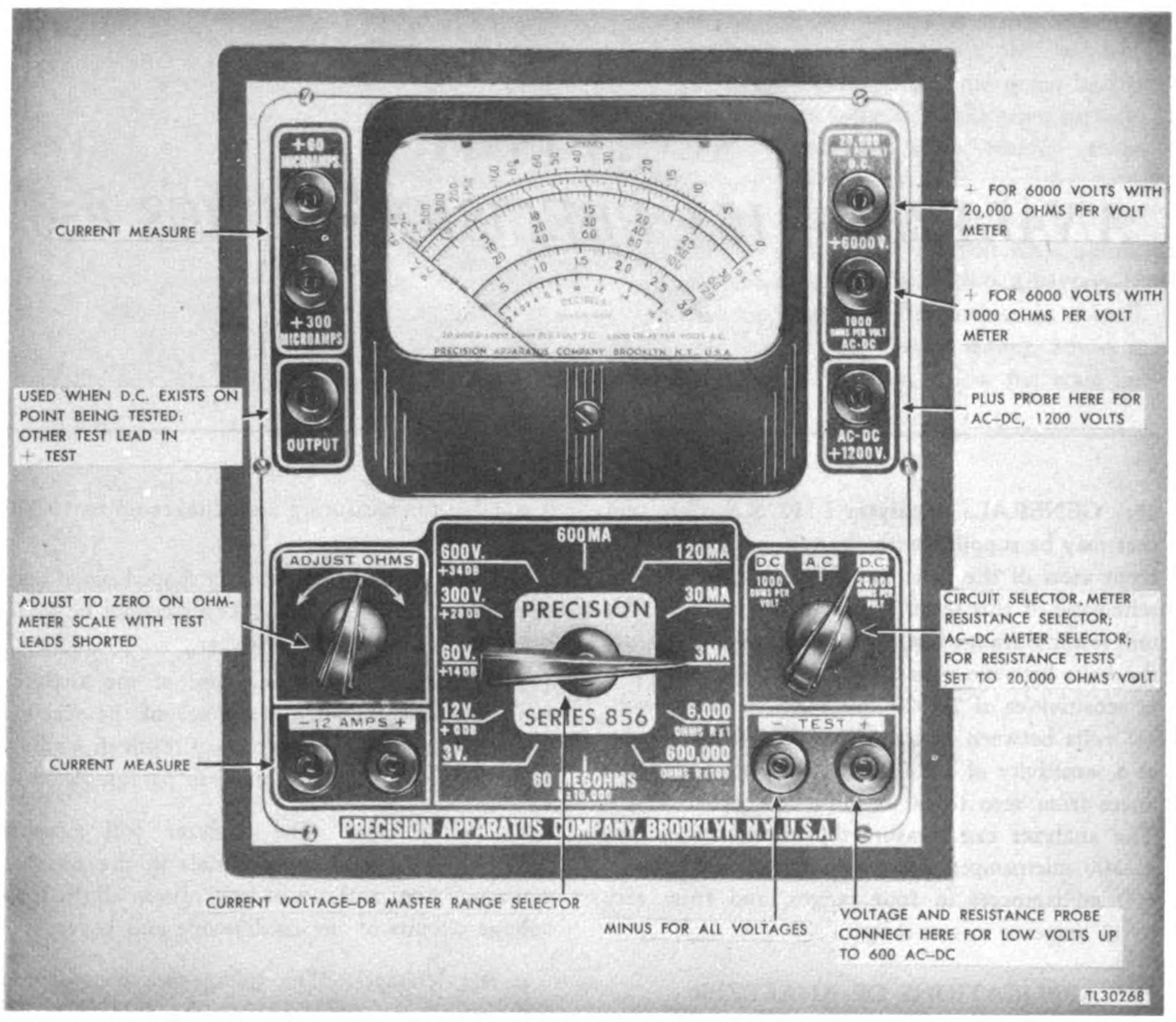


Figure 8. Analyzer I-153, Precision model 856, panel view.

20. A-C VOLTAGE MEASUREMENTS, 1,000-OHM-PER-VOLT SENSITIVITY.

a. Set the CIRCUIT SELECTOR switch to the a-c position for all a-c-voltage measurements.

b. For a-c-voltage measurements up to 600 volts, select the desired range on the rotary MASTER RANGE SELECTOR.

c. Insert the test leads into the polarized TEST tip jacks.

d. Apply the test leads across the circuit to be measured and read the proper *red* a-c correction scale, as follows:

0-3 volts	read directly on the separate V.A.C., only red scale.
0-12 volts	read the 120-volt scale, divide by 10.
0-60 volts	read directly.
0-300 volts	read the 30-volt scale, multiply by 10.
0-600 volts	read the 60-volt scale, multiply by 10.

21. D-C VOLTAGE MEASUREMENTS, 20,000-OHM-PER-VOLT SENSITIVITY.

a. Set the CIRCUIT SELECTOR switch to the D.C. 20,000 OHMS PER VOLT or 1,000 OHMS

PER VOLT position for all d-c voltage measurements. Use the 20,000-ohm-per-volt system for d-c voltage measurements across high resistances. The 1,000-ohm-per-volt system is accurate only for d-c voltage measurements across low resistances or low-resistance circuits.

b. For voltage measurements up to 600 volts, select the desired range on the rotary MASTER RANGE SELECTOR.

c. Insert the test leads into the polarized TEST tip jacks.

d. Apply the test leads across the circuit being measured, observing proper polarity. For d-c positive voltages, connect the positive lead to the voltage source and the negative lead to the chassis or ground. For d-c negative voltages, reverse the leads.

e. Read the d-c scale, as follows:

0-3 volts	read the 30-volt scale, divide by 10.
0-12 volts	read the 120-volt scale, divide by 10.
0-60 volts	read directly.
0-300 volts	read the 30-volt scale, multiply by 10.
0-600 volts	read the 60-volt scale, multiply by 10.

22. D-C VOLTAGE MEASUREMENTS, 1,000-OHM-PER-VOLT SENSITIVITY.

a. Set the CIRCUIT SELECTOR switch to the D.C. 1,000 OHMS PER VOLT position for all d-c voltage measurements at this sensitivity.

b. For voltage measurements up to 600 volts, select the desired range on the rotary MASTER RANGE SELECTOR.

c. Insert the test leads into the polarized TEST tip jacks.

d. Apply the test leads to the circuit being measured, observing proper polarity.

e. Read the d-c scale, as follows:

0-3 volts	read the 30 scale, divide by 10.
0-12 volts	read the 120 scale, divide by 10.
0-60 volts	read directly.
0-300 volts	read the 30 scale, multiply by 10.
0-600 volts	read the 60 scale, multiply by 10.

23. D-C CURRENT MEASUREMENTS.

a. General. Make all current measurement with the test leads in *series* with the load.

> CAUTION: Do not attempt to measure current in the presence of voltages exceeding 500 volts.

b. Operations. (1) Set the CIRCUIT SELECTOR switch to the D.C. 20,000 OHMS PER VOLT position for all d-c current measurements.

(2) For d-c current ranges of 3-600 ma inclusive, select the desired range on the rotary MASTER RANGE SELECTOR.

(3) Insert the test leads into the polarized TEST tip jacks.

(4) Apply the free ends of the test leads in *series* with the load, observing proper polarity. Connect the positive lead in the direction of the higher-potential source. Connect the negative lead in the direction of the lower-potential source.

(5) Read the d-c scale, as follows:

0-3 ma	read the 30 scale, divide by 10.
0-30 ma	read directly.
0-120 ma	read directly.
0-600 ma	read the 60 scale, multiply by 10.

(6) For the 60- and 300-microampere ranges, set the rotary MASTER RANGE SELECTOR to the 30 MA position. Insert the negative test lead into the negative TEST tip jack and the positive lead into the appropriate +60 MICROAMPS. or +300 MICROAMPS. tip jack located on the upper left-hand corner of the instrument panel. Apply the test leads in *series* with the load, observing polarity, and read the d-c scale as follows:

0-60 microamps	read directly.
0-300 microamps	read the 30 scale, multiply by 10.

(7) For the 12-ampere range, set the rotary MASTER RANGE SELECTOR to the 600 MA position. Insert the test leads into the polarized 12 AMPS tip jacks located on the lower left-hand corner of the instrument panel.

(8) Apply the test leads in *series* with the load, observing proper polarity.

(9) Read the d-c scale as follows:

0-12 amps	read the 120 scale, divide by 10.

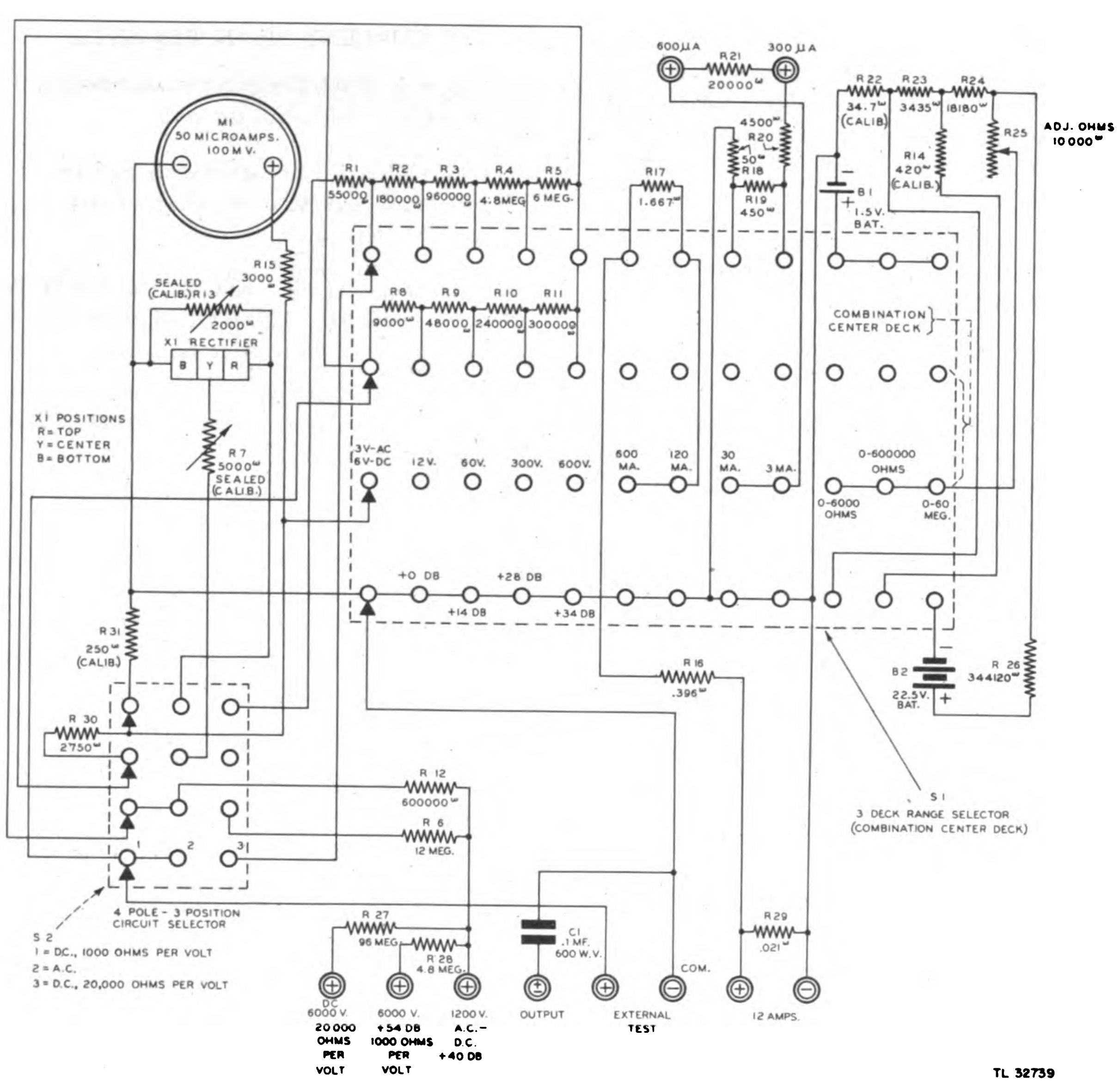


Figure 9. Analyzer I-153, Precision model 856, schematic diagram.

24. RESISTANCE MEASUREMENTS. Make all resistance measurements with the power *off* in the circuit being tested.

a. Set the CIRCUIT SELECTOR switch to the D.C. 20,000 OHMS PER VOLT position for all resistance measurements.

b. Set the MASTER RANGE SELECTOR to the desired ohmmeter range.

c. Insert the test leads into the polarized TEST tip jacks.

d. With the TEST tip jacks short-circuited, rotate the ADJUST OHMS control to obtain full-scale deflection before taking ohmmeter measurements for the range being employed.

e. Apply the free ends of the test leads across the circuit being measured.

f. Read the resistance measurements directly on the OHMS meter scale, as follows:

0-6,000-ohms range	read directly.
0-600,000-ohms range	multiply the reading by 100.

0-60-megohms range	multiply the reading by 10,000.

g. When ranges are changed repeat step *d*, (page 22).

25. OUTPUT-METER INDICATIONS.

a. There are two methods for obtaining output-meter indications. Following are the two methods:

(1) Make the connections from the secondary of the output transformer to the TEST tip jacks.

(2) If the secondary of the transformer is not accessible, insert the test leads into the OUTPUT tip jack and positive +TEST tip jack. Apply one of these leads to the plate of the output tube and the other lead to ground or the chassis of the component being tested. A 0.1-mf 600-volt capacitor is incorporated in the tester in series with the OUTPUT tip jack to block the d-c component.

b. With the use of either method, set the CIRCUIT SELECTOR switch to the A.C. position and rotate the RANGE SELECTOR to the highest voltage range. An output-meter indication will be observed when an a-c signal is present. If the meter indication is slight, use the next lower a-c voltage range, etc.

26. MAINTENANCE.

a. General. (1) This analyzer is a delicate instrument and no maintenance will be attempted by inexperienced personnel. Analyzers contain many parts which are more delicate than parts of a fine watch. Mechanical shocks or electrical overloads will damage the meter or affect its accuracy. Maintenance of this analyzer consists chiefly of battery replacement and, to a limited extent, replacing of component parts. Locate fault by continuity tests, resistance measurements, and visual inspection.

CAUTION: Do not attempt any adjustment or repair on the meter movement.

(2) The schematic diagram (fig. 9) shows the values of component parts.

(3) Replace batteries which are part of the meter when necessary. Need for replacement may be indicated by faulty meter operation or by periodic checks. When opening test equipment for inspection of batteries, visually inspect the wiring and component parts for loose connections, obviously overloaded components, dirty switch contacts, or other likely sources of trouble.

(4) In testing meter circuits with an ohmmeter, the sensitive indicating-meter movement of a piece of test apparatus should be disconnected first from the circuit.

b. Battery Testing and Replacing. (1) The ohmmeter ranges on Precision model, 856, analyzer are powered by Eveready No. 950, 1.5-volt and Burgess type No. 4156, 22.5-volt batteries or equivalents. Both batteries are mounted on the inside of the case and are readily accessible for testing or replacement (fig. 10).

(2) With the test leads inserted in the —TEST and +TEST jacks, and the circuit selector set on D.C. 20,000 OHMS PER VOLT and the MASTER RANGE SELECTOR set to the proper resistance range, short the tips of the leads together. If the pointer, with these leads shorted, cannot be brought to full-scale deflection by means of the ADJUST OHMS knob, the batteries should be tested and replaced. When replacing batteries, observe the polarity of the old batteries before removing and reconnect the fresh batteries in the same polarity.

c. Meter Zero Adjustment. The meter needle should point to zero on the a-c and d-c scales before any measurements are made with this analyzer. If the meter is not indicating zero when in normal position (no measurements being made), adjust it by turning the screw directly below the scale on the meter case.

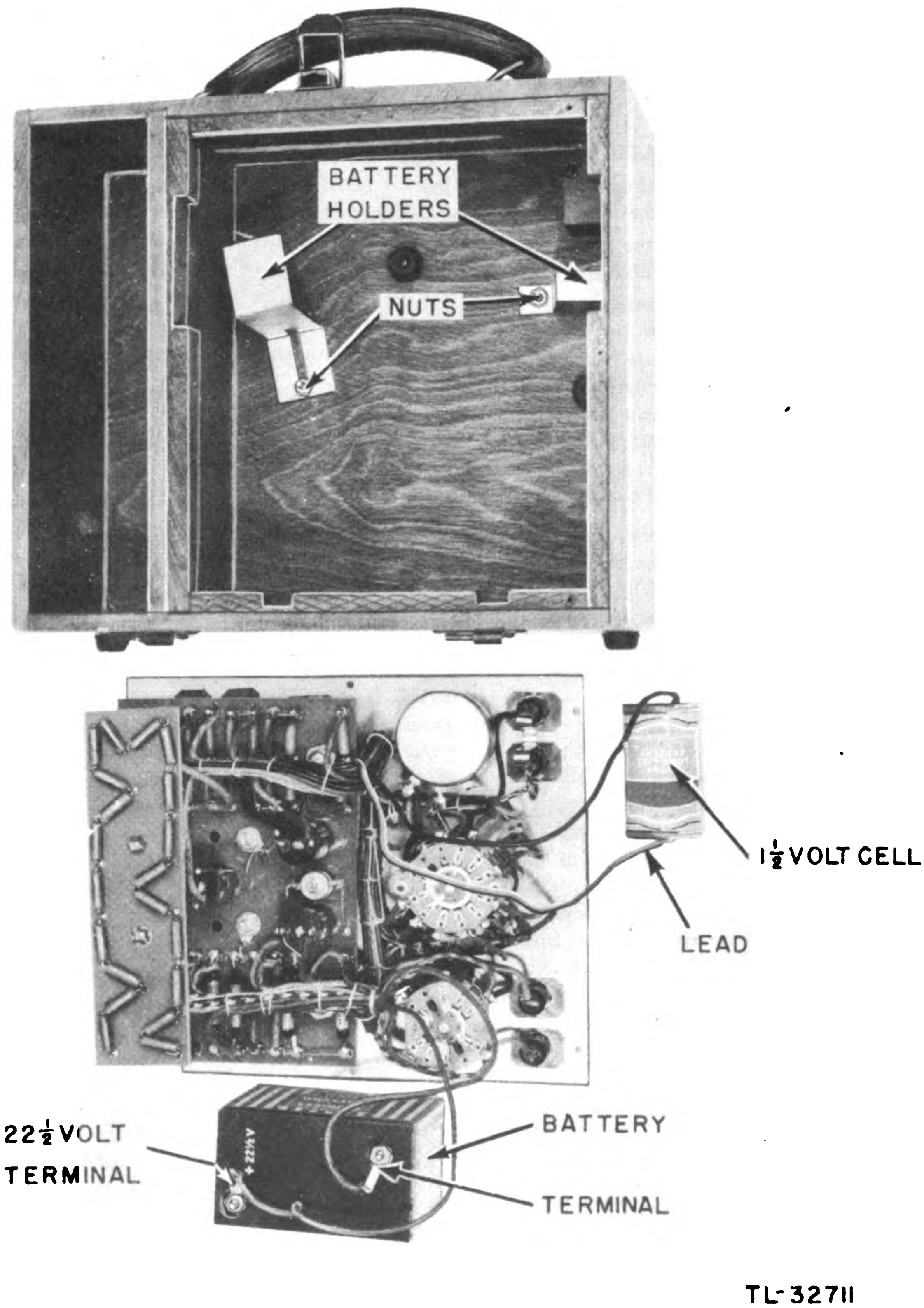


Figure 10. Analyzer I-153, Precision series 856, battery replacement.

SECTION V

ANALYZER, SUPREME MODEL 592

27. GENERAL.

a. The Supreme model 592, is an automatic, push-button operated multimeter. The front view of the panel is shown in figure 11. The schematic diagram is shown in figure 12. This unit is equipped to measure d-c volts between zero and 1,400 in seven ranges, at sensitivities of 25,000 and 1,000 ohms per volt; d-c current from zero to 14 amperes in eight ranges; a-c volts between zero and 1,400 in six ranges; and resistances from zero to 50 megohms in six ranges.

b. Use the buttons on the left side of the panel for the desired function of the meter (ammeter, voltmeter, ohmmeter, etc). Use the buttons on the right side of the panel for the desired range of the function selected. The — and + pin jacks directly below the meter are used for functions and ranges, except for the measurement of direct current between 1.4 amperes and 14 amperes. This range requires the heavy binding posts which are located above the meter and labeled —14A and +14A.

28. APPLICATIONS OF ANALYZER TO RADIO SET SCR-268-(*).

a. Limitations. (1) Operating voltages in Radio Set SCR-268-(*) cover a range from a fraction of a volt to about 11,000 volts. Voltages in parts of certain components cannot be measured accurately by the analyzers because they exceed the range of the analyzers. Such voltages appear in the transmitter, the rectifier, the modulator, the high-voltage power supply (to the cathode-ray tube), the oscilloscope, and the final amplifier and high-voltage power supply circuits of the keyer.

(2) The high frequency of most of the signal voltages in the receiver limits the use of the analyzer. These signal voltages are approximately 205 megacycles in the r-f and mixer circuits; 185 megacycles in the oscillator, buffer, and mixer circuits, and 20 megacycles in the i-f circuits. The analyzer is suitable for measuring a-c voltages up to 10,000 cycles only.

(3) The pulse and rectangularly shaped signal voltages in the oscilloscope and keyer cannot be measured accurately by the analyzer.

(4) A further limitation in the use of the analyzer is imposed by the high resistance of the receiver grid circuits. This resistance may result in loading, a condition explained in paragraph 6d.

b. D-c Voltages. The analyzer can measure safely all d-c operating potentials in the receiver and range units and can be used also in all the low-voltage circuits of the oscilloscope and keyer.

c. A-c Voltages. The voltage-measuring device included in the analyzer may be applied to all audio-frequency voltages within its range, such as the audio output of the receiver and the range unit, and the various audio pulses present in the keyer and oscilloscope. However, the accuracy of the meter decreases when it is applied to the nonsinusoidal waveshape of the pulses at different points in both the oscilloscope and the keyer.

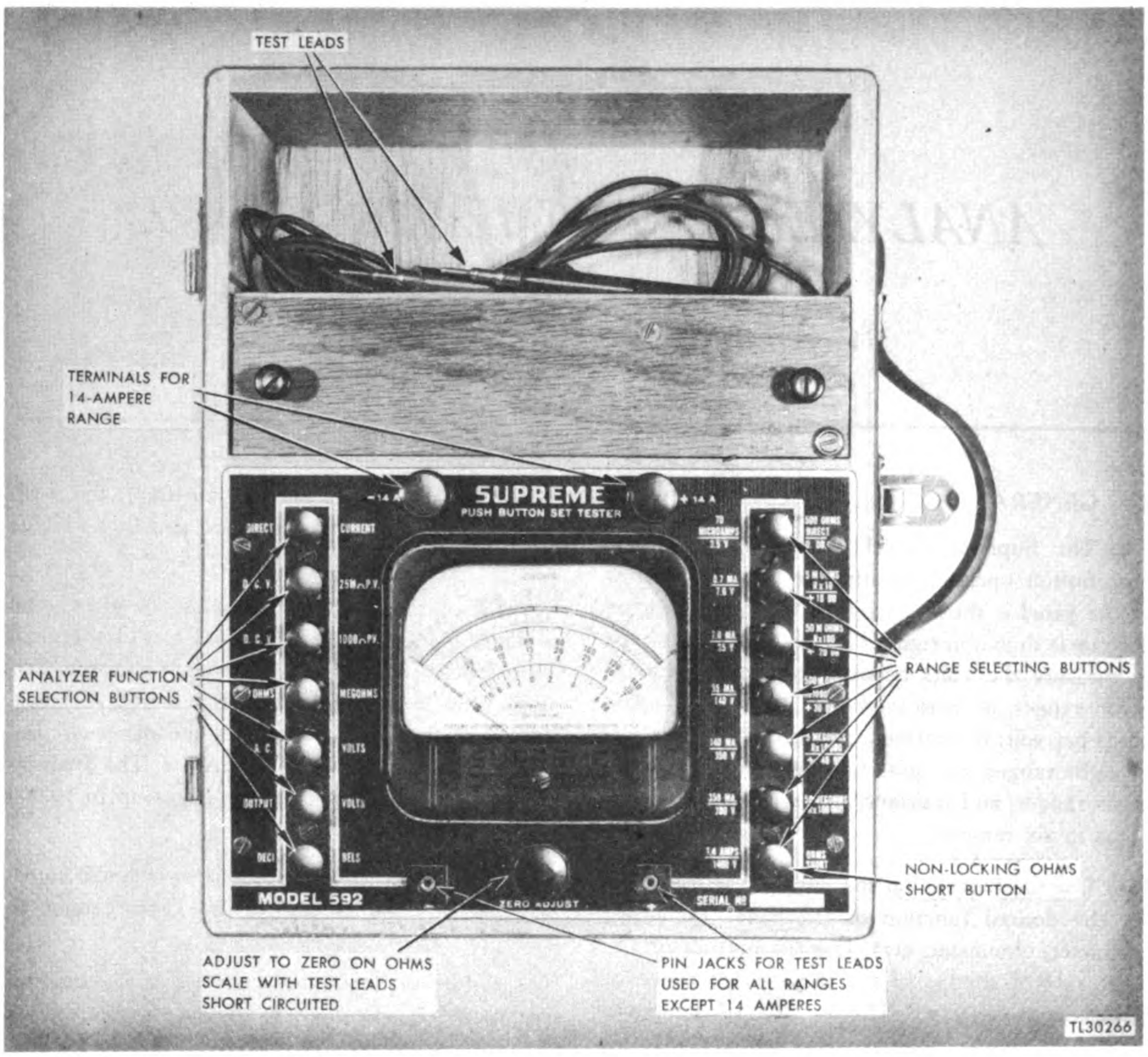


Figure 11. Analyzer, Supreme series 592, panel view.

d. *Resistance Measurements.* The analyzer can be used to make continuity tests and take resistance measurements in all components of the set, as these operations always are performed with no voltage applied to the circuit. The ohmmeter is particularly useful in making continuity test of cords and cables.

e. *Precautions.* Refer to paragraph 9 for precautions to be observed when handling meters.

29. D-C VOLTAGE MEASUREMENTS.

a. Depress the D.C.V. 25M P.V. or D.C.V. 1,000 P.V. button in the left-hand row for all d-c voltage measurements. Depress the D.C.V. 25M P.V. button for d-c voltage measurements in high-resistance circuits. The 1,000-ohm-per-volt system is accurate only for d-c voltage measurements across low-resistance circuits.

b. Select a suitable voltage range by depressing the proper button marked 3.5V, 7.0V, 35V, 140V, or 700V.

c. Insert the test leads into the — and + pin jacks located at the bottom of the panel.

d. Observing polarity, apply the free ends of the test leads across the circuit being measured.

For d-c positive voltages, connect the positive lead to the voltage source and the negative lead to the chassis or ground. For d-c negative voltages, reverse the leads. Where the actual voltage is unknown, depress the highest range button first and then successively depress the lower range buttons until the meter needle deflects as much as possible without going off scale.

e. When the voltage is known, read the proper *black* scale as follows:

0-3.5 volts	read the 35 scale, divide by 10.
0-7 volts	read the 7 scale directly.
0-35 volts	read the 35 scale directly.
0-140 volts	read the 140 scale directly.
0-350 volts	read the 35 scale, multiply by 10.
0-700 volts	read the 7 scale, multiply by 100.

30. D-C CURRENT MEASUREMENTS.

a. General. Make all current measurements with the test leads in *series* with the load.

> CAUTION: Do not attempt to measure current in the presence of voltages exceeding 500 volts.

b. Operation. (1) Depress the DIRECT CURRENT button in the left-hand row for all d-c-current measurements.

(2) For d-c-current measurements up to 350 ma, select a suitable current range by depressing the appropriate button marked 70 MICROAMPS., 0.7 MA, 7.0 MA, 35 MA, 140 MA, or 350 MA.

(3) Insert the test leads into the polarized — and + pin jacks located at the bottom of the panel.

(4) Observing polarity, apply the free ends of the test leads in *series* with the circuit being measured. Connect the positive lead in the direction of the higher-potential source and the negative lead in the direction of the lower-potential source.

(5) Read the proper *black* scale, as follows:

0-70 microamps	read the 7 scale, multiply by 10.
0-0.7 ma	read the 7 scale, divide by 10.
0-7 ma	read the 7 scale directly.
0-35 ma	read the 35 scale directly.
0-140 ma	read the 140 scale directly.
0-350 ma	read the 35 scale, multiply by 10.

(6) For the 1.4-ampere range, exercise care to see that only the 1.4 AMPS button in the right-hand row is depressed. All the other buttons in this row must be up when using the 1.4 AMPS button to measure current or voltage. Any button that happens to be down may be released by lightly pressing any of the remaining buttons in the right-hand row. The 1.4 AMPS button is non-locking and must be held down by the operator when used. With the 1.4 AMPS button in a depressed position, depress the DIRECT CURRENT button and apply the test leads as described in steps (1), (3), and (4) above. Read the 140 scale and divide by 100.

(7) For the 14-ampere range, connect the test leads to the binding posts marked —14A and +14A. Depress the DIRECT CURRENT button and any button in the right-hand row. Observing correct polarity, apply the free ends of the test leads in series with the circuit being measured. Read the 140 scale and divide by 10.

31. A-C VOLTAGE MEASUREMENTS.

a. Depress the A.C. VOLTS button in the left-hand row for all a-c voltage measurements.

b. For a-c voltage measurements up to 700 volts, select a suitable voltage range by depressing the appropriate button marked 7.0 V, 35 V, 140 V, 350 V, or 700 V.

c. Insert the test leads into the — and + pin jacks located at the bottom of the panel.

d. Apply the free ends of the test leads across the circuit to be measured.

e. Read the proper scale, as follows:

0-7 volts	read the red 7V A.C. scale directly.
0-35 volts	read the 35 scale directly.
0-140 volts	read the 140 scale directly.
0-350 volts	read the 35 scale, multiply by 10.
0-700 volts	read the black 7 scale, multiply by 100.

f. Where the actual voltage is unknown, depress the highest range button first, and then successively depress the lower range buttons until the meter needle deflects as much as possible without going off scale.

32. OUTPUT-METER INDICATIONS.

a. An output meter is a device used for measuring the output power of amplifiers, radio receivers, etc. The method of measurement is to apply the output of the amplifier to a load resistance in the meter and measure the voltage drop produced across this resistor. The scale is calibrated in volts.

b. Follow the procedure used for a-c voltage measurements described in paragraph 31 with one exception: Depress the OUTPUT VOLTS button instead of the A.C. VOLTS button. This action automatically connects a capacitor in series with one of the leads, blocking out the d-c component when measuring circuits where both a-c and d-c voltages exist. The capacitor will cause an error on low ranges.

33. RESISTANCE MEASUREMENTS. Make all resistance measurements with the power *off* in the equipment under test. There are two methods of making resistance measurements, as follows:

a. (1) Depress the OHMS MEGOHMS button in the left-hand row.

(2) Select a suitable range by depressing the appropriate button marked 500 OHMS DIRECT, 5M OHMS, 50M OHMS, 500M OHMS, 5 MEGOHMS, or 50 MEGOHMS.

(3) Insert the test leads into the polarized — and + pin jacks located at the bottom of the panel.

(4) Short-circuit the free ends of the test leads. Rotate the ZERO ADJUST control until the meter needle is at full-scale deflection or zero ohms.

b. (1) Depress, in turn, the OHMS MEGOHMS button, any resistance-range button in the right-hand row, and the nonlocking OHMS SHORT button.

(2) Adjust the ZERO ADJUST control for full-scale deflection.

(3) Depressing the OHMS SHORT button is the equivalent of connecting the test leads together, and its use is optional. (When using the 500 OHMS DIRECT range, adjust the ohmmeter by touching the leads together as in step *a*(4) to compensate for lead resistance and contact resistance sometimes encountered on corroded test leads.)

c. (1) Use the following steps in both methods. Connect the free ends of the test leads across the circuit being measured.

(2) Read the *green* ohms scale as follows:

0-500 ohms	read the ohms scale directly.
0-5M ohms	read the ohms scale, multiply by 10.
0-50M ohms	read the ohms scale, multiply by 100.
0-500M ohms	read the ohms scale, multiply by 1,000.
0-5 megohms	read the ohms scale, multiply by 10,000.
0-50 megohms	read the ohms scale, multiply by 100,000.

d. When ranges are changed, short-circuit the test lead and readjust the ZERO ADJUST control until the meter needle is at full-scale deflection.

34. MAINTENANCE.

a. General. (1) This analyzer is a precision instrument and no maintenance will be attempted by inexperienced personnel. Analyzers contain many parts which are more delicate than parts of a fine watch. Mechanical shocks or electrical overloads damage the meter or affect its accuracy. Complete maintenance of this analyzer will consist of battery replacement and, to a limited extent, replacing of component parts. Locate faults by continuity tests, resistance measurements, and visual inspection.

CAUTION: Do not attempt any adjustment or repair on the meter movement.

(2) The schematic diagram, figure 12, shows the values of component parts.

(3) Replace batteries, which are part of the meter, when necessary. Need for replacement may be indicated by faulty meter operation or periodic checks. When opening test equipment for inspection of batteries, visually inspect the wiring and component parts for loose connections, obviously overloaded components, dirty switch contacts, or other likely sources of trouble.

(4) In testing meter circuits with an ohmmeter, the sensitive indicating-meter movement of a piece of test apparatus should be disconnected first from the circuit.

b. Battery Testing and Replacing. (1) Supreme model 592, analyzer, uses four 1.5-volt batteries and one 45-volt battery for its ohmmeter. The various sections of the ohmmeter battery are made

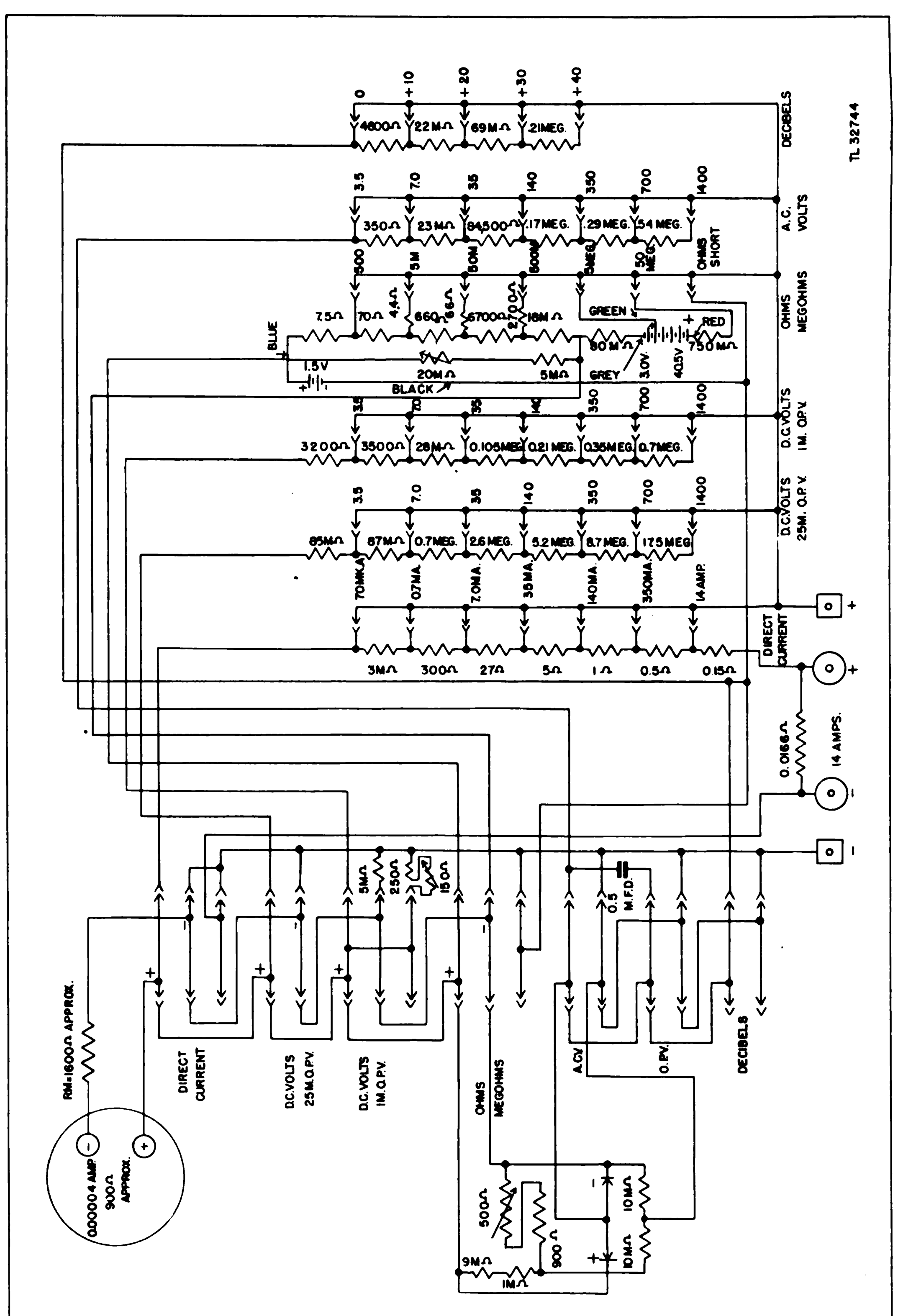


Figure 12. Analyzer, Supreme series 592, schematic diagram.

accessible by removing the center wooden panel on the front of the instrument. This panel is held in place by two screws on opposite corners of the panel.

(2) Insert the test leads in their jacks, depress the button marked OHMS MEGOHMS, and short the ends of the leads together. If the pointer cannot reach full-scale deflection on any of the four lowest ranges (500 ohms direct, Rx10, Rx100, Rx1,000), upon manipulation of the knob marked ZERO ADJUST, replace the two 1.5-volt cells that are nearest the panel and connected in parallel.

(3) If the pointer cannot be adjusted to full-scale deflection when on the 5-megohm (Rx10,000) range, replace the two 1.5-volt cells that are connected in series. These are in the same cell cartridge that contains the two cells in parallel but are farthest away from the panel.

(4) If the pointer cannot be adjusted to full-scale deflection on the 50-megohm (Rx100,000) range, replace the 45-volt battery. Remove the screws which will release the clamp. Insert the new battery, and make connections by means of the polarized plug.

CAUTION: Be sure to observe proper polarity. In the four 1.5-volt cells, the center terminal of the cell is positive.

c. Meter Zero Adjustment. The meter needle should point to zero on the 7V A.C. scale before any measurements are made with this analyzer. If the meter is not indicating zero when in normal position (all push buttons up), it may be adjusted by turning the screw directly below the scale on the meter case.

SECTION VI
TUBE CHECKERS

35. PURPOSE AND LIMITATIONS.

a. General. All tubes eventually become defective or useless because of burnt-out filaments or heaters, loss of emission, shorted or open elements, and other faults. An instrument called the tube checker, or tube tester, is used to detect defective tubes rapidly.

b. Tube-test Limitations. Tube testers can indicate only the difference between a given tube's characteristics and those which are standard for that particular type. Since the operating conditions imposed upon a tube of a given type may vary within wide limits, a tube tester cannot evaluate tubes in terms of performance capabilities for all applications. Occasionally, tubes will check perfectly but operate unsatisfactorily in the set because they are operating on a portion of their characteristics not covered in the test, or with much higher voltages than were used in the test. The tube tester, therefore, cannot be looked upon as a final authority in determining whether or not a tube is always satisfactory. An actual operating test in the equipment in which the tube is to be used will give the best possible indication of the tube's worth. Nevertheless, the tube tester is a most helpful device for indicating the serviceability of a tube.

36. TUBE CHECKING. The most common difficulty in radio sets is defective tubes; therefore, one step in locating trouble is to check the tubes thoroughly. (This does not apply to acorn tubes for reasons covered in par. 41*e*.)

a. Short Circuits. (1) Tubes should always be tested for short circuits first to avoid blowing fuses in the tube checker or damaging the instruments in it. Excessive current caused by a short-circuited tube can burn out the meter. The test for shorts will also detect many defective tubes that the tube checker would pass as satisfactory.

(2) A simple switching circuit that will connect in a small 6-volt lamp or neon bulb, instead of the tube-checker meter, is sufficient for this test. If the lamp is switched on before the meter is connected, excessive currents due to short-circuited elements will be indicated by the lamp. If the lamp remains dark, no elements are short-circuited.

(3) The number of short-circuited elements that can be shown by the lamp depends entirely upon the design of the tester. Usually only one or two elements, the most frequent offenders, can be indicated. This makes little difference though, because the purpose of the lamp is to indicate excessive plate current, regardless of which element in the tube is short-circuited. If the plate current is normal, the other tube tests may be performed with the meter in the circuit.

(4) None of the usual short-circuit tests that are made on a tube tell which element is causing the trouble. For practical purposes that knowledge is not important. If the tube checker shows that there is an undesired short circuit somewhere, the tube will be discarded. Certain short circuits are desirable, as for example, between the filament leads, and between the suppressor grid and cathode. The

information supplied with the tube checker usually indicates the proper settings of the switch used to test the tube for short circuits.

(5) Sometimes a tube will show a short circuit only when it is at a particular temperature. This is due to the expansion and contraction caused by the variation in the temperature of the metal parts inside the tube. While testing a tube, tap the tube with the hand or a small rubber mallet to see if any unusual indication is given.

b. *Effects of Gas on Tube Characteristics.* (1) Very small traces of gas in a vacuum tube will affect its characteristics adversely in a number of ways because positive ions are produced in the tube by collisions between the gas molecules and the electrons flowing to the plate. This effect is called ionization. The positive ions travel in the opposite direction from electrons, and normally end their existence by falling into the cathode or the negative-control grid. The ions which fall into the cathode tend to destroy the emission of thoriated-tungsten and oxide-coated cathodes, and this effect is sufficiently serious to limit the usefulness of the emitters.

(2) The positive ions produce irregularities in the space charge at the cathode, which cause a shot effect that makes the tube noisy.

(3) Mercury-vapor tubes, which utilize ionization to overcome a space-charge effect, *normally* show a bluish-white glow between the plate and cathode or heater. This glow indicates the presence of gas in any tube; but in other tubes, the gas may be very harmful because it allows an abnormal amount of current to flow. This excessive current may damage the primary of the transformer connected to the tube, or even damage the power supply. A glow near, or on, the surface of the glass of some tubes is caused by fluorescent materials (similar to that used in a cathode-ray tube) in the glass and does not interfere in any way with the operation of the tube.

(4) In modern tubes, the gas content is so small that danger of overheating because of ionization is small; however, gas may cause the characteristics of the tube to change. When the tube is operating in a radio component, such as a receiver, and the grid bias is small, a little ionization may cause grid current to flow. This flow of grid current reduces the input resistance of the tube, causing weak signals, broad tuning (if in an r-f amplifier), and distortion (if in an audio amplifier). It is, therefore, desirable to be able to test a tube for gas content.

c. *Testing for Gas.* (1) If the grid current is very small and the bias zero, the tube may be assumed to have a negligible amount of gas. This is the principle upon which the typical gas-test indicator works. For example, consider a simple triode with a B battery across plate and cathode and a C battery across grid and cathode. The plate current is a certain amount, depending upon the tube type and the voltages. Assume that C is a small battery, perhaps 1.5 volts. If the tube is gassy, current will flow in the grid circuit; the direction of flow would be from grid to filament, or from filament to grid, depending upon the potential of the grid, the gas pressure, the tube structure, and the potentials applied to the other electrodes.

(2) If a resistor R is connected in series with the grid circuit, the grid current will flow through it and develop a voltage across it. This voltage acts either with, or against, the voltage of the C battery (depending upon the direction of the flow of the grid current). In either case, the voltage across R alters the grid bias and a change in the plate current results. This change can be detected by the tube checker. If there were no gas, there would be no ionization, no grid current, no drop across R, and no change would occur in plate current. R usually is made about 500,000 ohms and a switch placed across it. If opening and closing this switch produces little or no change in plate current, there is little or no gas present. The gas indicator, then, is merely a series grid resistor with a switch across it. Changes in potential across this resistor manifest themselves by changes in the plate current.

d. *Cathode-heater Leakage Test.* (1) When a voltage is applied between the heater and cathode of an indirectly heated tube, there may be current flow due to a leakage path between the heater and cathode. Cathode leakage in one of the tubes used in Signal Corps radio sets often shorts some of them out of the circuit, decreasing the resistance in the circuit and increasing the current in the remainder of the tubes to such an extent that they burn out.

(2) The most practical test for dislodging such leakage consists of observing the plate-current reading for the tube when operated with the cathode connected to both B— and the heater. Now, if the cathode circuit is opened by disconnecting the cathode, the plate current reading will be zero if there is no leakage present. If there is any such leakage, the plate circuit will remain continuous, completing its path through this leakage path, and a definite value of plate current will still be indicated by the meter on the tube checker.

e. Types of Testers. Most tube testers are one of the two following types:

(1) One type is known as an *emission* tester. This operates on the theory that if a tube is beginning to weaken, it has been in service long enough for the emission of electrons from the heater to begin to decrease.

(2) The second type of tester is known as a *mutual-conductance* tester. In this type of tester, a fixed plate voltage is put on the tube and the grid bias is changed a fixed amount. The corresponding change in the plate current indicates the serviceability of the tube.

37. EMISSION TESTING.

a. The lessening of emission, or the lack of emission, is often an indication of the condition of the tube; however sometimes the emission may be perfectly satisfactory but the tube will be unsatisfactory. This condition will occur if a grid is disconnected internally so that a change of the grid bias cannot change the plate current. In many emission testers, all the elements of the tube, except the cathode, are connected to the plate to collect the emission. If some of these elements were disconnected or shorted, no indication of the condition would be given.

b. The filament, or heater, is operated at a rated voltage. After the tube has reached constant temperature, a low-positive voltage is applied to the plate and grids, and the electronic emission is read on the meter. Readings which are well below the average for a particular tube type indicate that the total number of available electrons has been so reduced that the tube is no longer able to function properly.

38. MUTUAL-CONDUCTANCE TESTING.

a. General. Because a mutual - conductance (transconductance) test takes into account a fundamental operating principle of the tube, this test (when properly made) will permit better correlation between test results and actual performance than does a straight emission test. There are two forms of mutual-conductance tests which can be utilized in a tube test.

b. Grid-shift Method. In the first form, appropriate operating voltages are applied to the electrodes of the tube. A plate current determined by the electrode voltage will be indicated by the meter. If the bias on the grid is then shifted by the application of a different grid voltage, a new plate-current reading is obtained. The difference between the two plate-current readings is indicative of the mutual conductance of the tube. This method of mutual-conductance testing commonly is called the *grid-shift* method, and depends on readings under static conditions which impose limitations not encountered in the dynamic method.

c. Dynamic Method. The *dynamic* mutual-conductance test is superior to the static mutual-conductance test because a-c voltage is applied to the grid. Thus, the tube is tested under conditions which approximate actual operating conditions. The alternating component of the plate current is read by means of an a-c ammeter of the dynamometer type. The mutual conductance of the tube is equal to the a-c plate current divided by the input signal voltage. If a 1-volt rms signal is applied to the grid, the plate-current meter reading in milliamperes multiplied by 1,000 is the value of the mutual conductance in micromhos.

d. Mutual Conductance. Mutual conductance is a rough indication of the design merit of a tube. This is because a low plate resistance and a high-amplification factor are desired, and the mutual conductance measures the extent to which this feature is attained. Tubes of equal-design merit, but with slightly different values of amplification factor, will have substantially the same value of mutual conductance under normal operating conditions. When tubes with widely different values of μ (amplification factor) are compared, the tendency is for the mutual conductance to be less for the high-amplification-factor tubes, and this effect is especially pronounced when there is a voltage drop in the cathode. In a particular tube, the mutual conductance depends primarily upon the plate current and to a small extent upon the combination of grid and plate voltages used to produce this current. The mutual conductance also increases as the plate current is increased. This follows from the fact that $G_M = \mu/R_P$, so that as the amplification factor is substantially constant, the mutual conductance varies inversely as R_P. The mutual conductance G_M (or, as it often called, the transconductance S_M) is defined as the rate of change of plate current with respect to a change in grid voltage with plate voltage constant. Thus:

$$G_M = \frac{\text{Change in plate current in amperes}}{\text{Change in grid voltage in volts}}$$

39. EFFECT OF LINE-VOLTAGE VARIATIONS ON THE TUBE CHECKER.

a. Unless some form of line-voltage indicator and compensating adjustments are incorporated in the tube checker, the readings will be seriously affected by line-voltage variations which are encountered in normal practice. If the line voltage is above normal, higher voltages than normal will be applied to the tube under test. The meter readings will be affected correspondingly, and will not be reliable indicators of the condition of the tube. The same is true if the voltage is too low.

b. To remedy this condition, provision is made for measuring the line voltage and for adjusting the voltages applied to the tubes. In some tube checkers, the line voltage can be read on the same meter used for the tube test.

c. Line-voltage variations are usually compensated for by providing the primary winding of the transformer in the tube checker with taps or potentiometers, so that the proper voltages may be provided to the tube under test, even though the line voltage may be above or below normal.

40. TEST EQUIPMENT RC-68-(*), TUBE CHECKERS.

a. One of the tests made upon multi-element tubes with Tube Checker I-157, Hickok model 540, is a mutual-conductance test, in which an a-c signal is applied to the grid and an output indication is obtained which is directly proportional to the mutual conductance and expressed in micromhos. At the same time the instrument also indicates quality by means of a scale divided into sections marked REPLACE, WEAK, GOOD. Tubes of the two-element type, like diodes and rectifiers, are checked by means of emission.

b. In Precision model 920, tube checker, multi-electrode tubes are checked by means of a modified emission check. Diodes, rectifiers, and other similar tubes are checked by means of a straightforward emission test. As with the Hickok unit, the Precision device also bears upon its meter indicator a REPLACE, WEAK, GOOD scale.

c. Another tube checker that may be included in the test equipment is the Supreme model 504-A. This instrument tests the quality of tubes by an emission check and is provided with a BAD TUBE, GOOD TUBE scale.

d. Since the designs of the tube checkers are not identical, indications of WEAK or GOOD for the same tube will vary as different tube checkers are used. This, however, should not cause confusion unless one instrument indicates a tube as being on the fringe of the GOOD range, whereas another may show it further along in the GOOD range. Under such circumstances the tube should be replaced. Under some conditions, mutual-conductance indications may be compared with stipulated values as furnished by the tube manufacturer. If this comparison is made and a discrepancy of as much as 15 percent to 20 percent is found, it can be accepted if the mutual conductance of the tube as indicated upon the tube checker is sufficiently high to justify the conclusion that the tube is good.

e. As comparatively few types of tubes are used in Radio Set SCR-268-(*), several samples of each type of tube (each sample known to be good and properly identified) should be available at the repair depot or wherever the repair work is done, so that periodic tests upon the tube checkers themselves can be made to determine their efficiency.

f. Unlike Hickok model 540, Precision model 920 and Supreme model 504-A tube checkers are equipped with voltage, current and resistance-measuring devices. These devices are independent of the operation of the instruments as tube checkers. Since these instruments contain only one meter indicator and are employed for tube-checking purposes as well as for voltage, current, and resistance measurements, and since the test equipment contains Weston model 772, Supreme model 592, or Precision model 856 analyzer, voltage, current, and resistance measurements should be performed with one of the other multimeter analyzers, if they are available.

g. In addition to the quality test, these tube checkers may be used to test for short circuits within the tube elements, for noise, for filament to cathode leakage, and for gas.

41. PRECAUTIONS.

a. Specific instructions on the operation of these tube checkers follow, but there are a few general details of major importance associated with these tests. One test, which must be made on all tubes before any other test is made, is the short-circuit test which establishes the existence of one or more short circuits between tube electrodes. Failure to make this test, in the event that a short circuit exists, may result in damage to equipment within the tube checker during routine testing.

b. Prior to any quality tests, the filament voltage must be adjusted on all tube checkers. These checkers are equipped to test all types of tubes embracing filament-voltage ratings as low as 1 volt and as high as 117 volts. The checkers are so designed that the filament circuit is activated at all times. Accordingly, the filament-voltage selector control must be correctly set before the tube under consideration is placed in its socket in the tube checker. Always return the filament-voltage-selector switch to its starting point (the lowest voltage output) after the tube has been tested and before a new tube is inserted. If this is done, there is little likelihood of damaging a tube which is not of the same type as was previously tested.

c. To safeguard against damaging the tube by accidentally depressing the button which applies plate voltage to it, always make certain that the filament-voltage-selector switch is properly set in accordance with instructions for the specific tube checker being used.

d. When several tubes are to be checked, segregate these tubes into groups in accordance with types. This will minimize the settings of the tube-checker controls.

e. Although tube failures are commonplace in the best of apparatus and one condition peculiar to the acorn-type tubes used in Receiver BC-406 will give trouble (excessive getter material causes short circuits from screen or plate to cathode), the acorn-type tubes should not be removed from their sockets until other tests on the receiver have definitely indicated that the defect is associated with the tube or tubes. Because of the rugged assembly and the design requirements which call for the shortest possible leads in these ultra-high-frequency circuits, removal of acorn tubes is a delicate operation. Even with careful handing these tubes may be damaged.

SECTION VII

TUBE CHECKER I-180, HICKOK MODEL 540

42. GENERAL.

a. Hickok model 540 tube checker (fig. 13) measures the mutual conductance of vacuum tubes of the multi-electrode type (including acorn tubes) and the emission of diodes and other rectifiers. The schematic is shown in figure 14. Instructions for setting the five controls, which are located in a row directly beneath the meter, are indicated upon the roller chart. The columns of numbers under the letters, A, B, FIL, L, and R indicate the positions of the knobs of the controls identified by the arrows. When using the red-green scale, the micromho switch is always set on 3,000.

b. The potentiometer L controls the sensitivity of the micromho meter. This knob is always set at GM when micromhos are read. The micromho switch to the right of the large meter selects the micromho scale to be read. When it is set at 3,000, the meter scale is read directly. When set at 6,000 or 15,000, the meter scale is multiplied by two and five respectively.

43. APPLICATION OF TUBE TESTER TO RADIO SET SCR-268-(*).

a. *Limitations.* (1) Tubes that appear good in tests still may not operate properly in the circuits to which they are applied. Such tubes should be replaced.

(2) The tube tester cannot be used to test the tube types, in the radio set, that appear in the following table:

Component	*Type No.*	*Coml No.*	*Use*
Transmitter	VT-127 or VT-127-A	100 TS	Transmitting tubes
Keyer	VT-46-A	866A	Hv rect
Keyer	VT-129	304TL	Final-pulse amplr
Modulator	VT-129	304TL	Modulator tubes
Modulator	VT-130	250TL	Blocking diodes
Oscilloscope	VT-111	1802-P4	Cathode ray
Oscilloscope	VT-119	879/2x2	Hv rect
Rectifier	VT-166	371-A	Hv rect

(3) The tube checkers provided with the test equipment are designed to indicate the quality or condition of the tubes in the set. One test made upon multi-element tubes is a mutual conductance test, in which an a-c signal is applied to the grid and an output indication, which is identified in terms of mutual conductance expressed in micromhos, is secured. Another test on multi-element tubes and on rectifier tubes is an emission test. The tester indicates quality in this latter case in terms of GOOD and REPLACE. The operator must know at all times which type of test he is making and what type of tube he is testing in order to properly interpret the results. Different types of tube-element tests are discussed in paragraphs 35-40. The Hickok model 540 measures the mutual conductance of vacuum tubes.

b. *Precautions.* Refer to paragraph 41 for a discussion of the precautions to be observed when using tube testers.

44. PRELIMINARY STEPS. Before making any tests on a tube, proceed as follows:

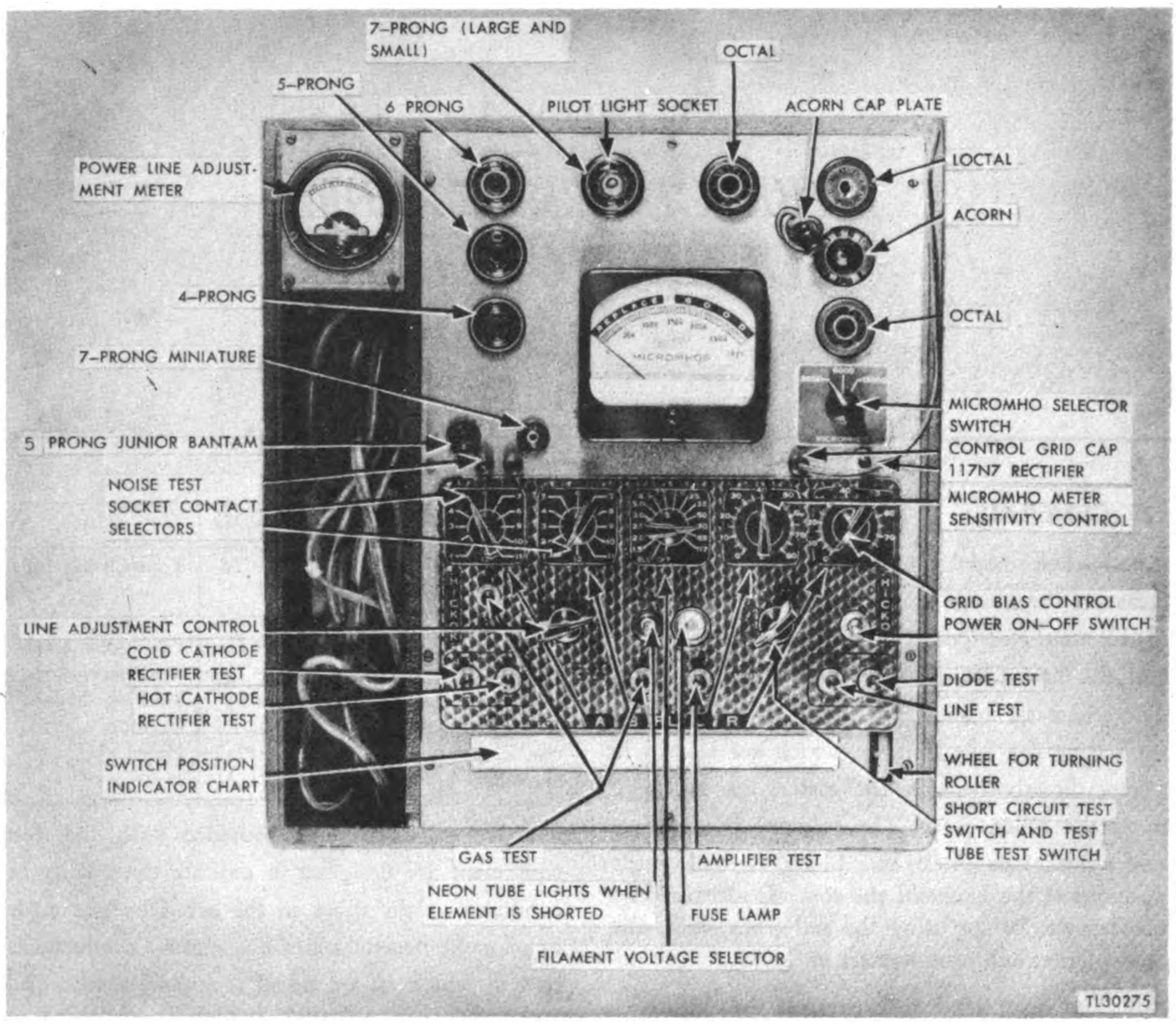


Figure 13. Tube Checker I-180, Hickok model 540, panel view.

a. Plug the line cord into a 50-60-cycle, 110-volt, a-c power outlet.

b. Set all the switches and controls in accordance with the instructions given on the roller chart at the bottom of the tube checker.

c. Insert the tube to be tested into the appropriate socket.

d. Throw the ON-OFF power switch to the ON position.

e. Adjust the LINE ADJUSTMENT knob until the needle of the power-line adjustment meter is over the red line on the meter scale.

45. SHORT-CIRCUIT TESTS.

a. Turn the SHORT TEST-TUBE TEST switch successively through positions 1, 2, 3, 4, and 5. If the neon tube glows continuously when the switch is on any of these positions, a short circuit is indicated and the tube should be discarded unless the roller charts states the contrary. Disregard a momentary flicker of the neon tube as the switch is turned, as this is caused by the charging of a capacitor in the circuit.

b. Intermittent shorts can be detected by tapping the tube with the hand while the switch is being turned. If the tube is free of shorts, turn the switch to the TUBE TEST position for appropriate further tests.

c. In the following scale, X under any SHORT-TUBE TEST switch position indicates that the neon lamp burns in that position if the elements are shorted.

Kind of short	*SHORT-TUBE TEST Switch Position*				
	1	2	3	4	5
FIL - CATHODE				X	X
FIL - GRID			X	X	X
FIL - PLATE	X	X	X		
FIL - SCREEN		X	X	X	X
CATHODE - GRID			X		
GRID - PLATE	X	X		X	X
GRID - SCREEN		X			
PLATE - SCREEN	X			X	X
CAP - FIL	X	X	X	X	
CAP - GRID	X	X			X
CAP - CATHODE	X	X	X		X
CAP - SCREEN	X				X
CAP - PLATE				X′	
SHELL - FIL	X				
SHELL - PLATE		X	X		
SHELL - GRID	X		X	X	X
SHELL - SCREEN	X	X	X	X	X
SHELL - CATHODE	X			X	X
SHELL - CAP		X	X	X	

46. NOISE TESTS. The two NOISE TEST jacks located just above the left top of the control panel are provided for special noise tests, if desired.

a. Connect the NOISE TEST jacks to an earphone or audio-amplifier system.

b. Rotate the SHORT TEST switch through positions 1, 2, 3, 4, and 5. Tap the tube with a finger while the switch is being turned. If the tube under test contains loose elements, loud crashes of static will be heard. In this manner, it is possible to detect intermittent shorts too momentary for the neon tube to detect.

c. Upon completion of this test, turn the switch to the TUBE TEST position for further tests.

47. AMPLIFIER TESTS.

> **CAUTION:** Do not make any of the following tests until short-circuit tests have been made, otherwise the instrument may be seriously damaged.

a. Allow the tube to warm up.

b. Set the micromho switch to the 3,000 position.

c. Depress the button marked AMPL TEST. The condition of the tube will then be indicated on the REPLACE, GOOD scale.

d. To read micromhos, set the L knob to the GM position and turn the micromho switch to the range desired. Depress the AMPL TEST button and read the micromho scale, as follows:

0-3,000 mhos	read directly.
0-6,000 mhos	read the scale and multiply by 2.
0-15,000 mhos	read the scale and multiply by 5.

> **NOTE:** The reading indicated should be the figure shown in the column marked MUT. COND.

48. DIODE TESTS.

a. Set the micromho switch to the 3,000 position.

b. Depress the DIODE TEST button. The condition of the tube will be indicated on the REPLACE, GOOD scale. A good diode will cause a meter deflection to the right of the arrow in the REPLACE scale, while a poor diode will cause a meter needle to fall to the left of this arrow.

> **CAUTION:** Do not press the AMPL or RECTIFIER test buttons when testing a diode element, as the applied high voltage will harm the delicate cathode.

49. RECTIFIER TESTS.

a. Set the micromho switch to the 3,000 position.

b. Depress the appropriate RECTIFIER TEST button. The button marked ST'D is for all fila-

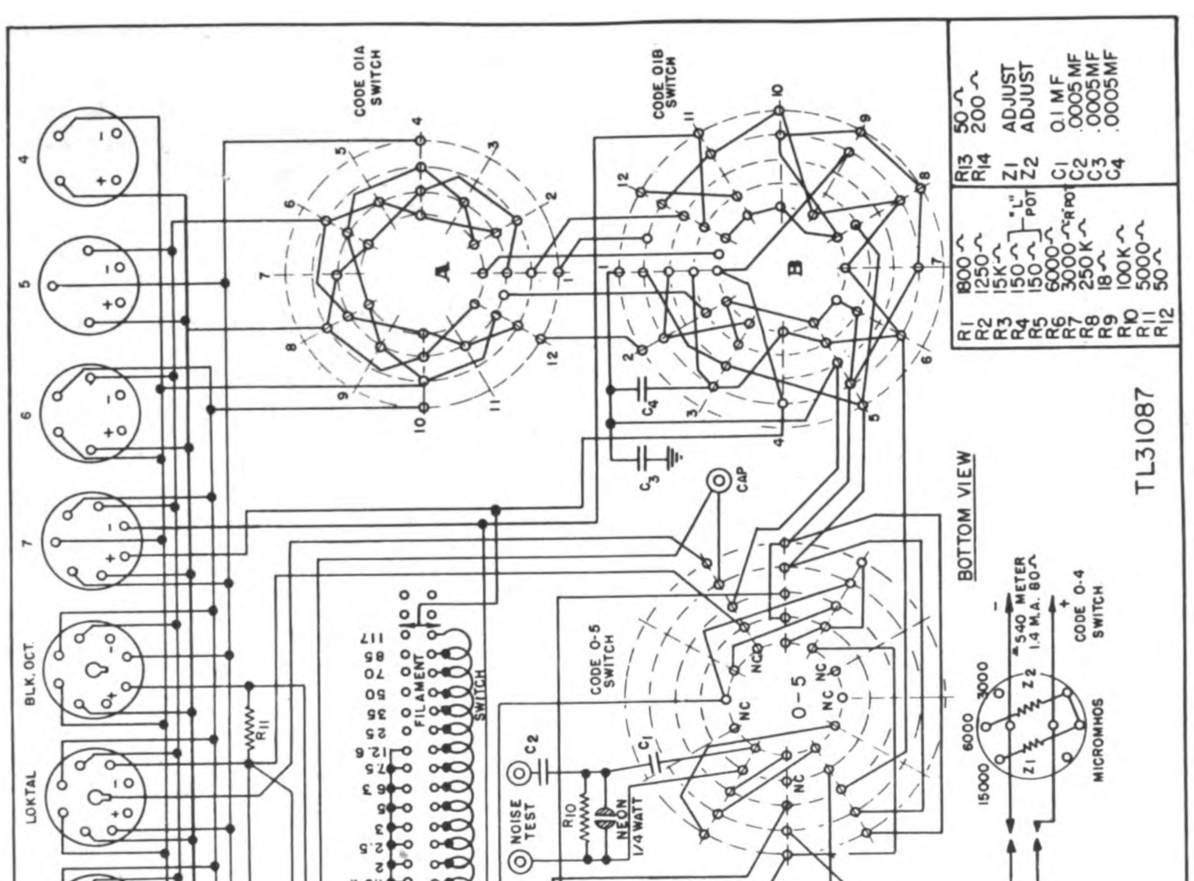


Figure 14. Tube Checker I-180, Hickok model 540, schematic diagram.

ment- or heater-type rectifier tubes. The button marked OZ4 is used when testing cold-gaseous, cathode-rectifier tubes such as OZ3 and OZ4. Rectifier tubes cause the meter needle to fall in the green sector of the scale, if the tubes are satisfactory. In addition, each plate of the full-wave rectifier tubes must be tested separately.

50. GAS TESTS.

a. Set the micromho switch to the 3,000 position.

b. Set the L control to the GM position.

c. Hold down the GAS NO. 1 button and adjust the R control until the large meter reads 100 micromhos.

d. Continue to hold down the GAS NO 1 button and press the GAS NO. 2 button. If the micromhometer indicator moves more than 1 scale division up the scale, the tube contains too much gas. Since some tubes develop gas after being heated for a period of time, allow the tested tube to warm up for several minutes before depressing the gas buttons.

51. MAINTENANCE.

a. General. This tester is a precision instrument, and no maintenance will be attempted by inexperienced personnel. Maintenance of this tube tester will consist chiefly of tube and fuse-lamp replacement and, to a limited extent, replacing of component parts. Locate faults by continuity tests, resistance measurements, voltage measurements, and visual inspection. The schematic diagram (fig. 14) shows the values of component parts and power-supply voltages.

CAUTION: Do not attempt any adjustment or repair of the meter movement.

b. Fuse Lamp. The tube checker contains a transformer operating from the a-c line for supplying the electrode potentials to the tube under test. A fuse lamp (standard 81 auto bulb) is in series with the primary of the input transformer and constitutes an automatic protective device against an overload of current damaging the instrument. It ordinarily will not need replacing even after being subjected to high current. However, if the tube checker fails to function when plugged into the proper a-c line, examine the fuse lamp and replace if necessary. Reference to figure 14 will show that the POWER LINE ADJUSTMENT METER operates even when the fuse lamp does not. The meter indication, therefore, should not be taken as a sign of proper a-c input to the tube tester.

c. Rectifier Tubes. If the fuse lamp operates satisfactorily and the tube tester still does not function, remove the panel and lift the tube tester out of its case. Examine the rectifier tubes and replace if necessary. Tube types 5W4G, 5W4GT, or 5X36T can be substituted for the 5W4 tube.

d. Visual Inspection. With the tester removed from the case, a visual inspection of the wiring and component parts can be made for loose connections, obviously overloaded components, dirty switch contacts, or other likely sources of trouble.

e. Periodic Tests. Several samples of each type of tube to be tested, each sample known to be good and properly identified, should be available so that periodic tests can be made on the tube tester to determine its efficiency.

f. Meter Zero Adjustment. The meter needle should point to zero (left edge of REPLACE segment) on the quality scale before any measurements are made with this tube tester. If the meter is not indicating zero when in normal position (no measurements being made), it may be adjusted by turning the screw directly below the scale on the meter case.

SECTION VIII

TUBE CHECKER I-157, PRECISION MODEL 920

52. GENERAL. Precision model 920 tube checker is a modern, push-button operated, radio-tube tester combined with rotary-range selective systems for obtaining measurements of a-c and d-c voltages, ohms, decibels, and current. The front view of the instrument is shown in figure 15 and the schematic in figure 17. Since the base sockets available upon the panel do not include sockets for the acorn-tube types, a special adapter is supplied with the instrument. The manner in which this adapter is plugged into its socket, which is located immediately above and to the right of the filament-selector switch F, is illustrated in figure 16.

53. APPLICATION OF TUBE TESTER TO RADIO SET-SCR-268-(*).

a. Limitations. (1) Tubes that appear good in tests still may not operate properly in the circuits to which they are applied. Such tubes should be replaced.

(2) The tube tester cannot be used to test the tube types, in the radio set, that appear in the following table:

Component	*Type No.*	*Coml No.*	*Use*
Transmitter	VT-127 or VT-127-A	100 TS	Transmitting tubes
Keyer	VT-46-A	866A	Hv rect
Keyer	VT-129	304TL	Final-pulse amplr
Modulator	VT-129	304TL	Modulator tubes
Modulator	VT-130	250TL	Blocking diodes
Oscilloscope	VT-111	1802-P4	Cathode ray
Oscilloscope	VT-119	879/2x2	Hv rect
Rectifier	VT-166	371-A	Hv rect

(3) The tube checkers provided with the test equipment are designed to indicate the quality or condition of the tubes in the set. One test made upon multi-element tubes is a mutual conductance test, in which an a-c signal is applied to the grid and an output indication, which is identified in terms of mutual conductance expressed in micromhos, is secured. Another test on rectifier tubes and on multi-element tubes is an emission test. The tester indicates quality in this latter case in terms of GOOD, WEAK, REPLACE. The operator must know at all times which type of test he is making in order to properly interpret the results. Different types of tube-element tests are discussed in paragraphs 35-40. This particular tester uses a modified emission test, which combines features of the mutual-conductance and straightforward emission tests.

b. Precautions. For a discussion of the precautions to be observed when using tube testers, refer to paragraph 41.

54. PRELIMINARY STEPS.

a. Depress the OFF button.

b. Connect the fused plug of the instrument to a 50-60-cycle, 110-125-volt, a-c source.

c. Refer to the tube-test roller chart for the tube number required and set the control knobs A, B, C, D, E, and F to the positions designated for that tube. Do not confuse these letters with the nine buttons bearing designations from A to J. These

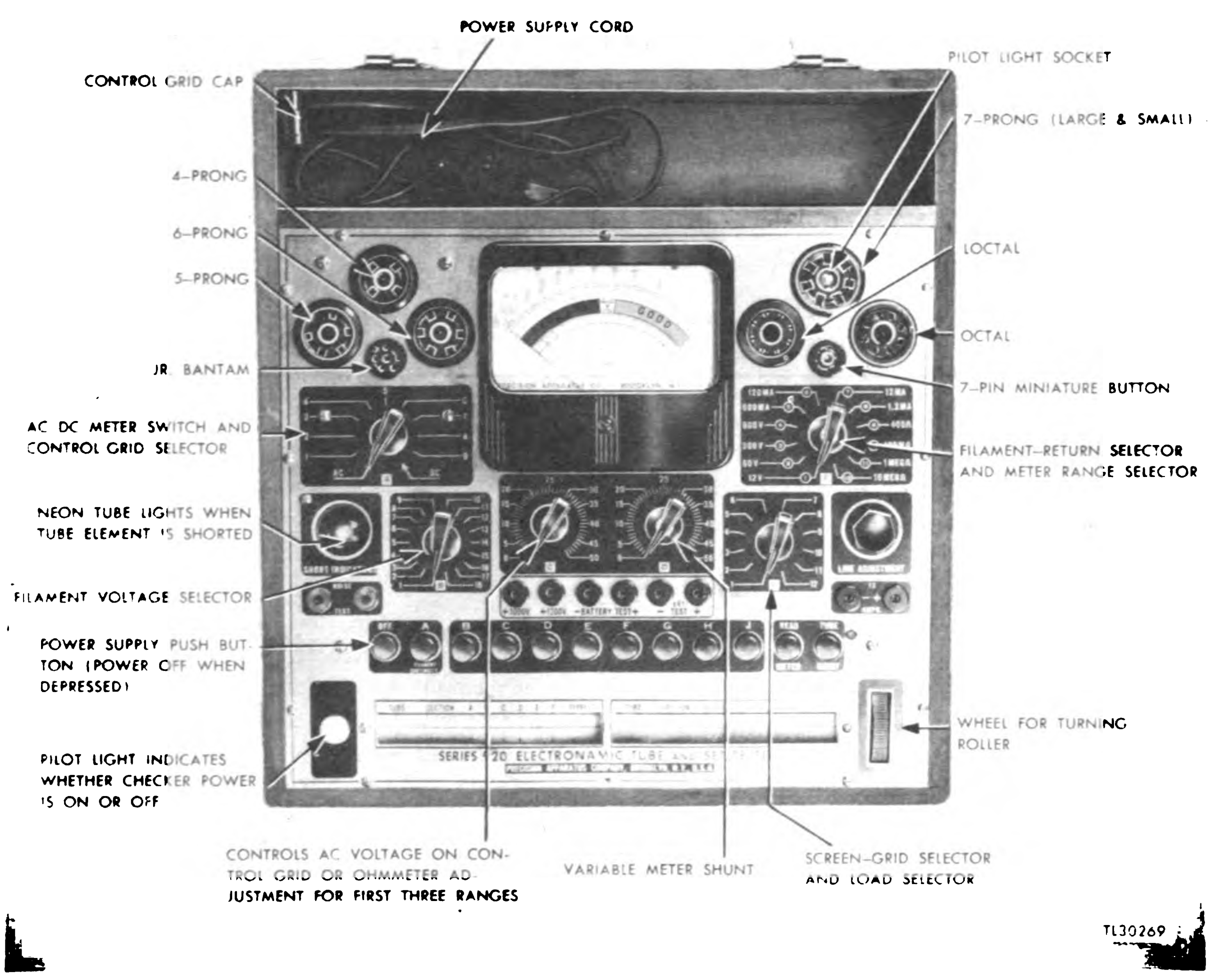


Figure 15. Tube Checker I-157, Precision model 920, panel view.

buttons are associated with the roller-chart column headed DEPRESS.

d. Press the TUBE MERIT button lightly and lift the finger. The button should remain in the up position. This operation turns on the pilot light, indicating that the power is on. The meter needle also moves to approximately half-scale deflection. If the TUBE MERIT button is pressed all the way down, the pilot light will go on but there will be no meter reading. To disengage this button, depress the OFF button which will always release any previously depressed buttons. Furthermore, a meter reading will be indicated only when control knob A is set to the tube-test positions 1 through 9.

e. Rotate the LINE ADJUSTMENT knob until the meter needle is in the center of the yellow scale over the arrow head.

f. Insert the tube to be tested in its proper socket and allow it to warm up. Connect the overhead cap if necessary.

g. If the meter needle deviates from the center of the scale, rotate the LINE ADJUSTMENT knob to bring it back to center.

CAUTION: Do not attempt to obtain tube - quality meter indications until

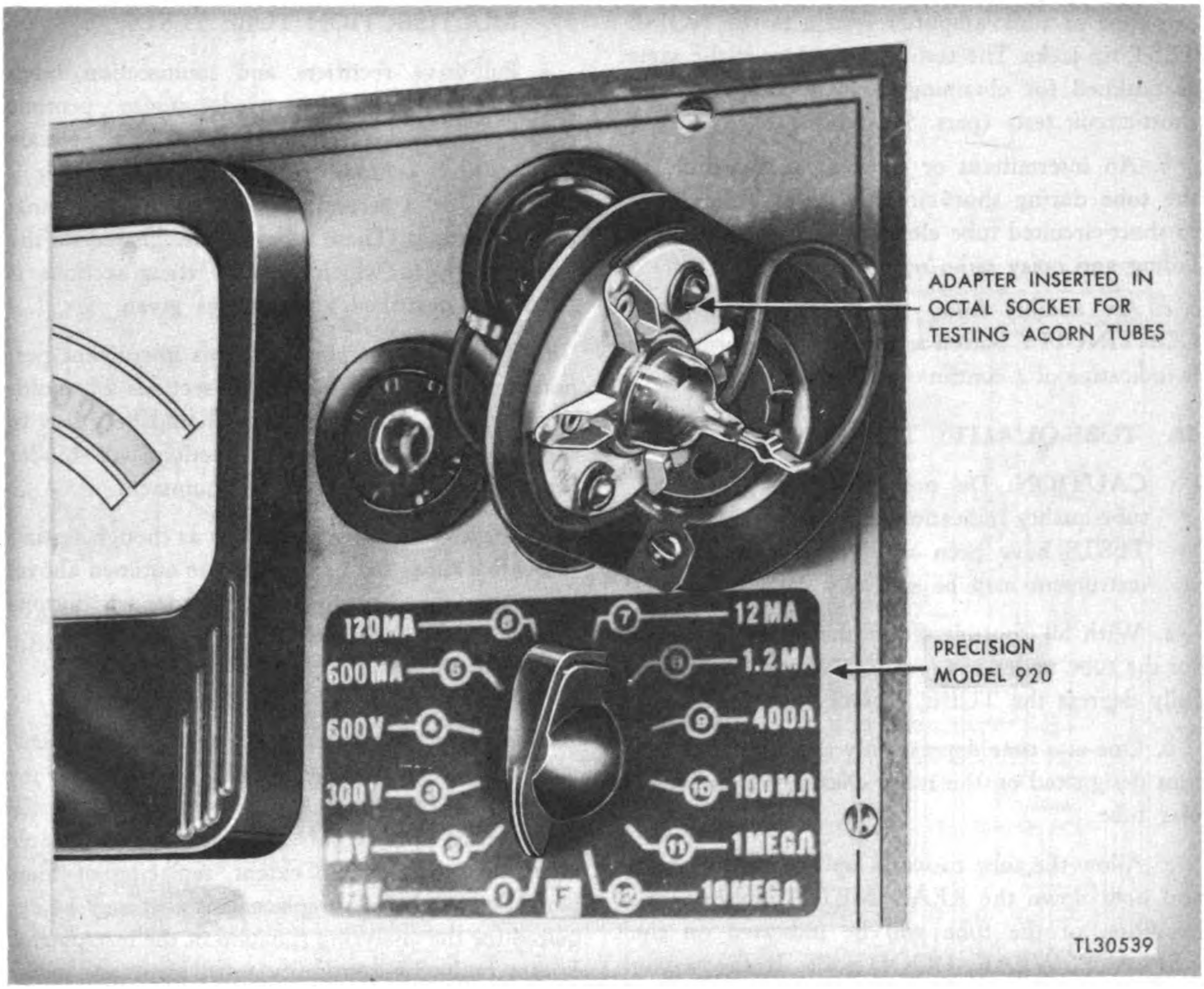


Figure 16. Tube Checker I-157, Precision model 920, acorn-tube adapter.

SHORT-CIRCUIT TESTS have been made, otherwise the instrument may be seriously damaged.

55. FILAMENT-CONTINUITY TESTS.

a. After taking the preliminary steps (par. 54), press button A unless another button is indicated by the roller chart.

b. The neon tube SHORT INDICATOR should light. If the neon tube fails to light, reject the tube under test as defective.

56. SHORT-CIRCUIT TESTS.

a. Make certain that the TUBE MERIT button is up.

b. Depress in succession the buttons lettered B, C, D, E, F, G, H, and J, while lightly tapping the tube. The neon tube will remain dark if no short circuit exists.

c. A discernable neon-lamp glow or continuous flickering when any one of the lettered buttons from B to J is depressed indicates an interelectrode high-resistance leakage or short circuit in the tube under test. The tube should be rejected without further testing, unless otherwise noted on the tube-checker roller chart.

57. AUDIBLE-NOISE TESTS.

a. An audible-noise test of defective and noisy tubes can be made, if desired, by connecting an earphone or audio-amplifier system to the NOISE TEST tip jacks. The testing procedure is the same as outlined for obtaining filament-continuity and short-circuit tests (pars. 55 and 56).

b. An intermittent or constant audible hum in the tube during short-circuit tests indicates loose or short-circuited tube elements. This is a cause of fading and noisy radio reception.

c. An audible hum, when the FILAMENT CONTINUITY button is depressed, is normal and is indicative of a continuous filament.

58. TUBE-QUALITY TESTS.

> CAUTION: Do not attempt to obtain tube-quality indications until short-circuit TESTS have been made, otherwise the instrument may be seriously damaged.

a. With all controls set at the proper positions for the tube under test and line adjustments made, fully depress the TUBE MERIT button.

b. One at a time depress only those lettered buttons designated on the roller chart for that particular tube.

c. Allow the tube to warm up and then depress and hold down the READ METER button. The condition of the tube will be indicated on the REPLACE, WEAK, GOOD scale. If the wrong push button is depressed, merely depress the OFF button, which also functions as a general release. This will disengage and return all buttons to their normal positions.

d. Depress the OFF button. The instrument is now ready to test another tube or section of a tube.

e. If a diode is being tested, disregard the REPLACE, WEAK, GOOD scale. A good diode will cause a meter deflection to the right of the arrow in the REPLACE scale, while a poor diode will cause the meter needle to fall to the left of this arrow.

f. It is advisable, when obtaining a tube-quality indication, to tap the tube under test. At times, tapping may cause a noticeable meter-needle fluctuation. Such fluctuation indicates a loose internal-element structure and may cause a noisy, fading condition.

59. MULTISECTION TUBE TESTS.

a. Full-wave rectifiers and multisection tubes such as double triodes, triode diodes, pentode diodes, duo diodes, frequency converters, pentode triodes, and pentode rectifiers contain either a second plate, a second triode, or other combination of sections. These tubes are designated on the roller chart, in which each of these sections is separately described and settings given.

b. The circuit employed in this instrument permits testing of the individual sections of multisection tubes. A complete test should be given to these types since one poor section will hinder proper operation in the radio equipment.

c. Treat each of these sections as though testing individual tubes for tube quality as outlined above, by setting the controls and lettered push buttons designated for each section.

60. MAINTENANCE.

a. General. This tester is a precision instrument and no maintenance will be attempted by inexperienced personnel. Maintenance of this tester will consist chiefly of fuse and tube replacement and, to a limited extent, replacing of component parts. Battery replacement also may be required for the analyzing function of the instrument. Locate faults by continuity tests, resistance measurements, voltage measurements, and visual inspection. The schematic diagram, figure 17, shows the values of component parts and power-supply voltages.

> CAUTION: Do not attempt any adjustment or repair of the meter movement.

b. Fuses. The tube checker contains a transformer operating from the a-c line for supplying the electrode potentials to the tube under test. Two 1-ampere fuses protect the tester from overload. These fuses are in series with each side of the a-c line and are incorporated in the male plug that connects to the a-c line. Should the tube checker fail to function when plugged into the proper a-c line, examine the fuses in the fused male plug and replace them if necessary. To replace the fuses it is not necessary to take this plug apart. Two holes located on the top of the plug allow

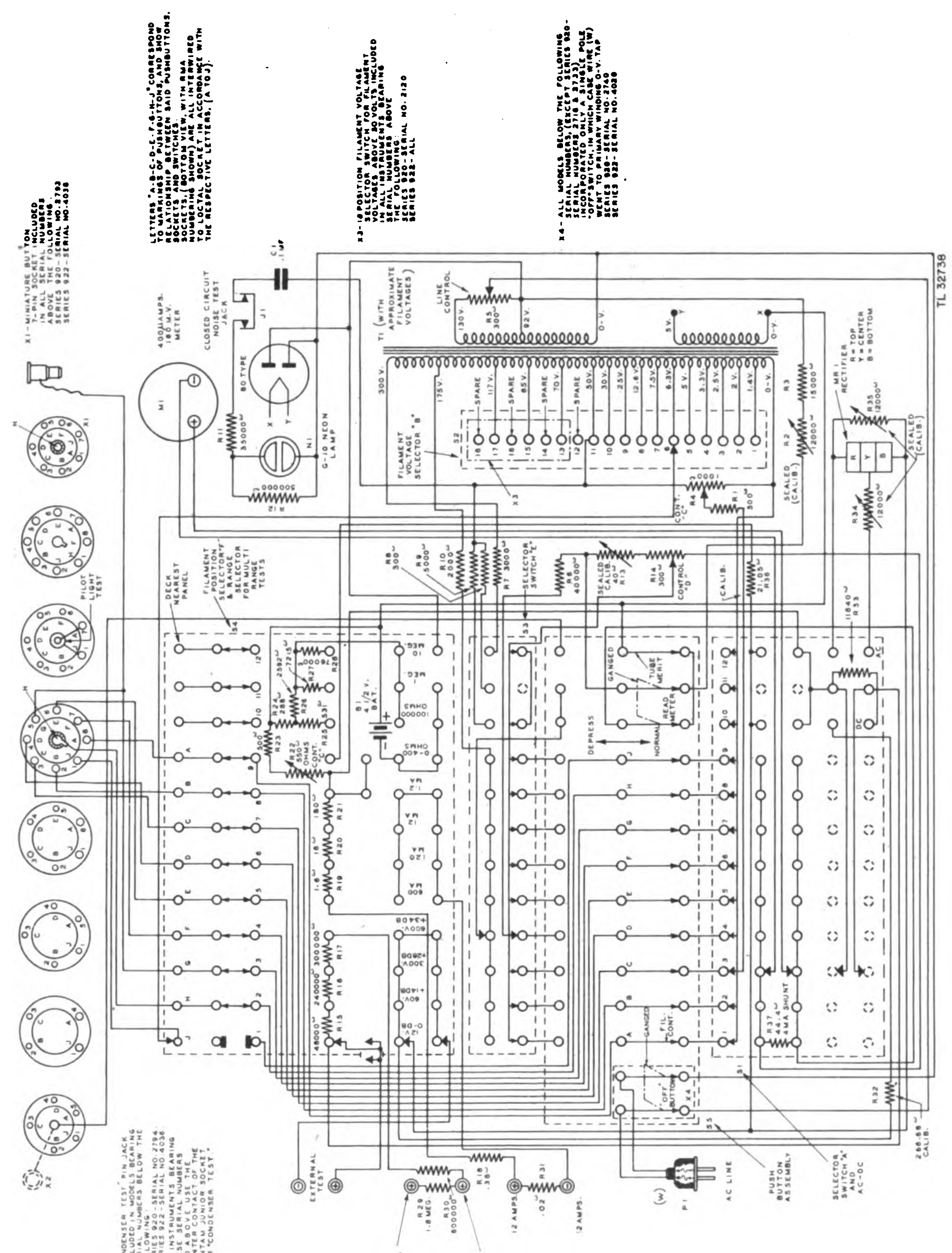


Figure 17. Tube Checker I-157, Precision model 920, schematic diagram.

for the insertion of a pointed object which will eject the fuses. Two new fuses can then be inserted in these holes.

c. *Rectifier Tubes.* A defective 80-type rectifier tube will prevent proper line-adjustment indication. When no indication at all can be obtained with the fuses intact, examine this tube and replace if necessary. The 80-type tube is located on the underside of the tester panel. Remove the retaining screws and lift out the complete unit.

d. *Visual Inspection.* With the tester removed from the case, a visual inspection of the wiring and component parts can be made for loose connections, obviously overloaded components, dirty switch contacts, or other likely sources of trouble.

e. *Periodic Test.* Several samples of each type of tube to be tested, each sample known to be good and properly identified should be available so that periodic tests can be made on the tube tester to determine its efficiency.

f. *Battery Replacement.* (1) Remove the 12 screws on the black line around the outer edge of the front panel.

(2) Using extreme care, lift panel upward.

(3) Disconnect the battery leads from the existing battery located in the upper right-hand corner of the case.

(4) Loosen the battery clamp and remove the battery.

(5) Replace the battery with a Burgess 5360 (4.5 volts) or equal.

(6) Tighten clamp and reconnect battery leads.

CAUTION: Observe proper polarity of the battery. The red lead goes to the positive (+) terminal and the black wire to the negative (—) terminal of the battery.

(7) Be sure to keep the lugs on the ends of the battery leads as close as possible to the side of the wooden case. If they are not, the resistor in the unit will bear against them when the panel is replaced and eventually be cut and cause a short circuit.

g. *Meter-zero Adjustment.* The meter needle should point to zero on the a-c and d-c scales before any measurements are made with this tube tester. If the meter is not indicating zero when in normal position (all push buttons up), it may be adjusted by turning the screw directly below the scale on the meter case.

SECTION IX

TUBE CHECKER I-157, PRECISION MODEL 920, USED AS AN ANALYZER

61. GENERAL. The Precision model 920, Tube Checker I-157, incorporates complete tube analyzing; a rotary-range-selector system providing for a-c and d-c voltage measurements from zero to 3,000 volts, at a sensitivity of 1,000 ohms per volt; d-c current measurements up to 12 amperes; resistance measurements up to 10 megohms; output-meter indications from zero to 3,000 volts; decibel readings in six ranges from —10 to +64 db; and d-c current measurements of leakage in electrolytic capacitors.

62. APPLICATION TO RADIO SET SCR-268-(*).

a. Use of Precision model 920 as an analyzer may lead to large voltage errors, since the application of a 1,000-ohm-per-volt voltmeter to the high-resistance circuits in Radio Set SCR-268-(*) will result in loading, a discussion of which is given in paragraph 6d. For this reason, use a 20,000- or 25,000-ohm-per-volt analyzer, if available, such as Weston model 772, Precision model 856, or Supreme model 592.

b. Further limitations, on the use of Precision model 920 tube checker as an analyzer, are given in paragraph 19 covering Precision model 856, analyzer.

CAUTION: For radio set analyzing, set control A to the A.C. or D.C. position before attempting to employ the range selector control F.

c. As a safety factor, *disconnect* the instrument's fused plug from the a-c line source before making measurements, except when employing the 0-10-megohm range, as noted below.

d. When a voltage or current of unknown value is to be measured, employ the highest range first. If the meter indication is slight, select the next lower range, etc. Follow this procedure throughout to prevent bending of the meter needle and overloading of the meter.

63. A-C VOLTAGE MEASUREMENTS.

a. Set control A to the A.C. position for all a-c voltage measurements.

b. For a-c measurements up to 600 volts, select a suitable voltage range on the range-selector control F.

c. Insert the test leads into the polarized EXT. TEST tip jacks.

d. Apply the free ends of the test leads to the circuit being measured, and read the proper red a-c correction scale as follows:

0-12 volts	read directly.
0-60 volts	read directly.
0-300 volts	read directly.
0-600 volts	read the 60 scale, multiply by 10.

64. D-C VOLTAGE MEASUREMENTS.

a. Set control A to the D.C. position for all d-c voltage measurements.

b. For d-c voltage measurements up to 600 volts, select a suitable voltage range by means of the range-selector control F.

c. Insert the test leads into the polarized EXT. TEST tip jacks.

d. Observing proper polarity, apply the free ends of the test leads across the load. For d-c positive voltages, connect the positive-test lead to the voltage source and the negative-test lead to the chassis or ground. For negative d-c voltages, reverse the leads.

0-12 volts	read directly.
0-60 volts	read directly.
0-300 volts	read directly.
0-600 volts	read the 60 scale, multiply by 10.

65. D.C. CURRENT MEASUREMENTS. Make all current measurements with the test leads in *series* with the load.

> **CAUTION:** Do not attempt to measure current in the presence of voltages exceeding 500 volts.

a. Set control A to the D.C. position for all d-c current measurements.

b. For d-c current ranges of 1.2 ma to 600 ma inclusive, select a suitable range by means of the range-selector control F.

c. Insert the test leads into the polarized EXT. TEST tip jacks.

d. Apply the test leads in *series* with the circuit being measured, making sure that proper polarity is observed. Connect the positive-test lead in the direction of the higher-potential source. Connect the negative lead in the direction of the lower-potential source.

e. Read the meter scale, as follows:

0-1.2 ma	read the 12 scale, divide by 10.
0-12 ma	read directly on 12 scale.
0-120 ma	read the 12 scale, multiply by 10.
0-600 ma	read the 60 scale, multiply by 10.

f. For the 12-ampere range, set control F to the 600 MA position.

g. Insert the test leads into the polarized 12 AMPS. pin jacks located at the lower right-hand portion of the panel immediately below the LINE ADJUSTMENT control.

h. Apply the test leads in *series* with the circuit being measured, making sure that proper polarity is observed.

i. Read the 12 scale directly.

> **NOTE:** When using the 12-ampere d-c range, never remove the leads from the pin jacks while current is flowing through the circuit. Failure to observe this caution will result in arcing at the pin jacks, and though it will not injure the meter, the jacks will gradually char.

66. RESISTANCE MEASUREMENTS.

a. *General*. All resistance measurements are made with control A in the D.C. position. Make resistance measurements with the power off in the circuit being tested. Always disengage one end of the resistance from the circuit before making resistance measurements. Otherwise, an indication of the true resistance value may not be obtained because the circuit involved may effectively shunt the resistance to be measured. If this should occur, the true reading will be reduced by an amount proportionate to the resistance of the included shunt network.

b. *Zero—400-Ohm (Low Ohms) Range*. (1) Set control A in the D.C. position.

(2) Rotate the range-selector control F to the 400 OHMS position. Note that the meter needle deflects even though the test leads are not used.

(3) Rotate control C so as to bring the needle to full-scale deflection.

(4) Insert the test leads into the polarized EXT. TEST tip jacks.

(5) Apply the test leads across the circuit being measured.

(6) Read the resistance measurement directly on the lower portion of the ohms scale. Indications for this range start at the left.

> **CAUTION:** Never allow the range-selector control F to remain in the 400 OHMS position when this low-ohms range is not being employed, otherwise a continuous

current will be drawn from the battery even when the instrument is being used for tube testing. The range selector may be set to any position (except 400 OHMS) without affecting the battery.

c. Zero—100M-OHM and Zero—1-MEGOHM Ranges. (1) Set control A in the D.C. position.

(2) Set the range-selector control F to the 100M-OHM or 1-MEGOHM position as required.

(3) Insert the test leads into the polarized EXT. TEST tip jacks.

(4) Short the test leads and adjust control C to obtain full-scale deflection.

(5) Apply the test leads across the circuit to be measured.

(6) Read the resistance measurements as follows:

0-100M ohms	read directly on the 0—100M-ohms scale.
0-1 Megohm	read the 0-100M-ohms scale, multiply reading by 10.

d. Zero — 10-MEGOHM Range. The 0 — 10-MEGOHM range is made possible through the use of the tube-checker power supply.

(1) Depress the OFF button.

(2) Connect the fused plug of the tube checker to a 110-125-volt, 50-60-cycle, a-c source.

(3) Press the TUBE MERIT button lightly and lift the finger. The button should remain in the up position. This operation turns on the pilot light, indicating that the power is on.

(4) Set control A to the D.C. position.

(5) Set control F to the 10-MEGOHM position.

(6) Insert the test leads into the polarized EXT. TEST tip jacks.

(7) Short the test leads and rotate the LINE ADJUSTMENT control to obtain a full-scale deflection.

(8) Apply the test leads across the resistance to be measured.

(9) Read the resistance measurements for this range on the zero-100M-ohm scale multiplied by 100.

67. OUTPUT - METER INDICATIONS. A-c voltage measurements at a sensitivity of 1,000 ohms per volt make this instrument suitable for use as an output meter. There are two methods that can be used for obtaining output-meter indications.

a. Make the connections from the secondary of the output transformer to the EXT. TEST tip jacks. If the secondary of the transformer is not easily accessible, use the second method.

b. Make the connections from the plate of the output tube and ground or chassis of the radio receiver to the EXT. TEST tip jacks with a good quality paper capacitor of approximately 0.25 mfd in series with one of the leads in order to block the d-c voltage appearing at the points across which the output measurements are taken.

c. With the use of either method noted above, set control A to the A.C. position and the rotary RANGE SELECTOR to the *highest* voltage range. An output-meter indication will be observed when an a-c signal is present. If the meter indication is slight, use the next lower a-c voltage range, etc.

d. The output meter also can be used to great advantage for obtaining comparisons in tube performance. This is accomplished by substituting different tubes in the radio equipment under test and noting the difference in the meter reading.

SECTION X

TUBE CHECKER, SUPREME MODEL 504-A

68. GENERAL. Supreme model 504-A is a push-button operated, combination tube tester, analyzer, and battery tester. The front view is shown in figure 18 and the schematic in figure 19. The tube-testing circuit employs the emission principle which is a test of the tube's ability to emit electrons from the cathode to other elements of the tube. No provision is made for testing acorn tubes.

69. APPLICATION OF TUBE TESTER TO RADIO SET SCR-268-(*).

a. Limitations. (1) Tubes that appear good in tests still may not operate properly in the circuits to which they are applied. Such tubes should be replaced.

(2) The tube tester CANNOT be used to test the tube types, in the radio set, that appear in the following table:

Component	*Type No.*	*Coml No.*	*Use*
Transmitter	VT-127 or VT-127-A	100 TS	Transmitting tubes
Keyer	VT-46-A	866A	Hv rect
Keyer	VT-129	304TL	Final-pulse amplr
Modulator	VT-129	304TL	Modulator tubes
Modulator	VT-130	250TL	Blocking diodes
Oscilloscope	VT-111	1802-P4	Cathode ray
Oscilloscope	VT-119	879/2x2	Hv rect
Rectifier	VT-166	371-A	Hv rect

(3) The tube checkers provided with the test equipment are designed to indicate the quality or condition of the tubes in the set. The test made upon multi-element tubes, and also on rectifier tubes, is an emission test. The tester indicates quality in this case in terms of GOOD TUBE and BAD TUBE. The operator must know at all times what type of test he is making, and what type of tube he is testing in order to properly interpret the results. For a discussion of different types of tube-element tests, refer to paragraphs 35-40.

b. Precautions. Refer to paragraph 41 for a discussion of the precautions to be observed when using tube testers.

70. PRELIMINARY STEPS.

a. Connect the power-supply plug to a convenient 60-cycle, 110-125-volt, a-c source.

b. Depress the locking-type button marked PRESS FOR BATT. AND TUBE TESTER located below button 1-9.

c. Depress and hold down the LINE ADJUST push button on the left side of the panel.

d. Adjust the OFF line-adjustment potentiometer until the meter needle indicates as close to half-scale deflection as possible. The meter will read in all positions of the potentiometer except the extreme counterclockwise position.

CAUTION: When not in use, turn the a-c line-adjustment potentiometer to OFF position.

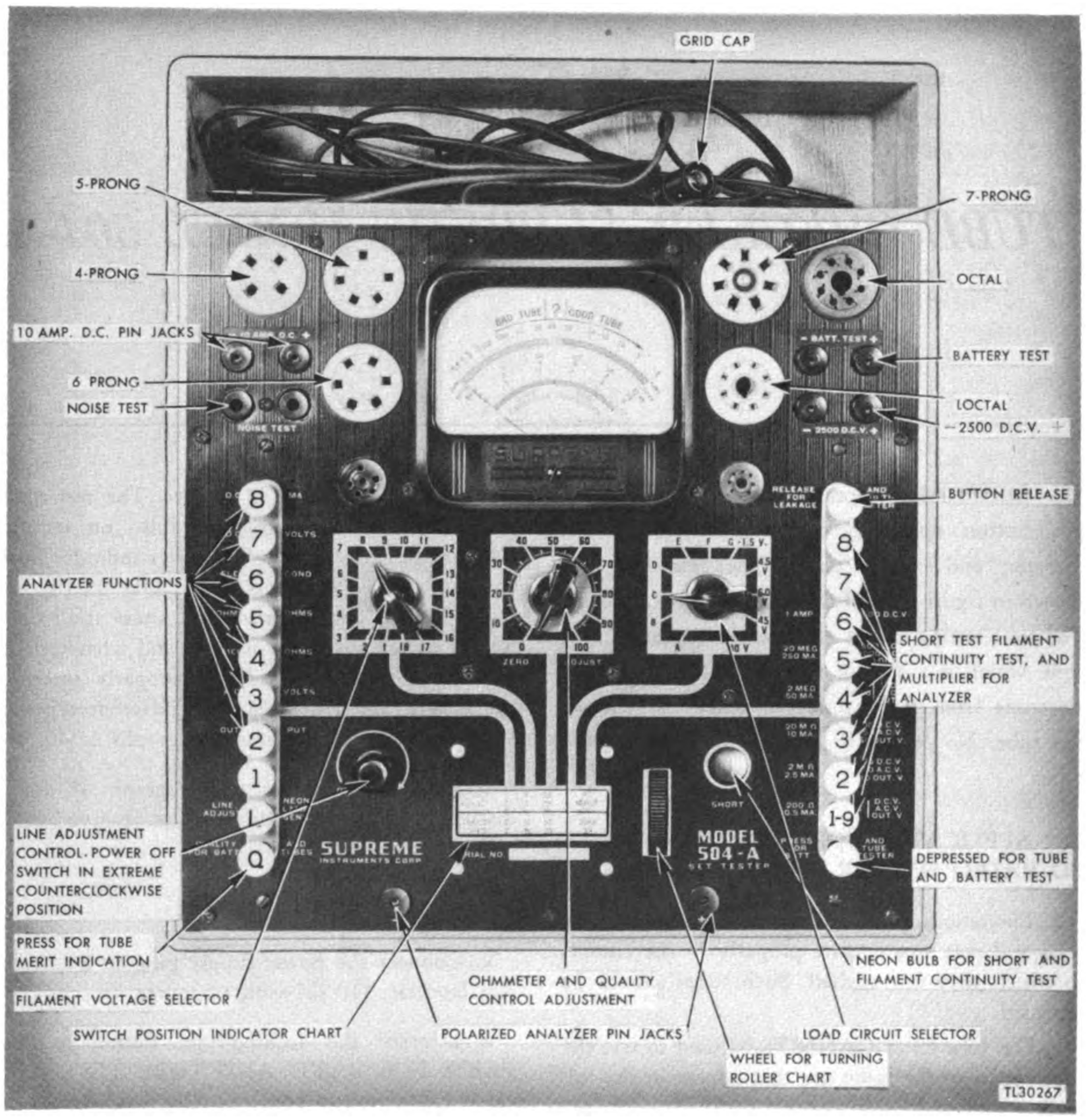


Figure 18. Tube checker, Supreme model 504-A, panel view.

71. FILAMENT, SHORT-CIRCUIT, AND LEAKAGE TESTS.

a. Rotate the roller chart by means of the thumb knob to the desired tube type. The letters A, B, C, DIO, etc. beside the tube type refer to footnotes which are listed on the lower part of the chart. In order to avoid confusion between octal and nonoctal tubes with the same number, all octal-tube settings are indicated by an asterisk (*).

b. Set the controls as marked in the respective columns of the roller chart, except the numbers under the last "arrow-way" by following the red 'arrow-way" to the proper controls.

c. Insert the tube to be tested into the appropriate socket, and connect the top-cap lead if the tube is a top-cap type.

d. Fully depress the RELEASE FOR LEAKAGE button to release any previously depressed buttons in the same row, then release this button.

e. Press the button on the *right side* of the tube checker that corresponds to the highest-numbered *filament* terminal (4 on four-prong, 5 on five-prong, 6 on six-prong, 7 on seven-prong, and 3, 7, or 8 on octal tubes, depending on filament terminations). The neon lamp should light, indicating filament continuity.

f. Depress successively buttons 1-9 to 8, on the *right side* of the tube checker, while watching the neon lamp. If the neon lamp glows steadily when any button is depressed, except the button depressed to show filament continuity, a short circuit or leaky circuit is indicated. In this case, discard the tube.

g. For high-leakage tests, depress the NEON LAMP SENS. button during the leakage tests in step *f*. This changes the leakage sensitivity from approximately 250,000 ohms to about 2 megohms, which is proper for all leakage checks except that taken between cathode and filament. If during the leakage tests both the NEON LAMP SENS. button and the push button corresponding to the cathode in the right-hand row are depressed, the neon tube may glow. In this case, release the NEON LAMP SENS. button; if the neon tube goes out, the tube under test is still good.

72. TUBE-QUALITY TESTS.

a. If the tube passes the filament and short-circuit tests, depress the button marked PRESS FOR BATT. AND TUBE TESTER.

b. Depress the numbered button or buttons as shown under the extreme right "arrow-way".

c. Allow the tube to warm up.

d. Depress the QUALITY FOR BATT. button and note the condition of the tube on the BAD TUBE, GOOD TUBE meter scale.

> **NOTE:** More than one test may be required when checking multisection tubes. These types will show two tests on the roller chart. After making the first test, reset the controls for the second test as indicated on the roller chart, depress the RELEASE FOR LEAKAGE button, then depress the PRESS FOR BATT. AND TUBE TESTER button before resetting the last push button row.

73. MAINTENANCE.

a. General. This tester is a precision instrument and no maintenance will be attempted by inexperienced personnel. Maintenance of this tube tester will consist chiefly of tube replacement and, to a limited extent, replacing of component parts. Battery replacement may also be required for the analyzing function of this instrument. Locate faults by continuity tests, resistance measurements, voltage measurement and visual inspection. The schematic diagram, figure 19, includes the values of component parts and power-supply voltages. Note that all double-throw, push-button switches make contact with the right-hand arrows when in their normal (up) position.

> **CAUTION:** Do not attempt any adjustment or repair of the meter movement.

b. Rectifier Tube. The megohms ranges, electrolytic-leakage section, and center-scale-line adjustment obtain power from a high-voltage winding of the transformer. This a-c voltage is converted to d-c by the type 71A tube operating as a halfwave rectifier. If the meter does not indicate when the preliminary line adjustment is made, lift the complete tester out of its case and check this tube to see if it is firmly seated in its socket or is inoperative. Replace a defective tube with a new one of the same type.

c. Visual Inspection. With the tester removed from the case, a visual inspection of the wiring and component parts can be made for loose connections, obviously overloaded components, dirty switch contacts, or other likely sources of trouble.

d. Periodic Tests. Several samples of each type of tube to be tested, each sample known to be good and properly identified should be available so that periodic tests can be made on the tube tester to determine its efficiency.

e. Meter Zero Adjustment. The meter needle should point to zero on the VOLTS MA scale before any measurements are made with this instrument. If the needle is not indicating zero when in normal position (all push buttons up), it may

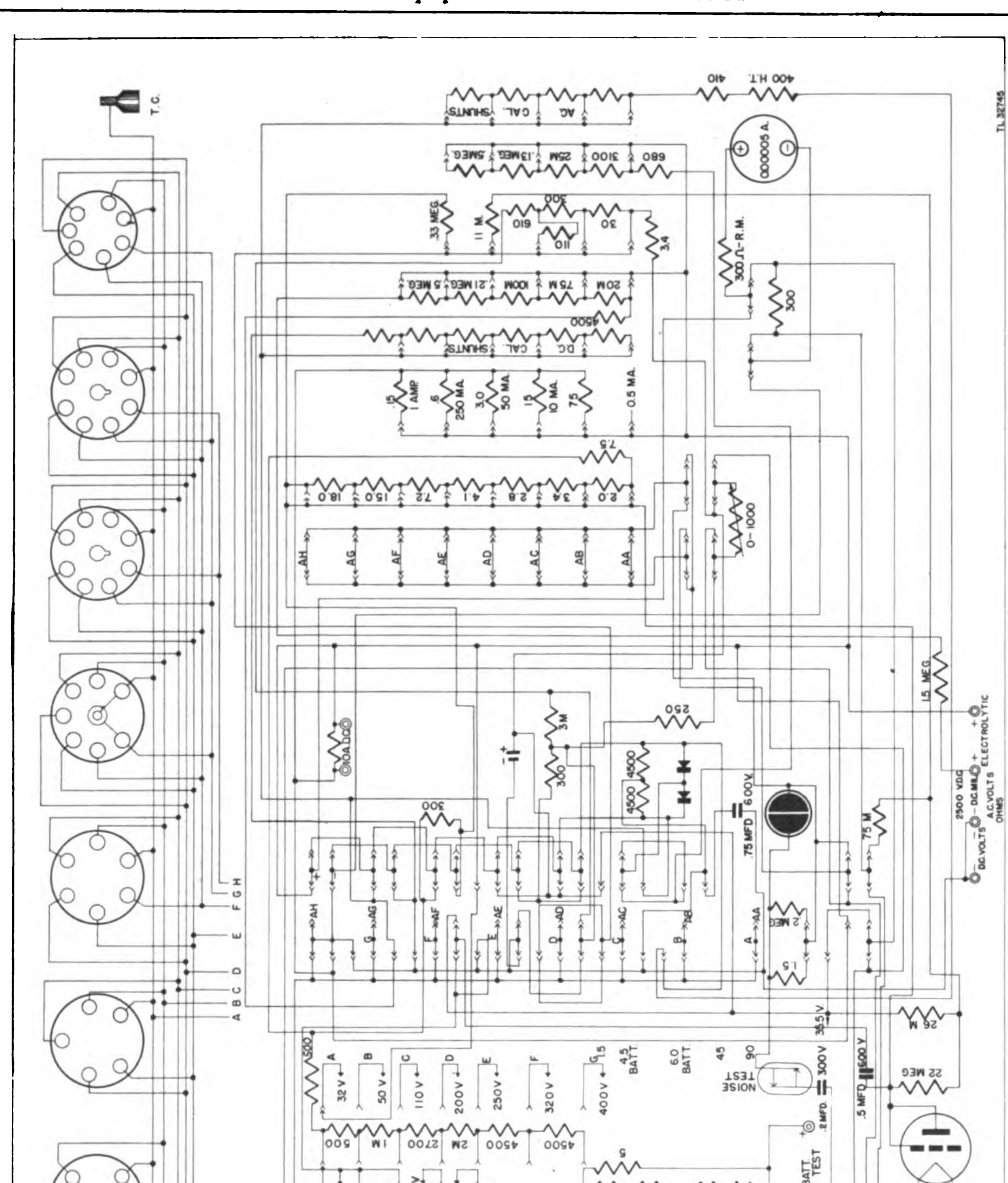


Figure 19. Tube checker, Supreme model 504-A, schematic diagram.

be adjusted by turning the screw on the meter case directly below the scale.

f. Battery Replacement. (1) This instrument may also be used as a set tester to make voltage, current, and resistance measurements. Since it is used as an ohmmeter, a 2-cell, 1.5-volt battery is used as a current source for the three lowest (200Ω, 2MΩ, 20MΩ) ranges. The two higher ohmmeter ranges (2 meg, 20 meg) use the d-c output of the instrument's rectifier as their source of current. If, with the instrument set up as an ohmmeter and the test leads shorted together, the meter pointer cannot be brought to full-scale deflection by means of the ZERO ADJUST knob, test and replace the battery if defective.

(2) To replace the battery, remove the seven screws on the outer edges of the panel. This will allow the instrument to be taken out of the case. Remove the old battery observing the proper polarity, and reconnect the two long battery leads to the terminals of the new battery (red wire to + terminal). Insert the battery in the bracket which is fastened to the bottom of the case, and replace the instrument in the case.

SECTION XI

TUBE CHECKER, SUPREME MODEL 504-A, USED AS AN ANALYZER

74. GENERAL. The Supreme model 504-A tube checker can be used to measure the following: a-c voltages from zero to 1,000 volts, and d-c voltages from zero to 2,500 volts, at a sensitivity of 1,000 ohms per volt; d-c current from zero to 10 amperes in seven ranges; resistances from zero to 20 megohms in five ranges; and output from zero to 1,000 volts in five ranges.

75. APPLICATION TO RADIO SET SCR-268-(*).

a. Voltage measurements made by means of the Supreme model 504-A tube checker may cause large errors. The application of this unit as a 1,000-ohm-per-volt voltmeter to the high-resistance circuits in Radio Set SCR-268 will result in loading (subpar. 6d). For this reason, use a 20,000 or 25,000 ohm-per-volt analyzer, such as the Weston model 772, Precision model 856, or Supreme model 592, whichever analyzer is available.

b. Further limitations on the analyzer functions of the Supreme model 504-A tube checker are given in paragraph 28 which discusses the Supreme model 592 analyzer in detail.

76. D-C VOLTAGE MEASUREMENTS.

> **CAUTION:** Do not attempt to measure voltages in excess of 500 volts.

a. Press the RELEASE FOR LEAKAGE AND MULTIPLIER button to release any previously depressed button in the same row.

b. Depress the D.C. VOLTS button in the left-hand row for all d-c voltage measurements.

c. For d-c voltage measurements up to 500 volts, select a suitable voltage range by depressing the proper button marked 5 D.C.V., 25 D.C.V., 100 D.C.V., 250 D.C.V., or 500 D.C.V.

d. Insert the test leads into the polarized + and — tip jacks located at the bottom of the panel.

e. Observing polarity, apply the free ends of the test leads across the load. For positive d-c voltages, correct the positive test lead to the voltage source and the negative test lead to the chassis or ground; for d-c negative voltages, reverse the leads.

f. Read the proper-correction scale as follows:

0-5 volts	read the 5 scale directly.
0-25 volts	read the 25 scale directly
0-100 volts	read the 10 scale, multiply by 10.
0-250 volts	read the 25 scale, multiply by 10.
0-500 volts	read the 5 scale, multiply by 100.

77. D-C CURRENT MEASUREMENTS. All current measurements are made with test leads in series with the load.

> **CAUTION:** Do not attempt to measure current in the presence of voltage exceeding 500 volts.

a. Press the RELEASE FOR LEAKAGE AND MULTIPLIER button to release any previously depressed button in the same row.

b. Depress the D.C. MA. button in the left-hand row for all d-c current measurements.

c. For d-c current measurements up to 1 ampere, select a suitable current range by depressing the appropriate button marked 0.5 MA., 2.5 MA., 10 MA., 50 MA., 250 MA., or 1 AMP.

d. Insert the test leads into the polarized + and — tip jacks located at the bottom of the panel.

e. Observing polarity, apply the free ends of test leads in *series* with the circuit being measured. Connect the positive lead in the direction of the higher potential source and the negative lead in the direction of the lower potential source.

f. Read the proper correction scale as follows:

0-0.5 ma	read the 5 scale, divide by 10.
0-2.5 ma	read the 25 scale, divide by 10.
0-10 ma	read the 10 scale directly.
0-50 ma	read the 5 scale multiply by 10.
0-250 ma	read the 25 scale, multiply by 10.
0-1 amp	read the 10 scale, divide by 10.

g. For d-c current measurements over 1 ampere and up to 10 amperes, depress the 1 AMP button and insert the test leads into the polarized —10 AMP. D.C. + tip jacks on the upper left corner of the panel.

h. Observing polarity, apply the free ends of the test leads in *series* with load being measured.

i. Read the 10-scale directly.

78. A-C VOLTAGE MEASUREMENTS.

a. Press the RELEASE FOR LEAKAGE AND MULTIPLIER button to release any previously depressed button in the same row.

b. Depress the A.C. VOLTS button in the left-hand row for all a-c voltage measurements.

c. For a-c voltage measurements up to 500 volts, select a suitable voltage range by depressing the proper button marked 5 A.C.V., 10 A.C.V., 50 A.C.V., 250 A.C.V., or 1,000 A.C.V.

d. Insert the test leads into the polarized tip jacks located at the bottom of the panel.

e. Apply the free ends of the test leads across the circuit to be measured.

f. Read the proper correction scale as follows:

0-5 volts	read the 5-scale directly.
0-10 volts	read the 10-scale directly.
0-50 volts	read the 5-scale, multiply by 10.
0-250 volts	read the 25-scale, multiply by 10.
0-1,000 volts	read the 10-scale, multiply by 100.

Where the actual voltage is unknown, depress the highest-range button first; then successively depress the lower-range buttons until the meter needle deflects as much as possible without going off-scale.

79. USE AS AN OUTPUT METER. Follow the same procedure outlined for a-c voltage measurements (par. 78) with the following exception: Depress the OUTPUT button instead of the A.C. VOLTS button. This automatically connects a capacitor in series with one of the leads and blocks out the d-c component when measuring circuits where both a-c and d-c voltages exist. The reactance of the capacitor will cause an error on low ranges.

80. RESISTANCE MEASUREMENTS.

a. Zero to 20,000 Ohm Range. (1) Press the RELEASE FOR LEAKAGE AND MULTIPLIER button to release any previously depressed button in the same row.

(2) Depress the OHMS button in the left-hand row.

(3) For resistance measurements up to 20,000 ohms, select a suitable range by depressing the appropriate button marked 200 OHMS, 2M OHMS, or 20M OHMS.

(4) Insert the test leads into the polarized pin jacks located at the bottom of the panel.

(5) Short the free ends of the test leads. Rotate the ZERO ADJUST rotary control until the meter needle is at full deflection on the ohm-scale.

(6) Turn off the power to the equipment under test, and connect the free ends of the leads across the circuit to be measured.

(7) Read the ohm-scale as follows:

0-200 ohms	read ohm-scale, divide by 10.
0-2,000 ohms	read ohm-scale, directly.
0-20,000 ohms	read ohm-scale, multiply by 10.

b. Zero to 2-MEGOHM and Zero to 20-MEGOHM RANGE. (1) For resistance measurements above 20,000 ohms and up to 20 megohms, connect the Supreme model 504-A power-supply plug to a convenient 60-cycle, 110-125-volt, a-c source.

(2) Depress the PRESS FOR BATT. AND TUBE TESTER button.

(3) Depress and hold down the LINE ADJUST button located on the left side of the panel.

(4) Adjust the OFF control until the meter needle is at half scale.

CAUTION: When not in use, turn this control to the OFF position.

(5) Press the RELEASE FOR LEAKAGE AND MULTIPLIER button to release the PRESS FOR BATT. AND TUBE TESTER button previously depressed.

(6) Depress the MEGOHMS button in the left-hand row.

(7) Depress the 2 MEGOHM or 20 MEGOHM button as desired.

(8) Insert the test leads into the polarized pin jacks at the bottom of the panel.

(9) Short the free ends of the test leads. Rotate the ZERO ADJUST rotary control until the meter needle is at full scale.

(10) Shut off the power to the circuit to be measured; then apply the free ends of the test leads across the resistance to be measured.

(11) Read the ohm-scale, as follows:
0-2 megohms, read ohm-scale, multiply by 1,000.
0-20 megohms, read ohm-scale, multiply by 10,000.

SECTION XII
OSCILLOSCOPES

81. CATHODE-RAY TUBES. The cathode-ray tube is a vacuum tube in which electrons emitted from a hot cathode are caused to move at very high velocity, formed into a beam, and then allowed to strike a special translucent screen which fluoresces or gives off light at the point where the beam strikes. A narrow beam of moving electrons is similar to a wire carrying current and is accompanied by electrostatic and electromagnetic fields. This beam can be deflected (have its direction changed) by applying external electrostatic or electromagnetic fields which exert a force on the beam as similar fields exert force upon charged bodies or upon a wire carrying current. Since this beam consists only of moving electrons, its weight and inertia are negligible; therefore it can be deflected easily and without any appreciable time lag. For this reason the beam instantly can be made to follow the variations in electric fields which are changing periodically at frequencies ranging from low audio to very high radio frequencies.

82. METHODS OF DEFLECTION.

a. The electrode arrangement which forms the electrons into a beam is called an electron gun. The gun alone produces a small spot on the screen, but whenever the beam is deflected by either magnetic or electrostatic fields, the spot moves across the screen a distance proportional to the force exerted. When the motion is sufficiently rapid, visual retention of the image makes the path of the moving spot (trace) appear to be a continuous line.

b. Electrostatic deflection is generally used in the small cathode-ray tubes and is produced by deflecting plates. Two sets of plates are placed at right angles to each other and electrostatic fields are created by applying suitable voltages across each set of deflecting plates.

c. The tube is mounted so that one set of plates produces a horizontal line when a varying voltage is applied to it; the other set of plates produces a vertical line under similar conditions. These plates are named *horizontal plates* and *vertical plates*, respectively. It is usually necessary to provide a mounting which can be rotated to some extent so that the lines actually will be horizontal and vertical.

83. OSCILLOSCOPES.

a. An oscilloscope is an instrument which contains a cathode-ray tube with its power supplies, suitable amplifiers for each set of deflecting plates, and special sweep circuits which permit the electron beam to be deflected across the screen. The amplifiers are used to increase the amplitude of small a-c voltages to values suitable for application to the two sets of deflecting plates. The amplifier which feeds the vertical plates is the vertical amplifier; the amplifier which feeds the horizontal plates is the horizontal amplifier. These amplifiers are ordinarily limited to operation in the audio-frequency range; therefore they cannot be used at radio frequencies.

b. In order that an a-c voltage may be studied on the screen of a cathode-ray oscilloscope, it is necessary not only to deflect the electron beam to a vertical direction in accordance with the magnitude of the voltage, but it must also be deflected in a horizontal direction so that the trace will be swept across the screen in the proper time relation to the frequency of the voltage being studied. If the varying voltage is merely applied to the vertical deflecting plates, the electron beam will oscillate up and down vertically in synchronism with the varying voltage, and the spot of light will trace a straight vertical line on the screen. It is evident that if the exact curved waveform of this varying voltage is to be traced, some means must be provided for shifting the beam simultaneously in a *horizontal* direction (while it is being moved up and down vertically by the voltage to be observed) so that the trace will be spread out. The horizontal deflection is obtained by applying a voltage called the *sweep* to the horizontal plates. The rate at which the beam is swept across the screen is called the sweep frequency.

84. WAVEFORMS.

a. In view of the extremely wide field of application of cathode-ray oscilloscopes, only limited applications of these oscilloscopes to Radio Set SCR-268-(*) will be considered. In this connection it is important to observe waveforms. Figure 20 illustrates the method by which waveforms in the plate circuit of a tube can be taken. The frontispiece shows a signal generator and a test oscilloscope being used to align the i-f stages of a receiver. To make such observations, the waveform-voltage source of the points across which the voltage waveform is to be observed, is applied to the vertical deflecting plates and an internal sweep or voltage varying *linearly* with time is applied to the horizontal deflecting plate as a time base. The true waveform of the signal voltage can then be observed without distortion, inasmuch as none is introduced by the horizontal-deflection voltage. A thyratron gas tube is usually used to generate the linear or saw-tooth voltage which is used for the sweep voltage. This type of voltage is essential since it is necessary for the electron beam to sweep across the screen at a *constant* rate of speed and *instantaneously* return to the starting point. The time for the return of the electron beam may be referred to as the fly-back time. If the sweep is nonlinear, the shape of the wave on the oscilloscope screen will not be a true picture of the voltage under test.

b. The conventional procedure when observing waveshapes is to operate the horizontal-deflection voltage at a submultiple of the observed frequency, so that several complete cycles appear on the screen. Furthermore, since the image drifts across the screen unless the ratio of the two frequencies remains constant and of a certain value, it is usually desirable to synchronize the horizontal-deflection voltage with the signal voltage applied to the vertical-deflecting plates.

c. This synchronization is accomplished by the injection of a small percentage of the signal voltage into the sweep-generator circuit in the test oscilloscope. The result is a linear-sweep voltage with a frequency equal to a multiple or a submultiple of the signal-voltage frequency, and with its phase directly proportional to the phase of the signal voltage. This keeps the image stationary upon the screen.

d. In order to obtain an accurate representation of the voltage waveform, a few precautions must be observed. For the protection of the operator and the oscilloscope, the approximate value of the voltages in the circuit under test must be known. Dependable data can be obtained from the oscilloscope only if its sensitivity and frequency characteristics are known. To make certain that the waveform will not be distorted, it is essential that the manner in which distortion takes place be understood and that precautions be taken to avoid such distortion.

e. The input to most oscilloscopes is between an input terminal and ground. The input terminal and ground is usually coupled to the grid of an amplifier through a capacitor. Seldom do the capacitors used have voltage ratings that exceed 450 volts. Unless the approximate value of voltage under test is known, therefore, break-down of the input capacitor may result and seriously damage the oscilloscope.

f. In some cases it may be necessary to observe waveforms in circuits whose voltage is much greater than the components within the oscilloscope are able to withstand. Accordingly, a voltage divider may be used to reduce the voltage to a value that will not damage the equipment. The keyer load, Test Set I-115, which is discussed in paragraph 160, is an example of a voltage divider wherein the voltage is reduced to 1/26 of the over-all voltage. It is very important that the oscillo-scope be securely tied to ground. Grounding the oscilloscope is a precaution that must be taken for the protection of the operator. Failure of some part of the voltage divider can raise the potential of the whole oscilloscope to a dangerous level if the case is not securely tied to ground.

85. FREQUENCY RESPONSE.

a. The frequency response of the oscilloscopes provided with Test Equipment RC-68-(*) is not suitable for direct application to the r-f, i-f, oscillator, and buffer systems in Receiver BC-406; however, all the audio-frequency circuits except the high-voltage circuits in Radio Set SCR-268-(*) do permit direct application. Usually only the best oscilloscopes use amplifiers which will amplify voltages whose frequency is below 20 cycles per second or above 100,000 cycles per second. The r-f and i-f stages may be checked by feeding an audio-modulated, r-f, or i-f signal into these stages and then applying the audio voltage detected by the receiver to the oscilloscope-deflecting plates. If the frequency of the signal is beyond the range of the deflection amplifier in the test oscilloscope, the waveform will be distorted.

b. Where the frequency of the signal to be measured exceeds the frequency range of the amplifier used in the test oscilloscope, the signal voltage being measured can be applied directly to the plates of the test oscilloscope without going through the test amplifier.

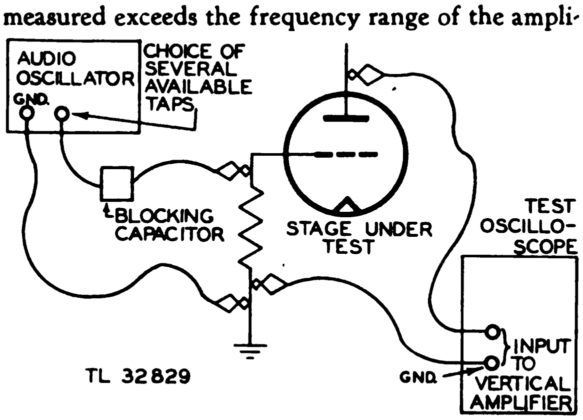


Figure 20. Test oscilloscope, signal output applied to vertical deflecting plates.

86. CHECKING FREQUENCY.

a. Without the Sweep Circuit. If a sine wave of a given frequency is applied to the vertical amplifier of an oscilloscope, and another sine wave of the same frequency is applied to the horizontal amplifier (without using the sweep circuit), a stationary pattern in the form of a straight slanting line, a circle, or an ellipse will appear upon the screen. It may be necessary to adjust the vertical and horizontal amplifier controls at this point. The exact pattern obtained depends upon the amplitude and phase relationship of the two sine-wave voltages. The essential point is that one of these three stationary patterns is obtained when the two voltages are of the same frequency and waveshape. If the frequencies are slightly different, the pattern will rotate. When one of the frequencies is twice that of the other, or three times the other, etc., more complicated patterns appear upon the screen. The frequency relationship is determined from the type of pattern obtained.

b. With the Sweep Circuit. (1) It is sometimes desirable to check the frequency of the switching oscillator in Receiver BC-406. The waveform produced by the switching oscillator is a square wave. If this square wave is applied to the vertical plates and a sine wave is applied to the external synchronizing-voltage circuit, the pattern obtained when the two frequencies are the same will be a square or rectangle of two heavy horizontal lines and two dim vertical lines.

(2) The technique for determining the frequency of the switching oscillator is as follows: the output voltage of the switching oscillator is applied to the vertical plates. The output voltage of an audio oscillator is connected to the external synchronizing-voltage circuit, and the frequency of this audio oscillator is set approximately to the switching frequency. The frequency of the audio oscillator is then carefully varied until a square-wave pattern is obtained, and finally the frequency of the switching oscillator is read from the setting on the audio-oscillator scale.

87. BASELINE DISPLACEMENT. Since so many of the grid and plate circuits in Radio Set SCR-268-(*) operate with sharp or rectangular pulse voltages and with one positive or negative polarity, the apparent visual baseline is displaced upon the test-oscilloscope screen. The high side of the vertical amplifier contains a blocking capacitor which blocks out the d-c component of the signal and permits only the a-c component of the signal to become available for the vertical deflecting plates of the oscilloscope cathode-ray tube. Inasmuch as both negative and positive voltages are therefore applied to the vertical deflecting plates, the positive voltage will cause the apparent visual baseline to drop by an amount proportional to this voltage. This is in conformity with one of the fundamental properties of a-c waves; namely, the area enclosed by the waves below the zero axis is invariably equal to the area enclosed by the waves above the zero axis. The apparent visual baseline for zero axis is therefore displaced upon the test oscilloscope, as compared with the location of the zero axis of the pulse actually existing at the grid-and-plate circuits being checked.

88. PHASE INVERSION. Another significant point to be emphasized is the fact that waveforms viewed upon the RCA models 155-A and 155-B and Supreme model 546, will appear inverted with respect to the waveform of the input. The Dumont model 224, on the other hand, gives an exact image of the input waveform. In other words, if the same trace is viewed on the Dumont model 224 simultaneously with either of the other units, the image on the Dumont model 224 will be inverted with respect to either of the other oscilloscopes. The reason for this is the difference in the number of stages of amplification in the oscilloscopes.

89. CROWDING OF PATTERN. Change in the amplitude of the sweep voltage or horizontal time base also affects the image. Reducing the length of the sweep or time base tends to crowd the pattern and thereby sharpen the appearance of any peaks which may be present; on the other hand, increasing the length of the sweep tends to flatten the image.

90. BURNING OF OSCILLOSCOPE SCREEN. The maximum input power to the fluorescent screen must not exceed the rated value. The use of screen-input power in excess of this value will adversely affect the fluorescent coating, depending upon the magnitude and duration of the power input. Injury to the screen may be evidenced by its temporary loss of sensitivity, its permanent destruction, or burning of the active screen material. A brilliant spot should not be permitted to remain on the screen, but should be kept in motion by means of an a-c voltage applied to the deflecting system in order not to exceed the maximum fluorescent-screen input rating. Until this voltage is applied, the fluorescent-screen input power should be kept low by means of the intensity control.

91. CHECKING HUM WITH THE OSCILLOSCOPE. Sometimes a sharp pattern cannot be obtained in spite of careful effort to adjust the intensity and focus controls. The trace of the image may appear as a thickened line with light and dark streaks appearing in it. To determine whether or not this condition is due to hum voltages, operate the frequency-range switch to the lowest frequency position (15-cycle range); then adjust the frequency control and the synchronous-voltage control until a stationary pattern is obtained. Adjustment of the horizontal- and vertical-gain controls may also be necessary. If the resulting pattern has the *appearance* of an amplitude-modulated wave, the original broad pulse may be attributed to hum voltages. The value of the existing hum voltage is estimated by the depth of the troughs in relation to the height of the entire pattern.

92. VOLTAGE MEASUREMENTS.

a. The test oscilloscope may be used also as a peak voltmeter for making peak-voltage measurements of the various waveshapes in the radio set. This application consists merely of calibrating the test oscilloscope so that a given vertical deflection represents a certain number of volts. The deflection caused by the unknown signal voltage is then measured and translated into volts.

b. Note that the oscilloscope measures the peak value of the a-c voltage applied. The standard a-c meters show the rms value of a sine wave, a-c voltage which may be converted to a peak value. The a-c meters, however, may be very misleading when applied to voltages whose waveforms are other than sine wave. A peak-to-peak calibrated oscilloscope should be used to measure distorted waveforms.

c. Figure 21 illustrates the relationship between rms, peak, and peak-to-peak voltage. According to this figure, the sine-wave output of an audio oscillator is applied to the vertical-amplifier terminals of the test oscilloscope. The output of the audio oscillator is adjusted for 0.7 rms volts as measured by the a-c voltmeter. The vertical-gain control of the test oscilloscope is then operated to obtain an overall peak-to-peak deflection of 1 inch. The peak voltage is 1 peak-volt. The peak-to-peak voltage is 2 volts. That is to say, 0.7 volts rms is equivalent to 2 volts peak-to-peak.

d. For most measurements of sine wave voltages, it is usually more convenient to use an rms (effective) voltage calibration of the test oscilloscope. Peak-to-peak calibration must be used to avoid erroneous voltage measurements of distorted waveforms such as those in the keyer and oscilloscope. The vertical amplifier-gain control of the test oscilloscope must be set at the position it assumed during calibration if the test oscilloscope is used as a voltage indicator.

e. Note that a signal of power-line frequency having an amplitude of approximately 2.2 volts peak-to-peak is provided at the front panel of the Dumont 224 oscilloscope as a source of test signal. Methods for calibrating the oscilloscopes for several values of peak-to-peak volts per inch are discussed below.

93. CALIBRATION OF DUMONT MODEL 224 TEST OSCILLOSCOPE.

a. One-volt-per-inch Calibration. Set the ATTENUATION control at 1:1. Connect the 60~ SIGNAL terminal to the Y-SIGNAL-INPUT terminal and with the Y-deflecting plate switch set to AMPLIFIER, adjust the Y-GAIN control to give a vertical deflection of 22 divisions. Since the 60-cycle signal is 2.2 volts peak-to-peak, the oscilloscope is now calibrated to give a deflection of 10 divisions per volt peak-to-peak input. This is equivalent to 1-inch-per-volt peak-to-peak input, since 10 divisions equal 1 inch. For instance, if a sine wave measuring 3 inches from peak to peak is observed, the peak-to-peak voltage for this wave is 3 volts. Similarly, with the ATTENUATION control set at 10:1 or 100:1, a 1-inch deflection will indicate 10 volts or 100 volts respectively.

b. Four-volt-per-inch Calibration. Set the ATTENUATION control at 10:1. Connect the 60~ SIGNAL terminal to the Y-SIGNAL-INPUT terminal and with the Y-deflecting-plate switch set to AMPLIFIER, adjust the Y-GAIN control to give a vertical deflection of 5.5 divisions. Since the 60-cycle signal is 2.2 volts peak-to-peak, the oscilloscope is now calibrated to give a deflection of 1 inch for a 4-volt, peak-to-peak input.

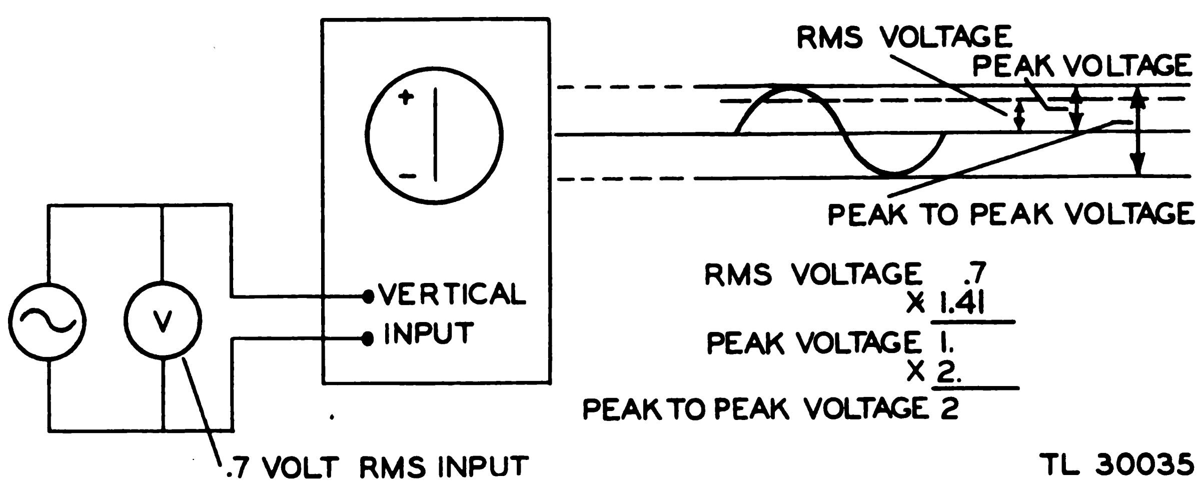


Figure 21. Rms, peak, and peak-to-peak voltages.

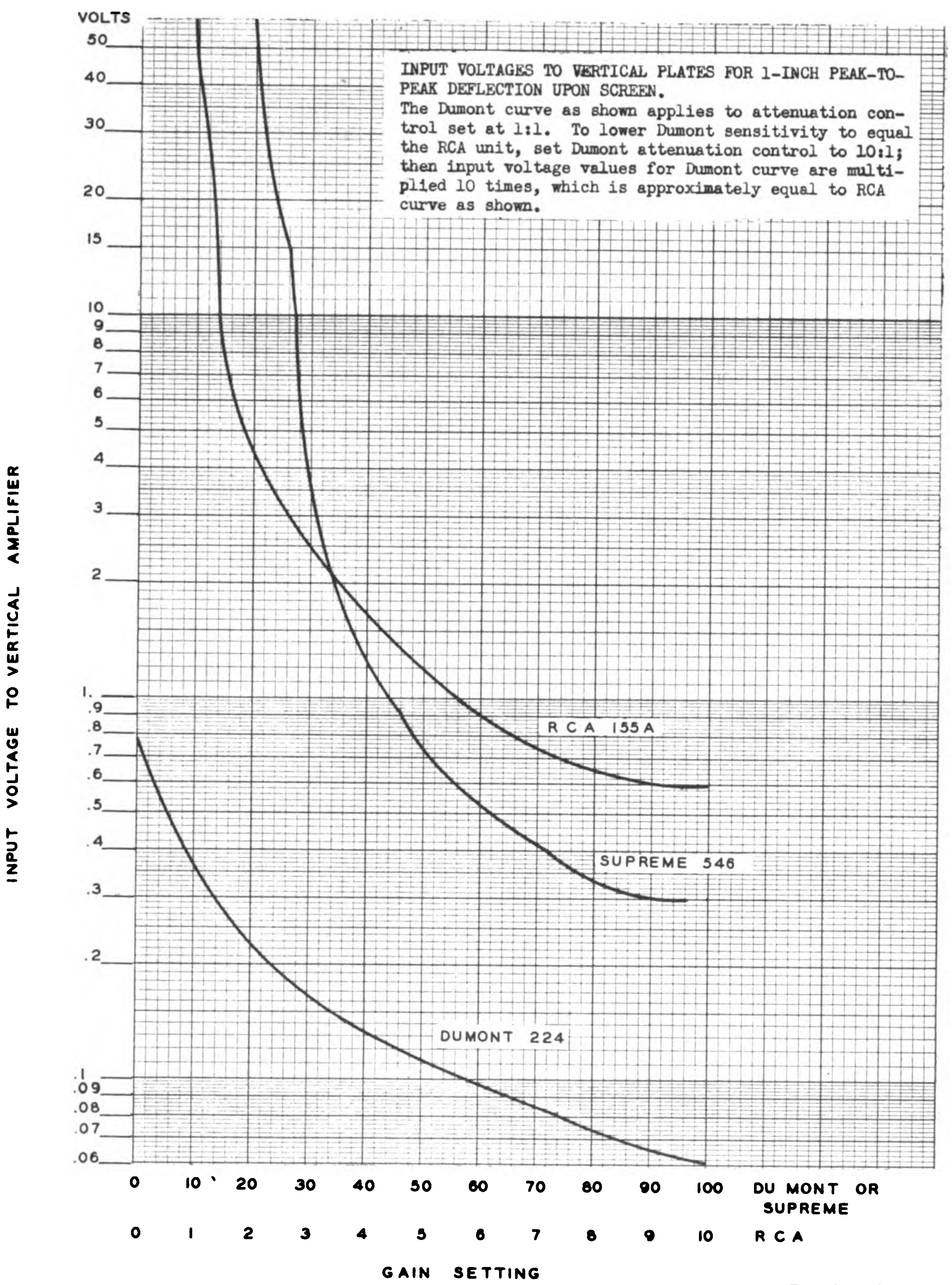


Figure 22. Voltage-gain calibration curves for oscilloscopes, Dumont model 224, Supreme model 546, and RCA model 155-A.

94. CALIBRATION OF RCA MODEL 155-A AND SUPREME MODEL 546 TEST OSCILLOSCOPES.

Connect the 5,000 and G-terminals of the a-f generator and the analyzer arranged as an a-c voltmeter, to the vertical amplifier terminals of the test oscilloscope. Set the a-f generator to 400 cycles and adjust its output until the analyzer reads one of the values covered in the table. Set the amplifier gain of the oscilloscope to a position that will give the oscilloscope deflection covered in the table corresponding to the analyzer reading. The oscilloscope will then be calibrated for the peak-to-peak volts per inch indicated under calibration. For instance, if the calibration is for 1 volt per inch and a sine wave measuring 3 inches from peak to peak is observed, the peak-to-peak voltage for this wave is 3 volts. Repeat for each analyzer reading covered in the following table:

Analyzer reading (Volts)	*Oscilloscope deflection (Inches)*	*Calibration Peak-to-peak (Volts per inch)*
0.7	2	1
1.4	1	4
3.6	1	10
9.0	¼	100

95. CHECKING TEST-OSCILLOSCOPE SENSITIVITY.

a. It is desirable to test the sensitivity of the test oscilloscope occasionally to determine whether the vertical amplifier is working properly. This may be done by applying a known audio-frequency voltage from the test oscillator to the vertical-amplifier terminals of the test oscilloscope in order to obtain a 1-inch peak-to-peak image. The vertical gain setting of the oscilloscope is then compared with the calibration chart illustrated in figure 22. This chart applies to the Dumont model 224, the RCA model 155-A, and the Supreme model 546. If the gain setting of the test oscilloscope and the known input-voltage readings fall approximately on the proper curve, the vertical amplifier and its associated circuits may be assumed to be working properly. On the other hand, if the gain of the test oscilloscope must be turned far in excess of that indicated on the calibration chart, the sensitivity of the test oscilloscope is deficient. Explaining this differently, after placing the test-oscilloscope control at some convenient setting, if the signal voltage from the test oscillator is greatly in excess of that indicated by the calibration chart to produce a 1-inch peak-to-peak signal, a defect exists in the vertical amplifier or its associated circuit.

b. The same principle is followed to determine the value of a signal voltage in the audio circuits of the radio-set components. It is assumed that the test oscilloscope is functioning properly. The unknown signal voltage is applied to the vertical-amplifier terminals and the vertical gain of the test oscilloscope is adjusted to obtain a 1-inch peak-to-peak pattern on the screen. The value of the unknown signal voltage may then be read directly from the chart. This calibration holds good only over the audio-frequency band, and these measurements may vary 10 to 15 percent.

c. Note that the required signal voltages differ greatly in proportion to small variations of the lower-gain settings in RCA model 155-A and Supreme model 546 oscilloscopes. For this reason, since the gain-control settings are not minutely subdivided, gain settings of less than 3 for RCA model 155-A oscilloscope and less than 30 for the Supreme model 546 oscilloscope will result in large errors.

SECTION XIII

OSCILLOSCOPE I-134, DUMONT MODEL 224

96. GENERAL. The Dumont model 224 oscilloscope is one of the instruments provided with Test Equipment RC-68-(*). It contains a 3 inch cathode-ray tube, amplifiers for producing both deflection voltages, a linear time-base generator or sweep circuit, and associated power supplies. The Y-amplifier has a uniform sine-wave frequency response up to 2 megacycles per second; whereas the X-amplifier responds uniformly to frequencies up to 110 kilocycles per second. The frequency range of the sweep or time base is from 15 to 30,000 cycles per second. Provision is also made to connect signals directly to both sets of deflecting plates when frequencies above the useful limits of the amplifiers are to be observed.

97. INPUT TO THE VERTICAL DEFLECTING PLATES.

a. The Dumont model 224 test oscilloscope provides for three forms of input to the vertical deflecting plates (figs. 23 and 24). One input arrangement is through the vertical-deflection input terminals indicated as Y-SIGNAL INPUT. This input may be controlled by a 3-step attenuator marked ATTENUATION 100:1, 10:1, 1:1, and an amplifier with a variable-gain control marked Y-GAIN.

b. Another input arrangement to the vertical deflecting plates is by means of a special high-frequency probe. Both probe and socket are illustrated in figure 23. When this probe input is used, the amplifier remains in the circuit, but the 3-step attenuator is cut out.

c. A third method of input to the vertical deflecting plates is directly to the plates through terminals D3 and D4. As stated previously, this method is utilized when frequencies above the useful limits of the Y-amplifier (approximately 5 megacycles) are to be observed. When this method is employed, the amplifier and attenuator are not used.

d. Observe that whenever terminals D3 and D4 are connected *directly* to a source of a-c voltage where d-c voltage is also present (such as across the plate and cathode of a vacuum tube), the d-c plate voltage will position the spot off the test oscilloscope screen. To avoid this, connect a supplementary positive voltage, equal in value to the tube-plate voltage and of proper polarity to buck the plate voltage, in series with the lead which joins the oscilloscope deflecting plate of the tube.

e. The selection of any one of these three input systems is accomplished by means of the controls marked TERMINALS-PROBE and TERMINALS-AMPLIFIER. An examination of the schematic illustrated in figure 24 will reveal the fact that whenever either of the first two methods is used, that is, when the amplifier is used and the TERMINALS-PROBE control is in either position, it is necessary to set the TERMINALS-AMPLIFIER control to the AMPLIFIER position to complete the circuit. When the third method is used, the signal is applied directly to the deflecting plates; then it is only necessary to set the TERMINALS-AMPLIFIER control to the TERMINALS position.

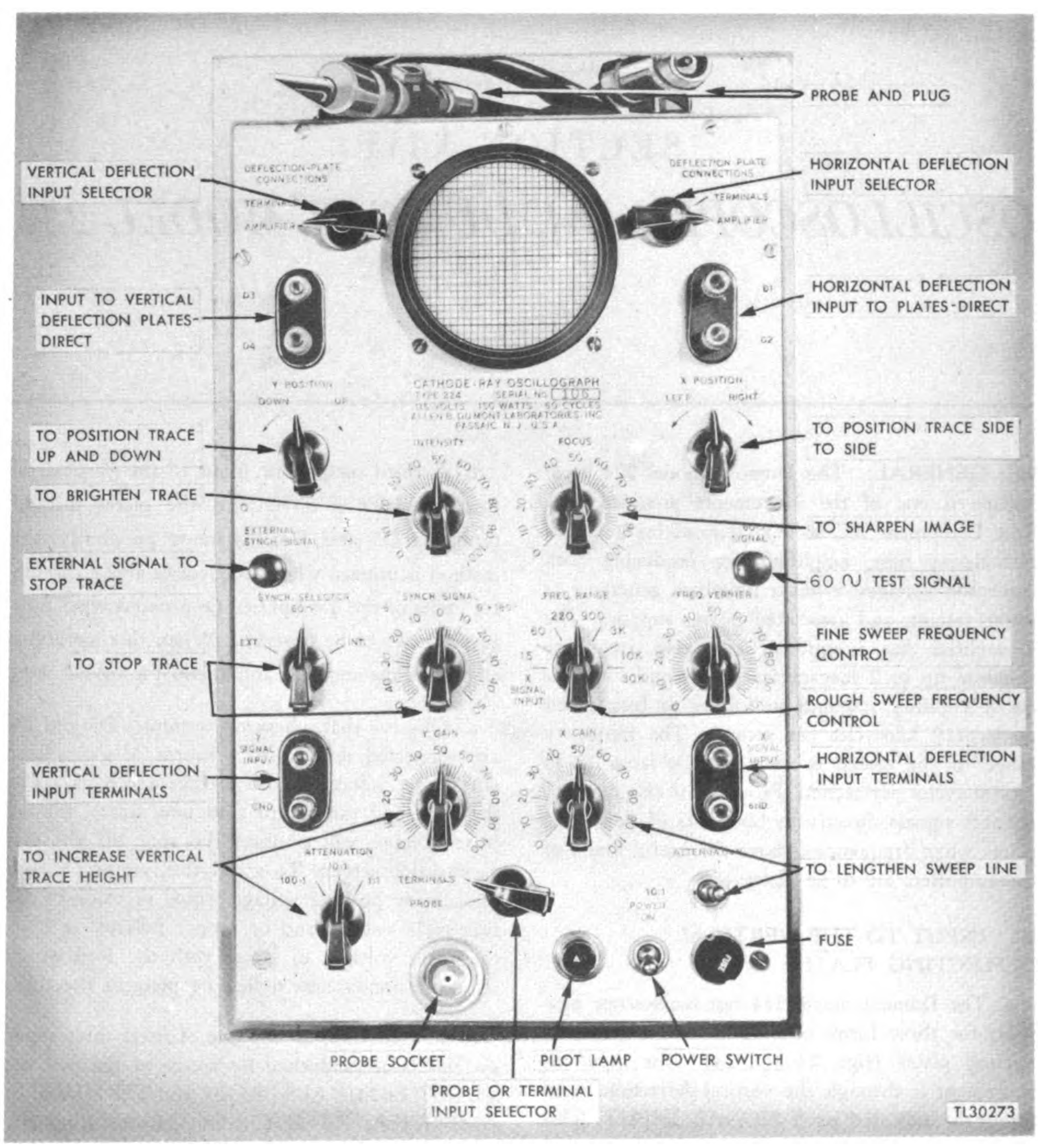


Figure 23. Oscilloscope I-134, Dumont model 224, panel view.

98. INPUT TO THE HORIZONTAL DEFLECTING PLATES.

a. The horizontal-deflection system employs two input arrangements. One of these is to the X-SIGNAL INPUT terminals. This input is controlled by a 2-step attenuator marked ATTENUATION 10:1, 1:1, and an amplifier with a variable X-GAIN control. The FREQ. RANGE control must be set to the X-SIGNAL INPUT position to complete the circuit with the result that the *sweep cir-*

cuit is cut out when the amplified input is applied to the horizontal deflecting plates.

b. The second method of input to the horizontal-deflecting plates is directly to the plates through terminals D1 and D2. *The amplifier attenuator and sweep circuit are not used.* The choice of either method is controlled by the TERMINALS-AMPLIFIER control.

99. CONTROLS AND TERMINALS.

a. Intensity Control. The INTENSITY control sets the bias between the control electrode or grid and cathode of the cathode-ray tube; thus the INTENSITY control determines the electron-beam current. In order to conserve tube life, it is desirable to keep the intensity of the trace as low as is consistent with convenience in use. To prevent burning the screen, a sharply focused line or spot of high intensity should never be permitted to remain stationary on the screen for any considerable period of time.

b. Focus Control. The FOCUS control sets the potential of the focusing electrode of the cathode-ray tube. There usually will be a setting for optimum focus at each intensity level.

c. X- and Y-positioning Controls. The controls marked X-POSITION and Y-POSITION adjust the location of the spot or trace on the screen in the horizontal and vertical directions, respectively. Each control is marked with the direction of movement of the spot it controls.

d. Y-signal-input and Probe Terminals. The signal used to provide the Y- (or vertical) deflection is connected to either the Y-SIGNAL INPUT terminals or the test-probe terminals, depending on the setting of the TERMINALS-PROBE switch.

e. Test Probe. This probe consists of a compensated 4:1 attenuator in an insulated probe supplied with a length of coaxial cable and a connector. The input capacitance is less than 20 $\mu\mu$f, which makes it possible to connect the probe to relatively high-impedance points without serious loading effects on these circuits. When this probe input is used the amplifier remains in the circuit, but the 3-step attenuator is cut out. Also, if the signal level at the probe tip is above a certain amount, it may not be possible to attenuate the signal sufficiently by means of the Y-GAIN control to keep the image on the screen.

f. Y-gain Control. A low-impedance, continuously variable attenuator supplies a continuous adjustment of the amplitude or deflection. The operator will notice that by means of this control the signal amplitude can never be reduced to zero, but that the amplitude in the extreme counter clockwise position is about 10 percent of that for the *full-gain* position. This feature, in conjunction with the use of the Y-attenuator, prevents overloading of the input stage of the amplifier as long as the pattern is no larger than full screen. In this way the operator will not be deceived by distortion caused by overload in the amplifier, providing the pattern is kept entirely on the screen.

g. Y - attenuation Control. A high - impedance attenuator of the compensated resistance-capacitance type is provided at the input of the Y-amplifier to reduce the input-signal voltage, whenever necessary, to a value that will not overload the amplifier. The attenuation ratios provided are 100:1, 10:1, 1:1.

h. Synchronizing-selector Switch. In order to maintain a stationary image on the oscilloscope screen, a voltage of appropriate frequency is applied to the gas tube which is used to produce a linear time base. The source of voltage to which the linear time base is synchronized is determined by the setting of the SYNC. SELECTOR. The following sources of synchronization are available: external, internal, and 60-cycle a-c.

(1) In the EXT. position, the switch permits synchronizing of the time-base oscillations with a signal voltage connected between ground and the EXTERNAL SYNCH. SIGNAL input post.

(2) When the switch is thrown to the 60-cycle position, the sweep may be synchronized to the frequency of the power line supplying the instrument.

(3) When the selector is in the INT. position, a portion of the signal voltage is picked off from a suitable point in the Y-amplifier and used to synchronize the sweep.

i. Synchronizing-signal Control. (1) This control allows the amount of synchronizing voltage applied to the grid of the gas triode to be adjusted to the optimum value and insure good synchronization. In addition, the polarity of the synchronizing signal upon which the synchronization occurs may be selected. Thus, synchronization from nonsymmetrical waveforms such as short pulses, etc., is assured.

(2) Always use the minimum amount of synchronizing voltage as long as it does not interfere with good synchronization. Excessive synchronizing voltage at the grid of the gas triode may introduce nonlinearity in the sweep.

j. External Synchronizing-signal Input. (1) When synchronization is required from a signal other than the power line or that amplified by the Y-amplifier, the desired signal voltage should be connected to the terminal marked EXTERNAL SYNCH. SIGNAL. Under such conditions, the SYNCH. SELECTOR control should be thrown to the EXT. position and the amplifier attenuator and sweep circuit are not used.

(2) Excessive synchronizing voltages fed to this terminal may couple into the X- or Y-amplifiers and cause distortion. Ten volts (peak-to-peak) is the maximum external synchronizing signal ever to be employed. The impedance of the external synchronizing-signal input circuit is 500,000 ohms. If only larger values of external synchronizing voltages are available, a suitable series resistor should be connected to the EXTERNAL SYNCH. SELECTOR terminal in order to reduce the synchronizing voltage to the maximum value given above.

k. Frequency-range Control. (1) The setting of the FREQ. RANGE selector determines the range of time base frequencies which are produced by operation of the FREQ. VERNIER control. The limits of each side of the six ranges are given by the numbers at each side of the dial pointer and are as follows: 15, 60, 220, 900, 3K, 10K, 30K. The letter K represents kilo or one thousand; thus, 30K represents 30,000 cycles per second.

(2) When the control is in the extreme counterclockwise position marked X-SIGNAL INPUT, the sweep circuit is disconnected, and the input of the X-amplifier is connected to the X-SIGNAL INPUT terminals.

l. Frequency-vernier Control. When the proper frequency range has been selected by means of the frequency-range control, the exact frequency necessary to stabilize the pattern on the screen can be obtained by means of the FREQ. VERNIER control.

m. X-signal-input Terminals. An external signal to be amplified along the X- or horizontal axis should be connected across the X-SIGNAL INPUT and GND. terminals. This terminal is connected to the input of the amplifier only when the FREQ. RANGE switch is in the X-SIGNAL INPUT position. The sweep circuit is not used.

n. X- and Y-deflecting-plate Switches. These switches allow the selection of connections to deflecting plates either directly, with a deflection factor of approximately 75 d-c volts per inch, or through the amplifiers. The deflecting plates can be directly connected to the front panel terminal posts. In addition, positive voltages are applied through 5-megohm resistors. It is therefore possible to examine larger signals by a-c coupling and by positioning up and down. When an unbalanced signal source is used, the deflecting-plate terminal to which signal voltage is not applied should be connected to ground by means of a separate lead.

o. X-amplifier-gain Control. The X-GAIN control is a continuously variable low-impedance attenuator which operates in conjunction with the X-ATTENUATION control to determine the amount of deflection along the X-axis.

p. X-attenuation Control. The input circuit of the X-axis amplifier incorporates a 2-position, high-impedance attenuator with attenuation ratios of 10:1 and 1:1. If the input voltage is over 5 volts rms, the attenuator should be set in the 10:1 position. For input voltages over 50 volts rms, an external attenuator should be used. Voltages exceeding this value will overload the input stage.

q. 60-cycle Test-signal Terminal Post. A signal of power-line frequency having an amplitude of approximately 2.2 volts peak-to-peak is provided at the front panel as a source of test signal.

100. LIMITATIONS. Several forms of distortion are possible in observing waveforms. While distortion can be eliminated by simple precautions in some cases, it is very difficult to eliminate in other cases.

a. Perhaps the most obvious point at which distortion can enter, is in the deflection amplifier. It is important, therefore, to know the frequency response of the amplifier being used so that an estimate may be made of the possibility of distortion for a given signal. The Dumont model 224 test oscilloscope is not suitable for application to the r-f, i-f, oscillator, and buffer system of Receiver BC-406. It is applicable to the 4,098 signal voltages existing in the radio set except where high voltages exist, in which case a voltage divider such as Test Set I-115 is used.

b. When signals of relatively high frequency are to be observed, the time of fly-back may become an appreciable fraction of the period of the signal. To avoid distortion from this source, adjust the sweep frequency so that several cycles of the signal appear upon the screen.

c. If the magnitude of the synchronizing voltage is too great, the image may be distorted by the fact that the sweep is terminated too soon. This may be avoided most simply by setting the synchronization control to zero while the sweep frequency is being adjusted. When the sweep frequency is as nearly as possible some integral submultiple of the signal frequency, the image will be almost stationary on the screen. The synchronizing voltage should then be turned up just enough to stop the apparent motion of the image on the screen.

d. The input impedance of the oscilloscope is much higher than the impedance at the point under test. The oscilloscope will not, therefore, change the time constant or the voltage at the point, and a true picture of the voltage may be observed. In some circuits, however, the impedance is very high (up to 10 megohms), and the oscilloscope will change the voltage or the time constant so radically that it will be very difficult to obtain a true picture.

e. The input capacitance of an oscilloscope is generally small, but it may be sufficient to alter the characteristics of a video amplifier or the tuning of a high-frequency oscillator.

f. The waveforms as viewed on the screen of the Dumont model 224 oscilloscope, using the vertical-amplifier system, are in phase with the signal voltage applied to the vertical-amplifier terminals of the test oscilloscope. With the same signal voltage applied to oscilloscopes of either the RCA models 155-A and 155-B or Supreme model 546, the observed waveforms will appear 180° out-of-phase (inverted) with respect to the Dumont oscilloscope.

101. WAVEFORM EXAMINATION WITH THE DUMONT MODEL 224 OSCILLOSCOPE.

CAUTION: It is inadvisable to operate this cathode-ray oscilloscope with the case removed. There are potential differences as high as 1,500 volts in this instrument, and it should be treated with utmost caution.

a. Operation. (1) Connect the power plug to a 115-volt, 60-cycle a-c source and turn the power switch to POWER ON position. The pilot lamp should light.

(2) Turn the TERMINALS-AMPLIFIER switch at the upper right to the AMPLIFIER position.

(3) Turn the INTENSITY control clockwise, causing a spot or trace to appear on the screen after the unit warms up. If the FREQ. RANGE control is at any other setting than the X-SIGNAL INPUT, a horizontal sweep or trace will be observed on the oscilloscope screen.

(4) Adjust the FOCUS control until the trace is as clear cut as possible. If the trace becomes too brilliant, retard the INTENSITY control.

CAUTION: Do not allow a fine trace or spot of high intensity to remain stationary on the screen for long periods. Burning or discoloration of the screen may result from concentrating the entire energy of the beam upon a small area for a considerable period of time.

(5) Apply the signal voltage to be observed to the Y-SIGNAL INPUT and GND. terminals, making certain that polarity is observed. The chassis of the unit under test is usually connected to the GND terminal, and the positive lead is connected to the Y-SIGNAL INPUT terminal.

(6) Set the SYNC. SELECTOR switch to the INT. position for most measurements.

(7) Turn the TERMINALS-PROBE switch located at the center and slightly above the bottom to the TERMINALS position.

(8) Place the TERMINALS-AMPLIFIER switch at the upper left in the AMPLIFIER position.

(9) Rotate the X-POSITION and Y-POSITION controls until the image is centered upon the oscilloscope screen.

(10) Adjust the X-GAIN, Y-GAIN, and both ATTENUATION controls to obtain an image of suitable size.

(11) Turn the FREQ. RANGE control to the desired range and adjust the FREQ. VERNIER control until the desired pattern appears. If the waveform does not remain stationary, adjust the SYNCH. SIGNAL control in a clockwise or counterclockwise direction, causing a locking in effect or synchronization.

> **NOTE:** This control must be rotated away from the zero position only far enough to stop the movement of the image. Excessive synchronizing voltage may cause distortion of the sweep voltage.

b. Calibration. The use of the test oscilloscope as a peak voltmeter is described in paragraph 92. Instructions for calibrating the Dumont model 224 oscilloscope so that it can be used to measure peak-to-peak volts per inch, are given in paragraph 93.

102. MAINTENANCE.

a. General. (1) Oscilloscope Dumont model 224 is a complex instrument. Its maintenance must not be attempted by inexperienced personnel.

(2) Complete maintenance on this oscilloscope consists chiefly of tube and fuse replacement and, to a lesser extent, replacing component parts. Faults are located by continuity tests, resistance measurements, voltage readings, signal tracing, and visual inspection.

(3) The schematic diagram (fig. 24) contains information concerning power-supply voltages, values of component parts, tube bases, and color coding of power leads. All tube locations are marked on the chassis label.

(4) An over-all check to determine whether or not the vertical-amplifier system is functioning properly is described in paragraph 95. However, these standards need not be rigidly adhered to. Even if the settings of the test oscilloscope vary widely from those illustrated in figure 22, do not attempt to adjust the vertical-amplifier system if the amplification of the test oscilloscope is large enough to produce an *undistorted* image of satisfactory amplitude.

b. Fuse Replacement. If the instrument fails, always check the fuse before removing the case and replace it if necessary. This oscilloscope uses a 2-ampere fuse.

c. Chassis Removal. The chassis can be removed from the case by first removing the seven retaining screws on the top of the panel and the two screws located at the rear of the cabinet.

> **CAUTION:** Voltages as high as 1,500 volts are present in this oscilloscope; therefore, proper care must be exercised while working with the case removed.

d. Circuit Analysis. (1) The Y-axis amplifier consists of an input attenuator, a cathode-loaded input stage V1, a stage of amplification V2, and a balanced phase-inverter deflection amplifier (V3 and V4). V3 is connected as a degenerative-video amplifier.

(2) The degeneration takes place in the unbypassed cathode resistor R19. The output of V3 will be an amplified inverted image of the signal applied to the grid. Voltage is developed across resistor R19 which is in phase with the grid signal of V3. Since the cathode of V4 is tied to the cathode of V3, its voltage changes in the same way that the signal applies to the grid of V3 changes. The grid of V4 is at ground potential for a-c because of C14. Therefore, when the cathode of V4 rises, the bias on that tube increases.

(3) This effect is the same as would be caused by a signal applied to the grid of V4 180° out-of-phase with the signal applied to the grid of V3. The outputs of the two tubes must then be 180° out-of-phase which is the requirement for push-pull operation. The output of V3 and V4 is then applied to the vertical deflecting plates of the cathode-ray tube V5.

(4) The X-axis amplifier consists of an input attenuator, a cathode-loaded input stage V6, and a phase-inverter deflection amplifier V8 and V9. The phase-inverter action of V8 and V9 is similar to that of V3 and V4 as explained above. The output of V8 and V9, operated in a push-pull circuit, is applied to the horizontal deflecting plates of the cathode-ray tube V5.

(5) V6, the 6SN7-type tube, actually consists of two amplifier tubes in one envelope. One of these tubes is used as the cathode-loaded input stage mentioned above. The other tube is used to amplify the synchronizing voltage which controls sweep generator V7.

(6) A thyraton gas tube V7 is used to generate the linear or saw-tooth voltage required for the sweep or time base. The frequency of this oscillator is controlled by the FREQ. RANGE switch S5 and the FREQ. VERNIER control R33. The output of this stage is applied to the X amplifier.

(7) The high-voltage section of the power supply V11 delivers approximately 1,000 volts negative with respect to ground. The low-voltage supply delivers approximately 400 volts positive with respect to ground for the amplifiers and sweep generator. In addition, an electronic voltage regulator V13 delivers 200 volts positive for the operation of all low-level stages. Its regulation and output voltage are determined by a factory adjustment of a potentiometer R69 mounted on the side of the chassis. This adjustment should not be changed except to compensate for variations in regulator tubes. A voltmeter should always be used when this adjustment is made to return the output to 200 volts.

e. Typical Voltage Values. The table following covers typical voltage values from vacuum-tube terminals to ground when the low-voltage rectifier is operating and no signal excitation is present.

TABLE I

TABLE OF TUBE-SOCKET VOLTAGES TO GROUND

All voltages are d-c unless followed by an asterisk (*).

All measurements are made with the hv-rectifier (type 80) tube removed.

All measurements are made with a 20,000-ohm-per-volt meter.

Type No.	Designation	Socket Terminals 1	2	3	4	5	6	7	8
6J5 (VT-94)	V1	0	6.3*	210	0	0	0	0	24
6AC7/1852 (VT-112)	V2	0	6.3*	0	0	0	75	0	115
6AG7 (VT-247)	V3	0	0	0	24	31	160	6*	260
6AG7 (VT-247)	V4	0	0	0	29	31	160	6.3*	260
6SN7GT (VT-231)	V6	3.5	150	28	0.8‡	210	11	0	6.3*
6Q5G	V7	0	6.3*	27	0.6	0.6	0	0	4
6SG7 (VT-211)	V8	0	0	29	12	29	100	6.3*	18.5
6SG7 (VT-211)	V9	0	0	29	12	29	100	6.3*	185
5Z3 (VT-145)	V10	420	390*	390*	420				
6V6 (VT-107)	V12		6.3*†	360	360	160		6.3*†	215
6SJ7 (VT-116)	V13		6.3*†	60	43	60	215	6.3*†	160

* A-c voltage. † Measured with attenuation at 1:1. ‡ Measured across pin 2 and pin 7.

f. The following table covers approximate resistance values from tube terminals to ground with no power supplied to the circuit using Analyzer I-167 or I-153-A:

TABLE II

TABLE OF TUBE-SOCKET RESISTANCES, OHMS TO GROUND

Type No.	Designation	Socket Terminals										
		1	2	3	4	5	6	7	8	9	10	11
6J5 (VT-94)	V1	0	0	30,000		200,000* to 00	200,000* to 00	0	75,000			
6AC7/1852 (VT-112)	V2	0	0	0	10 Meg	0	100,000	0	40,000			
6AG7 (VT-247)	V3	0	0	0	300,000	450	4.5 Meg	0	4.5 Meg			
6AG7 (VT-247)	V4	0	0	0	10,000	450	4.5 Meg	0	4.5 Meg			
3GP1/2537A3	V5	1.5 Meg		5 Meg	1 Meg		∞	0	5.0 Meg	5 Meg	1.5 Meg	1.5 Meg
6SN7GT (VT-231)	V6	480,000	60,000	9,000	180,000	35,000	15,000	0	0			
6A5G	V7	0	0	3.5 Meg	5,600	20,000	80,000	0	15,000			
6SG7 (VT-211)	V8	0	0	2,000	1.5 Meg	2,000	4.5 Meg	0	4.5 Meg			
6SG7 (VT-211)	V9	0	0	2,000	1.5 Meg	2,000	4.5 Meg	0	4.5 Meg			
5Z3 (VT-145)	V10	4 Meg	200	200	4 Meg							
80 (VT-80)	V11	1,100	170,000	170,000	1,100							
6V6 (VT-107)	V12		∞	4.5 Meg	4.5 Meg	500,000		∞	28.000			
6SJ7 (VT-116)	V13		∞	190,000	160,000	190,000	28,000	∞	500,000			

* Reads 200,000 ohms with probe at TERMINALS position.

(∞) Reads infinite with probe at PROBE position.

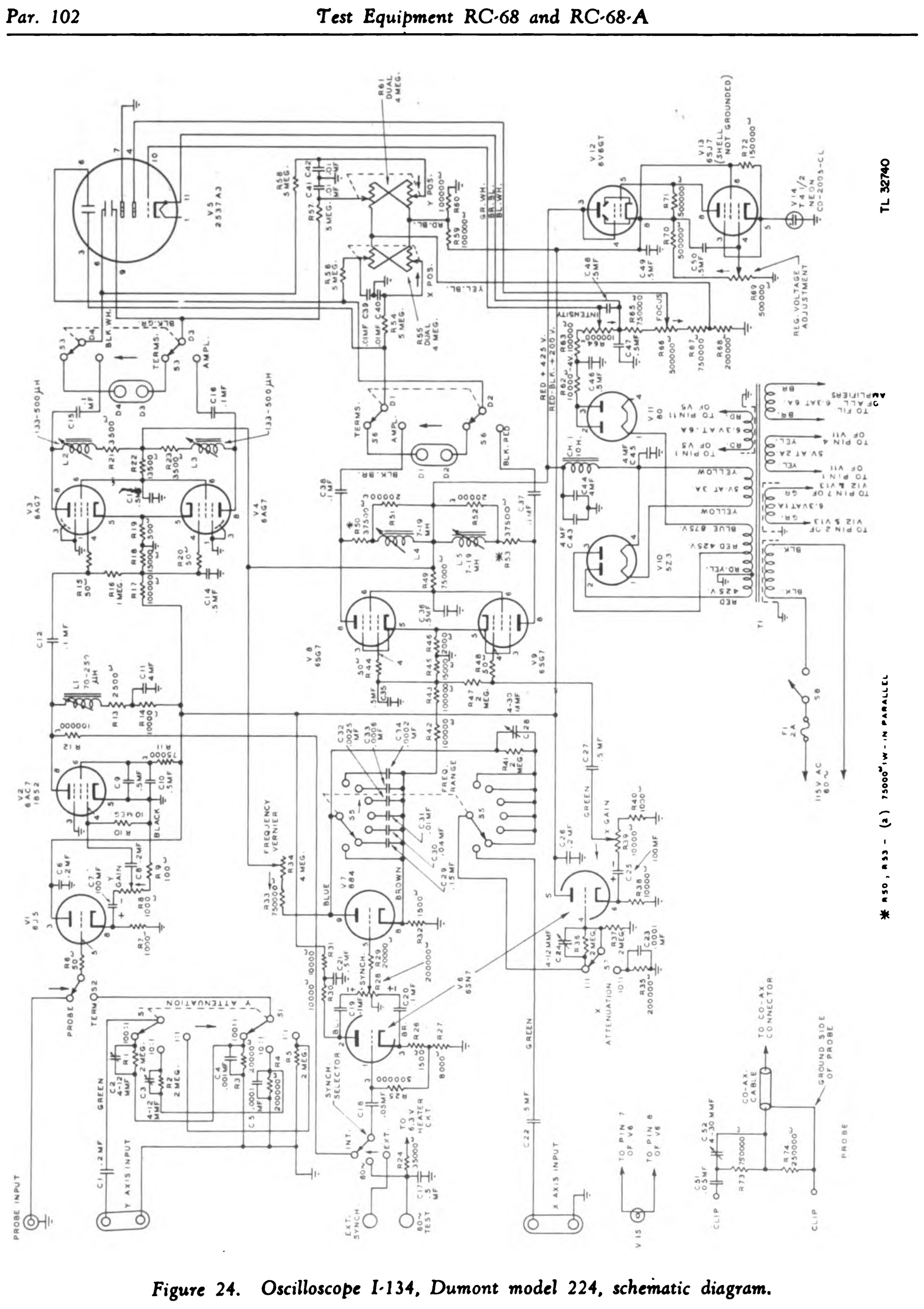


Figure 24. Oscilloscope I-134, Dumont model 224, schematic diagram.

SECTION XIV

OSCILLOSCOPES, MODELS RCA-155-A AND RCA-155-B

103. GENERAL. Oscilloscopes RCA-155-A and RCA-155-B are identical for all practical purposes, and are also used to study the waveshapes of voltages in various components of Radio Sets SCR-268 and SCR-268-B. The front view and schematic diagram of Oscilloscope RCA-155-A are clearly illustrated in figures 25 and 26, respectively. The frequency response of the vertical and horizontal amplifiers is from 20 to 90,000 cycles, and the frequency range of the sweep circuit is from 15 to 22,000 cycles.

104. INPUT TO VERTICAL DEFLECTING PLATES. All input to the vertical deflecting plates is made through the terminals which are located at the extreme lower left of the oscilloscope (fig. 25). By means of the OFF-ON AMPLIFIER switch, it is possible to apply the signal-voltage input either directly to the vertical plates or through an amplifier with a variable GAIN control located at the left center of the panel. When the OFF-ON AMPLIFIER control is in the ON position, the amplifier is connected into the vertical deflecting-plate system. When the OFF-ON AMPLIFIER control is in the OFF position, the amplifier is cut out of the circuit.

105. INPUT TO THE HORIZONTAL DEFLECTING PLATES.

a. The horizontal deflecting-plate circuit allows a signal voltage with or without amplification, to be applied to the horizontal deflecting plates by means of the terminals located at the bottom right portion of the panel. In this method the sweep circuit is not used.

b. The horizontal circuit amplifier, which has a variable GAIN control located at the lower right of the panel, is used to amplify all voltages fed to the horizontal plates except when the AMPLIFIER switch is in the OFF position. This amplifier controls the length of the sweep when the sweep circuit is used, and controls the amplitude of the signal when the sweep circuit is cut out.

106. CONTROLS AND TERMINALS.

a. Intensity Control. The INTENSITY knob controls the bias on the grid of the cathode-ray tube which in turn determines the quantity of electrons emanating from the cathode. A sharply focused spot or trace of high brilliance should never be permitted to remain stationary on the screen, since discoloration and burning of the screen will result. This control is also used to shut off the unit by turning it to its extreme counterclockwise position until a distinct snap is heard.

b. Focus Control. The FOCUS control determines the distance at which the electron beam focuses. In general, for a given setting of the INTENSITY control, the FOCUS control should be set for maximum distinctness of the spot or image.

c. Centering Controls. The two controls marked VERTICAL CENTERING and HORIZONTAL CENTERING, control the d-c potential between the two deflecting plates of each pair and thereby allow adjustment of the position of the spot or

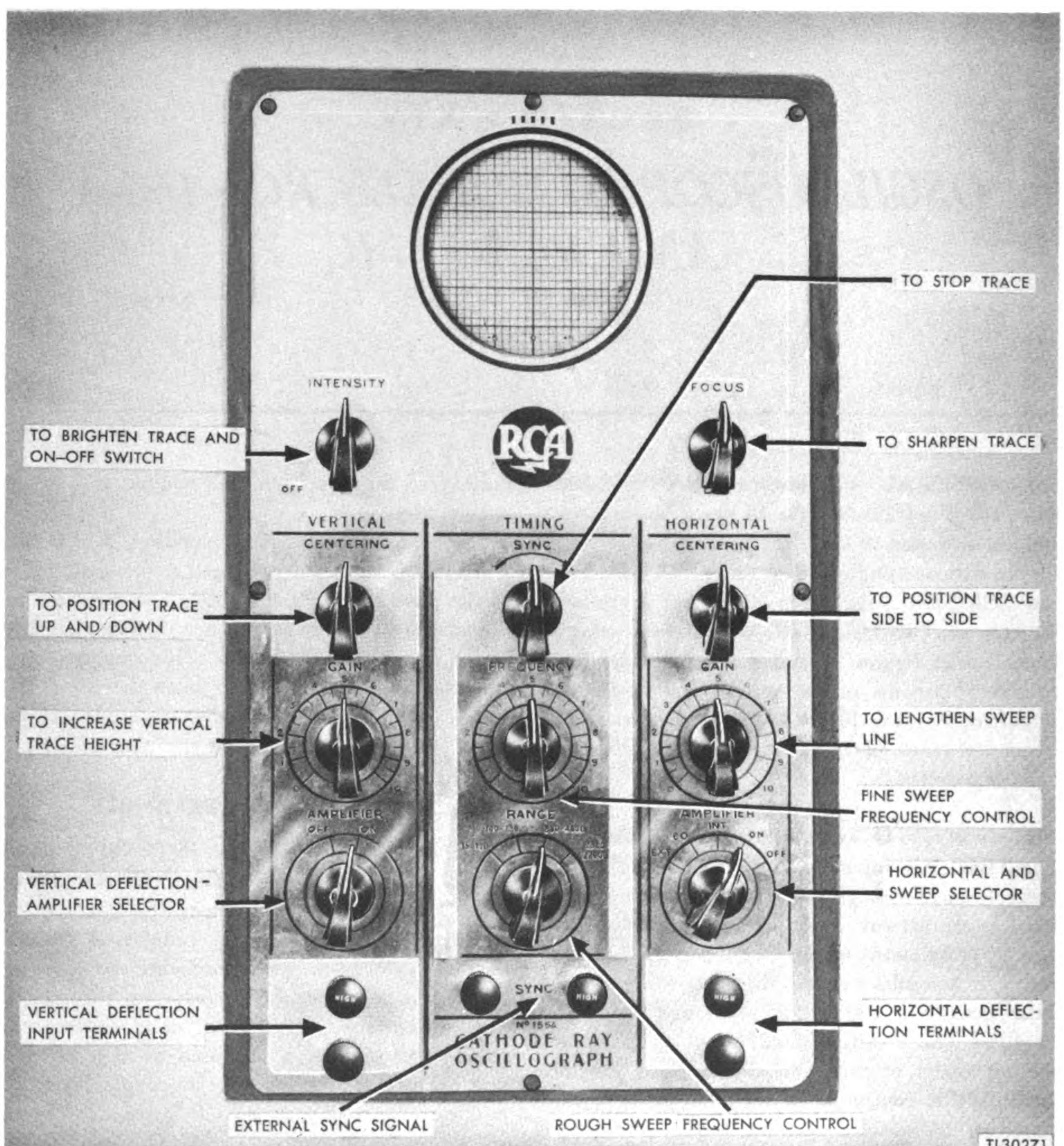


Figure 25. Oscilloscope, RCA model 155-A, panel view.

image. Since there is sufficient voltage across these controls to allow moving the spot off the screen, both controls should be set at approximately mid-position when the unit is first turned on.

d. Binding Posts. There are three pairs of binding posts on the unit. Voltage applied across the pair located at the extreme left will cause a vertical deflection; whereas voltage applied across the pair located at the extreme right will cause a horizontal deflection. The SYNC binding posts are used when it is desired to synchronize the sweep circuit with an external signal voltage. The posts marked HIGH are insulated from ground, while the posts marked 0 are common and grounded to the chassis.

e. Vertical Amplifier. The VERTICAL AMPLIFIER switch connects the vertical binding posts at the extreme lower left either directly to the vertical deflecting plates on the cathode-ray tube, or through an amplifier to these deflecting plates. In either case, there is a capacitor in the circuit which blocks off any d-c component. When the switch is in the ON position the amplifier is in the circuit.

f. Vertical-gain Control. The GAIN control at the extreme left center is a potentiometer in the input circuit of the vertical amplifier. With the VERTICAL AMPLIFIER switch in the ON position, this potentiometer controls the amplitude of vertical deflection.

g. Horizontal Amplifier. (1) The HORIZONTAL AMPLIFIER switch at the lower right of the panel has five positions. When it is in the EXT position, the time base or sweep is controlled by a synchronizing voltage supplied from an external source and connected to the terminals marked SYNC.

(2) With the AMPLIFIER switch in the 60-position, the 60-cycle heater voltage is used to synchronize the sweep frequency.

(3) In the INT position, a portion of the signal voltage applied to the vertical deflecting plates is used to synchronize the sweep circuit.

(4) When the AMPLIFIER switch is set to ON, the horizontal binding posts at the extreme lower right are connected through an amplifier to the horizontal deflecting plates on the cathode-ray tube. The sweep circuit is cut out.

(5) In the OFF position, the horizontal binding posts are connected directly to the deflecting plates. In both the ON and OFF positions there is a blocking capacitor in the input circuit.

h. Horizontal-gain Control. The HORIZONTAL-GAIN control at the extreme right center is a potentiometer in the input circuit of the horizontal amplifier. With the HORIZONTAL AMPLIFIER switch in the EXT, 60, INT, or ON position, this potentiometer controls the amplitude of the horizontal deflection. Due to the capacitive load on this input potentiometer when operating at the higher-audio frequencies, a linear sweep will not be obtained at all settings of this control. For best results, the control should be set for maximum linearity.

i. Range Control. The RANGE control selects the range of time-base frequencies as follows: 15-120, 100-750, 550-4,500, and 2,500-22,000.

j. Frequency Control. The FREQUENCY control is a rheostat which provides a vernier adjustment of the sweep frequency in order to stabilize the pattern on the screen. In conjunction with the RANGE switch, it gives a continuous adjustment of frequency up to 22,000 cycles per second.

k. Synchronizing-signal Control. The SYNC control at the top center of the panel is a potentiometer controlling the amount of synchronizing voltage applied to the grid of the gas triode to insure good synchronization. In general, it should be set clockwise only as far as is necessary to lock the image, since excess synchronizing voltage introduces nonlinearity in the sweep.

107. LIMITATIONS. Several forms of distortion are possible in observing waveforms. While distortion can be eliminated by simple precautions in some cases, it is very difficult to eliminate in other cases.

a. Perhaps the most obvious point at which distortion can enter is in the deflection amplifier. It is important, therefore, to know the frequency response of the amplifier being used, so that an estimate may be made of the possibility of distortion for a given signal. The RCA model 155 test oscilloscope is not suitable for application to the r-f, i-f, oscillator, and buffer system of Receiver BC-406. It is applicable to the 4,098 signal voltages existing in the radio set except where high voltages exist, in which case a voltage divider such as Test Set I-115 is used.

b. When signals of relatively high frequency are to be observed, the time of fly-back may become an appreciable fraction of the period of the signal. To avoid distortion from this source, it is well to adjust the sweep frequency so that several cycles of the signal appear upon the screen.

c. If the magnitude of the synchronizing voltage is too great, the image may be distorted by the fact that the sweep is terminated too soon. This may be avoided simply by setting the synchronization control to zero while the sweep frequency is being adjusted. When the sweep frequency is as near as possible to some integral submultiple of the signal frequency, the image will be almost stationary on the screen. The synchronizing voltage should then be turned on just enough to stop the apparent motion of the image on the screen.

d. In general, the input impedance of the oscilloscope is much higher than the impedance at the point under test. Therefore the oscilloscope does not change the time constant or the voltage at that point, and a true picture of the voltage can be observed. In some circuits, however, the impedance is very high (up to 10 megohms) and the oscilloscope changes the voltage or the time constant so radically that it is very difficult to obtain a true picture.

e. The input capacitance of an oscilloscope is generally small, but it may be sufficient to alter the characteristics of a video amplifier or the tuning of a high-frequency oscillator.

f. The waveforms as viewed on the screen of the Oscilloscope RCA model 155-A, RCA model 155-B, and Supreme model 546, using the vertical-amplifier system, are 180° out-of-phase (inverted) with the signal voltage applied to the vertical terminals of the test oscilloscopes. When the same signal voltage is applied to the Dumont model 224 oscilloscope, the observed waveforms will appear in-phase. The waveforms as viewed on the Dumont model 224 oscilloscope appears 180° out-of-phase with the waveform as shown on either the RCA model 155-A or Supreme model 546 oscilloscope.

108. WAVEFORM EXAMINATION WITH OSCILLOSCOPES MODELS RCA-155-A AND RCA-155-B.

> **CAUTION:** Do not attempt to operate the equipment when withdrawn from the case. The high potentials used are dangerous.

a. Operation. (1) Connect the power plug to a 110-120-volt, 50-60-cycle a-c source.

(2) Turn the INTENSITY control clockwise so that the dial pointer faces approximately upward, causing a spot or trace to appear on the screen after the unit warms up. If the spot or trace is too brilliant, retard the INTENSITY control.

> **CAUTION:** Do not allow a spot or trace to remain stationary on the screen for any length of time. Discoloration or burning of the screen will result.

(3) Adjust the FOCUS control for maximum distinctness of the spot or trace.

(4) Apply the signal voltage to the binding posts at the extreme lower left, observing polarity. The positive lead is connected to the HIGH terminal while the chassis of the unit under test is usually connected to the 0 terminal.

(5) Place the HORIZONTAL AMPLIFIER switch at the extreme right in the INT position.

(6) Turn the VERTICAL AMPLIFIER at the extreme left to the ON position.

(7) Turn the RANGE control to the desired range and adjust the FREQUENCY control until the desired number of images appear. If the image on the screen does not remain stationary, rotate the SYNC control at the top center of the panel in the direction of the arrow. Note that this control must be rotated only far enough to stop the motion. Excessive synchronizing voltage will cause distortion.

(8) Adjust the VERTICAL CENTERING and HORIZONTAL CENTERING controls to locate the image at the center of the screen.

(9) Rotate the VERTICAL GAIN and HORIZONTAL GAIN controls to obtain an image of suitable size.

b. Calibration. The use of the test oscilloscope as a peak voltmeter is described in paragraph 92. Instructions for calibrating the RCA model 155-A or RCA model 155-B test oscilloscope so that it can be used to measure peak-to-peak volts per inch, are given in paragraph 94.

109. MAINTENANCE.

a. General. (1) Oscilloscopes RCA model 155-A and RCA model 155-B are complex instruments and no maintenance must be attempted by inexperienced personnel.

(2) Complete maintenance on these oscilloscopes will consist chiefly of tube and fuse replacement, and to a lesser extent, replacing component parts. Fault location can be ascertained by continuity tests, resistance measurements, voltage readings, signal tracing, and visual inspection.

(3) The schematic diagram (fig. 26) contains information concerning power supply voltages, d-c resistances of transformer windings, and values of component parts. Consult figure 27 for tube-socket arrangements and voltages at tube pins.

(4) An over-all check to determine proper performance of the vertical amplifier system is described in paragraph 95. However, these standards need not be rigidly achieved. Even if the settings of the test oscilloscope vary widely from those illustrated in figure 22, do not attempt to adjust the vertical amplifier system if the amplification of the test oscilloscope is large enough to produce an *undistorted* image of satisfactory amplitude.

b. Circuit Analysis. (1) The following description of circuit operation is presented as an aid in trouble shooting. For the schematic diagram, consult figure 26.

(2) An amplifier consisting of a single 6C6-tube (V4) constitutes the means of obtaining gain for the voltage applied to the vertical-deflection system. The input to this stage is to a high-resistance potentiometer R1 which is used as the GAIN control. An isolation capacitor C1 is made a part of the input circuit to exclude any direct current which may be associated with the circuit being observed. The plate or output circuit of the 6C6-tube is composed of the two following elements in series: a resistor R3, and an inductor L2. Resistor R4 is in series with the positive voltage to the plate from the rectifier supply. Coupling from the amplifier plate to the cathode-ray tube is made through a capacitor C2.

(3) The amplifier for the voltage applied to the horizontal deflecting plates using another 6C6-tube (V5) is identical with that described above.

(4) Switches S1 and S2-S3 are provided to disconnect either or both amplifiers, thereby applying the voltage to be observed directly to the deflecting plates. Extra contacts are used on the input switch S2-S3 to the horizontal amplifier for feeding in the saw-tooth oscillator signal voltage.

(5) The synchronizing system uses an 884-tube (V3), which is a thyratron gas tube, and acts as a sweep generator or saw-tooth oscillator. The frequency range of this oscillator is from 15 to 22,000 cycles per second and is controlled by the RANGE switch S4 and the FREQUENCY control R12.

(6) The signal from this oscillator has a saw-tooth waveshape obtained as follows: A d-c potential is applied across a capacitor and resistor in series in the plate circuit of the 884-tube. This voltage charges the capacitor until the ionization potential (plate voltage at which the gas in the tube ionizes) is reached. When the 884-tube ionizes, the capacitor is short-circuited and the voltage across it drops to nearly zero. The tube immediately deionizes and allows the capacitor to start charging again; thus, a saw-tooth or linear voltage is developed across the capacitor. The capacitor C7, C8, C9, or C10 is selected by the position of the RANGE switch S4 and determines the frequency range. R12 is a vernier adjustment of the frequency.

(7) With the HORIZONTAL AMPLIFIER set to EXT, 60, or INT, the voltage across this passes through the horizontal amplifier 6C6 (V5) to the horizontal plates of the 906-cathode-ray tube.

(8) Potentiometer R8, which is the SYNC control, adjusts the amount of synchronizing voltage applied to the grid of the 884-tube.

(9) From the hot cathode of the cathode-ray tube (V6), 906-type, the electrons emitted are accelerated and focused into a beam. The beam is directed toward and strikes a chemical coating on the inside face of the tube. The electron beam, striking the screen, causes it to fluoresce or give off light. Visible indication of the beam is thus produced at the point of impact. Without further control, the beam would merely produce a spot of light in one position on the screen; however, centering controls are employed to position the spot at any point on the screen.

(10) The beam, in its path from the cathode to the screen, passes between the two sets of deflecting plates. Since the beam (of electrons) is negative, and since like charges repel while unlike

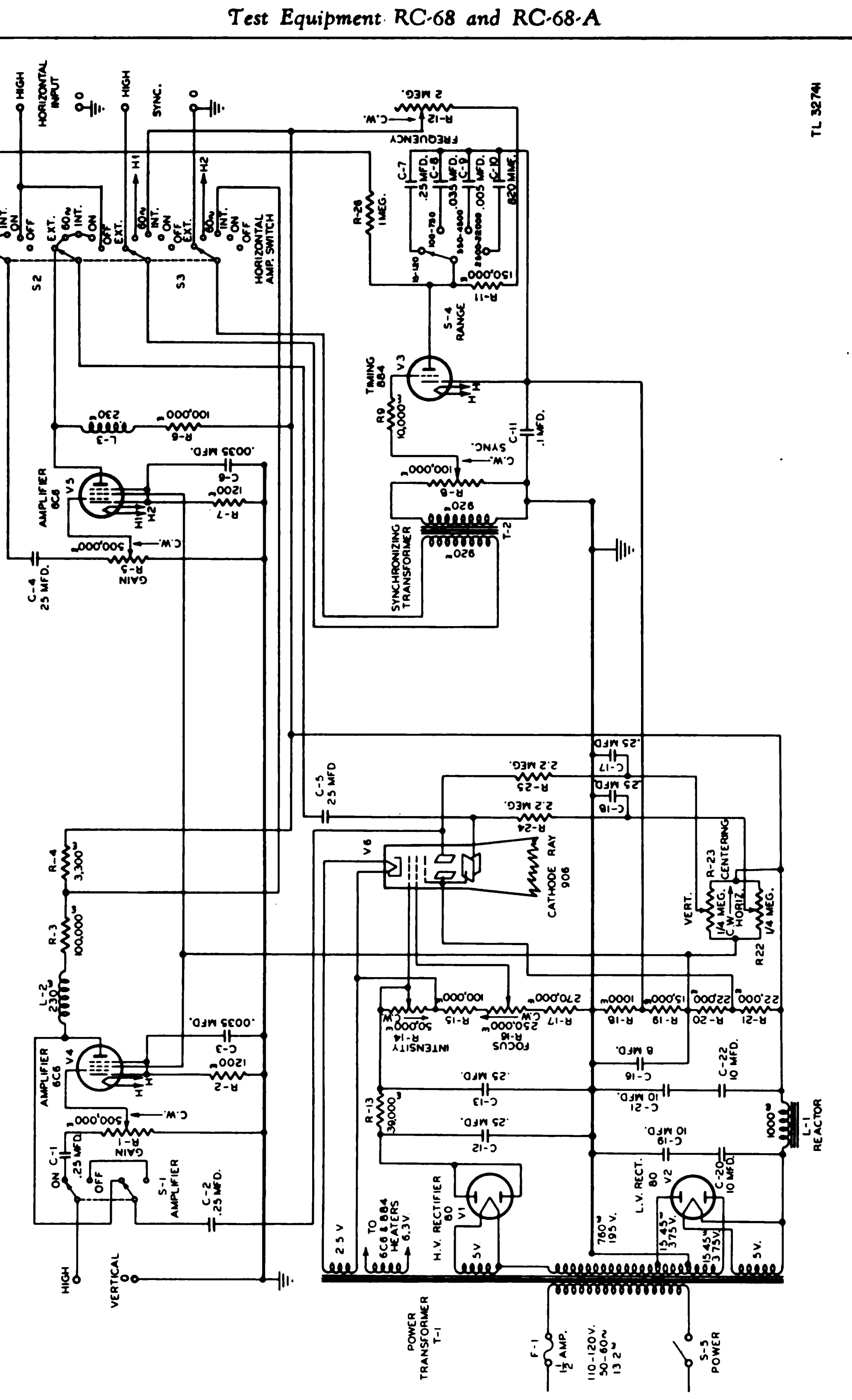


Figure 26. Oscilloscope, RCA model 155-A, schematic diagram.

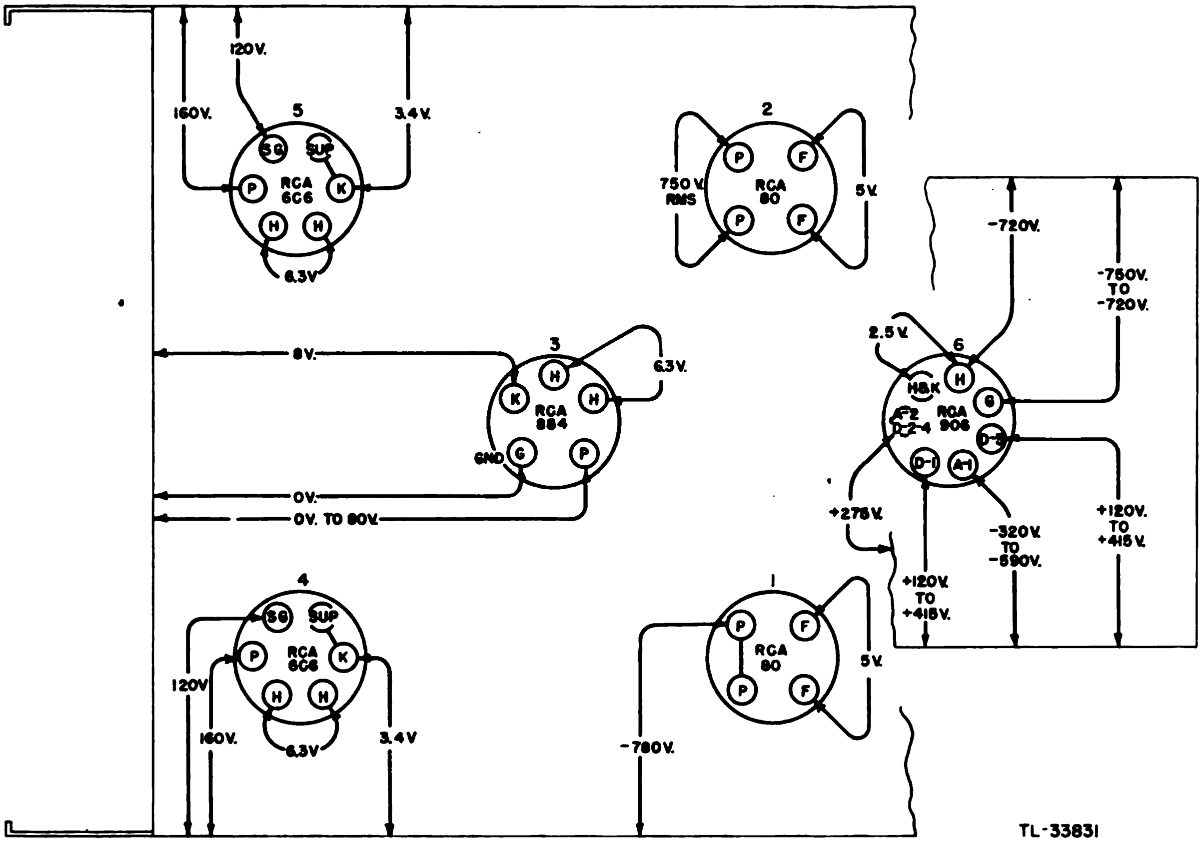


Figure 27. Oscilloscope, RCA model 155-A, tube-socket diagram.

charges attract one another, voltages or potentials on the deflecting plates cause deflection of the beam. Therefore, voltages applied to these plates cause the beam or spot to move across the fluorescent screen and produce a line or trace on the screen instead of a spot.

(11) Potentiometer R23 is used to center the electron beam vertically; potentiometer R22 is used to center it horizontally.

(12) Potentiometer R14 controls the intensity by changing the bias voltage on the intensity or control grid of the tube.

(13) Potentiometer R16 controls focusing by changing the voltage applied to the focusing anode of the tube.

(14) There are two power supplies in the test scope. One supply uses a type-80 tube (V2) and is employed in a conventional full-wave rectifier circuit to furnish low voltage for the amplifiers, sweep generator, and centering controls. Another rectifier which also uses a type 80-tube (V1), supplies high voltage for the electron gun in the cathode-ray tube.

c. Voltages to Ground. The table on page 88 lists tube-element voltages to ground and cathode current for aid in trouble shooting.

> CAUTION: While working on the chassis of the oscilloscope, care must be taken to have the power supply completely disconnected. This is most easily accomplished by removing the high-voltage rectifier tube from its socket and discharging the filter capacitors C12 and C13.

d. Tubes. All tubes, with the exception of the RCA model 906 cathode-ray tube, can be tested with the tube tester and replaced if necessary. The amplifier, oscillator, and the two rectifier tubes will age according to loss of emission; whereas the determining factor in the life of the RCA model

TABLE III

TABLE OF TUBE-ELEMENT VOLTAGES TO GROUND AND CATHODE CURRENT

RADIOTRON							Anode volts to ground dc		Deflecting plates to ground dc		Filament or heater volts ac
Socket No.	Type	Function	Cathode volts to ground dc	Screen-grid volts to ground dc	Plate volts to ground dc	Cathode current ma-dc	No. 1	No. 2	D_3	D_1	
1	RCA-906	Cathode-ray	−720*	....	....	....	−320 to −590*	+275	+120 to +415	+120 to +415	2.5
2	RCA-80 (VT-80)	Low-voltage rectifier	....	....	375 (RMS)	8	....	....	....	....	5.0
3	RCA-80 (VT-80)	High-voltage rectifier	....	....	+780*	....	....	....	....	....	5.0
4	RCA-6C6	20-90,000-cycle amp	+3.4	+120	+160	3	....	....	....	....	6.3
5	RCA-6C6	20-90,000-cycle amp	+3.4	+120	+160	3	....	....	....	....	6.3
6	RCA-884 (VT-222)	15-22,000-cycle osc	+8.0	....	0 to +80*	0.16 to 2.0	....	....	....	....	6.3

*Cannot be correctly measured with ordinary voltmeter.

906 is the deterioration of the fluorescent screen. Excessive wear on this tube and the approach to its limit of life is indicated by inability to obtain a satisfactory focus, and also by the screen becoming streaked and spotted. When installing a new cathode-ray tube, some rotation may be required to bring the axes of deflection into their proper horizontal and vertical planes. This is accomplished by loosening the screw on the tube-socket clamp, rotating the socket as desired, and tightening the screw.

e. Fuse Replacement. A small 1.5-ampere cartridge fuse is used in the primary circuit of the power transformer. This fuse is intended for the protection of the entire power system of the oscilloscope; therefore, it must neither be replaced by a fuse having a higher current rating nor should it be shorted out. A fuse failure should be carefully investigated before a replacement is made, since a surge in current from the power-supply line or shorted rectifier-tube elements may be the cause for the breakdown. Sometimes a fuse may open from the heat generated at one of its clip contacts. These points should be kept clean and make firm contact with the fuse.

SECTION XV
OSCILLOSCOPE, SUPREME MODEL 546

110. GENERAL.

a. Oscilloscope Supreme model 546 is another instrument that may be provided for the study of waveforms and voltages. It contains a 3-inch cathode-ray tube, vertical and horizontal amplifiers, a linear time base or sweep generator, and a regulated power supply. Figures 28 and 29 are a photograph and schematic, respectively. Both the vertical and horizontal amplifiers are designed to produce an undistorted pattern on the screen of the cathode-ray tube. The vertical amplifier is especially compensated to pass a 60-cycle square-wave voltage and frequencies up to 90 kilocycles. The internal-sweep generator is of the thyratron gaseous-discharge type and provides a horizontal linear sweep from 15 to 30,000 cycles per second.

b. Direct connections to both the vertical and horizontal deflecting plates are provided for the observation of voltages whose frequencies are above the useful limits of the amplifiers.

111. INPUT TO THE VERTICAL DEFLECTING PLATES.

a. Oscilloscope Supreme model 546 provides for two forms of input to the vertical deflecting plates. One input arrangement is through the vertical-deflection input terminals indicated as VER and GND in figure 28. This input is under the control of an amplifier with a variable-gain control marked VERT. GAIN.

b. Another input arrangement is directly to the vertical-deflecting plates through the terminals marked V-PLATE and GND. When this method is used, the VERT. GAIN control must be turned to the OFF position to complete the circuit, simultaneously eliminating the vertical amplifier from the circuit.

112. INPUT TO THE HORIZONTAL DEFLECTING PLATES.

The horizontal-deflection system also provides for two forms of input. One of these is through the horizontal-deflection terminals marked HOR and GND. This input is under the control of an amplifier with a variable-gain control marked HOR. GAIN. The sweep selector must be placed in the EXT. SWEEP position. Another form of input is directly to the horizontal deflecting plates through the terminals marked H-PLATE and GND. When this method is used, the HOR. GAIN control must be turned to the OFF position to complete the circuit. The horizontal amplifier and sweep circuit are not used.

113. CONTROLS AND TERMINALS.

a. *Intensity Control.* The INTENSITY control serves to set the bias on the grid of the cathode-ray tube. In this manner, the brilliance of the image may be adjusted. A sharply focused line or spot of high intensity should not be permitted to remain stationary on the screen or discoloration of the screen will result.

b. *Focus Control.* The FOCUS control sharpens the trace on the oscilloscope screen.

c. *Vertical- and Horizontal-position Controls.* The controls marked VERT. POSITION and

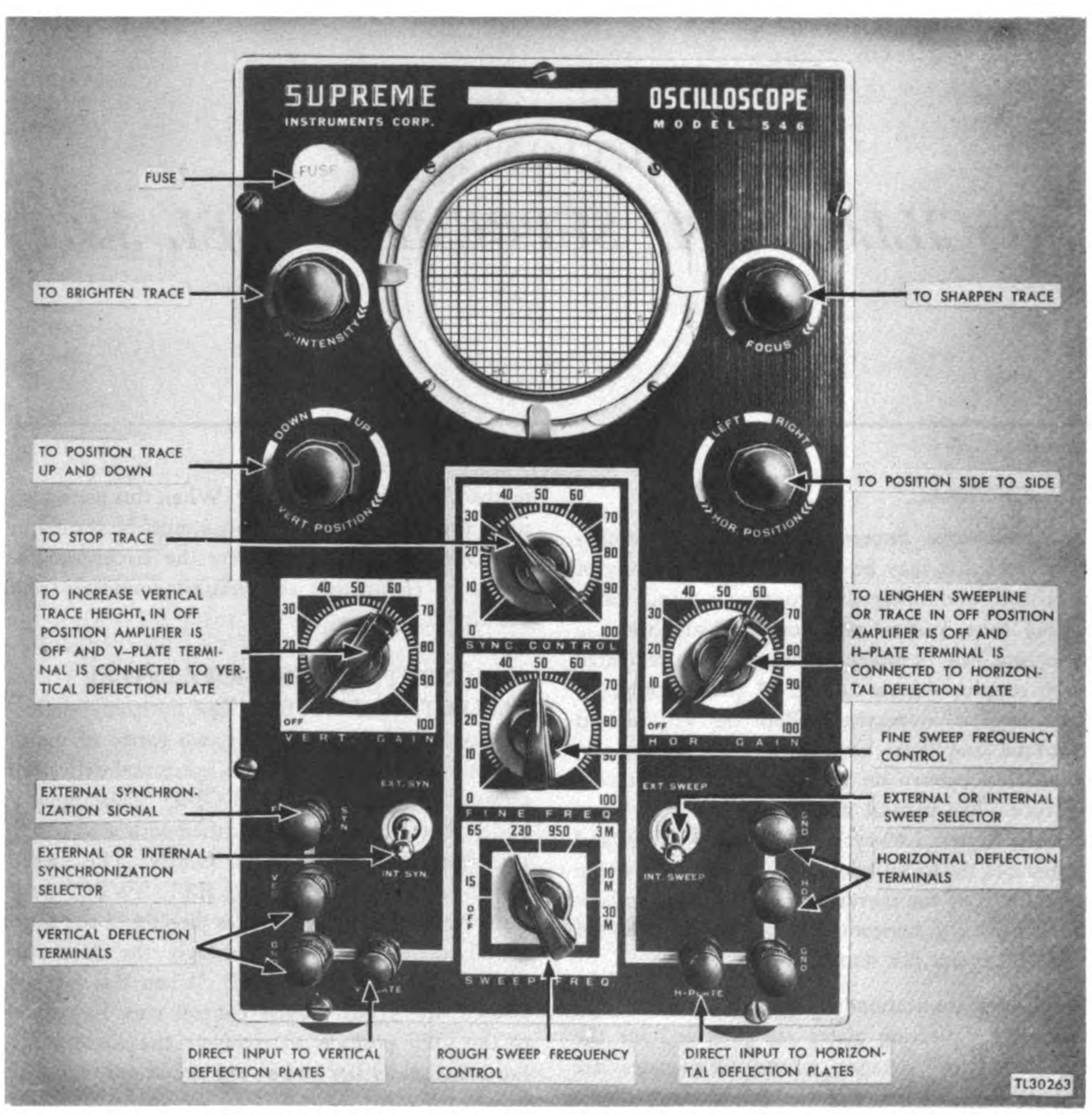


Figure 28. Oscilloscope, Supreme model 546, panel view.

HOR. POSITION are used to center the trace on the screen. Each control is marked with the direction of motion of the trace it produces.

d. *Vertical-gain Control.* The control marked VERT. GAIN serves to adjust the vertical amplitude of the trace. When it is in the OFF position, the vertical amplifier is eliminated from the circuit and the V-PLATE terminal is connected directly to the vertical deflecting plate.

e. Horizontal-gain Control. The control marked HOR. GAIN is a potentiometer in the input circuit of the horizontal amplifier. It controls the amplitude of the sweep or waveforms applied to the horizontal deflecting plates. When the HOR. GAIN control is in the OFF position, the horizontal amplifier is eliminated and the sweep is not used.

f. Synchronizing-selector Switch. (1) The toggle switch marked EXT. SYN.—INT. SYN. determines the source of signal to which the linear sweep or time base is synchrônized. In the INT. SYN. position, a suitable voltage is taken from the plate circuit of the vertical amplifier and applied to the control grid of the thyratron saw-tooth generator, thus synchronizing it.

(2) When the switch is in the EXT. SYN. position, the linear sweep may be synchronized by a signal connected between the EXT. SYN. and GND binding posts.

(3) In either case, the sweep selector must be in the INT. SWEEP position to allow synchronization.

g. Synchronizing-signal Control. The SYNC. CONTROL determines the amount of synchronizing voltage which is applied to the grid of the thyratron to stabilize the trace. This control works in conjunction with the VERT. GAIN control and should be advanced only a sufficient amount to lock the trace on the oscilloscope screen. Excessive synchronizing voltage results in a distorted pattern and consequently should be avoided.

h. Sweep-frequency Control. The control labelled SWEEP FREQ. determines the range of sweep frequencies which operation of the FINE FREQ. control will produce. The limits of each of the six ranges are given by the numbers to either side of the dial pointer and are as follows: 15, 65, 230, 950, 3M, 10M, and 30M. The letter M represents 1,000; therefore, 30M is 30,000 cycles per second. When the control is in the OFF position, the sweep circuit is prevented from oscillating.

i. Fine-frequency Control. The FINE FREQ. control provides a vernier adjustment of the frequency in the frequency range selected by the SWEEP FREQ. control.

j. Sweep-selector Switch. With the EXT.-INT. SWEEP toggle switch in the INT. SWEEP position, a saw-tooth voltage is automatically applied to the horizontal-amplifier input. When this switch is in the EXT. SWEEP position, any external voltage may be applied to the horizontal-deflection system through the terminals marked HOR and GND. The horizontal amplifier is then included in the circuit and the sweep voltage from the thyratron is cut out of the circuit.

k. Binding Posts. (1) The terminals marked EXT. SYN. and GND are used to supply an external-synchronizing voltage to the thyratron saw-tooth generator. In this case the toggle switches should be in the EXT. SYN. and INT. SWEEP positions.

(2) The terminals labeled VER and GND are used to apply a voltage to the vertical-deflection system. In this method the VERT. GAIN control must be in any position except OFF.

(3) The terminals marked V-PLATE and GND are used to apply a voltage directly to the vertical deflecting plates. The VERT. GAIN control must be in the OFF position. The applied voltage should not exceed 500 volts (peak).

(4) The terminals marked HOR and GND are used to apply a voltage to the horizontal-deflection system. The sweep selector must be in the EXT. SWEEP position and the HOR. GAIN control in any position except OFF.

(5) The terminals labeled H-PLATE and GND connect directly to the horizontal deflecting plates when the HOR. GAIN control is in the OFF position. The applied voltage should not exceed 500 volts (peak).

114. LIMITATIONS. Several forms of distortion are possible in observing waveforms. While distortion can be eliminated by simple precautions in some cases, it is very difficult to eliminate in other cases.

a. Perhaps the most obvious point at which distortion can enter is in the deflection amplifier; therefore, it is important to know the frequency response of the amplifier being used, so that an estimate may be made of the possibility of distortion for a given signal. The Supreme model 546 test oscilloscope is not suitable for application to the r-f, i-f, oscillator, and buffer system of Receiver BC-406. It is applicable to the 4,098 signal voltages existing in the radio set except where high voltages exist, in which case a voltage divider such as Test Set I-115 is used.

b. When signals of relatively high frequency are to be observed, the time of fly-back may become an appreciable fraction of the signal period. To avoid distortion from this source, it is well to adjust the sweep frequency so that several cycles of the signal appear upon the screen.

c. If the magnitude of the synchronizing voltage is too great, the image may be distorted by the fact that the sweep is terminated too soon. This may be avoided most simply by setting the synchronization control to zero while the sweep frequency is being adjusted. When the sweep frequency is as near as possible to some integral submultiple of the signal frequency, the image will be almost stationary on the screen. The synchronizing voltage should then be turned up only a sufficient amount to stop the apparent motion of the image on the screen.

d. In general, the input impedance of the oscilloscope will be much higher than the impedance at the point under test; thus, the oscilloscope will not change the time constant or the voltage at the point and a true picture of the voltage may be observed. In some circuits, however, the impedance is very high (up to 10 megohms), and the oscilloscope will change the voltage or the time constant so radically that it will be very difficult to obtain a true picture.

e. The input capacitance of an oscilloscope is generally small, but it may be sufficient to alter the characteristics of a video amplifier or the tuning of a high-frequency oscillator.

f. The waveforms as viewed on the screen of the Supreme model 546 and RCA models 155-A and 155-B oscilloscopes, using the vertical-amplifier system, are 180° out-of-phase (inverted) with the signal voltage applied to the vertical terminals of the test oscilloscope. With the same signal voltage applied to the Dumont model 224 oscilloscope, the observed waveforms will appear in-phase. The waveform as viewed on the Dumont model 224 oscilloscope appears 180° out-of-phase with the waveforms shown on either the RCA model 155-A or Supreme model 546 oscilloscope.

g. Do not apply voltage in excess of 500 volts (peak) to either the vertical or horizontal deflecting plates.

115. WAVEFORM EXAMINATION WITH OSCILLOSCOPE SUPREME MODEL 546.

> **CAUTION:** It is inadvisable to operate this cathode-ray oscilloscope with the case removed. There are potential differences as high as 1,000 volts in this instrument, and it should be treated with proper caution.

a. Operation. (1) Turn all the rotary controls to the extreme counterclockwise position and throw the toggle switches to the down position.

(2) Connect the power supply plug to a 110-120 volt, 60-cycle a-c source.

(3) Advance all the rotary controls, including the bar-pointer knobs, to approximately one-half normal rotation in a clockwise direction.

(4) Regulate the INTENSITY control until a green fluorescense appears on the screen of the cathode-ray tube and adjust the VERT. POSITION and HOR. POSITION controls until the fluorescent image is centered.

(5) Adjust the FOCUS and INTENSITY controls for a well-defined horizontal line. If the trace becomes too brilliant, retard the intensity control.

> **CAUTION:** Do not allow a trace or spot of high intensity to remain stationary on the screen for long periods. Burning or discoloration of the screen may result from concentrating the entire energy of the beam to a small area for a considerable period.

(6) Apply the signal voltage to be observed to the VER and GND terminals located in the extreme lower left-hand corner, observing polarity. Adjust the VERT. GAIN and HOR. GAIN controls until the complete image is visible. The image most likely will appear as a crosshatching.

(7) Turn the SWEEP FREQ. control to the desired range and adjust the FINE FREQ control until the desired number of cycles appear. If the waveform does not remain stationary, advance the SYNC. CONTROL in a clockwise direction only a sufficient amount to stabilize the waveform. Oversynchronization may result in a distorted figure.

b. Calibration. The use of the oscilloscope as a peak voltmeter is described in paragraph 92. Instructions for calibrating the Supreme model 546 test oscilloscope so that it can be used to measure peak-to-peak volts per inch are given in paragraph 94.

116. MAINTENANCE.

a. General. (1) Oscilloscope Supreme model 546 is a complex instrument; therefore, no maintenance must be attempted by inexperienced personnel.

(2) Complete maintenance on this oscilloscope will consist chiefly of tube and fuse replacement and, to a lesser extent, replacing component parts. Fault location can be ascertained by continuity tests, resistance measurements, voltage readings, signal tracings, and visual inspection.

(3) The schematic diagram (fig. 29) contains information concerning power supply voltages and values of component parts.

NOTE: Certain design changes may have been made during manufacture of the oscilloscope in use. In case circuits are conflicting, use as final authority the schematic diagram in the manufacturer's manual accompanying your instrument.

(4) An over-all check to determine proper performance of the vertical-amplifier system is described in paragraph 95; however, these standards need not be rigidly achieved. Although the settings of the test oscilloscope vary widely from those illustrated in figure 22, do not attempt to adjust the vertical-amplifier system if the amplification of the test oscilloscope is sufficient to produce an undistorted image of satisfactory amplitude.

b. Voltages to Ground. The following table lists the more important operating potentials for aid in trouble shooting. The d-c voltages indicated are as measured by a 1,000-ohm-per-volt meter from pin to chassis except as indicated on cathode-ray tube. Looking at the base of the tubes with the filament pins at the bottom, note that the pin numbers run clockwise from the left-hand filament pin No. 1.

TABLE IV

TABLE OF OPERATING POTENTIALS TO AID TROUBLE SHOOTING

Tube Type	Use	Pin No.	Voltage
80 (VT-80)	LV rect	1	+ 400
80 (VT-80)	HV rect	2 or 3	—1050
6C6	Vertical amp	2	+ 250
		3	+ 80
		4	+ 2.2
		5	+ 2.2
6C6	Horizontal amp	2	+ 180
		3	+ 80
		4	+ 2.1
		5	+ 2.1
885	Sweep gen	2	+ 25
		4	+ 4.1
906*	Cathode-ray	2	0 to — 25
		3	+ 260 to +550
		4	+ 80 to +350
		5	+ 200 to +400
		6	+ 900

*All measurements made between pin 7 and pins indicated. Do not measure from pin 2 (grid) to chassis.

> **CAUTION:** Extreme care should be taken while making measurements with the chassis removed from the case. Dangerous potentials exist in the circuit of the cathode-ray tube and its power supply.

c. Circuit Description. For aid in trouble shooting, the following description is presented:

(1) These are the six principal sections of the Supreme model 546; the cathode-ray tube, power supply for cathode-ray tube, vertical amplifier, horizontal amplifier, low-voltage power supply for amplifiers, and an internal sweep oscillator. Referring to the schematic diagram, the type-80 rectifier tube with filaments A-A has 350 volts applied to each plate. The common negative return for this section (low-voltage power supply) is the chassis, and the filament center tap is the positive output which connects to L1. This supplies the voltage dividers R1, R2, R3, and R4 which distribute the operating potentials to the amplifiers and sweep-generator tubes. The type-80 rectifier tube with filaments B-B, supplies voltage to resistors R5, R6, R7, R8, and R9 to provide the operating potentials to the cathode-ray tube, type 906. This is a half-wave rectifier circuit with the tube in series with the 800 volts winding 350 + 450 and the above-mentioned voltage divider. R9 regulates the bias voltage on the grid of the 906 tube and thus is the INTENSITY control. R7 is connected to the second anode of the 906 tube and is indicated on the panel as the FOCUS control. R10 and R11 provide a variable potential which can be adjusted to provide either negative or positive voltage with respect to the chassis. The common terminal connects to the deflecting plates through RR and controls the position of the image on the screen.

(2) The vertical amplifier is of the fixed-bias type and uses a 6C6 tube. The horizontal amplifier employs automatic bias by means of R21 in the cathode circuit. The input of these amplifiers is controlled by R17 and R18, VERT. GAIN and HOR. GAIN respectively.

(3) The sweep generator uses a type-885 thyratron oscillator and the frequency is adjusted by means of C13. C14, etc. (SWEEP FREQ.) and R25 (FINE FREQ.). The switches connecting to C10 and C11 are located on the rear of the VERT GAIN and HOR. GAIN controls. The toggle switches which connect to C8 and C9 are the EXT. INT. SWEEP and EXT. INT SYNC. respectively.

> **CAUTION:** Care should be taken while making measurements with the instrument connected to the power line. Voltage between the electrode of the cathode-ray tube and rectifiers are extremely dangerous.

d. Fuse Replacement. (1) A 2-ampere fuse is used in the primary circuit of the power transformer. This fuse is intended for the protection of the entire power system of the oscilloscope and should not be replaced by a fuse having a higher current rating; neither should it be shorted out. Before a replacement is made the fuse failure should be carefully investigated, since there usually is a definite cause for the break-down. A surge in current from the power-supply line or shorted rectifier-tube elements may be the cause.

(2) In the event of a fuse break-down, first check the power source. If the trouble seems to be internal, disconnect the oscilloscope from the power source and remove the chassis from the metal case. Remove the two type-80 rectifier tubes, apply power, and check the voltages on the secondary of the power transformer. If these values conform to those listed on the schematic diagram (fig. 29), disconnect the power and check C1 and C2, the filter capacitors. These are electrolytic capacitors and cannot be correctly measured by an ohmmeter unless polarity is observed. After the rectifier tubes are removed, if the instrument continues to blow fuses, check the power transformer for a possible short circuit between the windings and the terminations.

e. Tubes. (1) All tubes except the type-906 cathode-ray tube, can be tested with the tube tester and replaced when necessary. The amplifier, oscillator, and the two rectifier tubes will wear in accordance with loss of emission; whereas the determining factor in the life of the cathode-ray tube is the deterioration of the fluorescent screen. Excessive wear and aging of this tube are indicated both by inability to obtain satisfactory focus, and by evidences that the screen is becoming streaked and spotted.

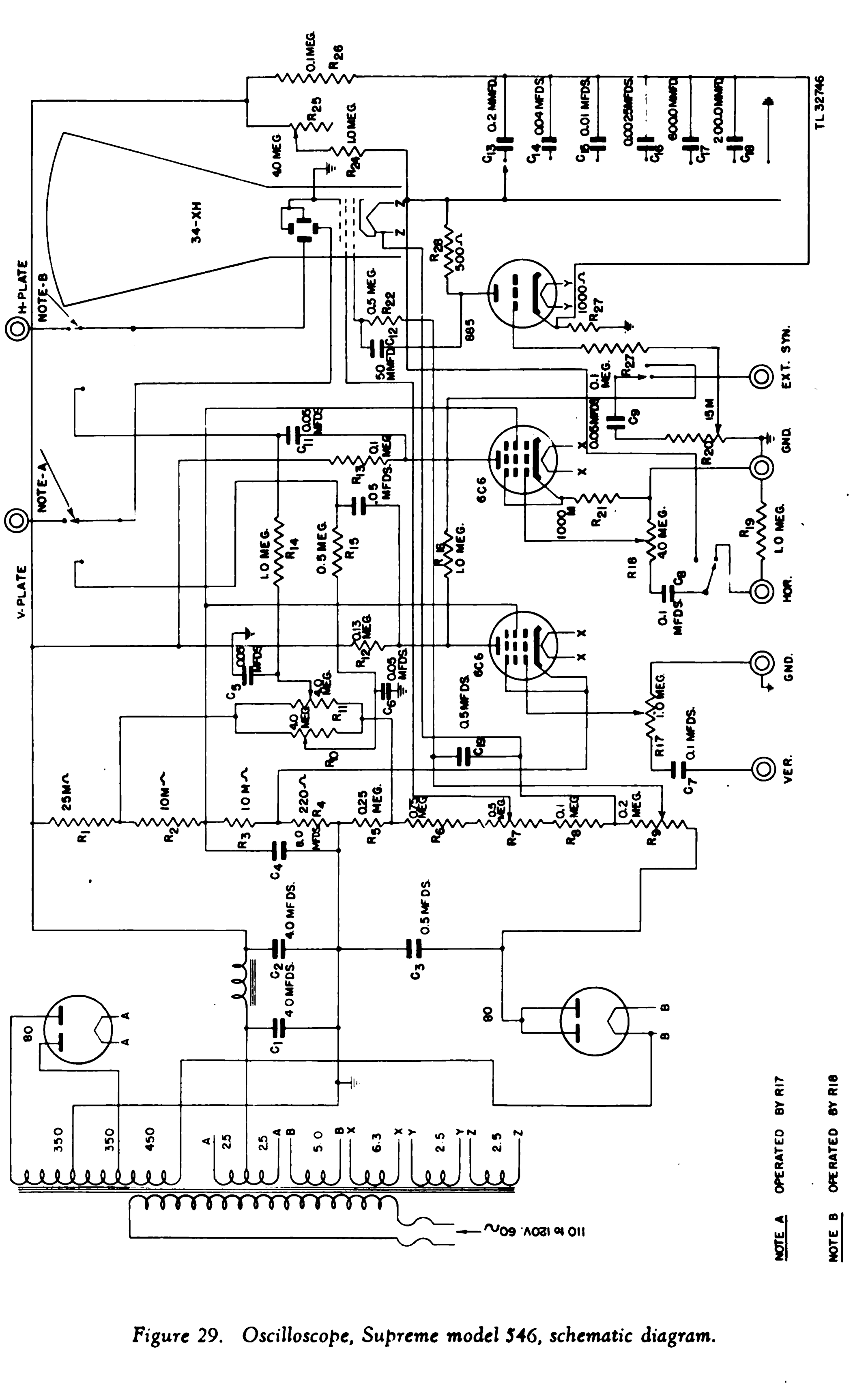


Figure 29. Oscilloscope, Supreme model 546, schematic diagram.

(2) If either of the amplifiers or the oscillator is not working, check the merit of the tube involved. Also check the type-80, low-voltage rectifier-pin potentials and replace that tube if necessary.

SECTION XVI
SIGNAL GENERATORS

117. GENERAL.

a. Among the numerous operations necessary for maintenance and repair of Receiver BC-406 and BC-406-A, are adjustments of the r-f and mixer circuits, oscillator system, and i-f amplifier. These adjustments require the application of ultra-high-frequency signals for which purpose the test equipment includes signal generators such as Measurements models 78-B and 78-C, and the Ferris model 18-B.

b. A signal generator is a device for producing an artificial signal and consists of a thoroughly shielded oscillator coupled to an attenuating system that is capable of producing known voltages ranging from about 1 microvolt to 100,000 microvolts with the test equipment provided. Provision is made for modulating this voltage to 30 percent at 400 cycles. In addition, Measurements models 78-B and 78-C permit modulation at 8,200 and 625 cycles, respectively.

c. Signal generators are applied in two different ways. The first method applies the generator as a source of signal at the antenna terminals of Receiver BC-406 and BC-406-A. In this method the purpose is to establish the sensitivity of the receiver and thus determine the need for adjustment of the r-f, oscillator, and i-f systems.

d. The second basic function of the signal generator is to provide a signal for the location of trouble in the r-f, oscillator, mixer, and i-f systems. This method consists of applying a test signal to various points of the circuit under test, and observing the change in signal output. This establishes the amount of amplification available in the respective stages of the circuit under test, and, where the proper gain is not present, indicates the approximate location of the defect. Supplementary tests with other apparatus are then made to locate the defective component of the particular stage. Figure 30 illustrates the proper test connections for using the signal generator as a source of signal input to the i-f stages of the receiver. The frontispiece shows Receiver BC-406-A being aligned by means of a signal generator and test oscilloscope.

118. R-F OSCILLATOR SYSTEM.

a. The r-f voltage is generated by an oscillator operating in a conventional circuit such as a Colpitts or Hartley. The r-f frequency usually is varied by means of a variable capacitor in the tuned circuit associated with the r-f oscillator. In addition, switches are usually provided so that the coil in this tuned circuit may be replaced by another coil of a different value. In this manner, the entire frequency range of the r-f oscillator is shifted. Oscillators may have provision to work over many ranges, depending upon the use for which they are designed.

b. The signal generator should employ an r-f oscillating system that covers its radio-frequency range in fundamentals, and must be so designed that when sine-wave modulation is desired, this sine wave is undistorted for all of the radio fre-

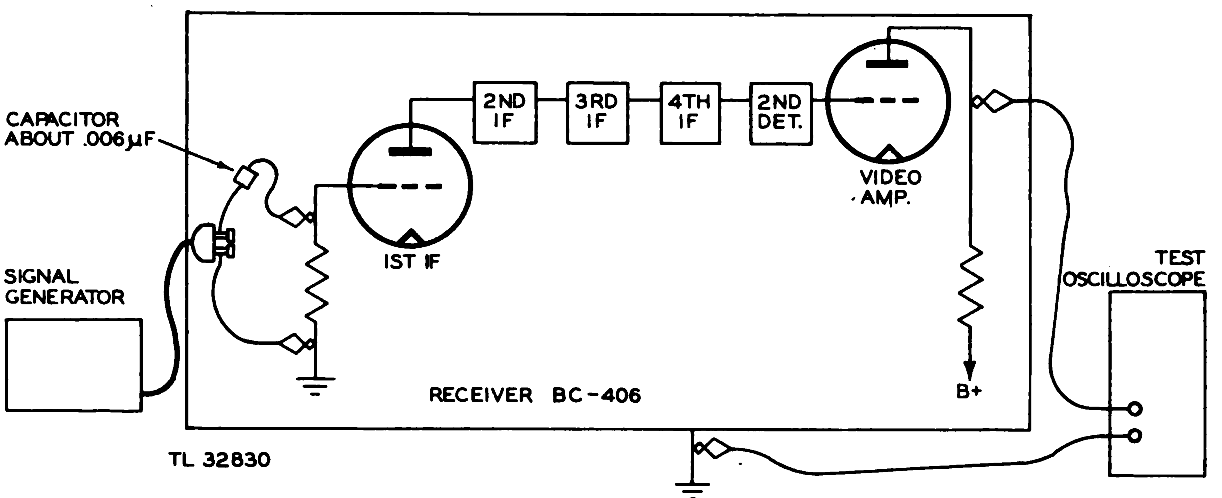


Figure 30. Signal generator, test connections.

quencies covered. The use of fundamental frequencies is required to obtain an accurately calibrated voltage output at all frequencies within the range of the instrument. Accuracy of the frequency calibration of the r-f oscillator is usually from ½ to 1 percent.

c. A comparison of the signal generators supplied with Test Equipment RC-68-(*) shows that the frequency range varies for each instrument. Furthermore, in contrast with Measurements model 78-B, Measurements model 78-C and Ferris model 18-B cannot be tuned to the ultra-high frequency of 205 megacycles. When these latter units are employed use is made of the second harmonic of a fundamental of approximately 102.5 megacycles or thereabouts, depending upon the exact receiver-alignment frequency. When this method is used, notice that the output of the signal generator tuned to a subharmonic of the receiver frequency may have to be increased several hundred, if not a thousand times, depending upon the basic sensitivity of the receiver.

119. AUDIO MODULATOR.

a. Practically all of the r-f signal sources intended for use in the radio-service field provide for audio modulation. Audio voltage is generated by an audio-oscillator system which is designed for low distortion, stable frequency, and constant output voltage. The frequency is usually fixed at 400 cycles per second, although additional modulating frequencies may be provided. Measurements model 78-B employs modulation at either 400 or 8,200 cycles per second. The modulation frequency of Measurements model 78-C can be set to either 400 or 625 cps, while the Ferris model 18-B microvolter has one fixed modulating frequency of 400 cps.

b. In the majority of cases the audio voltage is a close approach to a sine wave, and varies in output level according to the design of the instrument in general. In a few instances provision is made for variable control of the output signal level. This is an advantage because it allows the application of the audio signal to tube circuits where high-level audio signals will cause overload.

c. The maximum available a-f output voltage is usually determined by the level needed to modulate the r-f voltage of the signal generator. The modulation of the r-f voltage by the audio voltage is usually 30 percent, which is the percentage of modulation employed in the three signal generators mentioned above. Switches are provided so that the modulation may be shut off when not desired.

120. R-F SIGNAL OUTPUT.

a. Reference-level Indicators. (1) If the signal generator is to be used to feed a signal to some sort of radio equipment such as a radio receiver, it is desirable to have some means of varying the output voltage of the r-f oscillator. The most desirable range of the output indicating device may then be used, and the output of the r-f oscillator may be adjusted to the value best suited for the desired test conditions.

(2) Signal generators are therefore provided with calibrated attenuators in order to vary accurately the output voltage. To use the attenuating system properly, it is necessary that the r-f oscillator output level be known; otherwise, the calibrated attenuating system is meaningless because the level of the voltage being attenuated is unknown.

(3) Therefore, signal generators contain an r-f reference-level indicator so that it is possible to identify definitely, with, of course reasonable tolerance, the output-signal level. The reference signal level indicator bears reference-level markings so that the r-f output may be set to a predetermined signal level. The Measurements models 78-B and 78-C merely have a red line on the meter; whereas the Ferris model 18-B has a reference-level indicator calibrated for zero to 1.2 volts.

(4) The r-f reference-level reading or setting is adjusted by a control which varies the amplitude of the r-f voltage generated by the r-f oscillator. This control is usually used to change the plate voltage of the r-f oscillator, since the amplitude of the r-f voltage generated by an oscillator is proportional to the applied plate voltage.

(5) After the r-f oscillator has been adjusted for proper indication on the r-f reference-level indicator, the calibrated attenuation system may be used with more or less accuracy.

b. Accuracy of Output Voltage. (1) The accuracy of the output-voltage levels indicated by the attenuators is subject to wide tolerance because of the difficulty of controlling the action of the attenuators at this high frequencies used in these systems. Accuracy depends upon the four following factors: leakage, the design of the attenuator network, the highest voltage available from the output, and the frequency of the signal. Usually the highest order of accuracy is found in the range of lower frequencies. At higher frequencies, the error may be as great as 15 percent.

(2) The use of harmonics further precludes the possibility of a high order of accuracy in output-voltage ratings, because by-passing effects become more pronounced as the order of the harmonic increases. Calibration of an attenuator on a fundamental does not apply with the same order of accuracy to the harmonics.

(3) The higher the signal output, the greater is the problem of attenuation and shielding. Leakage is increased as the signal output is increased. Most existing instruments furnish an output of about 100,000 microvolts (0.1 volt).

(4) It is interesting to note the wide difference in design of the attenuators of the signal generators supplied with Test Equipment RC-68-(*). Measurements model 78-B and 78-C employ variable inductive coupling; whereas the Ferris model 18-B uses a resistance pad.

121. LIMITATIONS AND PRECAUTIONS.

a. Radiation. One highly significant detail relating to the application of virtually all signal generators used at these high frequencies, is radiation from the output cables as well as from the metal cans which house the terminating resistance across the output-cable terminals. The exact amount of radiation from these cables and shield cans is not known, but it is sufficient to cause error unless precautions are taken when the devices are used with the receiver. Proof of this is provided by the fact that a change in the position of the cable along the length of the exposed receiver chassis changes the amount of signal input to the receiver; consequently, this change varies the indication upon the output indicator.

b. Grounding. An additional detail of importance relating to the signal generators is the need for proper grounding. Not only is the ground connection to the grounded output-cable terminal important, but it is also essential that this ground terminate *not at the chassis but at the ground point for the bypass capacitors associated with the tube circuit which receives the signal from the signal generator.* In addition, all apparatus used with the signal generator must be connected mutually and brought to a common ground.

c. Length of Leads. Use very short leads to connect the output terminals of the signal generator to the receiver. Leads longer than 2 inches at a frequency of 200 megacycles will cause serious errors in output voltage.

d. *Impedance Matching.* Among the requirements placed on any system for transferring power from one circuit to another, impedance matching is one of the most important. It is an electrical rule that in order to transfer maximum energy from one circuit to another, the impedances of the two circuits must be matched. The signal generators provided with Test Equipment RC-68-(*) terminate in a resistance of approximately 30 ohms; whereas the antenna impedance of the r-f input stages of the receiver is 300 ohms for each stage. It is evident then, that a perfect impedance match requires some sort of impedance-matching device. Plug PL-218 (par. 165) is such a device and is provided with the test equipment for use in applying the r-f output of the signal generator to the antenna-input stages of Receiver BC-406.

e. *Output Coupling.* Take care when applying the signal generator to a circuit inasmuch as the secondary of the output transformer can shunt or short-circuit the bias or other operating potential in the circuit. For example, to prevent the loss of grid bias when the output of the signal generator is applied to the grid of an i-f stage in Receiver BC-406, it is necessary to insert a capacitor in series with the hot lead. Figure 30 illustrates the proper test connections.

f. *Output Level.* In contrast to the audio oscillator which has an output of the order of 25 volts, the signal generator has an extremely small output. Its maximum output is 100,000 microvolts, which is equivalent to 0.1 volt. When the signal generator is used, the output voltage must be greatly amplified before it can cause an observable deflection on the oscilloscope screen. The amplification usually takes place in the receiver under test and in the amplifier circuit of the test oscilloscope.

SECTION XVII

SIGNAL GENERATOR I-126, MEASUREMENTS MODEL 78-B

122. GENERAL. Signal Generator I-126 (fig. 31) provides modulated or unmodulated r-f signals over two frequency bands. One band is known as the RED band because the frequency calibration is in red ink upon the calibration chart and covers the frequency band from 15 to 25 megacycles. The other band is known as the BLACK band because the frequency calibration upon the calibration chart is in black ink and covers the frequency band from 195 to 225 megacycles. Selection of either band is accomplished by means of a plunger RANGE SWITCH operated from the front of the panel (fig. 31). The RANGE SWITCH selects either of the two coils illustrated in figure 34. The calibration curves are mounted upon a sliding frame which moves in two metal grooves mounted on the bottom of the cabinet.

123. R-F OSCILLATOR. The r-f oscillator system employs a special type of high-frequency tube, which is type 9002 (fig. 32) in a Colpitts circuit. The r-f frequency dial is carried on a drum (fig. 33) which rotates with the tuning capacitor shaft and may be varied by turning the TUNING knob located at the extreme left.

124. MODULATOR.

a. The audio oscillator used in the modulator section operates on the resistance-tuned principle and has low distortion, stable frequency, and constant output voltage. It consists of a 2-stage resistance-coupled audio amplifier which has a portion of its output fed back to its input through frequency-selective network, so that oscillation occurs at one frequency. The amplitude of the oscillation is controlled by a degenerative network in the cathode of the first amplifier tube. This degenerative network includes a small lamp filament in such a manner that an increase in oscillation amplitude causes an increase in the resistance of the lamp filament. In turn, the amount of degenerative or negative feedback is increased and maintains a constant amplitude of oscillation.

b. The modulation frequency is determined by the time constants of the regenerative resistance-capacitance network. The MODULATION switch (fig. 31) adjusts the resistance to the correct value to produce 8,200 and 400 cycles per second. By setting this switch to the OFF position, the grid of the 7C5 tube is shorted to ground; thereby turning off the modulation.

c. The audio-output amplitude has been adjusted to produce 30 percent modulation. Modulation is accomplished by varying the plate voltage of the r-f oscillator.

125. ATTENUATOR.

a. The mutual inductance-type attenuator shown at the extreme right-hand corner of figure 31, gives a logarithmic variation of output voltage with linear displacement of the movable tube. This attenuator consists of a grounded metallic tube placed so that one end is near the r-f oscillator coil. A second coil is attached to the movable inner tube which can be moved linearly inside the grounded

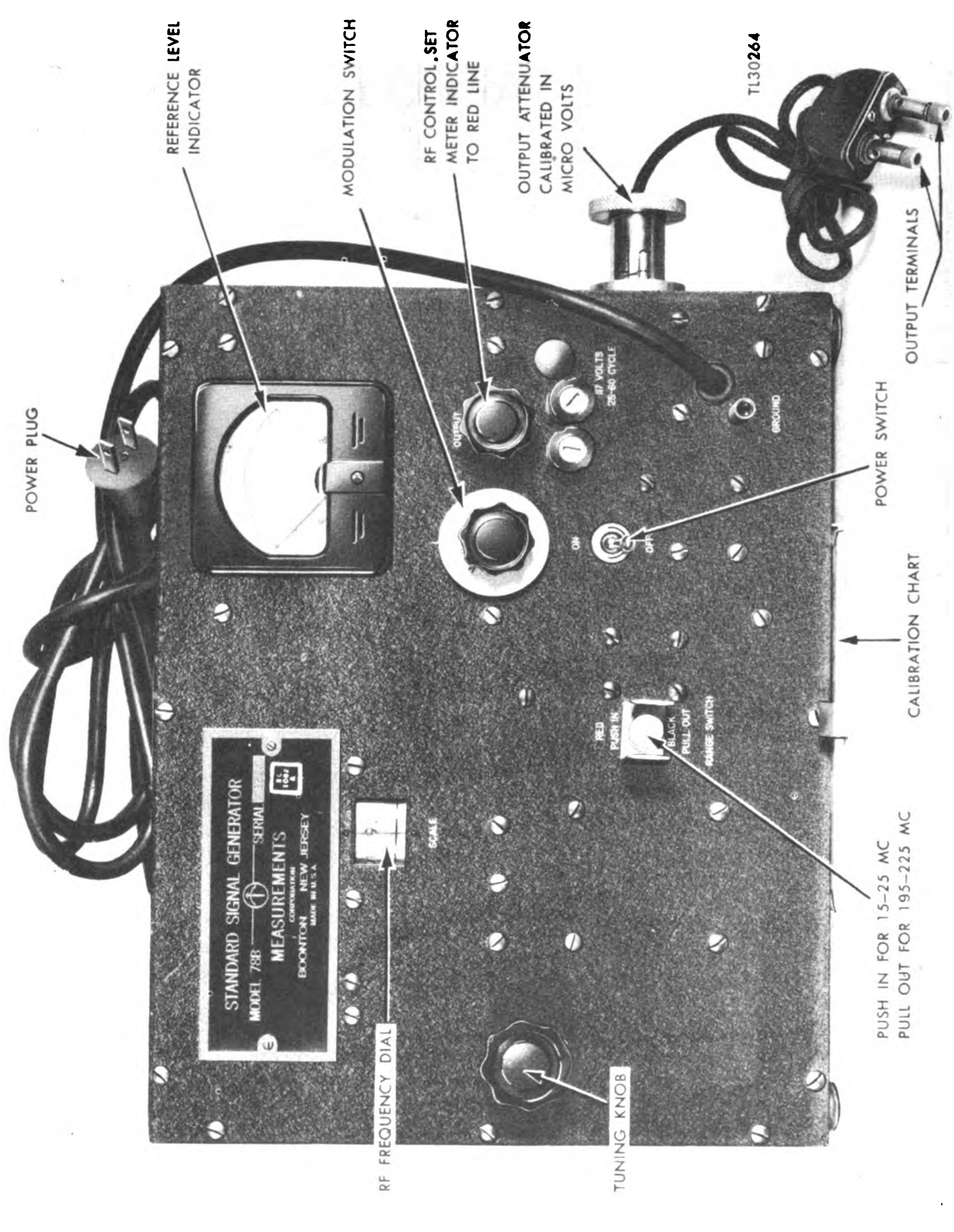


Figure 31. Signal Generator I-126, Measurements model 78-B, panel view.

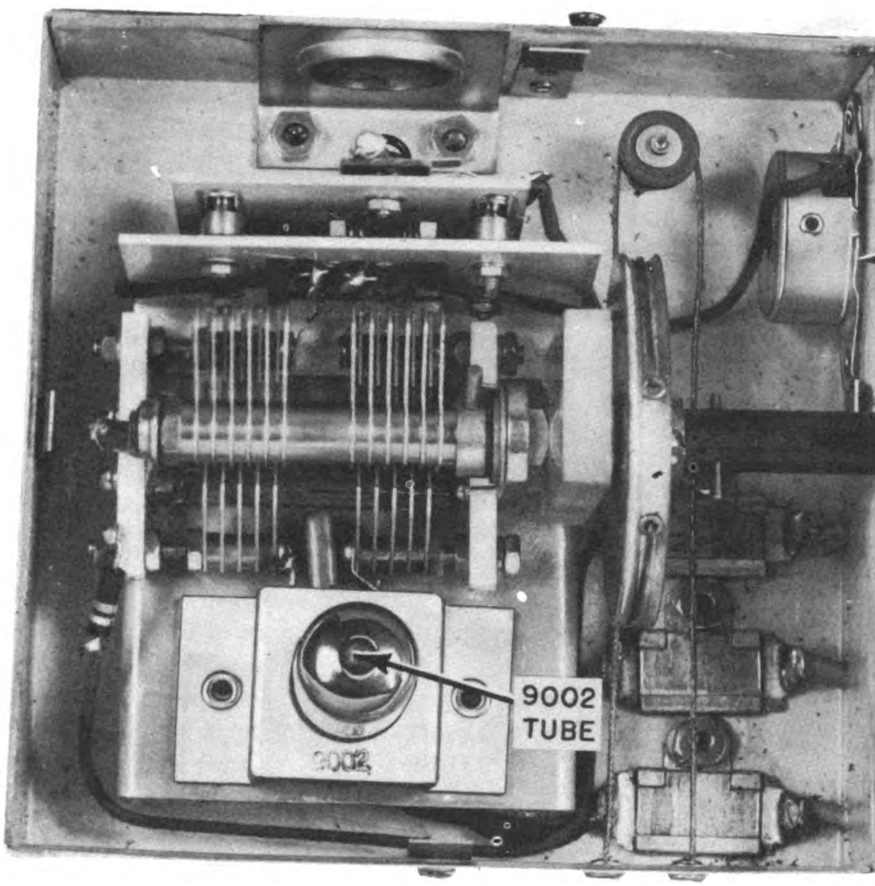


Figure 32. Signal Generator I-126, Measurements model 78-B, r-f unit, shield removed.

outer tube to change the coupling and thus vary the output voltage or signal strength. The movable coil is connected to the output terminals by a cable which is terminated in its characteristic impedance of 34 ohms to eliminate standing-wave errors. Note that one of these terminals is grounded and that a separate GROUND terminal is mounted (fig. 31) upon the front panel. It is necessary to reset the OUTPUT meter as the attenuator coupling is varied.

b. The OUTPUT meter indicates the oscillator grid current so that a standard fixed input to the attenuator is maintained. As the signal generator is tuned through its frequency range, it is necessary to readjust the OUTPUT meter to the red mark by means of the OUTPUT knob. This knob controls the plate voltage applied to the r-f oscillator.

126. POWER SUPPLY.

a. The power supply employs a power transformer having an unusually large core cross-section capable of operating on frequencies as low as 25 cycles. It is possible to operate the instrument on 60-cycle or higher frequencies without any change in power supply. The high voltage is rectified by a full-wave rectifier 7Y4 tube and filtered to eliminate a-c ripple. No electrolytic capacitors are used in the instrument.

b. A type VR-150-30 gaseous-regulator tube is used to maintain constant plate voltage on the r-f

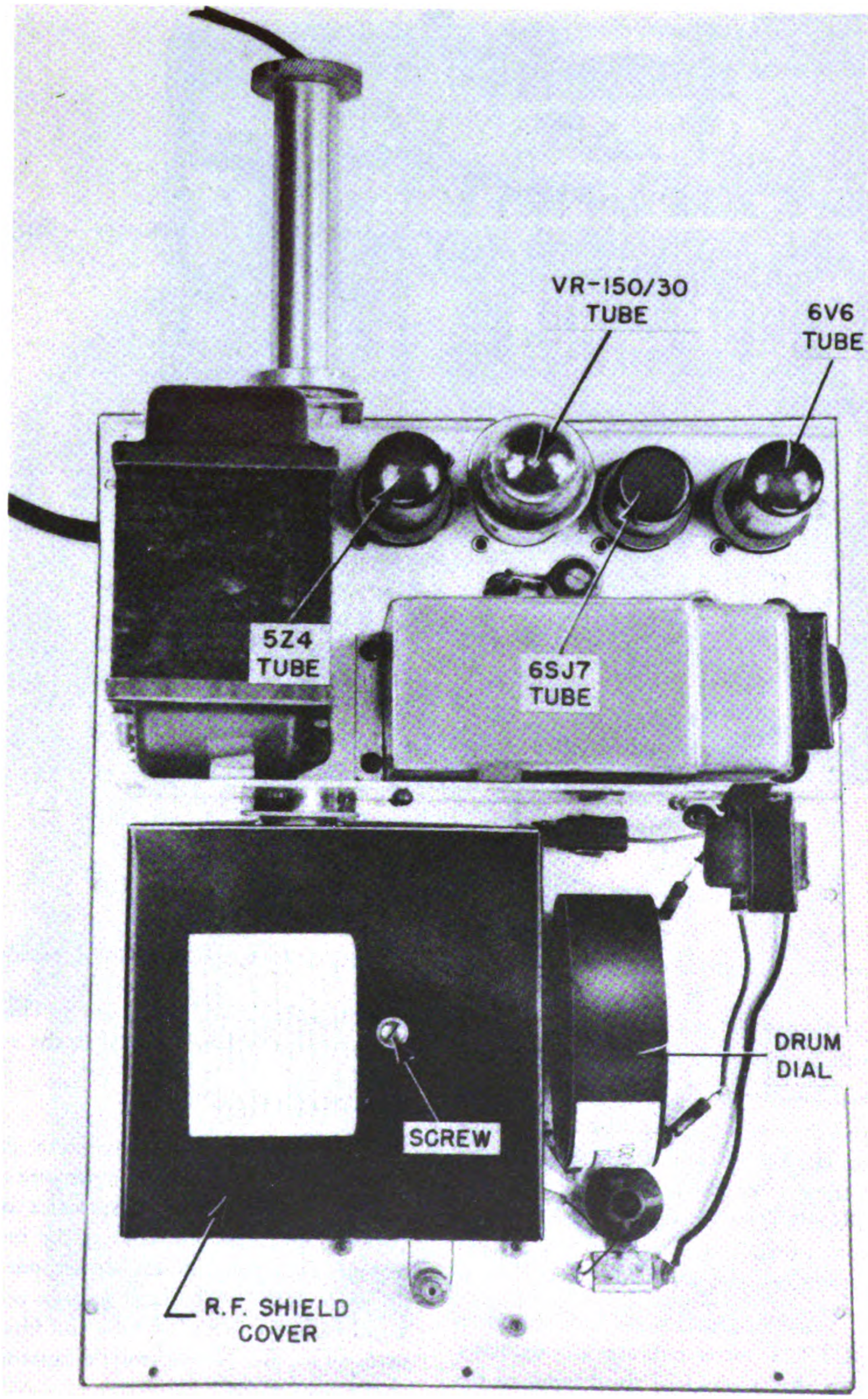


Figure 33. Signal Generator I-126, Measurements model 78-B, rear view with case removed.

oscillator in order that the output and frequency of the generated carrier will be substantially independent of power-supply variations.

c. One-ampere, panel-mounting fuses have been inserted in each side of the power line to protect the instrument against damage, if attempts are made to operate the instrument on direct current or 220 volts. It is important that these be replaced with fuses of the correct type, otherwise the instrument may be damaged seriously.

127. APPLICATIONS AND LIMITATIONS.

a. General. The signal generator included with Test Equipment RC-68-(*) is used in connection with the alignment and repair of the radio-frequency stages of Receivers BC-406 and BC-406-A. The proper signal input for alignment of the r-f and i-f stages of the receiver is provided, and the same signal is used to trace signals for fault location in these stages. Figure 30 illustrates the proper test connections for using the signal generator as a source of signal input to the i-f stages of the receiver.

b. Frequency Range. The signal generator can be used as a source of signals for only those fundamental frequencies that fall within the range for which it is designed. Naturally, the harmonics of these signals are also present.

(1) Measurements model 78-B has two frequency ranges: 15 to 25 megacycles, and 195 to 225 megacycles.

(2) Measurements model 78-C also has two frequency ranges: 15 to 25 megacycles, and 90 and 125 megacycles.

c. Modulation Frequency. The audio frequencies at which the carrier signal is modulated are predesignated and can therefore only be applied to those circuits designed for the same audio frequencies.

(1) Measurements model 78-B has two modulating frequencies that can be applied to the signal generated: 400 cycles per second, and 8,200 cycles per second.

(2) Measurements model 78-C also has two modulating frequencies that can be applied to the generated signal: 400 cycles per second, and 625 cycles per second.

d. Output Coupling. There is no blocking capacitor in the output circuit of this signal generator, and the secondary of its output transformer can provide a short-circuited path for d-c potentials, for example, bypassing the bias or any other operating potential. For this reason care must be taken in making connection of the test leads when applying the signal voltage to a circuit under test. For instance, if the signal-generator output terminals are connected directly across the grid circuit of any i-f stage, the grid bias will be shorted out if a blocking capacitor is not inserted in series with the *hot* lead. The proper connection for applying a signal voltage to the grid of the first i-f is illustrated in figure 30. When working at approximately 200 mc, the value of the blocking capacitor should be about 0.002 mf; when working in the i-f system at approximately 20 mc, the value of this blocking capacitor should be about 0.006 mf.

e. Impedance Matching. It is advisable to avoid wide variance between the output impedance of the signal generator and the impedance of the circuit to which the signal is being applied. No internal provision is made for selecting different output impedances, but Plug PL-218 is provided with Test Equipment RC-68-(*) to be used when feednig the output of the signal generator into the antenna input of Receiver BC-406-A. The use of Plug PL-218 in this capacity is illustrated in figure 60.

f. Frequency Accuracy. The signal generator is *not* a primary signal standard. Each time it is used for receiver aligning, check it against a frequency meter which has the proper crystal for the frequency range desired.

g. Sparks. Due to the fact that filter capacitors are connected across the power transformer primary to ground, a small spark may be noted when the ground lead from the signal generator is connected to the chassis of the receiver. This is a normal condition.

128. OPERATING INSTRUCTIONS.

a. Plug the power-line cord into a 117-volt line having a frequency of 25 to 60 cycles.

b. Throw the OFF-ON power switch to the ON position and allow about 30 seconds for the tubes to warm up.

c. Adjust the reading on the OUTPUT meter to the red mark by means of the OUTPUT knob. If no reading is obtained, check the plunger switch marked RANGE SWITCH and make sure that it is either all the way in or all the way out. Inspect the two 1-ampere fuses available on the front of the panel. These fuses are easily removed by unscrewing them from their sockets.

d. To select either of the two frequency bands, push the RANGE SWITCH either all the way in or pull it all the way out. For the low-frequency band, 15 to 25 megacycles, push the RANGE SWITCH all the way in; for the high-frequency band, 195 to 225 magecycles, pull the switch all the way out.

e. Pull out the frequency calibration chart which is mounted upon a sliding frame attached to the bottom of the cabinet, and determine the setting of the frequency dial for the desired frequency.

f. Adjust the frequency dial marked SCALE to this setting by means of the TUNING knob located at the left side of the panel.

g. To secure a modulated output, turn the MODULATION dial to the 400 or 8,200 position. To remove the modulation, set the dial to OFF.

h. The output is controlled by the sliding tube at the right side of the instrument to which is attached the output cable with output terminals. This output is indicated on the scale which is engraved on the sliding tube. Pulling the tube out completely decreases the output to 1 microvolt; whereas pushing the tube in completely increases the output to 100,000 microvolts.

i. Very short leads must be used to connect the output terminals to the receiver under test. Leads longer than 2 inches at 200 megacycles will cause serious errors in output voltage.

j. Insert in series with the output leads the correct dummy-antenna resistance determined by subtracting 34 ohms from the desired value. For example, Receiver BC-406 and BC-406-A operate from individual antenna impedances of 300 ohms, so that the dummy-antenna resistor is 300 ohms minus 34 ohms, or 266 ohms. Since the receiver is designed for operation from a balanced input line, this dummy-antenna resistor should be equally divided in each side of the line; that is, it should have 133 ohms in each leg. In actual practice, 150 ohms are placed with each leg of the output cable between the signal-generator output terminals and the receiver input. For detailed instructions consult paragraph 165.

k. Make sure that the OUTPUT meter is adjusted to the red line; otherwise the output voltage indicated on the engraved scale will not be correct. In this connection note that the output-voltage indication is subject to inaccuracies at high frequencies, especially when the output voltage is low. The *effect* of leakage from the cable becomes important at low output settings of the attenuator and decreases as the attenuator is set for a higher signal output.

129. MAINTENANCE AND REPAIR.

a. *General*. (1) In ordinary maintenance and repair work, care should be taken not to change the position or adjustment of the output or r-f oscillator coils. It is imperative that in the event any parts are removed for inspection or replacement, they must be replaced exactly as before. Neglect of this precaution may result in output-voltage error of many hundred percent, or it may even set up leakage fields so great that the instrument is rendered useless.

(2) If interrupted service does occur and the trouble cannot be easily located, only experienced personnel should undertake trouble shooting and recalibration of this instrument with precision-testing equipment.

b. *Fuses*. (1) If no reading is obtained on the output meter, the fuses should be inspected. They are located near the power cord and are readily accessible from the front of the panel.

(2) Whenever a fuse is blown, it should be replaced with a standard 1-ampere, type-3AG fuse.

(3) If the fuses continue to blow, the power supply should be checked for correct voltage and frequency.

c. Tubes. (1) An inspection of the VR-150 /30 voltage-regulator tube, visible thru the louvres on the right-hand side of the case, will disclose whether or not the B+ supply is functioning. The absence of a purple glow in this tube indicates possible trouble in the rectifier tube, power transformer, filter capacitors, or the line filter.

(2) The tubes can be tested and replaced easily after the case has been removed. Remove the generator from the case in the following manner: Place the instrument on its back on a bench and remove the 12 screws around the edge of the panel. The front panel to which are attached all of the components may then be lifted from the case. Place the panel face down on the bench and remove the screw which holds the black r-f shield cover in place; then inspect the r-f unit.

(3) It may be well to insert a new type 9002 tube, since some tube testers do not adequately indicate usefulness of the tube as a high-frequency oscillator. The type 9002 tube should have a mutual conductance of at least 1,800 microhms as measured on a dynamic mutual-conductance tester. The plate voltage of the a-f oscillator varies with the range switch and with the setting of the OUTPUT knob.

(4) A dull red glow of the filament lamp in the oscillator circuit indicates sufficient negative feedback, and under normal conditions the modulator tube 7C5 should have no difficulty in supplying this small amount of power without distortion.

(5) The audio-output amplitude has been adjusted by the manufacturer to produce 30 percent modulation. A VR-150/30 regulator tube is used to hold the plate supply to the constant value of 150 volts d-c. The audio is adjusted to deliver 45 peak volts (32 volts rms) by means of the feedback control at the top of the modulation and power unit (45 volts is 30% of 150 volts). Due to the large amount of negative feedback and automatic control effected by the lamp filament, the modulator will continue to deliver 45 peak volts over a wide range of power-supply voltage.

d. Power Unit. If the trouble is localized in the power unit, remove this unit from the front panel in the following steps:

(1) Unsolder the wires leading from the terminal strip located just above the drum dial.

(2) Unsolder the twisted red and black leads from the power-line by-pass capacitors located on the front panel directly under the power transformer.

(3) Remove the knobs marked OUTPUT and MODULATION and remove the ½-inch nuts underneath them.

(4) Remove the six screws that hold the power unit in place and lift the entire unit from the front panel.

(5) Care should be taken to remove only the proper screws in this procedure, as other loose screws may cause trouble.

(6) After the trouble has been located and the repairs made, the instrument can be reassembled by reversing the order of the above-mentioned steps. Care should be taken not to disturb the adjustment of the three variable rheostats, unless recalibration is necessary.

e. Percent Modulation Recalibration Procedure. (1) The rheostat marked AUDIO OSCILLATOR controls the percentage modulation.

(2) To adjust the modulation percentage, a vacuum-tube voltmeter arranged to block off d-c should be connected to the B lead to the oscillator and to ground.

(3) The output control knob should be turned all the way up (maximum) and the rheostat turned until a peak reading of 45 volts or 32 volts rms of audio voltage is indicated on the vacuum-tube voltmeter (vtvm).

(4) It is of course necessary that the modulation switch be set on either 400 or 8,200 in order to do this.

(5) Since the VR-150/30 tube holds the applied plate voltage constant at 150 volts, the carrier will be modulated 30 percent by the 45 peak volts of modulation.

f. Attenaution Output Calibration Procedure. The relative calibration of the mutual-inductance attenuator is fixed, but the absolute reference level of 100,000 microvolts or $\frac{1}{10}$ volt can be adjusted.

(1) A sensitive vacuum-tube voltmeter having low input capacity and very short leads in order to produce a self-resonant frequency above 300 megacycles, should be connected across the output terminals. The attenuator should be adjusted to read

100,000 microvolts with the range switch set for a 90- to 125-megacycle range on the model 78-C or a 195- to 225-megacycle range on the model 78-B.

(2) The modulation must be turned OFF.

(3) The output control should be set at approximately ¾ of its full rotation clockwise; then the rheostat marked OUTPUT METER CALIBRATION located on the side of the power unit chassis should be adjusted until the output meter reads on the red mark with the frequency dial set at about 100 megacycles on model 78-C or 210 megacycles on model 78-B.

(4) The setscrew located in the hole in the knurled knob on the attenuator slider should be loosened, and the position of the output pick-up coil adjusted until the vtvm reads $\frac{1}{10}$ volt.

(5) This can be accomplished by moving the ¼-inch chrome-plated tube which projects from the high-frequency oscillator coil, and should be oriented in the same direction as the oscillator coil for maximum pick-up.

(6) The setscrew in the knurled knob should then be tightened securely.

(7) The switch should now be changed to the low-frequency range and the frequency dial adjusted to about 20 megacycles.

(8) With the attenuator still adjusted to read 100,000 microvolts, the output knob should be adjusted until the vtvm reads $\frac{1}{10}$ volt.

(9) The rheostat inside the r-f oscillator shield (fig. 32) then should be adjusted until the meter reads opposite the red mark.

(10) The rheostat is accessible from the top of the r-f oscillator just to the right of the frequency-scale drum.

g. Voltage from Vacuum-tube Terminals to Ground with Power and Rectifier Turned on. The following table gives typical values of voltage from vacuum-tube terminals to ground with the power and rectifier turned on:

TABLE V

TABLE OF TUBE-SOCKET VOLTAGES TO GROUND

All voltages are dc unless followed by an asterisk (*). All measurements are made with a 20,000-ohm-per-volt voltmeter.

Type No.	Designation	Socket terminals							
		1	2	3	4	5	6	7	8
7L7	Amplifier	0	70	65	1.6		0	2	6.5*
7C5	Modulator	0	230	150			0	9	6.5*
UR150-30 (VT-200)	Voltage regulator		0	270		150		270	
7Y4	Rectifier	0		235*			235*	270	6.5*
		Plate		Grid		Filament			
9002 (VT-202)	R-f oscillator	40 to 110		—0.3		6.5*			

* A-c voltage.

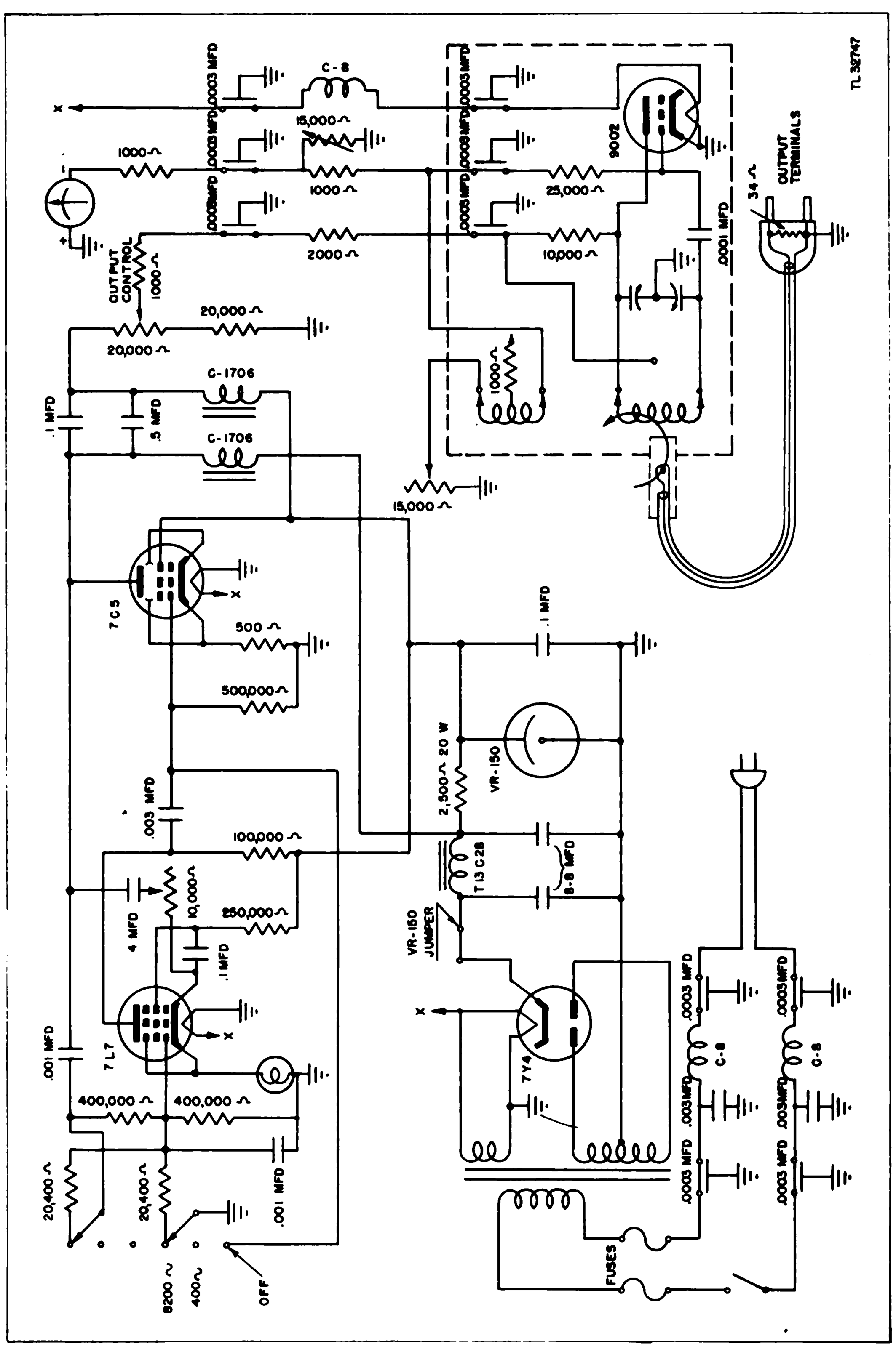


Figure 34. Signal Generator I-126, Measurements model 78-B, schematic diagram.

h. Resistance Values from Tube Terminals to Ground Using Analyzer I-167 or I-153-A. The following table covers approximate resistance values from tube terminals to ground with no power supplied to the circuit and using Analyzer I-167 or I-153-A.

TABLE VI

TABLE OF TUBE-SOCKET RESISTANCES, OHMS TO GROUND

Type No.	Designation	Socket terminals							
		1	2	3	4	5	6	7	8
7L7	Amplifier	0	140,000	295,000	350		395,000	400	0
7C5	Modulator	0	50,000	40,000			480,000	450	0
UR150-30(VT-200)	Voltage regulator		0	40,000		40,000		40,000	
7Y4	Rectifier	0		400			400	40,000	0
		Plate		Grid	Filament				
9002 (VT-202)	R-f oscillator	40,000		25,000	0				

SECTION XVIII

SIGNAL GENERATOR, MEASUREMENTS MODEL 78-C

130. DIFFERENCES BETWEEN MEASUREMENTS MODELS 78-B AND 78-C.

a. Measurements model 78-C is identical with Measurements model 78-B, except for the ranges of frequencies and choice of modulation. Measurements model 78-B covers two frequency ranges: 15 mc to 25 mc, and 195 mc to 225 mc; whereas Measurements model 78-C covers two frequency ranges: 15 mc to 25 mc, and 90 mc to 125 mc.

b. The other difference between the two instruments is that Measurements model 78-B provides for modulation at 400 cycles and 8,200 cycles per second; while Measurements model 78-C makes provision for modulation at 400 cycles and 625 cycles per second.

131. APPLICATION TO RADIO SET SCR-268-(*).

a. In all other respects, the two units are alike. Note, however, that the highest frequency available with the Measurements model 78-C is 125 mc. This limitation necessitates the use of the second harmonic in alignment of the r-f channels of Receiver BC-406 and BC-406-A; that is, the signal generator is tuned to 102.5 mc instead of 205 mc.

b. Since the second harmonic is always weaker than the fundamental, the attenuator calibration does not apply to the second harmonic, and the output of the Measurements model 78-C will have to be increased a great deal to equal the output of a signal generator tuned to 205 mc. However, it is possible to determine the relative gain per stage even though the actual sensitivity is unknown. In other words, all comparisons of relative sensitivity are possible except the determination of absolute sensitivity which requires a signal voltage at the fundamental sensitivity of 205 mc.

c. With the exception of the frequency setting and lack of absolute output indication, the procedure for the use and application of Measurements model 78-C signal generator is precisely the same as that for Measurements model 78-B, described in paragraphs 127 and 128. Therefore, reference to the schematic of model 78-B may be made in connection with model 78-C, bearing in mind that the manufacturer's instruction book should be consulted for correct values of component parts.

SECTION XIX

SIGNAL GENERATOR, FERRIS MICROVOLTER 18-B

132. GENERAL. The Ferris microvolter, model 18-B, is another type signal generator provided with Test Equipment RC-68-(*). This instrument is a 4-tube, 4-band, ultra-high-frequency signal generator, operative over the frequency band of 18 megacycles to 155 megacycles. The individual frequency bands are: 18 mc to 34 mc, 32 mc to 60 mc, 55 mc to 105 mc, and 100 mc to 155 mc. These lettered band desginations appear upon the front panel of the instrument (fig. 35) The schematic diagram of the instrument is illustrated in figure 37.

133. CIRCUIT DESCRIPTION.

a. The microvolter consists of a 955 tube (VT-121) used in a Hartley oscillating system; a 76-tube (VT-133) used as a 400-cycle oscillator to develop the modulating voltage; a 5Y3GT-tube (VT-197-A) as a full-wave power rectifier; a 1055-A neon tube as a B+ voltage regulator; and a 955 tube (VT-121) used as a diode rectifier for the r-f reference-level indicator.

b. The 400-cycle audio oscillator is adjusted for approximately 30 percent modulation. A switch marked MODULATION is provided, to shut off modulation when not desired.

c. The attenuator system consists of an attenuator and an inductive potentiometer calibrated from 0.1 microvolt to 10 microvolts. The attenuator 5-position decade unit with ranges of 1.0, 10.0, 100.0, 1,000.0, and 10,000.0 times the settings of the variable attenuator. The maximum output from the generator is 100,000 microvolts.

d. The output cable terminates in a 30-ohm resistor contained in a small metal housing which also mounts the two output terminals.

e. The r-f reference-level indicator is a vacuum-tube voltmeter of the diode type, utilizing a 955-tube with the grid and plate joined together. The reference-level indication upon this meter must be 1.0 volt for proper application of the attenuator calibrations.

f. Tuning is done by means of a variable capacitor with a vernier adjustment (fig. 35). Calibration of the device is indicated upon calibration curves supplied with the instrument.

134. USE OF SECOND HARMONIC. The highest frequency available from Ferris microvolter 18-B is below the carrier frequency of 205 megacycles required for the receiver. This necessitates the use of the second harmonic of a 102.5-megacycle setting of the tuning dial. Since the second harmonic is weaker than the fundamental, the output voltage must be increased. This upsets a direct reading of the signal output supplied from the signal generator to the receiver under test for the reason that the settings of the output attenuators apply to the fundamental frequency generated by the signal source, and *not* to the second harmonic. It is still possible to determine the relative gain per stage of the receiver, even though the actual sensitivity is unknown. In other words, all comparisons of relative sensitivity are possible except the determination of absolute sensitivity.

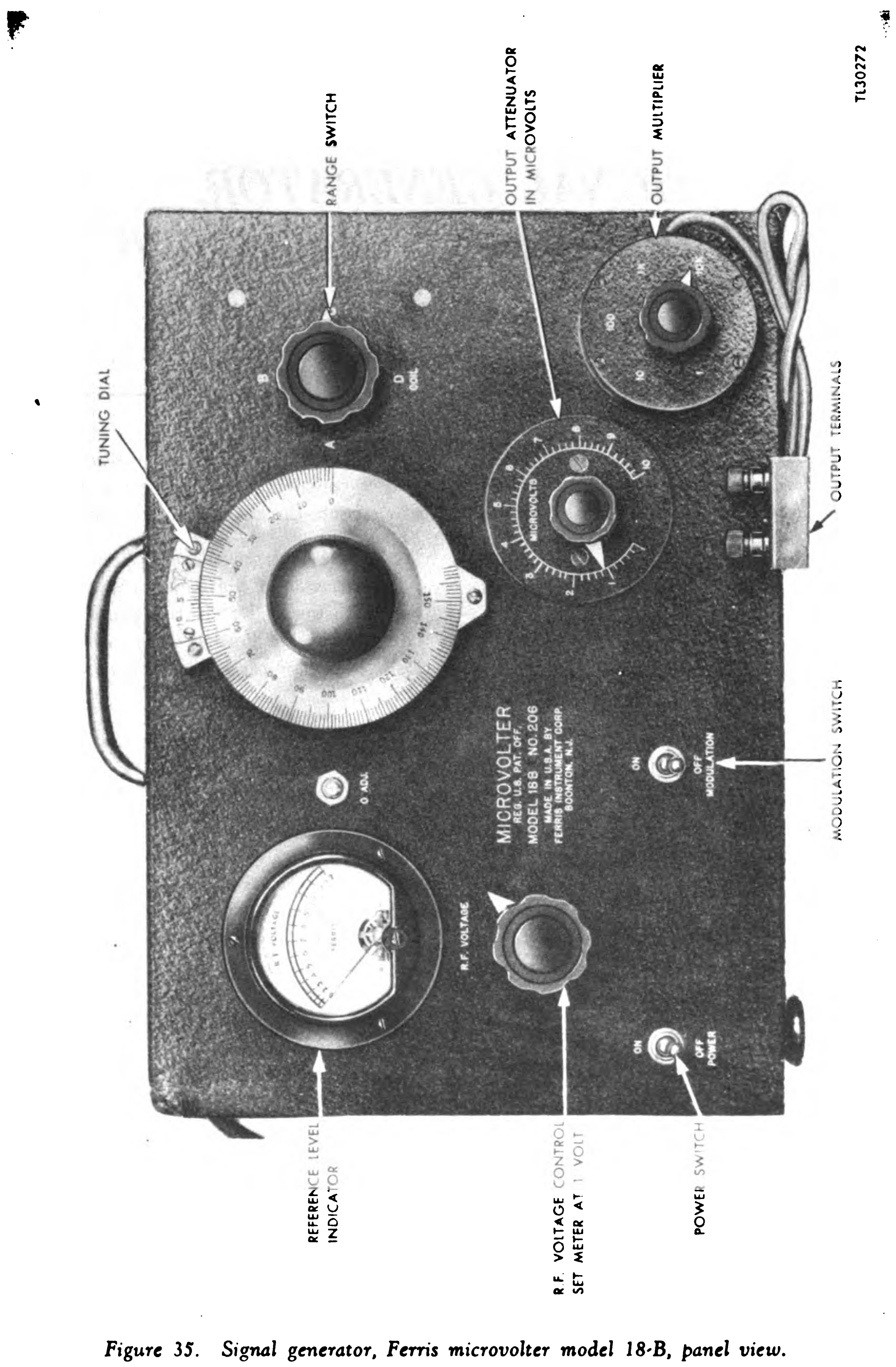


Figure 35. Signal generator, Ferris microvolter model 18-B, panel view.

The latter requires a signal voltage at the fundamental frequency of 205 megacycles.

135. APPLICATIONS AND LIMITATIONS.

a. General. The signal generator included with Test Equipment RC-68-(*) is used in connection with the alignment and repair of radio-frequency stages of Receiver BC-406 and BC-406-A. The proper signal input for alignment of the i-f stage of the receiver is provided, and the second harmonic of one of the listed frequencies is used for the r-f stages. These signals are used to trace signals for fault location in these r-f stages. Figure 30 illustrates the proper test connections for using the signal generator as a source of signal input to the i-f stages of the receiver.

b. Frequency Range. The signal generator can be used as a source of signals for only those frequencies that fall within the range for which it is designed or for the proper harmonic of one of these frequencies. The Ferris model 18-B has four frequency ranges: 18-34 megacycles, 32-60 megacycles, 55-105 megacycles, and 100--155 megacycles.

c. Modulation Frequency. The audio frequencies at which the carrier signal is modulated are predesignated and can therefore only be applied to those circuits designed for the same audio frequencies. Ferris model 18-B has only one modulating frequency which is 400 cycles.

d. Output Coupling. No blocking capacitor exists in the output circuit of this signal generator, and the secondary of its output transformer can provide a short-circuited path for d-c potentials, as for example, bypassing the bias or any other operating potential. For this reason, care must be exerted in making connection of the test leads when applying the signal voltage to a circuit under test. For instance, if the signal-generator output terminals are connected directly across the grid circuit of any i-f stage, the grid bias will be shorted out if a blocking capacitor is not inserted in series with the hot lead. The proper connecton for applying a signal voltage to the grid of the first i-f stage is illustrated in figure 30. When working at approximately 200 mc, the value of the blocking capacitor should be approximately 0.002μf. When working in the i-f system at about 20 mc, the value of this blocking capacitor should be approximately 0.006μf.

e. Impedance Matching. It is advisable to avoid wide variance between the output impedance of the signal generator and the impedance of the circuit to which the signal is being applied. No internal provision is made for selecting different output impedances, but Plug PL-218 is provided with Test Equipment RC-68-(*) to be used when feeding a signal from the signal generator into the antenna input of Receiver BC-406-A. The use of Plug PL-218 in this capacity is illustrated in figure 60.

f. Leakage. Although every effort is made to confine the transfer of signals from the signal generator to the load through the output cable, some leakage directly from the cable and from the case that mounts the output cable terminals is unavoidable. Every effort should be made to shield the output cable from exposed receiver circuits. In the case of Receiver BC-406, this is done by running the cable along the edge of the receiver chassis. This cable must be run on the outside of the chassis, so that the metal wall is between the cable and the exposed circuits of the set.

g. Sparks. Because of the presence of filter capacitors across the primary of the power transformer, sparks may be noticed when the GND terminal of the signal generator is connected to the chassis of the receiver. This is a normal condition.

h. Precautions. Microvolters and signal generators are frequently damaged by careless usage. Instruments designed to be operated by alternating current should never be connected to a d-c source of power. Furthermore, the case should be grounded to avoid shocks to the operator. If this is not done, the case will be above ground potential due to the filter capacitors connected across the power line (fig. 37).

136. OPERATION OF FERRIS MICROVOLTER 18-B. Operation of the Ferris microvolter is carried out according to the following procedure:

a. Plug the power cord into a 115-volt, 50- to 60-cycle a-c power supply.

b. Throw the POWER switch to the ON position, and allow the unit to warm up for a few minutes.

c. Turn the R-F VOLTAGE control counterclockwise as far as it will go, thus removing the plate voltage from the r-f oscillator and reducing its output to zero.

d. Note the indication upon the R-F VOLTAGE meter. If the indication is not zero, adjust the O ADJ screw for zero indication upon the meter.

e. Set the COIL knob to the desired frequency range, and the tuning dial to the desired frequency. Consult the calibration chart provided with the unit.

f. Rotate the VOLTAGE control clockwise. The meter indication should increase, and the reference level of 1.0 volt on the r-f voltage meter should be reached without approaching the limit of rotation of the R-F VOLTAGE control.

g. A correct indication on the r-f voltage meter should be available on all ranges, but will vary with changing frequency and require resetting as the tuning is changed. The meter should be set at 1.0 volt in order to read the output directly in microvolts. At this setting the output in microvolts is equal to the reading on the microvolt dial multiplied by the setting of the attenuator knob which is located at the extreme lower right on the panel.

h. Thus, a setting of 5.5 on the microvolt dial (fig. 35), and a setting of 1K on the attenuator knob, represent a signal output of 5.5 microvolts x 1,000 or 5,500 microvolts, assuming the r-f voltage meter to read 1.0 volt. If the MICROVOLTS dial is set at 8.0 and the attenuator is set at 1.0, the output is 8.0 x 1.0 or 8.0 microvolts, etc. If for any reason (such as aging of the r-f oscillator tube) the r-f reference meter reading cannot be brought up to the 1.0-volt mark, reduce the reading to 0.5 volts and multiply by 0.5, the product of microvolt dial times attenuator settings.

i. Throw the MODULATION switch to ON position for 30 percent modulation at 400 cycles.

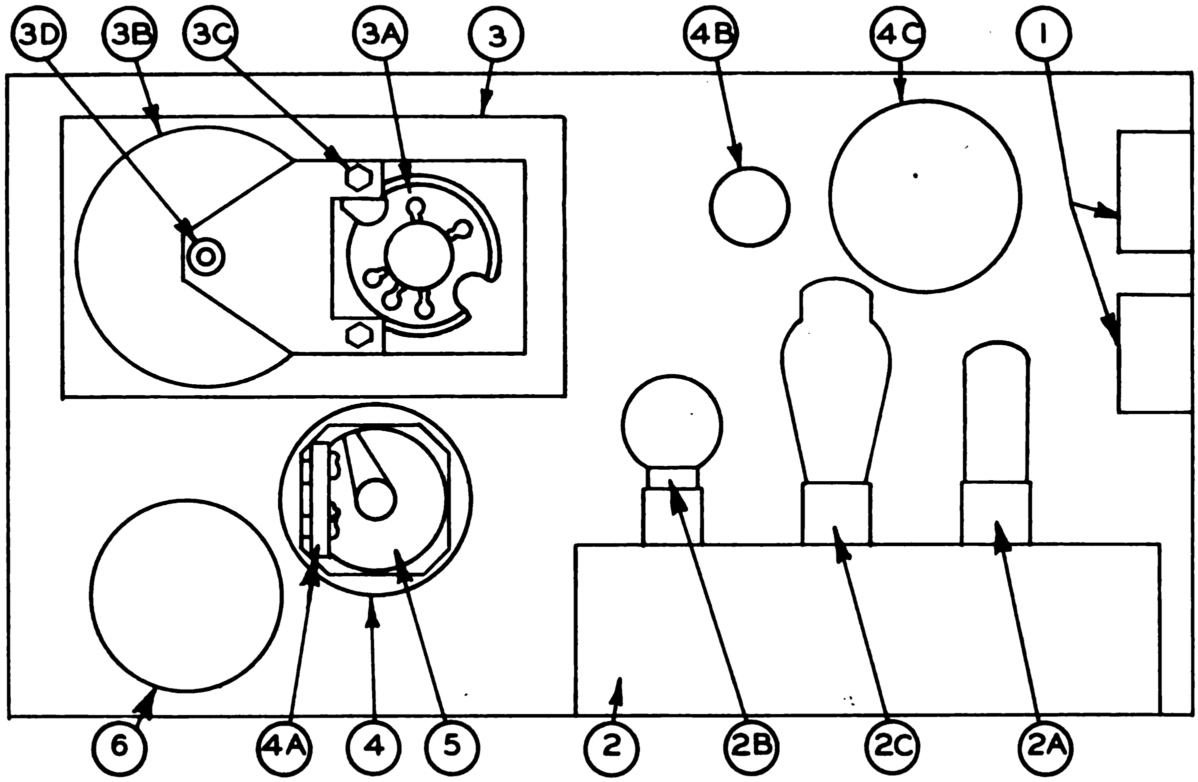
j. Because of the low output impedance of the signal generator, when the instrument is applied to circuits of higher impedance, the insertion of compensating resistor is required in order to make up the required impedance. When the Ferris microvolter 18-B is applied to Receiver BC-406 antenna-input terminals, place a 150-ohm resistor in series with each leg of the output cable, between the signal-generator terminals and the receiver input (fig. 60).

k. In connecting the output terminals to the receiver under test extreme care must be taken to use the shortest possible connecting leads, as a few inches of connecting wire may make a great difference in the results. Errors of several hundred percent frequency occur when leads of the order of 6 to 12 inches long are used, particularly when working into a reactive load, such as a tube grid.

137. MAINTENANCE AND REPAIR.

a. General. In the event that the instrument should develop trouble which cannot be easily located, it should be serviced only by experienced personnel who have the necessary testing equipment to localize the fault and who can perform the proper maintenance tests. The design of microvolter model 18-B is infinitely more critical and dependent upon the exact placement of parts than is the case with instruments intended for lower frequencies. It is imperative that any parts removed for inspection or replacement must be replaced in exactly the same positions, and all wiring must be replaced precisely as originally found. Neglect of this precaution may result in output-voltage errors of several hundred percent, or the introduction of serious leakage fields so great as to make the instrument unusable. The tubes should first be checked when trouble develops in the instruments. Since the 955 (VT-121) acorn-type high-frequency tube has a rather short life, it should be inspected immediately.

b. Tubes. (1) The rectifier and the audio-oscillator tubes, type 5Y3GT (VT-197-A) and 76 (VT-133) respectively and the neon-regulator tube, type 1055-A are accessible (fig. 36) upon removal of the back of the outer case.



1. F18AQ-1 LINE FILTER UNIT
2. F18AP-6 AUDIO OSCILLATOR MODULATION & POWER SUPPLY
2A. 5Y3-GT RECTIFIER TUBE
2B. 1055-A NEON VOLTAGE REGULATOR
2C. 76 AUDIO OSCILLATOR TUBE
3. F18AO-6 R.F. OSCILLATOR UNIT
3A. 955 R.F. OSCILLATOR TUBE
3B. FAO-10 R.F. COIL ASSEMBLY
3C. BRACKET NUTS
3D. COIL DRUM BEARING NUT
4. F18AH-2 VTVM CALIBRATE' SLIDEWIRE ASSEMBLY
4A. 955 VTVM TUBE
4B. VTVM ELECTRICAL ZERO ADJUST
4C. VTVM INDICATING METER
5. FAH-4 CALIBRATED SLIDEWIRE
6. F18AA-5 STEP ATTENUATOR

TL 32724

Figure 36. Signal generator, Ferris microvolter model 18-B; rear of chassis.

(2) The r-f oscillator tube, type 955 (VT-121), is reached by removing the copper shield cover of the r-f oscillator unit, type 163-A.

(3) The r-f voltmeter tube, type 955 (VT-121), can be reached by removing the shield cover over the slide-potentiometer unit which is located directly under the r-f oscillator unit.

(4) All covers must be carefully replaced and the screws which fasten these covers in place must be drawn up tightly after any inspections or tube replacements. The back cover of the outer case must be fastened securely in place to avoid external leakage from the generator.

c. R-f Voltage Meter Test. (1) If the coil switch is set between points or the R-F VOLTAGE control turned all the way to the left, the R-F VOLTAGE meter should read zero. If it is not possible to bring this reading to zero, trouble exists in the voltmeter circuit.

(2) The most prevelent symptom of trouble is a strong deflection below zero, which indicates that current is flowing backwards through the meter. This can be caused by a defective resistor in the voltmeter circuit, a defective neon regulator, an open circuit, or by a defective voltmeter tube.

(3) Replace the tube and observe if its heater is operative. A glow can usually be seen in the tube when the heater is lighted.

(4) If this does not clear the trouble, trace out the circuit with a continuity tester. The zero-adjusting voltage obtained from the neon regulator is used merely to stabilize contact potentials in the tube and to balance out initial current.

(5) The output voltage of the neon regulator can be read between ground (minus) and the rivet head appearing on the audio-oscillator terminal panel midway between the lugs marked C and B. This should be in the vicinity of 65 volts.

d. Attenuation Test with Vacuum Tube Voltmeter. (1) First of all the maximum output voltage of 0.1 volt obtained with the meter set at 1.0, the set attenuator at 10K, and the potentiometer dial at 10 (100,000 microvolts) should be checked, provided a vacuum tube voltmeter of suitable characteristics is available. Keep leads at minimum length to avoid step up in the leads. If this test shows the output to be approximately 0.1 volt, the first fixed step of the attenuator is known to be correct; then, using a receiver without automatic volume control (BC-406-A), proceed as follows:

(2) Set the signal generator for 10-microvolts output (MICROVOLTS dial at 10, OUTPUT MULTIPLIER at 1). Connect the receiver to the signal generator through the usual dummy antenna, tune for correct frequency, and adjust the volume control to give a suitable output as indicated on an output meter or oscilloscope connected to the receiver.

(3) Turn the MICROVOLTS dial on the signal generator to zero, set the OUTPUT MULTIPLIER to 10, and increase the MICROVOLTS dial setting until the same output is obtained as before. The MICROVOLTS should read 1.0 since this gives 10-microvolts indicated output as before. The receiver must be steady during this test. If line voltage or anything else varies, the test should be repeated.

(4) Similar checks are made between other attenuator ranges at 100 and 1,000 microvolts by reducing the receiver sensitivity.

(5) Very close (±5%) checks should be obtained at frequencies up to about 75 megacycles. At higher frequencies than this, greater errors may be expected.

e. Voltage Tests. (1) The output voltage of the power unit, measured from terminal B to ground, should be 100 to 110 volts d-c. The heater voltage should be 6.2 to 6.4 volts a-c with a normal 115-volt a-c line.

(2) The B voltage appearing at the r-f oscillator unit is variable, depending upon the position of the R-F VOLTAGE control, since this control varies the r-f oscillator output by varying its plate voltage. The plate voltage is modulated before it reaches this control in order to preserve the control-modulation percentage as the r-f oscillator output is varied.

f. Voltages from Vacuum-tube Terminals to Ground with Power and Rectifier Turned on. The following table gives typical views of voltage from vacuum-tube terminals to ground with the power and rectifier turned ON:

TABLE VII

TABLE OF TUBE-SOCKET VOLTAGES TO GROUND

All voltages are d-c unless followed by an asterisk (*). All measurements are made with a 20,000 ohm-per-volt voltmeter.

Type No.	Designation	Socket terminals 1	2	3	4	5	6	7	8
955 (VT-121)	R-f oscillator	0	0-117	—0.15	6.3*	0			
955 (VT-121)	R-f voltmeter	6.3*	0	0	0	0.7-2.3			
76 (VT-76)	Audio oscillator	6.3*	120-140	0	4.8	0			
80 (VT-80)	Rectifier	320	325*	325*	320				
1055-A	Voltage regulator	0 and 60							

* A-c voltage.

g. *Resistance Values from Tube to Ground Using Analyzer I-167 or I-153-A.* The following table covers approximate resistance values from tube terminals to ground with no power supplied to the circuit and using Analyzer I-167 or I-153-A:

TABLE VIII

TABLE OF TUBE-SOCKET RESISTANCES, OHMS TO GROUND

Type No.	Designation	Socket terminals 1	2	3	4	5	6	7	8
955 (VT-121)	R-f oscillator	0	129,000	0	180,000	0			
955 (VT-121)	R-f voltmeter	0	0	0	0	8,500			
76 (VT-76)	Audio oscillator	0	12,000	0	750	0			
80 (VT-80)	Rectifier	18,000	290	290	18,000				
1055-A	Voltage regulator	0 and 12,000							

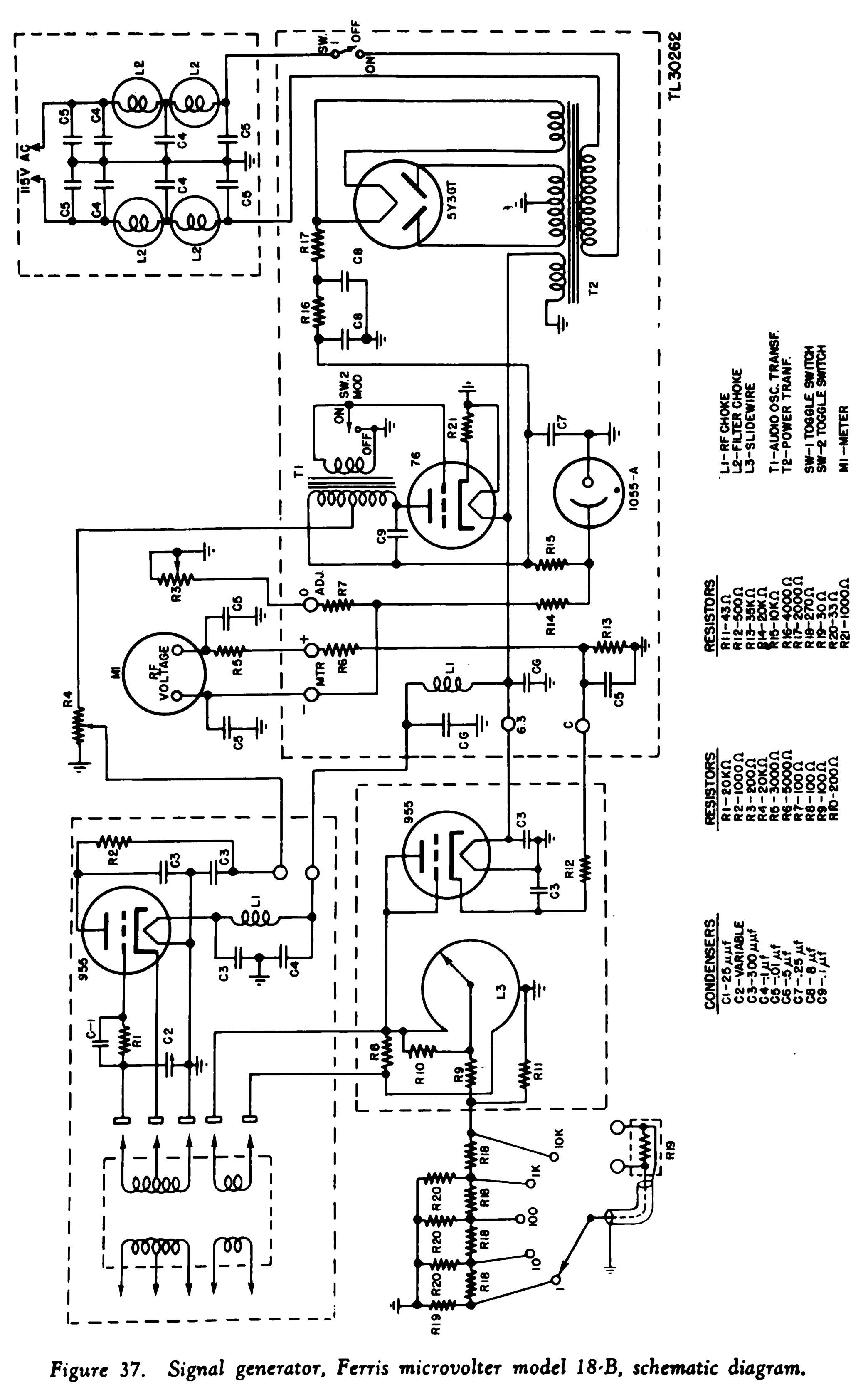


Figure 37. Signal generator, Ferris microvolter model 18-B, schematic diagram.

SECTION XX
AUDIO OSCILLATORS

138. GENERAL.

a. Purpose. Circuits containing audio voltages are to be found in many components of the radio set, such as the keyer, receiver, oscilloscope, and range unit. The maintenance and repair of these audio circuits require a signal source at audio frequencies. For this purpose Test Equipment RC-68-(*) includes audio oscillator, Hickok model 198 and audio oscillator, Supreme model 563.

b. Nomenclature. In contrast with radio-frequency signal sources, the name signal generator is seldom used in connection with audio-signal sources. No rigid rule controls this practice, but it has become customary to use the word oscillator.

c. Description. An audio oscillator is a device for producing an unmodulated, alternating voltage which can be continuously varied in frequency to cover the complete audio spectrum (approximately 15 cycles to 20 kilocycles per second). A method of applying this signal voltage to the grid of a tube is illustrated in figure 38. Although there are many forms of audio oscillators, basically they all consist of a means of generating an audio-frequency signal with vacuum tubes. This signal, with or without amplification, is fed to an amplifier-output stage which is transformer-coupled to the output terminals. The output terminals provide verious impedance taps to match the output impedance of the audio oscillator to the input impedance of the circuit to which the audio voltage is applied. The audio oscillator also includes a power supply for the tubes.

d. Calibration. To provide accurate frequency control, some form of indicator which is usually a neon bulb is used to calibrate the instrument. By means of the neon bulb, the 60-cycle line frequency is compared with the 60-cycle frequency generated by the oscillator. A calibration-adjustment control is used to set the oscillator to the point where the neon bulb flickers at an extremely low rate. At this point, the frequency of the audio voltage generated by the oscillator is the same as the line frequency.

e. Output Voltage. The output voltage can be adjusted by means of an audio-output control which is continuously variable and usually marked for reference settings.

f. Requirements. Requirements of audio oscillators are: good frequency stability, accurately calibrated frequency, good waveform, and uniformity of output over the frequency range.

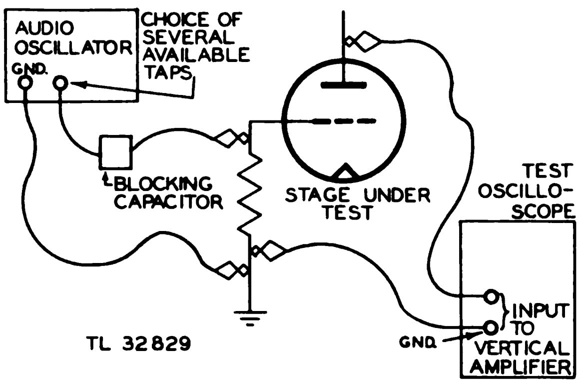


Figure 38. Audio oscillator, test connections.

(1) As far as stability and accurate calibration is concerned, a good oscillator is accurate to about 2 or 3 percent.

(2) When the oscillator is properly constructed, the waveform of the output voltage is practically sinusoidal.

(3) The oscillator should deliver substantially constant output through the entire frequency range to the extent that the output amplifier produces no frequency discrimination. The need for uniform output over the whole frequency range, or at least over that portion of the range which is used for checking a-f amplifiers or portions of an a-f system, cannot be stressed too strongly. Absence of such uniformity leads to incorrect observations or measurements when checking such systems, unless the output is measured and adjusted at each test frequency.

139. FUNDAMENTAL FREQUENCY OSCILLATORS.

a. Similarity of A-f and R-f Oscillators. Audio-frequency oscillators must bear some semblance to r-f oscillators, as both represent oscillating systems. It is impossible to segregate a-f oscillators into a type which has no equal in any frequency range with respect to circuit structure. A-f oscillators differ from r-f oscillators in the constants of the components. However, in contrast with r-f oscillators, wherein the harmonic output of the oscillator is often used as the test signal, such is seldom the case in a-f oscillators wherein the fundamental signal developed by the oscillator is the one used as a test signal.

b. Types. The manner in which the output-signal frequencies are produced in vacuum-tube a-f oscillators can be separated into the following two types:

(1) The fundamental frequency oscillator in which the oscillating circuits are resonated to the frequency available at the output.

(2) A unit in which the oscillating circuits produce two signals of different frequency and when mixed, produce the final signal available at the output.

c. Circuit Constants. The fundamental a-f oscillator is comparable to an r-f oscillator, except that it is necessary to use much larger values of inductance and capacitance. Because of this increase in size in the case of inductance, iron-core coils must be used in order to conserve space. High-priced oscillators where air-core coils are employed are exceptions. The cores are provided with air gaps to decrease the possibility of saturation which would result in poor waveform. Capacitances required to produce audio frequencies are so large that the use of variable capacitors are out of the question; consequently, it is usually necessary to use a number of fixed capacitors in conjunction with a switching system and to cover the frequency range in steps.

d. Amplitude of Oscillation. In order to minimize harmonic distortion in such fundamental frequency a-f oscillators, the amplitude of oscillations is kept fairly low. To secure the required output, supplementary amplifiers are employed.

e. Frequency Stability. Frequency stability is accomplished in two ways. Generally speaking, resistance stabilization is one method and is used in the majority of systems. The second method uses a buffer amplifier between the oscillating system and the supplementary amplifier or load. The buffer amplifier effectively isolates the oscillating system and tube from the load.

f. Hickok Model 198. The Hickok model 198 uses a 2-stage resistance-coupled amplifier in which the voltage developed by the output of the second tube is applied to the input of the first tube. This arrangement will oscillate because each tube produces a phase shift of 180°, thereby causing the output of the second tube to supply an input voltage to the first tube which has exactly the right phase to sustain oscillations. A negative feedback is used to prevent distortion and provide a sine-wave output. The frequency of oscillation is determined by the choice of grid circuit leak resistance and variable grid capacitance.

140. BEAT-FREQUENCY OSCILLATORS.

a. General. (1) In contrast with the Hickok model 198, the Supreme model 563 is a beat-frequency oscillator. The principle of operation of a beat-frequency oscillator, as its name implies, is based upon the use of two high-frequency oscillators whose outputs differ somewhat in their respective frequencies and are combined to produce a *difference* or *beat* frequency. For instance, if one oscillator is set at 100,000 cycles and the other at 95,000 cycles, the resultant audible-beat note when the two frequencies are combined will be 5,000 cycles.

(2) For convenience, one of the two oscillators is maintained at a fixed frequency; the other oscillator is varied to produce the beat frequency. The outputs of the two oscillators are fed into a detector, where they are combined and rectified. The beat frequency is obtained in the output of the detector or mixer circuit. The undesired high frequencies are filtered out so that only the audible-beat frequency remains. The frequency range obtainable is determined by the ratio of the variable to the fixed capacity used in tuning the variable-frequency oscillator. The audio beat-frequency signal is usually applied to an amplifier-output stage which is transformer coupled to the output terminals. These terminals provide various impedance taps to match the output impedance of the audio oscillator to the input impedance of the circuit to which the audio voltage is applied. The audio-output control is continuously variable and usually is marked for reference settings.

(3) Beat-frequency oscillators are widely used in audio-frequency measuring because they allow a continuous sweep through the entire audio-frequency range with one turn of a dial. The waveform is practically sinusoidal when the oscillator is properly constructed and the frequency stability is entirely satisfactory for most audio work, provided an initial adjustment is made to check one point of calibration. Furthermore, the beat-frequency a-f oscillator, like the fundamental-frequency a-f oscillator, delivers substantially constant output through the entire frequency range to the extent that the output amplifier introduces no frequency discrimination.

b. Calibration. (1) As with fundamental-type audio oscillators, beat-frequency a-f oscillators are also equipped with means for calibration. A definite calibrating point is established upon the dial and some means is provided whereby a calibrating signal may be injected into the circuit to beat against the output signal developed in the mixer. In beat-frequency oscillators, an indicator in the form of a meter, tuning eye, or a neon tube is then used as a visual indication to facilitate adjustment of the calibrating-trimmer capacitor provided for such purposes.

(2) The calibrating trimmer is adjusted for zero beat between the calibrating frequency and the frequency being generated by the oscillator. In some cases such calibration is done without the use of an injected calibrating frequency. Instead, the tuning dial is set at zero frequency and the calibrating trimmer is adjusted for accurate zero-beat indication upon the meter, the neon tube, or whatever form of indicator is employed. The Supreme model 563 utilizing this method has a calibration adjustment which gives a zero beat between the two beat-frequency oscillators.

c. Frequency Locking. (1) Unless special precautions are taken to avoid it, the frequency of the weaker oscillator will tend to lock into synchronism with the frequency of the stronger oscillator when the frequency of the former closely approaches the frequency of the latter. Under these circumstances the two oscillators are in a condition of zero beat and no audio-frequency output is obtained.

(2) Prevention of frequency locking requires the complete electrical isolation of the two oscillators so that they cannot interact upon each other. Adequate shielding of the two oscillators, particularly the weaker one, will minimize interaction due to stray fields. Nevertheless, the outputs of the two oscillators must be combined and in order to prevent interaction at this point, a buffer amplifier is usually interposed between the weaker oscillator and the point at which the two frequencies are mixed. The function of the buffer amplifier in this case is to prevent the stronger oscillation in the mixing circuit from getting to the output circuit of the weak oscillator.

d. Frequency Stability. (1) Care must be taken that neither of the high-frequency oscillators vary in frequency, as this would result in a change of the beat-frequency. Assuming that one of the oscillators is operating at 100,000 cycles and the other at 99,000 cycles, a 0.1 percent change in frequency by the first would vary the beat frequency by 100 cycles either one way or the other. The resultant beat becomes 900 cycles or 1,100 cycles rather than the expected 1,000 cycles. The discrepancy would be more pronounced at beat frequencies below 1,000 cycles.

(2) Changes in temperature due to vacuum tubes and other heat-producing apparatus is probably the major factor which causes frequency instability. The oscillator coils and capacitors should possess a high inherent stability which will enable them to be affected only slightly by temperature changes. In addition, these coils and capacitors should be located at a reasonable distance from heat-producing apparatus.

(3) If the two oscillators are made as nearly identical as possible, changes in temperature and operating potentials will affect both oscillators equally. The frequency change in one will be offset by the corresponding frequency change in the other. Since both frequency variations will tend to be in the same direction, they will maintain a constant beat frequency.

(4) A symmetrical placing of the components and rigid mountings will further assist in minimizing frequency instability. Both oscillators are usually of the electron-coupled type and have comparatively high-frequency stability.

e. Choice of Fundamental Frequencies. (1) The frequencies of the two oscillators also have a significant influence upon frequency stability. If the fundamental frequencies are made low, frequency stability is attainable by the fact that an undesired change in frequency of either oscillator will vary the resulting beat frequency very little. On the other hand, the lower the fundamental frequencies, the greater the percentage difference between them when they beat to produce a high-audio frequency. Consequently, the effects of temperature and other factors will influence both oscillators differently. Since the frequency change in one will not be compensated by the frequency change in the other, there will be a certain amount of frequency instability.

(2) When a high frequency is employed, the ratio of inductance to capacitance, when using commercially available capacitors can be decreased, thus increasing the frequency stability. This is offset by the fact that a slight variation in the fundamental frequency changes the beat frequency very little. General practice would seem to indicate that a fundamental frequency between 100 and 350 kilocycles offers an excellent compromise between the various conflicting factors.

f. Tuning Capacitor. In a beat-frequency oscillator, the entire audio-frequency range may be covered easily with a single variable air capacitor. The range covered depends upon the capacitor chosen. In order that readings will be well-spaced at the lower frequencies, the capacitor plates are shaped to give a logarithmic scale. Beyond the audio-frequency range, the plate shape may be designed to give either a logarithmic or linear scale.

g. Elimination of Harmonics. (1) If both of the fundamental oscillators contain harmonics, the detector output will be a beat frequency which also contains harmonics. In order to obtain a harmonic-free beat-frequency output, at least one oscillator (for convenience usually the fixed-frequency oscillator) is thoroughly filtered.

(2) A number of methods can be used for such filtering. One of these consists of arranging an electron-coupled oscillator for the fixed-frequency unit wherein the output of the oscillator is coupled to the mixer by means of a tuned circuit in the plate system. This tuned circuit is resonated to the fundamental frequency being produced by that oscillator. Similar coupling of the fixed-frequency oscillator, if it is of conventional design, can be used wherein the resonant circuit which is acting as a filter serves as a coupling link between the fixed-frequency oscillator and the mixer. The fact that harmonics are being produced by the variable-frequency oscillator is not significant because these harmonics cannot beat against the harmonics produced in the oscillating circuit of the fixed-frequency oscillator. The trap prevents the harmonics of the fixed-frequency oscillator from reaching the mixer.

141. OUTPUT COUPLING.

a. Inasmuch as the output of an audio oscillator may be applied to circuits of various impedances, provision is usually made in the instrument for selecting suitable values of output impedances. In many cases, however, the impedance of the circuit under test may be much greater than the output impedances provided, as, for example, when feeding directly into the grid of an amplifier tube which is operating as class A. The impedance of this tube may be as large as several megohms.

b. This high impedance is actually connected across the secondary of the output transformer of the audio oscillator. The effect that the secondary has on the primary circuit is then exactly as if a high impedance were inserted in series with the primary circuit. As a result, the plate-load impedance of the audio-oscillator output tube is greatly increased from that which would be present with a lower impedance connected across the secondary circuit. This in turn make the output tube operate over a portion of its dynamic characteristic that is nonlinear. It is evident that this condition causes distortion.

c. Distortion caused by applying the audio oscillator into high-impedance circuits is avoided by paralleling this high impedance with a resistor of suitable value, such as 5,000 ohms. The resultant impedance is slightly less than 5,000 ohms and therefore may be connected to the 5,000-ohm output-impedance terminals. In actual practice the 5,000-ohm resistor is connected directly across the 5,000-ohm terminal and ground, and a blocking capacitor of approximately 0.005μf is connected from the 5,000-ohm output terminal to the grid of the tube in order to avoid a loss of bias. This resistor, of course, is not necessary when the device to which the audio-oscillator signal voltage is applied has an input impedance comparable to any of the output impedances available.

142. FREQUENCY MEASUREMENT.

a. With Sweep Circuit of Oscilloscope. In addition to providing a signal voltage for signal tracing and trouble localization, the audio oscillator may also be used to measure the frequencies of audio signals. This is accomplished by applying the signal voltage, whose frequency is to be checked, to the vertical deflecting plates of a test oscilloscope. The audio-oscillator output is then applied to the horizontal sweep circuit through the synchronizing circuit and varied in frequency until only a single stationary cycle or pulse is observed on the oscilloscope screen. The frequency setting of the audio oscillator is then, the frequency of the voltage being measured. This method necessitates setting the frequency range of the test oscilloscope so that the frequency of the audio oscillator falls within this range. A better method of measuring frequency is to apply the signal voltages without using the sweep circuit.

b. Without Sweep Circuit of Oscilloscope. In this method the audio-oscillator is applied directly to the horizontal plates of the test oscilloscope without being distorted into a sweep. The sine-wave signal voltage whose frequency is to be measured is applied to the vertical deflecting plates. The resultant Lissajous figure can then be used to determine the frequency of the signal voltage. When the frequencies are exactly the same, the result will be a stationary straight line, ellipse, or circle, depending upon the phase relationships between both voltages.

143. APPLICATION TO RADIO SET SCR-268-(*).

a. There are many places in the component units of Radio Set SCR-268-(*) where audio-frequency signal voltages are involved. One of these audio-signal voltages is the pulse-frequency voltage which is determined by the keyer in the transmitter portion of Radio Set SCR-268-(*). This frequency is 4,098 cycles per second and represents the frequency of the signal pulses fed to the oscilloscope after detection in the receiver. The audio oscillator may be used as a source of signal voltage for testing the audio channels of the receiver.

b. Another source of audio voltage present in the channels feeding Oscilloscope BC-412-A is the switching oscillator of Receiver BC-406-A. The output of the switching oscillator is fed to the spread channel of Oscilloscope BC-412-A. The frequency is approximately 1,200 cycles per second for Radio Sets SCR-268, SCR-268-A, and SCR-268-B, and is variable from approximately 400 to 800 cycles per second for Radio Set SCR-268-C.

c. The audio oscillator also serves a very important function in maintenance operations on other channels of Oscilloscope BC-412-A. The normal operation of Oscilloscope BC-412-A when used on the mount, requires that a sine-wave signal of 4,098 cycles be fed into the sweep channel. This signal can be secured from either the Hickok model 198 or Supreme model 563 audio oscillator when Oscilloscope BC-412-A is being tested on the bench.

d. Furthermore, either of these audio oscillators can serve as the source for spread-channel voltage in place of the switching oscillator system in the receiver. The testing of Oscilloscope BC-412-A is thus possible without the use of Receiver BC-406-A.

SECTION XXI

AUDIO OSCILLATOR, I-151, HICKOK MODEL 198

144. GENERAL.

a. Description. The Hickok model 198 is illustrated in schematic form in figure 42. A 6SJ7 (VT-116) tube and a 6V6G (VT-107-B) tube are used in a resistance-capacitance oscillator system which is the equivalent of a relaxation oscillator, but negative feedback is used to limit the magnitude of regeneration in order to provide a sine-wave output.

b. Frequency. The frequency oscillation is determined by the values of R11, R12, R13 and the capacity values of C1. When the frequency range is changed, different values of fixed resistance are connected into the oscillating system. The three following frequency ranges are available: from 20 to 200 cycles; 200 to 2,000 cycles; and 2,000 to 29,000 cycles. Selection of these ranges is determined by the RANGE SELECTOR switch (fig. 39). A continuous change in frequency over each band is accomplished by variation of the dual-section tuning capacitor C1 in the schematic diagram (fig. 42). This is identified in the photograph (fig. 39) as the FREQUENCY CONTROL.

c. Output. The output of the resistance-capacitance oscillator systems 6SJ7 and 6V6G is fed into a dual triode 6SN7 (VT-231). By employing phase inversion between the two sections of this tube, the equivalent of a push-pull stage is obtained.

d. Operating Voltages. Operating voltages are secured from a full-wave rectifier system utilizing a 6X5GT (VT-118-A) tube.

e. Calibrating System. A calibrating system is provided whereby a neon lamp actuated from the 60-cycle power source is coupled to the output within the instrument. By means of this arrangement, the frequency setting of the audio oscillator at 60, 120, and 180 cycles can be compared with the standard line frequency by noting the zero-beat action when the two frequencies are alike or when one is a multiple of the other. If a discrepancy occurs in the frequency calibration of the oscillator system, compensation is made by adjustment of a special trimmer. Special frequency-calibration markers are indicated upon the tuning scale of the oscillator at 625 and 4,098 cycles.

f. Load Impedance. The output system is designed to accomodate various impedance loads, thus output terminals are provided for 10, 250, 500, and 5,000 ohms. The value of the load impedance connected across these terminals (fig. 39) can affect the waveform of the output voltage. If at all possible, the load impedance should equal the impedance of the output transformer. A poor mismatch will distort the output wave and limit the extent to which the OUTPUT CONTROL can be advanced and still retain a sine-wave output.

145. APPLICATIONS.

a. General. The principle use of the audio oscillator in the repair and maintenance of Radio Sets SCR-268-(*) is in providing a signal for signal tracing and trouble shooting in audio circuits. Figure 38 illustrates the proper test connections, but bear

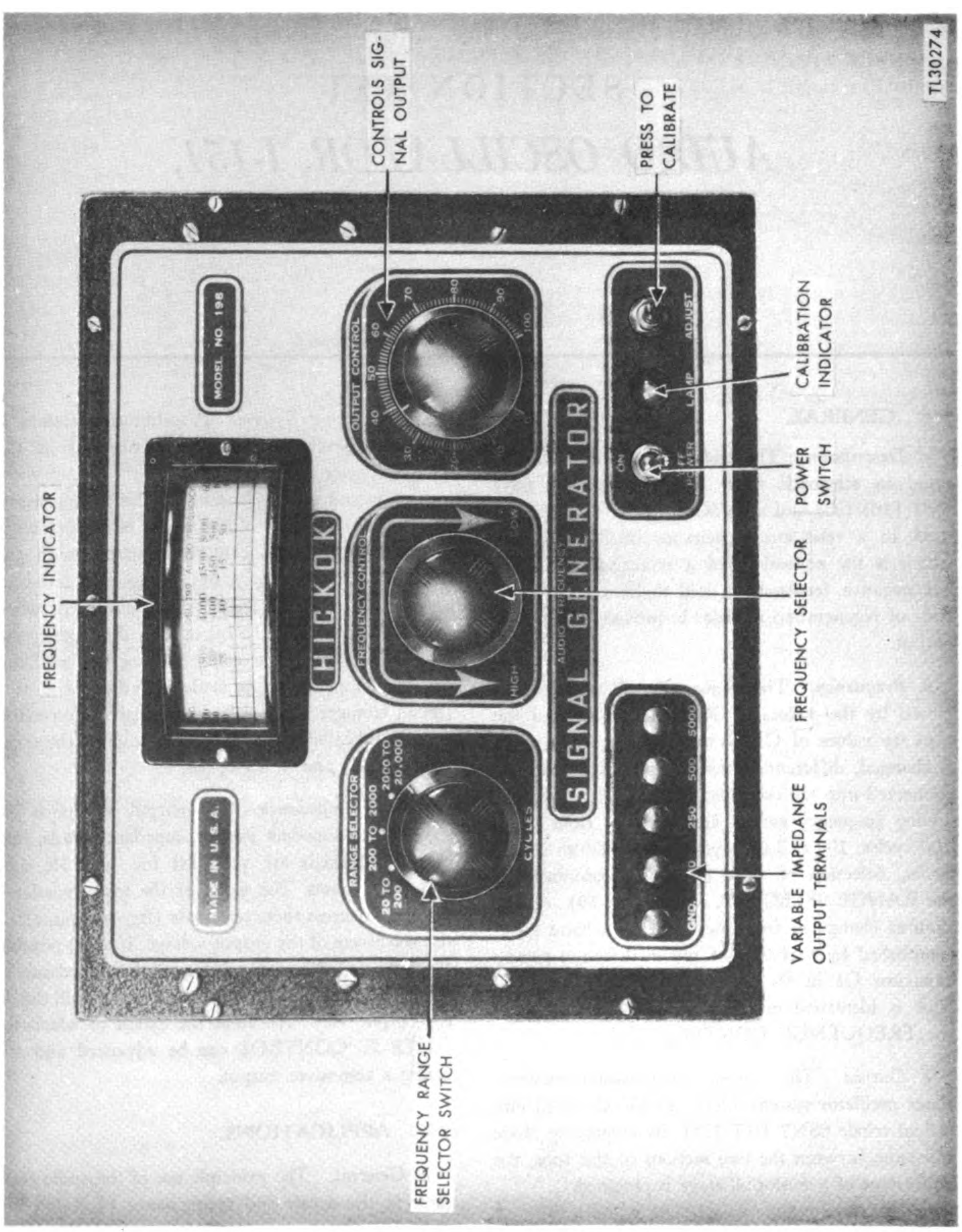


Figure 39. Audio Oscillator I-151, Hickok model 198, panel view.

in mind that the visual indicator (the test oscilloscope) need not, as indicated in the figure, be connected to the same stage as the signal input.

b. Circuits. (1) The circuits in the components of Radio Set SCR-268-(*) in which waveforms can be tested with this oscillator as the signal source are as follows:

Component	*Circuits*
Keyer	Pulse-forming circuits
Keyer	Sync circuits to range unit
Receiver	Switch oscillator and switch-amplifier circuits
Receiver	2d detector and video stages
Oscilloscope	Sweep circuits
Oscilloscope	Pulse amplifier
Range Unit	Audio circuits

(2) This audio oscillator can be used as a signal source on the test bench to check proper intensity, focus, sweep, vertical line, and spread in Oscilloscope BC-412-A.

c. Frequency Measurement. In some cases, if a more accurate means is not available, the audio oscillator can be used to measure the frequency of audio signals. The most prominent examples of such measurement are the sync output of the keyer and the output of the switch oscillator in the receiver, but it must be understood that this is not an accurate measurement. The method used is described in paragraph 142.

146. LIMITATIONS AND PRECAUTIONS.

a. Range. The range of frequencies covered by this audio oscillator is from 20 to 20,000 cycles per second; consequently, the audio oscillator is used only in circuits designed for audio frequencies. Do not attempt to use this instrument to test i-f or r-f stages.

b. Output Coupling. There is no blocking in the output circuit of the oscillator, and the secondary of its output transformer can provide a short-circuited path for d-c potentials such as bypassing the bias or any other operating potential. For this reason care must be taken in making connection of the test leads when applying the signal voltage from the oscillator to a circuit under test. The proper connection for applying a signal voltage to the grid of a tube is illustrated in figure 38.

c. Output Impedance. A distorted signal will result when there is a great difference between the output impedance of the oscillator and the impedance of the circuit to which the signal is being applied. Provision is made for selecting suitable output impedances, but in many cases the impedance of the circuit under test may be much greater than any of the output impedances provided on the oscillator. In such instances, an additional external connection is required (par. 141).

147. OPERATION OF HICKOK MODEL 198.

CAUTION: Do not operate the instrument from a d-c voltage supply. Do not apply excessive d-c voltage across any of the output terminals, as there is no blocking capacitor in this circuit and a d-c voltage might damage the output transformer.

a. Connect the power cord to a suitable source of 110-volt, 50-60 cycle a-c voltage.

b. Turn the POWER switch to ON position. The neon LAMP should light up immediately.

c. Allow several minutes for the components to reach a stable temperature.

d. Set the RANGE SELECTOR to the 20 TO 200 CYCLES position.

e. Adjust the FREQUENCY CONTROL so that the hairline of the indicator is on 60 cycles, assuming a 60-cycle supply line; otherwise adjust to the supply-line frequency.

f. Advance the OUTPUT CONTROL to the maximum clockwise position.

g. Depress the ADJUST button.

h. With the ADJUST button depressed, slowly rotate the FREQUENCY CONTROL knob to each side of the 60-cycle position until the neon LAMP either glows steadily or constantly remains partially darkened. This indicates a zero beat between the oscillator frequency and the supply-line frequency. Flickering of the neon light will be noticed on either side of this setting. The rate of flickering will be equal to the number of cycles per second that the oscillator frequency differs from the supply-line frequency of 60-cycles (assuming a 60-cycle a-c line supply). If the calibration is correct, the dial should read exactly 60 when the neon LAMP ceases flickering.

i. If an error is found in calibration, that is, if the zero-beat condition is found with the dial setting indicating a frequency above or below 60 cycles, immediately check the dial adjustment.

(1) Rotate the dial past the lowest frequency as far as it will go. The hairline on the dial lens should line up with the red line on the dial proper. If this condition is satisfied, it may be necessary to make an adjustment (subpar. (2) below).

(2) It is not expedient to make any adjustment to correct errors in calibration if the existing calibration is found to be within 2 percent or within one cycle at the 60-cycle-per-second setting on the dial. If, however, an error in excess of this amount is found, set the dial to read exactly 180 cycles. Depress the ADJUST button. With this button depressed, use a screwdriver to vary the correction control which is accessible through an opening in the left side of the case, until a zero beat is indicated on the neon LAMP. This is a delicate adjustment because the oscillator frequency is equivalent to the third harmonic of the line-supply frequency.

j. If the calibration (subpar. *h* above) is correct, set the RANGE SELECTOR and FREQUENCY CONTROL to the desired frequency. Note that the exact calibration for 625 and 4,098 cycles is indicated by a red line drawn inward on the printed scale.

k. Take the output voltage at any of the output impedances of 10, 250, 500, or 5,000 ohms at the output binding posts as desired. Where the waveform is important, it is imperative that the output be properly terminated in the correct load. If an exact match of output impedance and load cannot be obtained, use the binding posts of the impedance nearest in value to the load. When the load impedance is larger than 5,000, connect a 5,000-ohm resistor across the 5,000 and GND output binding posts.

l. Adjust the output voltage by means of the OUTPUT CONTROL illustrated in figure 39.

m. In order to avoid loss of bias and also to protect the transformer against d-c, it is good practice to use a 0.005-microfarad capacitor in series with the grid lead.

148. MAINTENANCE.

a. This audio oscillator is a precision instrument and maintenance must not be attempted by inexperienced personnel.

b. Complete maintenance on this oscillator will consist chiefly of tube replacement and, to a lesser extent, replacing component parts. Fault location can be ascertained by continuity tests, resistance measurements, voltage readings, signal tracing, and visual inspection.

c. In audio oscillators of the fundamental-frequency type, unsatisfactory operation is most often due to defective switch contacts. These contacts are continually exposed to and affected by accumulations of dirt, corrosion, and wear. Such difficulties frequently make the contact resistance so high that erratic operation or complete failure to operate at one or more of the fixed frequencies results.

d. Periodic cleaning of all contacts with carbon tetrachloride, tightening contact-arm tension if necessary, and storing the instrument in a cabinet when not in use will take care of many of the normal causes of irregular operation.

e. The schematic diagram (fig. 42) contains information regarding tube bases, tube element voltages, power supply voltages, and values of component parts.

f. Note that the resistance of the 6-watt biasing lamps (VT-6), (fig. 40), should measure 300 ohms each, or 600 ohms from the cathode of 6SJ7 (VT-2) to ground.

g. Figures 40 and 41 show the chassis removed from the case and indicate tube locations.

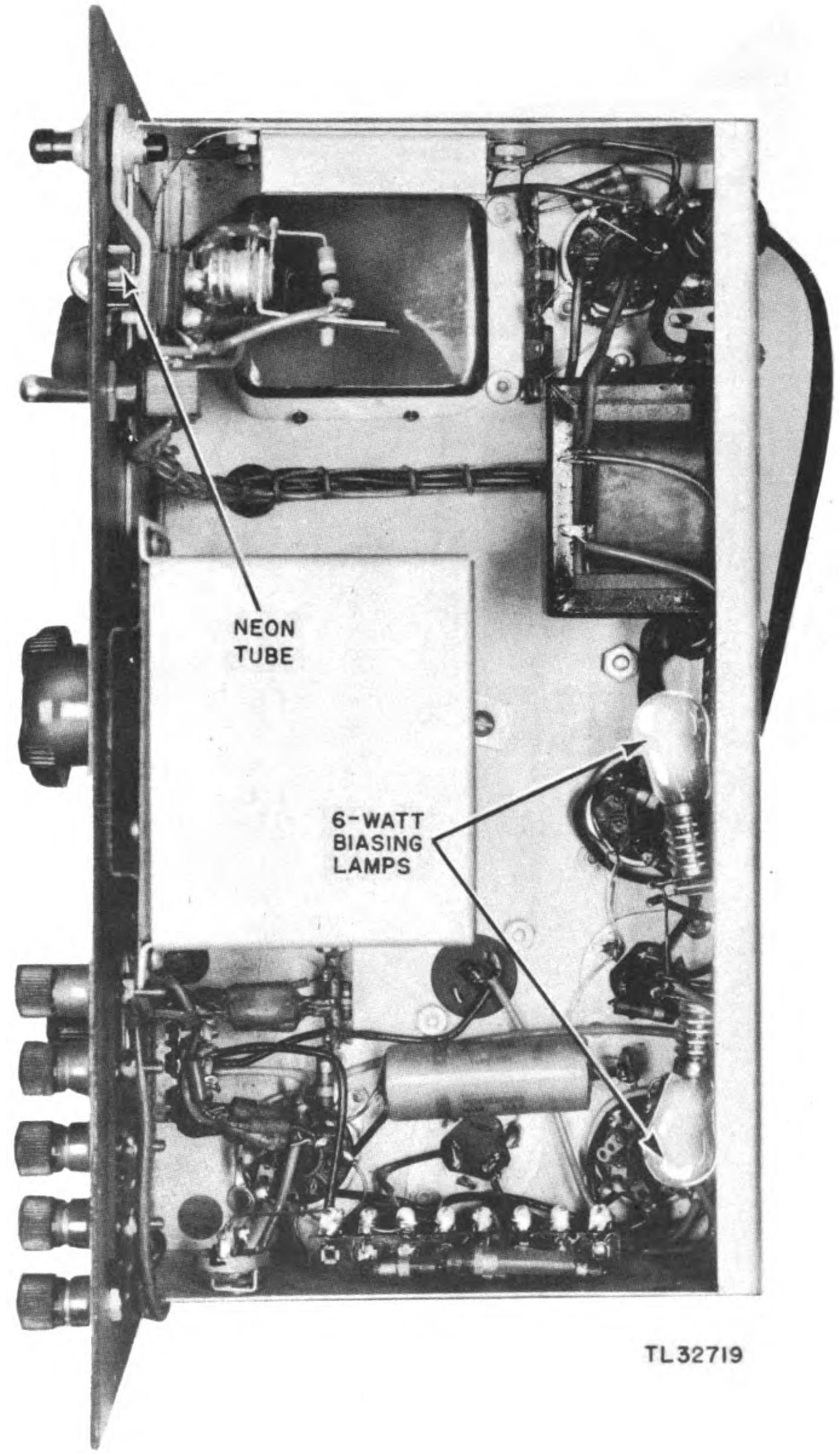


Figure 40. Audio Oscillator I-151, Hickok model 198, bottom view, case removed, showing lamp location.

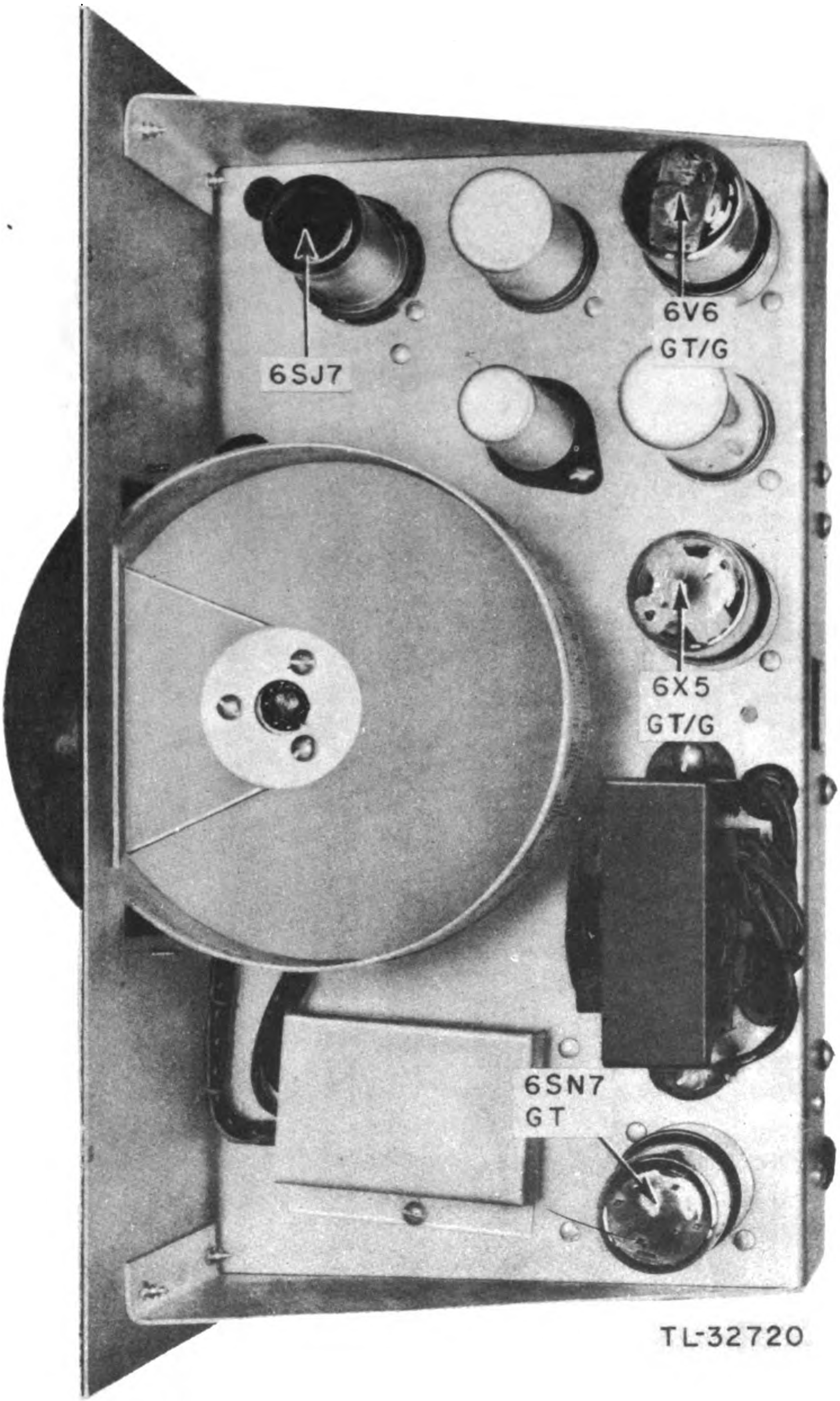


Figure 41. Audio Oscillator I-151, Hickok model 198, top view with case removed.

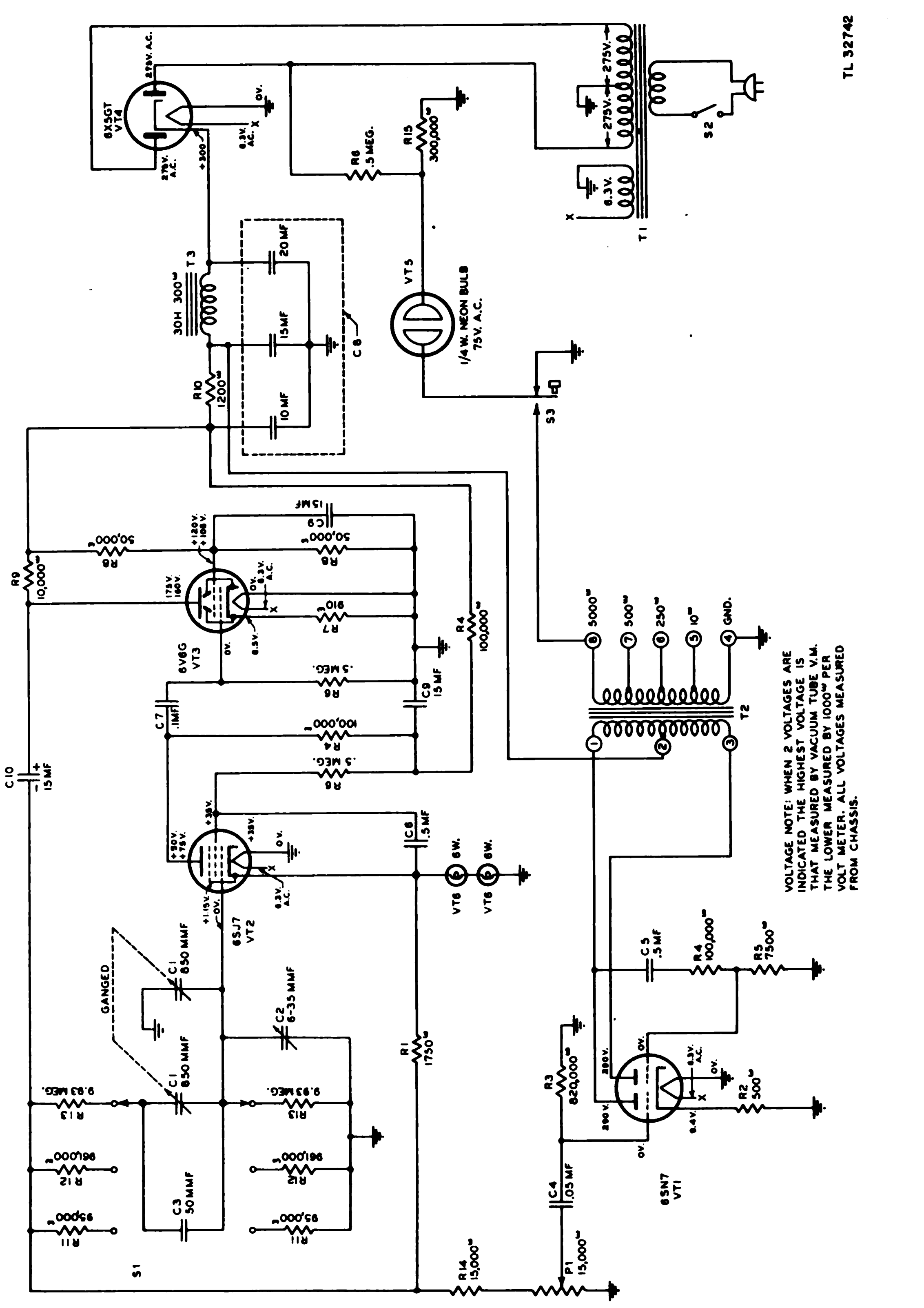


Figure 42. Audio Oscillator I-151, Hickok model 198, schematic diagram.

SECTION XXII

AUDIO OSCILLATOR, SUPREME MODEL 563

149. DESCRIPTION.

a. The Supreme model 563 is a self-contained portable beat-frequency audio oscillator generating frequencies continuously variable from 30 to 15,000 cycles per second. An impedance-matching transformer provides output voltages at output impedances of 250 ohms, 500 ohms, and 5,000 ohms, center tapped for push-pull operation. An amplitude output control which is continuously variable is provided.

b. As shown in the circuit diagram (fig. 46), the two r-f oscillators using type 6SK7 (VT-117) tubes are of the electron-coupled oscillator type. The fixed oscillator has a tuned plate circuit effectively eliminating harmonics of the fundamental, and it is inductively coupled to the cathode of the mixer tube type 6C5 (VT-65). The variable oscillator has a tuning coil, fixed capacitor, and trimmer, which are identical with those of the fixed oscillator. The variable oscillator also has a variable tuning capacitor and a calibration-adjusting capacitor. The output of the variable oscillator is applied through normal resistance-capacitance (RC) coupling to the grid of the mixer tube. The resulting audio beat frequency is filtered through a choke capacitance network which eliminates the r-f frequencies. This filtered voltage is applied to the grid of the tube 6C5 (VT-65) audio-amplifier tube through a 500,000-ohm potentiometer which serves as the OUTPUT control.

c. A neon lamp (fig. 43) in the output circuit of the 6C5 (VT-65) amplifier tube is used as a zero-beat indicator.

150. APPLICATION TO RADIO SET SCR-268-(*).

a. General. The principle use of the audio oscillator in the repair and maintance of Radio Set SCR-268-(*) is in providing a signal for signal tracing and trouble shooting in audio circuits. Figure 38 illustrates the proper test connection, but the visual indicator (the test oscilloscope) need not, as indicated in the figure, be connected to the same stage as the signal input.

b. Circuits. (1) The circuits in the components of Radio Set SCR-268-(*) in which waveforms can be tested, using this oscillator as the signal source, are as follows:

Component	*Circuits*
Keyer	Pulse-forming circuits
Keyer	Sync circuits to range unit
Receiver	Switch-oscillator and switch-amplifier circuits
Receiver	2d detector and video stages
Oscilloscope	Sweep circuits
Oscilloscope	Pulse amplifier
Range Unit	Audio circuits

(2) For example, this audio oscillator can be used as a signal source on the test bench to check for

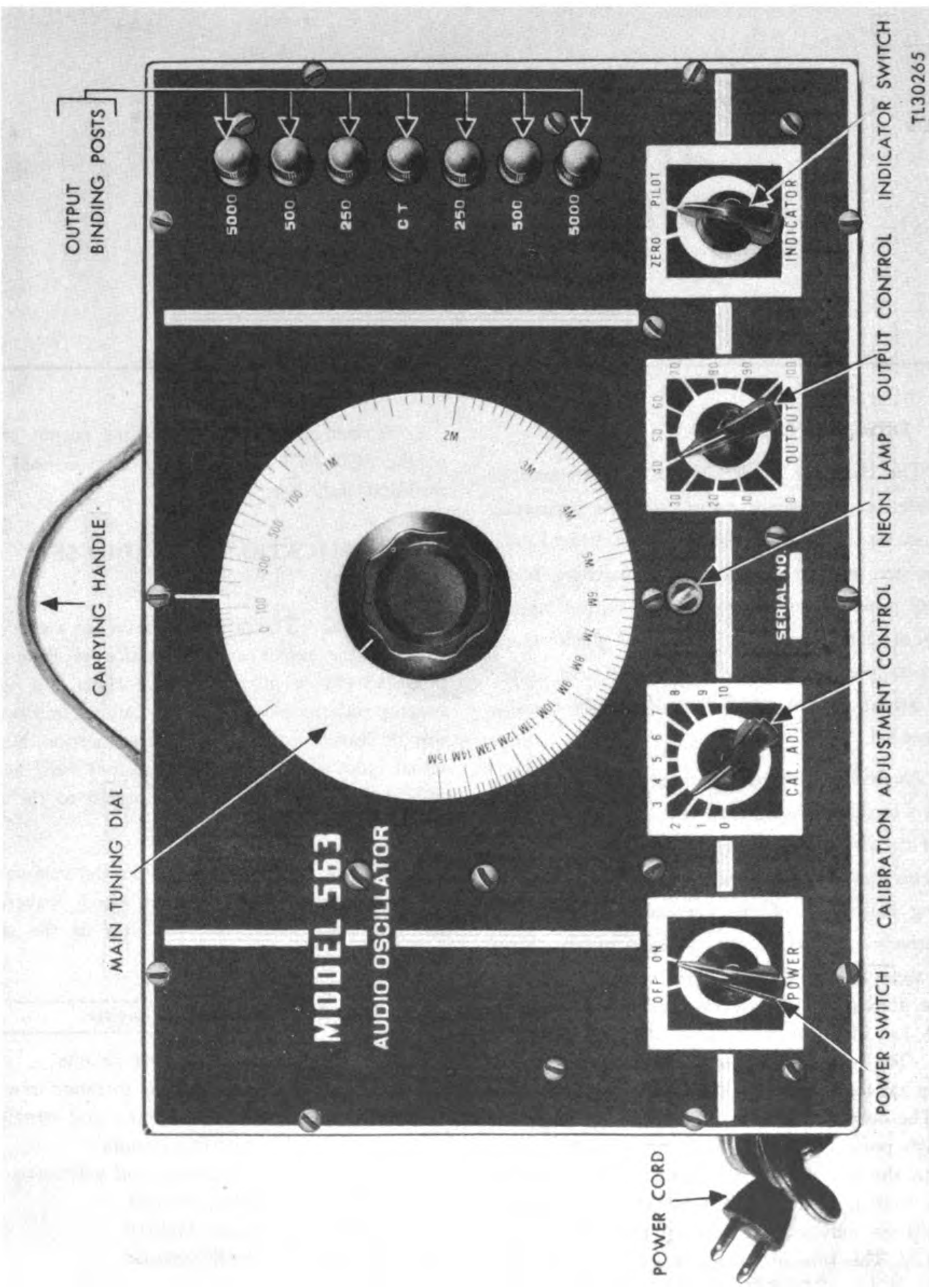


Figure 43. Audio oscillator, Supreme model 563, panel view.

proper intensity, focus, sweep, vertical line, and spread in Oscilloscope BC-412-A.

c. *Frequency Measurement.* In some cases, if a more accurate means is not available, the audio oscillator can be used to measure the frequency of audio signals, chiefly the sync output of the keyer and the output of the switch oscillator in the receiver. It must be understood that this is not an accurate measurement. The method used is described in paragraph 142.

d. *Range.* The range of frequencies covered by this audio oscillator is from 20 to 20,000 cycles per second, and consequently the audio oscillator can be used only in circuits designed for audio frequencies. *Do not use this instrument to test i-f or r-f stages.*

e. *Output Coupling.* There is no blocking capacitor in the output circuit of the oscillator, and the secondary of its output transformer can provide a short-circuited path for d-c potentials. For this reason care must be exerted in making connection of the test leads, when applying the signal voltage from the oscillator to a circuit under test, not to bypass the bias or any other operating potential. The proper connection for applying a signal voltage to the grid of a tube is illustrated in figure 38.

f. *Output Impedance.* A distorted signal will result when there is a big difference between the output impedance of the oscillator and the impedance of the circuit to which the signal is being applied. Provision is made for selecting suitable output impedances, but in many cases the impedance of the circuit under test may be much greater than and of the output impedances provided on the oscillator. In such instances an additional external connection is required. A discussion of this is given in paragraph 141.

151. OPERATING PROCEDURE.

a. Attach the power cord to a 115-volt, 60-cycle a-c supply.

b. Turn the POWER switch to the ON position.

c. Turn the OUTPUT control to full clockwise position, 100 on the dial.

d. Set the INDICATOR switch to the ZERO position.

e. Rotate the main tuning dial to the 0 mark.

f. Allow the oscillator to warm up for several minutes, then adjust the CAL. ADJ. control until the zero-beat indicator (neon lamp) fails to glow, or until there is the longest lapse of time between flashes. This determines the position of zero beat

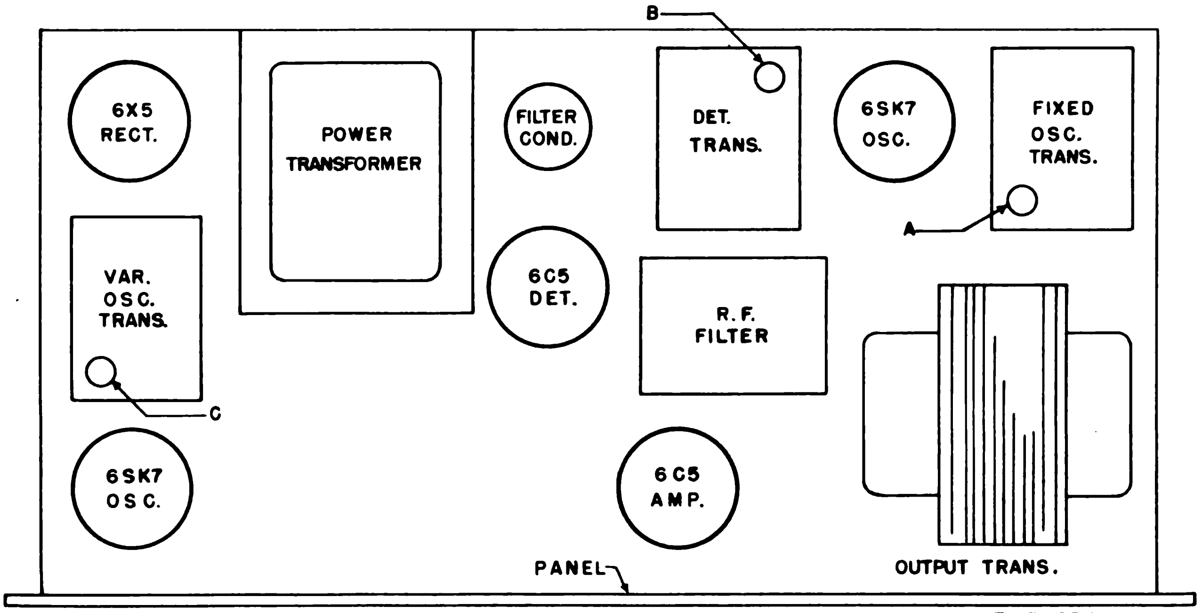


Figure 44. Audio oscillator, Supreme model 563, chassis arrangement.

between the fixed and variable oscillators, and completes the calibration.

g. Turn the INDICATOR control to the PILOT position. The neon lamp should glow constantly.

h. Set the main tuning dial to the desired frequency.

i. Take the output voltage at the proper pair of output binding posts on the right edge of the panel. For instance, use both 5,000-ohm binding posts for a 5,000-ohm output impedance. The CT terminal is used only for push-pull and other balanced-input systems under test. Use the pair of output binding posts which match the input of the circuit under test. If an exact match of output impedance and load cannot be obtained, use the binding posts of the impedance nearest in value to the load. When the load impedance is larger than 5,000 ohms; connect a 5,000-ohm resistor across the 5,000-ohm output binding posts.

j. For most applications use the alligator leads supplied with the instrument to connect the impedance-matching binding posts to the circuit to which the signal is to be applied. If radiation, or hum pick-up becomes objectionable, use shielded leads.

k. In order to avoid loss of bias and also to protect the transformer against direct current, it is good practice to use a 0.005-microfarad capacitor in series with the grid leak.

l. Turn the OUTPUT control (fig. 43) to adjust the signal voltage input.

152. MAINTENANCE.

a. General. (1) Audio oscillator Supreme model 563 is a precision instrument, and no maintenance will be attempted by inexperienced personnel.

(2) Complete maintenance on this audio oscillator will consist chiefly of tube replacement and, to a lesser extent, replacement of component parts. Fault location can be ascertained by continuity tests, resistance measurements, voltage readings, signal tracing, and visual inspection.

(3) Figure 44 is a diagram of the chassis layout and figure 45 shows the arrangement (bottom view) and voltage measurements of tube sockets. The schematic diagram (fig. 46) contains information regarding tube bases, power-supply voltages, and values of component parts.

CAUTION: Disconnect the power-supply cord from the power source before removing the instrument from the case. Should the instrument fail to operate, remove it from its case by removing the four

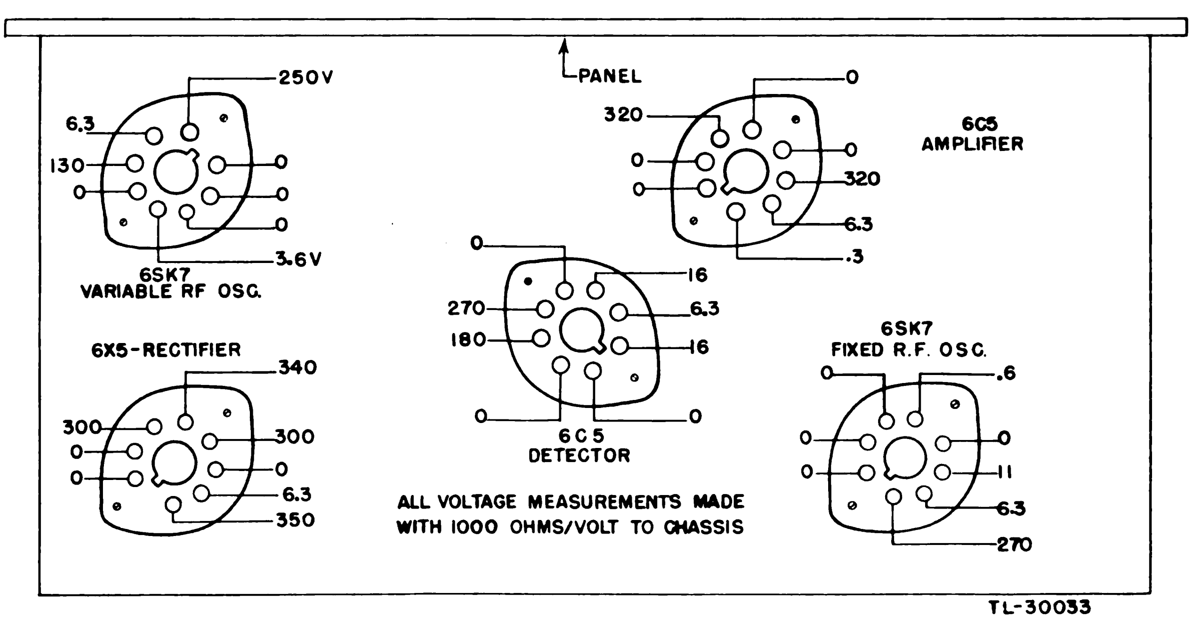


Figure 45. Audio oscillator, Supreme model 563, tube-socket voltages to ground.

screws holding the bottom bumpers and front panel screws. It is not necessary to disconnect the a-c line cord from the chassis.

b. Frequency Instability. (1) Since the audio-frequency voltages are obtained by tuning a variable-frequency oscillator, any undesired influences which affect the frequency of either oscillator will cause frequency instability. In practice, frequency instability is generally caused by changes in tube characteristics, wide fluctuations in line voltage, and mechanical troubles, such as wear on tuning-capacitor bearings, loosening of screws which anchor components to the chassis, and defective grounding contacts. All these troubles which cause small variations in the circuit capacitance across tuned circuits affect the frequency, and at low frequencies the percentage variation in frequency may be considerable.

(2) If the characteristics of the tubes used as the variable- and fixed-frequency oscillators are not similar, some instability may be caused, particularly at low frequencies. If it becomes necessary after a period of use to replace one of the oscillator tubes, it is a good idea to replace both, choosing a pair of tubes which give most stable operation in the beat-frequency oscillator.

c. Fuses. As a preliminary check after the instrument has failed, test for fuse failure with an ohmmeter. In the event of fuse failure, do not place the instrument in operation by shorting the fuse clips together or by replacing with a fuse of higher current rating. To complete the preliminary check, see that all tubes are mounted in their sockets properly. This check having been made, if the instrument does not operate, remove the tubes for testing.

d. Tube Voltages. The actual condition of the circuits of the audio oscillator may be determined by measuring the d-c voltages at the various tube elements. Figure 45 is a bottom view of the tube-base layout and shows the normal voltage at each tube element. These voltages are measured with respect to chassis and should not vary more than ±20%. Greater variations represent trouble in the particular circuit being tested. These voltages are measured with a standard 1,000-ohm-per-volt meter.

e. Recalibration Procedure. (1) With the instrument removed from the case, place it in operation as described in paragraph 151.

(2) Set the tuning capacitor completely out of mesh, and check to see that the reference line of the dial coincides with the indicator line on the panel.

(3) Connect the 5,000-ohm impedance-matching binding posts to the vertical input circuit of an oscilloscope.

(4) Some standard source of signal is required: either an accurately calibrated laboratory a-f oscillator or an accurate crystal-controlled oscillator, such as Calibrator I-168.

(5) Connect this standard source of signal directly into the horizontal plates of the oscilloscope without going through the sweep circuit, and set the standard source of signal at 15,000 cycles if that frequency is within its range.

(6) Set the dial of the Supreme model 563 oscillator at 15,000 cycles and rotate the dial to either side of this setting until a stationary circle, ellipse, or slanted straight line is obtained on the oscilloscope screen, indicating that the frequency of the Supreme model 563 is equal to the frequency of the standard signal generator.

(7) Unless there is trouble in the instrument being calibrated, the point reached in operation (6) should be very close to the 15M mark on the dial. Note the error in the dial reading and, should it be low (say at 14M), turn trimmer adjustment A (fig. 44) in a counterclockwise direction, approximately 1/3 revolution. Reset the dial to the 0 mark and adjust trimmer screw C (fig. 44) until zero beat is indicated by the neon light. Again check the calibration at the 15M mark, using the oscilloscope as an indicator and using the standard 15M-cycle signal as a reference.

(8) Repeat this procedure until the 15M marke is correctly calibrated. After each adjustment of trimmer capacitor A it is necessary to reset the dial to the 0 mark and to obtain the zero-beat by adjusting trimmer screw C.

(9) In cases where the initial error in the dial reading is high rather than low, adjust screw A in a clockwise direction rather than counterclockwise and proceed as described above (subpar. (7)).

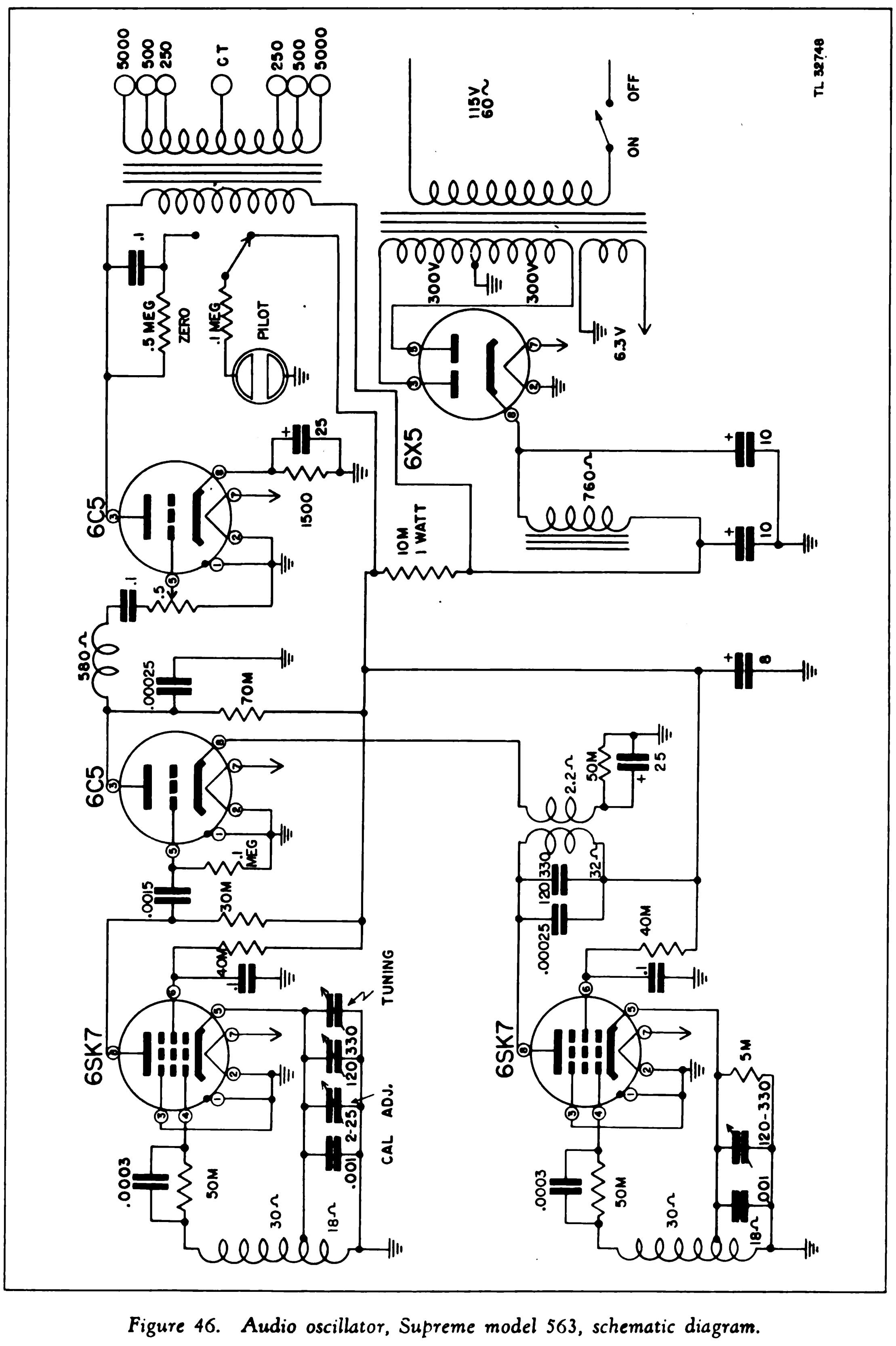


Figure 46. Audio oscillator, Supreme model 563, schematic diagram.

(10) Adjust screw B (fig. 44) for maximum output as indicated on the oscilloscope. Set CAL. ADJ. control to 5 and main tuning dial to the 0 mark. Zero-beat the instrument by adjusting screw C. This places the CAL. ADJ. control in the position that will give the greatest variation from zero beat. Unless the capacitor plates have been bent, the remainder of the dial will now be calibrated.

(11) If it is desired to check other points than both ends of the scale, set the standard source of a-f signal to the desired frequency. Then turn the tuning dial of Supreme model 563 until the frequency of the Supreme model 563 coincides with that of the standard source of a-f signal as indicated by the figures on the oscilloscope; that is, a stationary circle, ellipse, or straight line. Note the reading of the Supreme model 563 dial. It should be the same frequency as the standard source of a-f signal. Check as many points as desired.

SECTION XXIII
THERMOCOUPLE INSTRUMENTS

153. PURPOSE.

a. In order to operate Radio Set SCR-268 efficiently, it is essential that the transmitting system be properly adjusted. To facilitate this adjustment, grid and plate milliammeters are provided on the transmitter to measure the grid and plate currents respectively. Any adjustments made on the transmitting system causes a change in reading of these meters.

b. However, the meter readings on the transmitter are not a sufficient indication of the actual energy projected into space by the radio set. For example, it is possible to adjust the transmission system to the point where extremely intense standing waves and consequently high radio-frequency voltages will result along the transmission line between the transmitter and the transmitting antenna. This condition can occur even when the transmitter meter readings are perfect and the transmitter tuning knob has been correctly adjusted for minimum grid current. Investigation will show that the actual power in the transmitting antenna is very low.

c. For proper adjustment of the transmitting system, it therefore necessary to use some sort of field strength meter capable of abstracting and measuring the radio-frequency energy emitted from the transmitting antenna. The instruments previously described for measuring alternating current are based on the d'Arsonval moving-coil principle. While these instruments are accurate at low frequencies, they are inaccurate at radio frequencies because of distributed capacity and other effects.

d. At high frequencies, a suitable means of measuring currents is the thermocouple milliammeter. It is highly accurate over a broad range of frequencies and is also used at audio frequencies when accuracy is important.

154. THEORY OF OPERATION.

a. In the thermocouple milliammeter the direct or alternating current to be measured is sent through a heater, which heats the junction of two dissimilar metals. When two dissimilar metals are joined together and their junction heated, a voltage is generated which is proportional to the temperature difference between the heated junction and the open end of the thermocouple. A sensitive milliammeter is connected to the open ends and is usually calibrated to indicate the current through the heater.

b. Figure 47 is a simplified diagram of the type of thermocouple instrument supplied with Test Equipment RC-68-(*). The thermocouple consists of two small wires of dissimilar metal electrically welded together at their junction. The heavy line represents one type of metal and the thin line another. A variety of metals may be used to form the thermocouple; the most common combination is constantan and copper. The radio-frequency current to be measured passes through and heats a resistance indicated as HEATER STRIP in figure 47. The junction of the thermocouple is thereby heated, resulting in the generation of a d-c voltage which is proportional to the heat applied. This d-c voltage causes a flow of direct current through the movable coil of the milliammeter as indicated in the diagram.

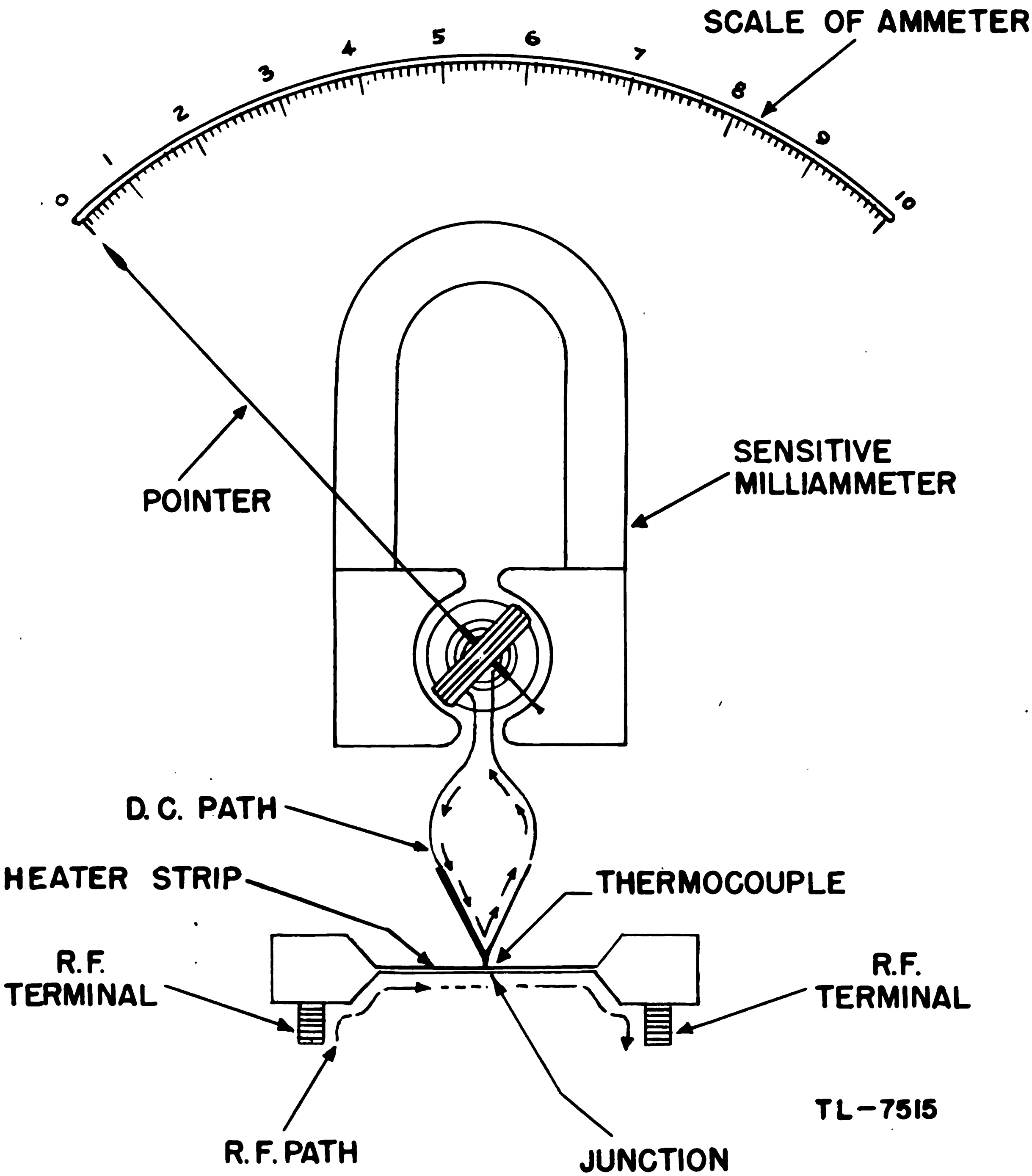
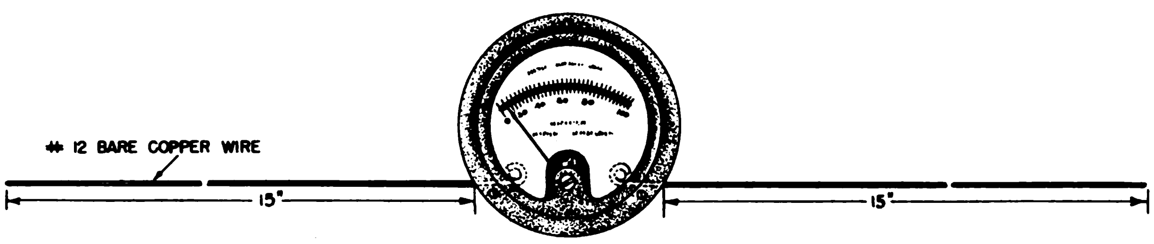
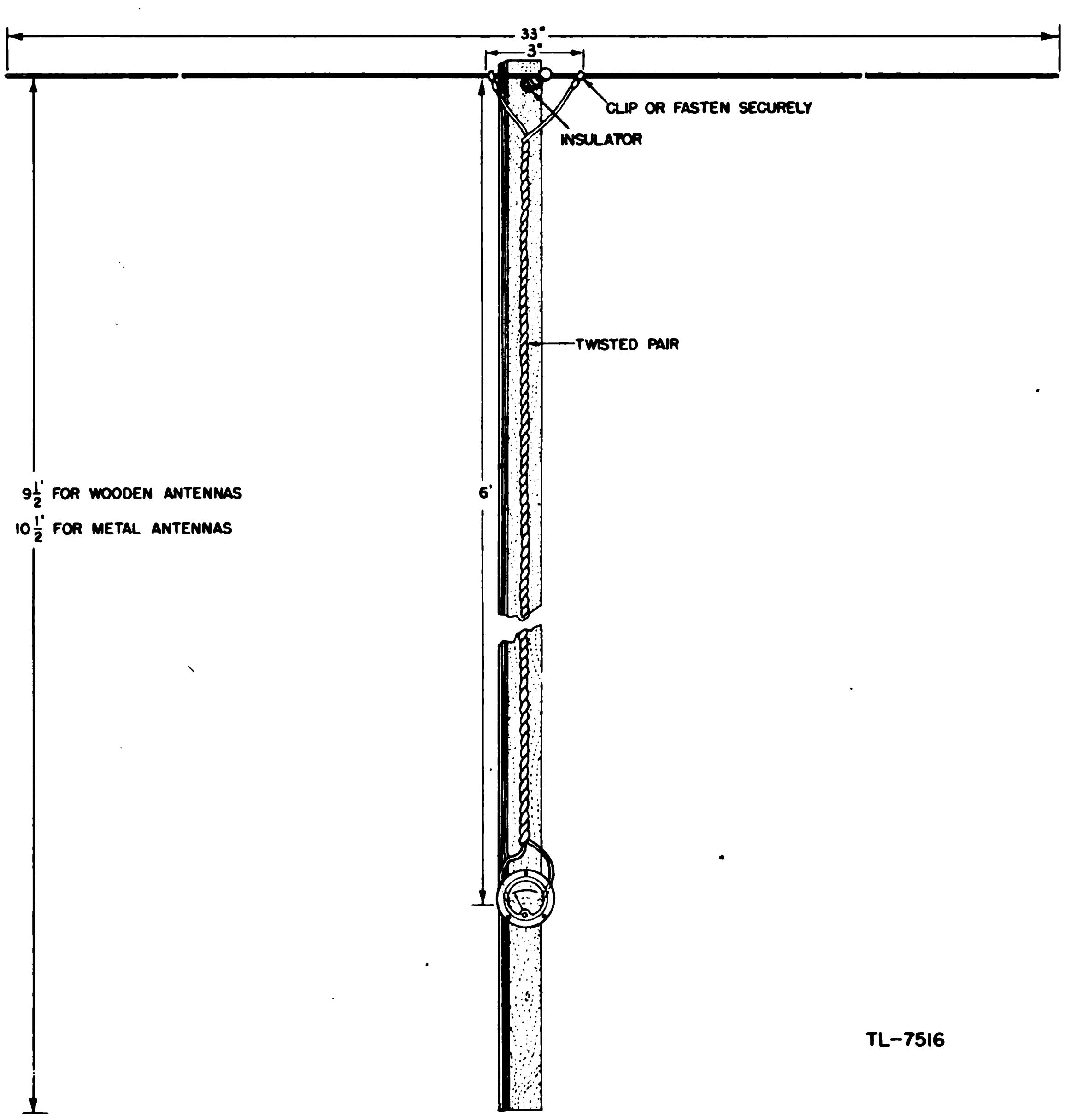


Figure 47. Thermocouple and milliammeter, schematic diagram.

c. The heating effect is proportional to the square of the radio-frequency current being measured, whereas the voltage generated across the junction of the thermocouple is proportional to the heating effect. Therefore, the motion of the pointer over the scale increases approximately proportionally to the square of the radio-frequency current passed through the heating strip. Because of these factors, the scale



(1) Weston model 425 thermocouple with antenna.



(2) Weston model 425 thermocouple with antenna mounted on pole.

Figure 48. Internal-type thermocouple connections for transmitter output measurements.

of the milliammeter used with the thermocouple is crowded at the lower end and more open at the upper end.

d. The heater strip is selected so that its resistance at high frequencies is little different from that at low frequencies. For this reason the thermocouple instrument may be used to measure current in r-f, a-f, and d-c circuits.

155. SHUNTS. The range of a thermocouple instrument can be increased by soldering a shunt made of a short piece of copper wire across the thermocouple lugs. If the range is to be doubled, the pointer is brought to full-scale readings by means of 60-cycle alternating current. A shunt is then soldered between the thermocouple lugs so that the instrument reads one-half the full-scale value. The current passing through the instrument will then be represented by the reading of the instrument multiplied by two. Shunts on radio-frequency instruments should be as short as possible and placed both parallel and close to the thermocouple. If they are placed outside the instrument case, the instrument will not read exactly the same on radio frequencies as it does on low frequencies.

> **NOTE:** It is not intended that using personnel change the range of the thermocouples, because the range of the thermocouples provided with Test Equipment RC-68-(*) is adequate to fulfill their desired function.

156. DAMAGE CAUSED BY STRONG FIELDS.

a. Keep the thermocouple instrument out of strong electrostatic or electromagnetic fields. This can usually be arranged by placing the instrument in a position where these fields are at a minimum. Strong fields tend to create eddy currents in the instrument structure and, although the internal instrument wire is arranged to present a very small loop area, eddy currents or circulating currents due to strong high-frequency fields may burn up the thermocouple.

b. When an antenna is connected to the thermocouple instrument as illustrated in figure 48 keep the antenna perpendicular to the plane of the transmitting antenna of Radio Set SCR-268-(*) until the radio set is at least 40 yards distant. The thermocouple antenna may then be turned parallel to the transmitting antenna and moved towards or away from the radio set until a suitable deflection is obtained on the meter.

SECTION XXIV

THERMOCOUPLES, WESTON MODEL 425 AND WESTON TYPE D

157. DIFFERENCE BETWEEN TYPES.

a. The thermocouples provided with Test Equipment RC-68-(*) may be either Weston model 425 or Weston type D. These differ in that the former is an internal thermocouple; whereas the latter is an external thermocouple.

b. In the Weston model 425, the thermocouple and milliammeter are contained in one case (fig. 48).

c. The Weston type D thermocouple is external to the milliammeter (fig. 49). The d-c voltage generated by the thermocouple is applied to a Weston model 507 milliammeter by means of cord P (Cord CD-728). This permits the dipole and thermocouple to be erected at a distance from the transmitting antenna and the model 507 milliammeter to be read at the trailer mount.

158. COMPENSATING STRIPS. The Weston model 425 and Weston type D thermocouple instruments are compensated to overcome the large errors due to the difference in temperature between the heater strip and the open ends of the thermocouple when no current is flowing. This is accomplished by the use of compensating strips which have the same thermal characteristics as the heater strip itself. The cold ends of the thermocouple are connected to the compensating strips, and the hot-junction is connected to the heater strip. Since the temperature of the compensating strips and the heater strip is the same when no current is flowing, there is a temperature balance; however, when cur-

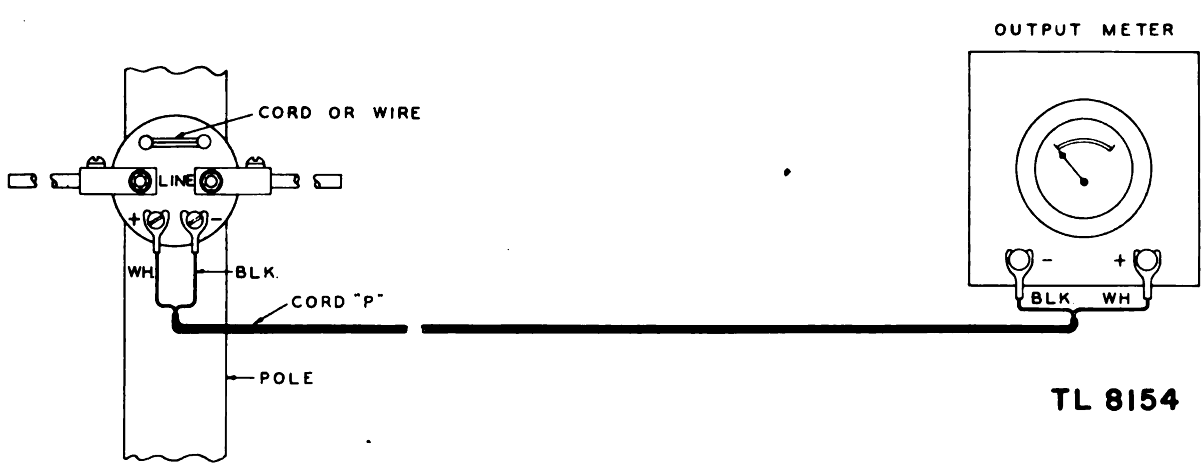


Figure 49. External-type thermocouple connections for transmitter output measurements.

rent heats the heater strip, there is a resultant *difference* in temperature between the cold and hot ends. This temperature difference produces a voltage which is a result only of the temperature rise in the heater strip. External temperature variations of quite large magnitude are therefore completely eliminated.

159. APPLICATION TO RADIO SET SCR-268-(*).

a. Antenna Mounting. When a thermocouple is used to give an indication of the r-f output of the transmitting antenna, it is necessary to provide an antenna for the thermocouple.

(1) This may take either of two forms when Weston model 425 is used. If it is possible to mount the thermocouple on a nearby tree or something similar, the arrangement shown in figure 48① may be used. Another arrangement is illustrated in figure 48②. The antenna may be made from No. 12 bare copper wire, since this gauge is stiff enough to hold its shape. The dimensions given in figure 48 ① and ② have given satisfactory results.

(2) The Weston type D thermocouple has facilities for mounting dipole rods which are supplied with the thermocouple (fig. 49).

b. Measurements. (1) Specific instructions for making transmitter output measurements and transmitting-antenna patterns are beyond the scope of this book. In general, however, the thermocouple is positioned at a distance from the transmitting antennas so that a suitable deflection of the meter needle is obtained. Various adjustments are then made on the transmitting system and the effect on the thermocouple meter noted. The aim is to obtain the maximum reading on the meter consistent with frequency stability of the radio-set transmitter.

(2) The Weston model 425 ammeter is calibrated for 0 to 100 milliamperes; the Weston model 507 output meter is calibrated for 1 to 10 units. In either case the reading obtained is relative because it is only a measure of the radio-frequency energy flowing through the thermocouple and *not* an absolute measure of the actual radio-frequency output of the radio set. Absolute output readings cannot be taken with accuracy because of the many variables involved, such as distance, nature of terrain, height above ground, temperature, humidity, angle of radiation, and nearby reflecting bodies. Relative readings, however, are very useful inasmuch as they enable the radio set to be adjusted for maximum output and also allow transmitting-antenna pattern taking.

c. Precautions Against Disturbance. The thermocouple instrument is very sensitive to field disturbances. Side echoes from reflecting bodies in the near vicinity greatly affect the readings. Moving objects such as trucks may cause violent fluctuations of the meter needle. With the arrangement used in figure 48, changes in the reading will usually occur when someone approaches the meter in order to read it. for these reasons, it is essential that certain precautions be taken if accurate results are to be obtained.

(1) Wherever possible, mount the thermocouple sc that it will not be affected by metal or moving objects.

(2) Be sure that it is securely mounted. A 1- or 2-inch shift in position may greatly affect the reading of the meter.

(3) When the Weston model 425 thermocouple is used, do not approach closer than necessary to take readings. The latter precaution does not apply when the Weston type D thermocouple is used as in figure 49, since cord P (Cord CD-728) carries d-c voltage to the output meter which is 30 or 40 yards away. The observer may therefore approach the output meter without affecting the thermocouple.

SECTION XXV
SPECIALIZED TEST EQUIPMENT

160. KEYER LOAD, TEST SET I-115.

a. The function of Test Set I-115 is to provide an artificial load for use in testing Keying Units BC-409 and BC-409-A. An outline-dimensional sketch of the test set is shown in figure 50. A schematic diagram is shown in figure 51.

b. The constants of the RC series network in the test set simulate the action of the load presented by Modulator BC-435-A to the keying unit. The time constant of this network determines the characteristics of the keyer-pulse waveshape under the test conditions. This time constant is not necessarily the same as is obtained in actual service, especially where changes have been made in the keyer output circuit.

c. Signals of a high voltage cause a large deflection on the oscilloscope screen and may even cause the image to pass off the screen. In order to provide a signal which may be observed on the screen, the keyer output signal is applied across the input terminals of the test set and reduced to one twenty-sixth of its value by means of the voltage divider (formed by resistances 3-1, 3-2, and 3-3) before it is applied to the test oscilloscope. The test oscilloscope is then used to determine the waveshape and peak voltage of the keyer pulse. Switch 4 is used to discharge the high voltage which may remain trapped in capacitor 1.

d. The test connections for using Test Set I-115 are shown in figure 52.

161. MAINTENANCE OF KEYER LOAD, TEST SET I-115.

a. General. The following tests are for use in locating trouble in this test set and for determining the input-to-output voltage ratio of the voltage divider. The voltage ratio must be determined from time to time, as the resistances making up the voltage divider will vary considerably with age and use.

CAUTION: HIGH VOLTAGES SUFFICIENT TO CAUSE DEATH ON CONTACT ARE BROUGHT INTO THIS TEST SET AND MAY REMAIN IN THE BLOCKING CAPACITOR. ALWAYS OPERATE THE SHORTING SWITCH BEFORE MAKING ANY CONNECTIONS OR ADJUSTMENTS.

b. Over-all Performance Tests. Make these tests before the test set panel is removed to determine the location of trouble. Repeat them after troubles have been corrected and the panel has been replaced.

LIST OF TESTING EQUIPMENT*

1 Analyzer I-167 or I-153-A, and associated cord equipment with plugs and test picks.
1 Polarized Outlet Box BC-672-B.
1 Cord CD-487.
1 Cord CD-502, red.
1 Cord CD-502, black.

*Equipment not supplied with Radio Set SCR-268-(*) is obtainable from Signal Corps depots.

(1) Operate the shorting switch on Test Set I-115.

(2) Set up the connections to the test equipment shown in figure 53, first connecting Cords CD-502 to Test Set I-115 and to the plug of Cord CD-487. Be careful not to short-circuit the clips against the shell of the plug. Then connect Cord CD-487 to the polarized outlet box.

(3) Adjust the output of the power unit to 120 volts.

(4) With the shorting switch held in the operated position and the analyzer set to read a-c volts on the 10-volt scale, read and record the voltage across the output terminals of Test Set I-115.

(5) Allow the shorting switch to assume its normal unoperated position.

(6) Determine the input-to-output voltage ratio by dividing 120 by the numerical value of the voltage read in step (4). (The ratio is usually about 26:1). Record this value with that of step (4). This value may then be referred to for future use and need not be recalculated, unless there is a material change in the voltage read in step (4).

(7) With the analyzer set to read a-c volts on the 10-volt scale, make sure that the voltage read across the output terminals is lower than was observed in step (4). If the voltage reading does not change, it is an indication that the shorting switch is inopera-

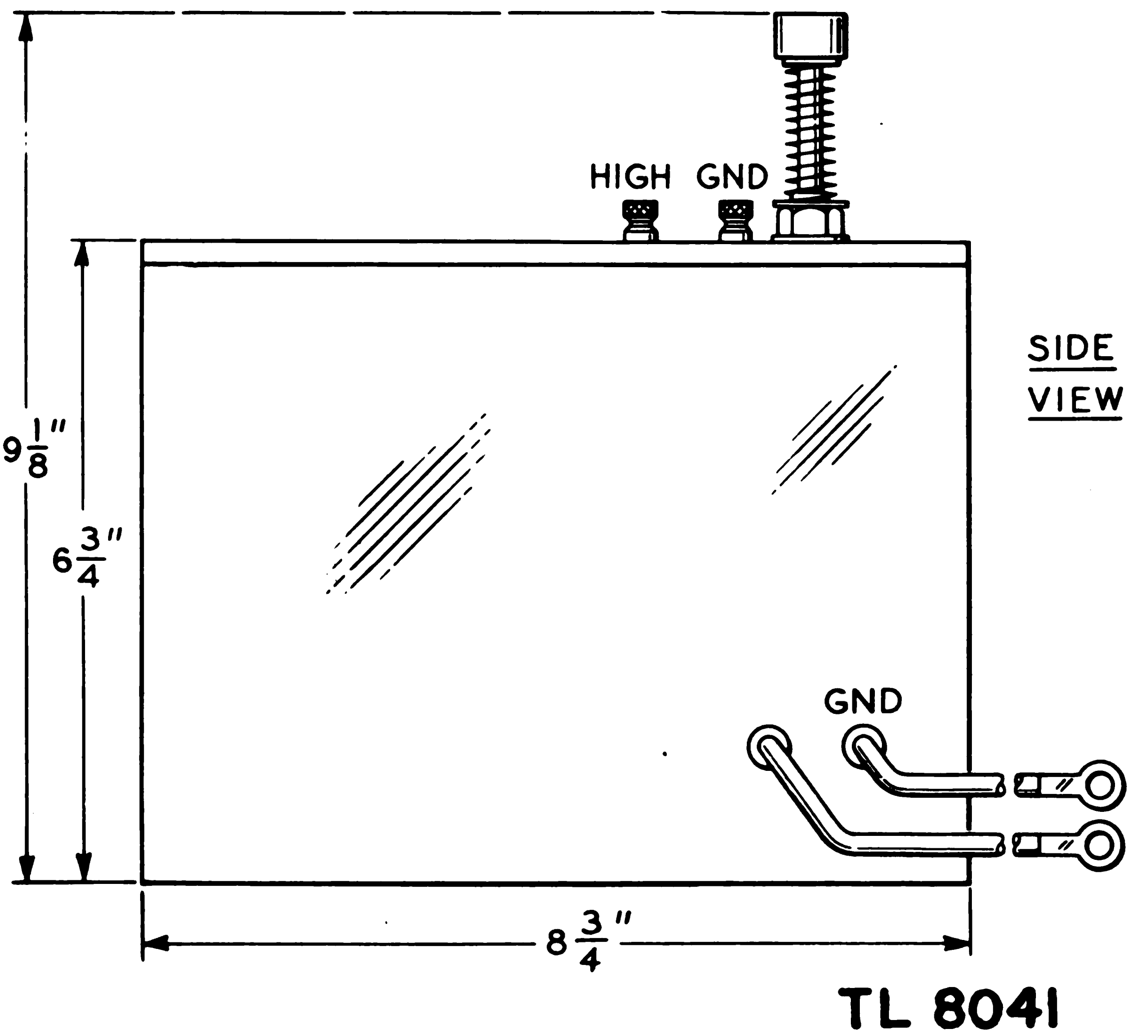
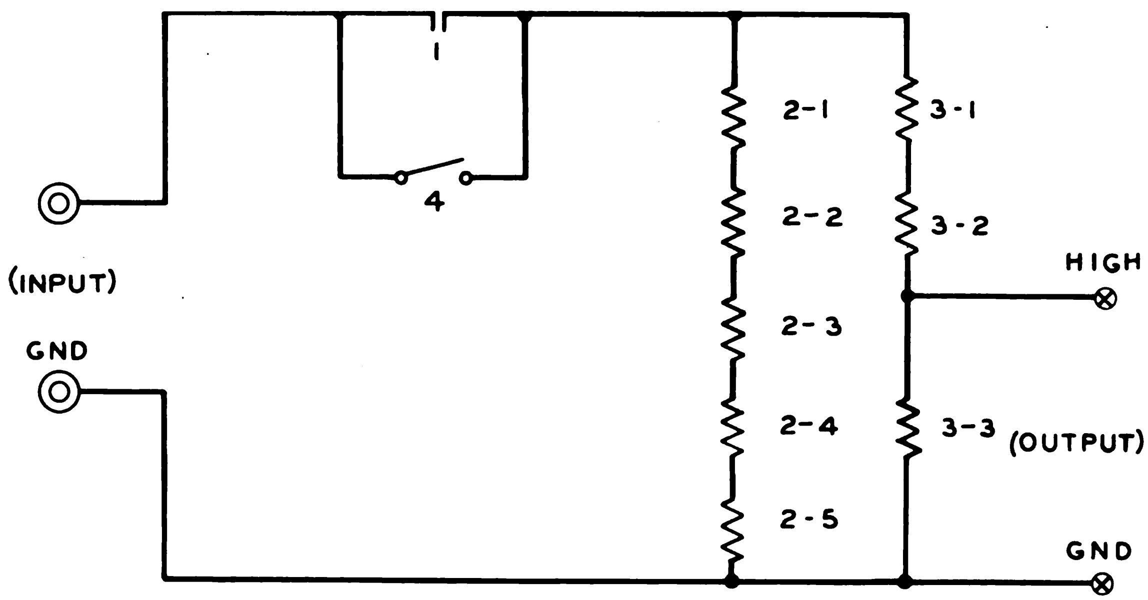


Figure 50. Keyer Load, Test Set I-115; outline-dimensional sketch.



APP. PART NO.	DESCRIPTION	NAME	MADE BY OR EQUIVALENT
1	1 M.F. 5000V. D.C. TYPE NO. 5009	CAPACITOR	AEROVOX CORP.
2-1 TO 2-5	CARBON TYPE D5 500ω 5 WATT	RESISTOR	CONTINENTAL CARBON, CO.
3-1	10,000ω BT2		INTERNATIONAL RES. CO.
3-2	15,000ω BT2		
3-3	1000ω BT2		
4		SHORTING SWITCH	WESTERN ELECTRIC CO.

TL 8123

Figure 51. Keyer Load, Test Set I-115; schematic diagram.

tive or the capacitor is short-circuited. If no voltage reading is obtained on either test, an open circuit is indicated.

c. Visual Inspection. If the over-all performance tests indicate trouble in the test set, remove the top panel. Examine carefully all wiring and apparatus. Look for foreign material, such as pieces of loose wire or solder chips, and for defective apparatus and parts. Check the alignment of the switch shorting bar and its associated leaf spring terminals, and make sure that the capacitor is firmly held in place.

d. *Trouble-shooting Data.* The following table lists resistance values across various terminals as measured with the analyzer used as an ohmmeter. The top panel must be in place when making these measurements. See figure 51 for a schematic diagram of the test set.

TABLE IX

RESISTANCE VALUES

Terminals	*Meter control position*	*Meter scale*	*Resistance (ohms)*	*Probable cause of incorrect reading*
Input	R x 1,000	0-3 megohm	2280*	Shorting switch inoperative, wrong values of resistance, short-circuited or open resistance.
	R x 10,000	0-inf	inf†	Capacitor or switch short-circuited.
Output	R x 10	0-30,000	965	Short-circuited or open resistances. Resistance changed because of age or usage.

* Shorting switch operated.

†Shorting switch normal (unoperated).

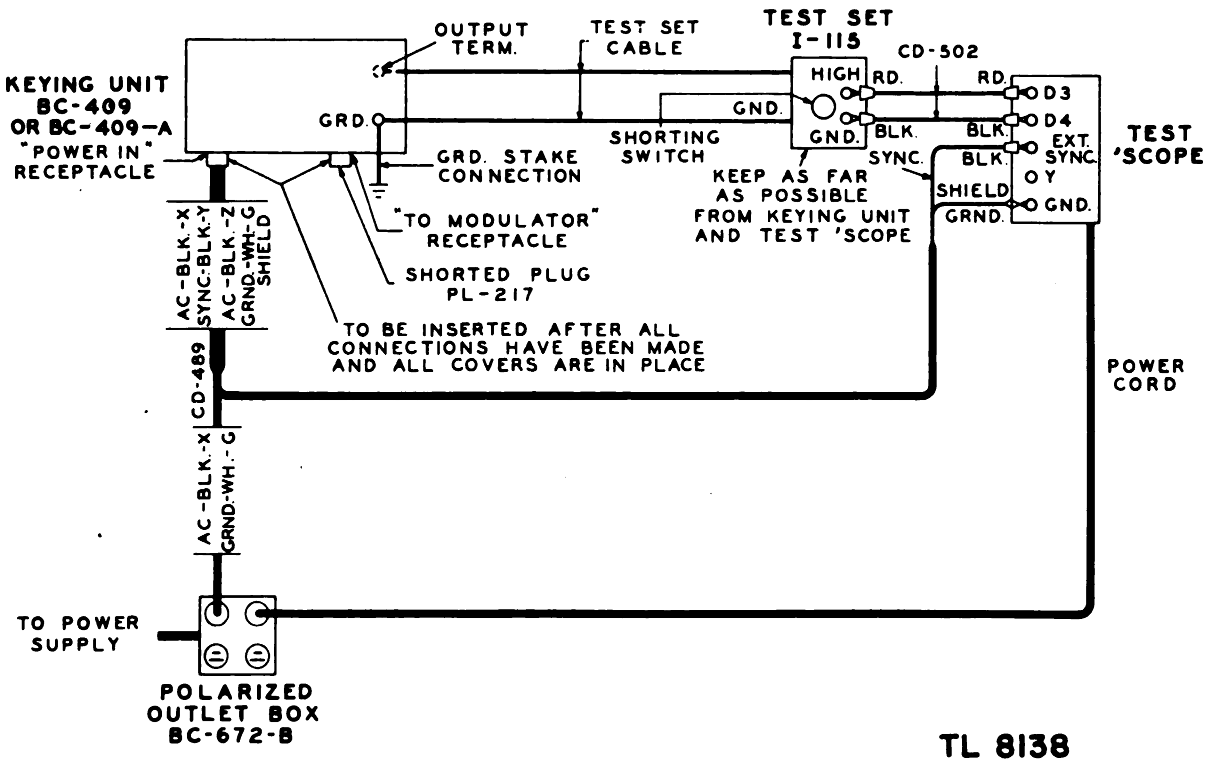


Figure 52. Test connections for artificial load test.

162. SYNCHRONOUS REPEATER, TEST SET I-114.

a. Function. (1) Test Set I-114 is provided mainly for testing the five synchronous repeaters of Radio Set SCR-268-(*). An outline-dimensional sketch of this test set is shown in figure 54 and a schematic diagram is illustrated in figure 55. The test set has two 5-position switches, one of which selects the repeater to be tested; the other switch selects the pair of repeater windings to be tested.

(2) In addition to testing synchronous repeaters, Test Set I-114 can also be used to test for crossed, grounded, and open cable leads, or as an a-c voltmeter for voltages of 150 volts or less.

(3) When testing repeaters, cable 27, which normally connects to the gun director, is usually plugged into the 19-terminal receptacle of the test set. The repeaters may also be tested by plugging cables 15 or 24 into this receptacle (for Radio Set SCR-268-C, the foregoing does not apply to cable 24). Receptacles are provided for connecting alternating current to the test set, and the repeater switch of the test set is used to connect this alternating current to the rotor of one of the five repeaters in the radio set. By setting the voltmeter in one of the first three positions, the resultant voltage induced in any two of the three stator windings of the repeater can be read on the voltmeter.

(4) The repeater rotor is then turned and the maximum induced voltage determined. By reference to the associated altitude dial, or the angular-height counter, the position of the rotor when the maximum voltage was induced may be determined. A satisfactory test of the repeater windings is indicated if the repeater rotor is turned 3,200 mils (180°) from one point of maximum voltage to the next point of maximum voltage. Repeat this test for the other two combinations of stator windings of the repeater. A continuity test is also made of the cable leads and low-voltage slip ring contacts between the test set and the repeater, incidental to the test of the repeater windings.

b. Locating and Connecting. Locate the test set near an appliance outlet, such as the outlet on the keyer, and close enough to the trailer mount to permit easy communication between the man making the test and the man operating the controls on the trailer. Connect the test set shown in figure 56. Alternating current may be connected to the test set either by cable 9, Test Cord CD-520, or Test Cord H. When the test set is connected, one of its a-c receptacles will not be used. Avoid short-circuiting the live terminals in the unused male receptacle. The settings of the switches on the test set select the repeater and the stator windings of the repeater under test, as shown in Table X, on page 156.

c. Test of Repeater Windings. (1) Position the antennas at an angular height of about 750 mils, as indicated by the counter on the converter. Operate the toggle switch on the test set, and not the reading of the test set voltmeter.

(2) If the voltmeter does not deflect, there may be a poor connection between the prongs of the cable connector on cable 27 and the test set receptacle. Press the cable connector firmly into the test set receptacle to eliminate this possibility. Other causes of failure of the voltmeter to deflect are: open cable leads, faulty slip ring, open repeater winding or connection, and rotor of repeater in such a position that no voltage is being induced in the particular stator winding under test. Move the voltmeter switch to a different one of its first three positions.

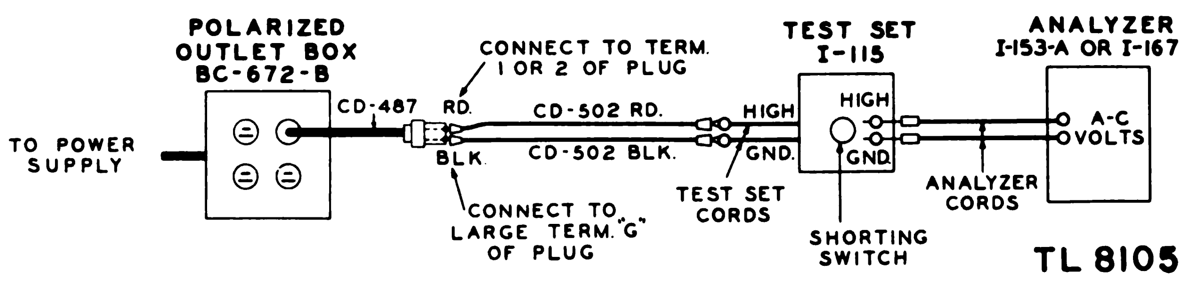


Figure 53. Keyer load, test set, test connections.

TABLE X

TEST SWITCH SETTINGS FOR TESTING STATOR WINDINGS OF SYNCHRONOUS REPEATERS

Test set switch settings		A-c across cable leads (rotor)	Voltmeter across cable leads (stator)	Provides test of repeater stator windings
Repeater switch	Voltmeter switch			
AF	1	14 and 15	1 and 2	Azimuth, fine
AF	2	14 and 15	1 and 3	Azimuth, fine
AF	3	14 and 15	2 and 3	Azimuth, fine
AC	1	4 and 5	6 and 7	Azimuth, coarse
AC	2	4 and 5	6 and 8	Azimuth, coarse
AC	3	4 and 5	7 and 8	Azimuth, coarse
EF	1	14 and 15	11 and 12	Angular height, fine
EF	2	14 and 15	11 and 13	Angular height, fine
EF	3	14 and 15	12 and 13	Angular height, fine
EC	1	4 and 5	16 and 17	Angular height, coarse
EC	2	4 and 5	16 and 18	Angular height, coarse
EC	3	4 and 5	17 and 18	Angular height, coarse
ALT	1	14 and 15	9 and 10	Altitude
ALT	2	14 and 15	9 and 19	Altitude
ALT	3	14 and 15	10 and 19	Altitude

If the voltmeter still does not deflect, an open circuit is indicated. Cable 27 may be eliminated as a possible source of the trouble by disconnecting cable 15 (for azimuth repeaters) from Terminal Box JB-23 or JB-73 and plugging this cable into the test box in place of cable 27.

(3) If the voltmeter deflects when the toggle switch on the test set is operated, have an assistant rotate the proper handwheel on the trailer mount to change the position of the repeater under test until the voltage read on the meter is at a maximum. (Use the range handwheel for positioning the altitude repeater.) With the a-c voltage at 120 volts, this maximum voltage should be 108 to 112 volts. In the case of the coarse angular-height repeater, it will not be possible to obtain this voltage on one and sometimes two of the stator windings, because it is normally rotated only about 87° when the elevation handwheel is rotated from one stop position to the other. On these windings, all that can be done is to note that the voltage changes as the elevation handwheel is rotated.

(4) With the voltage at a maximum, note the following reading:

Repeater under test	Reading
Coarse or fine azimuth	Azimuth (mils) on azimuth ring on trailer mount.
Coarse angular height	No reading.

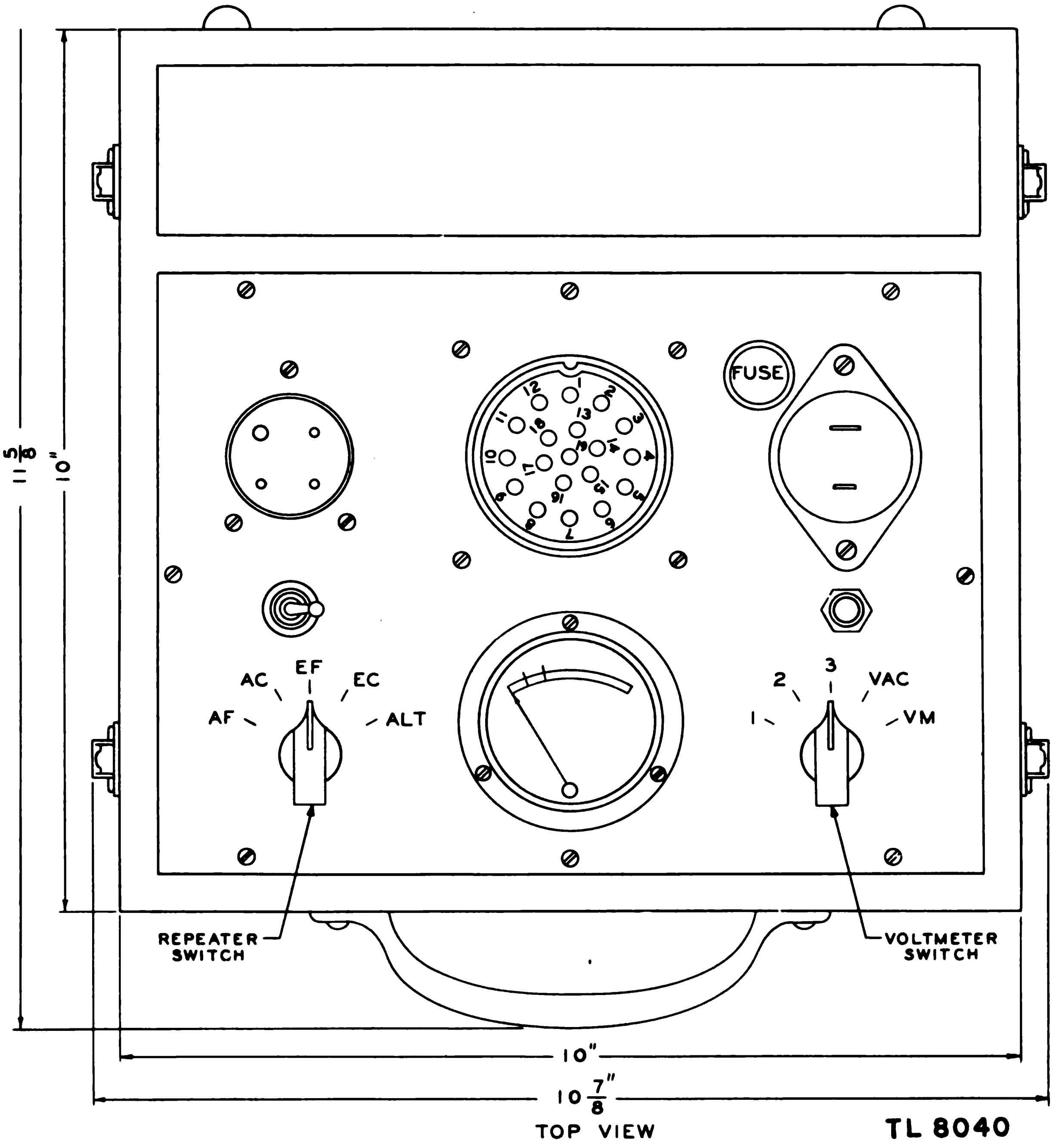
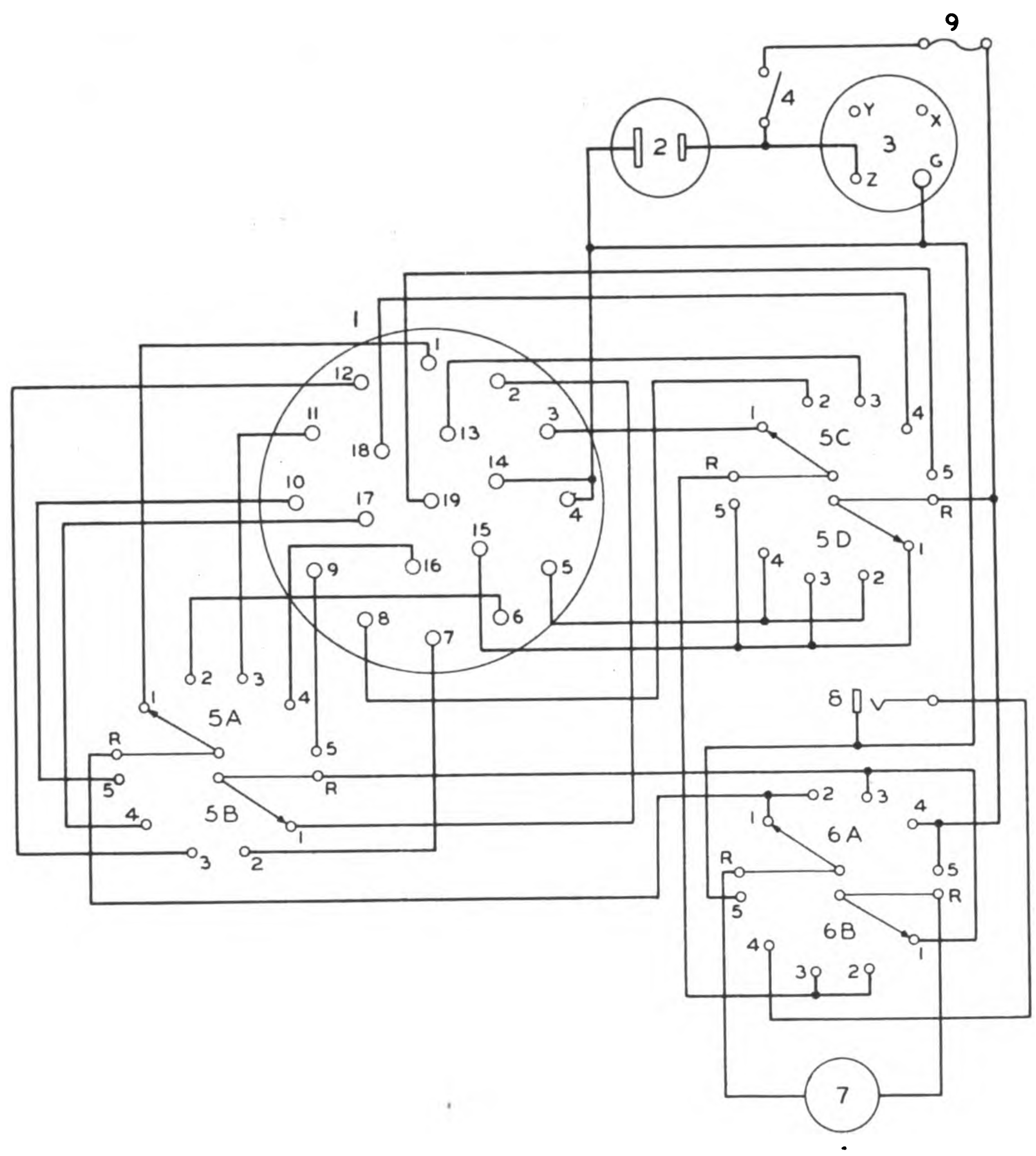


Figure 54. Synchronous repeater, Test Set I-114; outline-dimensional sketch.

Repeater under test	*Reading*
Fine angular height	Elevation (mils) on converter angular-height counter.
Altitude	Altitude (yards) on converter altitude dial.

(5) Again rotate the proper handwheel so as to rotate the repeater rotor 180°. The voltage read on the test-set meter should decrease to zero and then increase to the maximum value as previously read. The change in the previous scale or counter reading will be as follows, to move the rotor to 180°.



APP. PART NO.	DESCRIPTION		NAME	MADE BY OR EQUIVALENT
1	ESO-681739-2		RECEPTACLE	WESTERN ELECTRIC CO.
2	POLARIZED # 4898		FLUSH MOTOR PLUG	HARVEY HUBBELL INC.
3	# F-6854		RECEPTACLE	RUSSELL & STOLL CO.
4	PER ESO-614549-3 (S.P. S. T.)		TOGGLE SW.	ARROW HART & HEGEMAN MFG.CO.
5A TO 5D	2 SECT. 4 POLE 5 POS.# 2515	1/2"LG. SHAFT	SELECTOR SW.	CENTRALAB INC.
6A, 6B	1 SECT. 2 POLE 5 POS.# 2505		SELECTOR SW.	
7	A-C 0-150V. MODEL 517 FLUSH TYPE 2 1/2" METAL CASE		VOLTMETER	WESTON ELECTRIC INSTRUMENT CO.
8	OPEN CIRCUIT # 701		JACK	MALLORY - YAXLEY CO.
9	5 AMP. 250V. 3AG # 1358		FUSE	LITTELFUSE LABORATORIES

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Figure 55. Synchronous repeater, Test Set I-114, serial No. 244 or higher; schematic diagram.

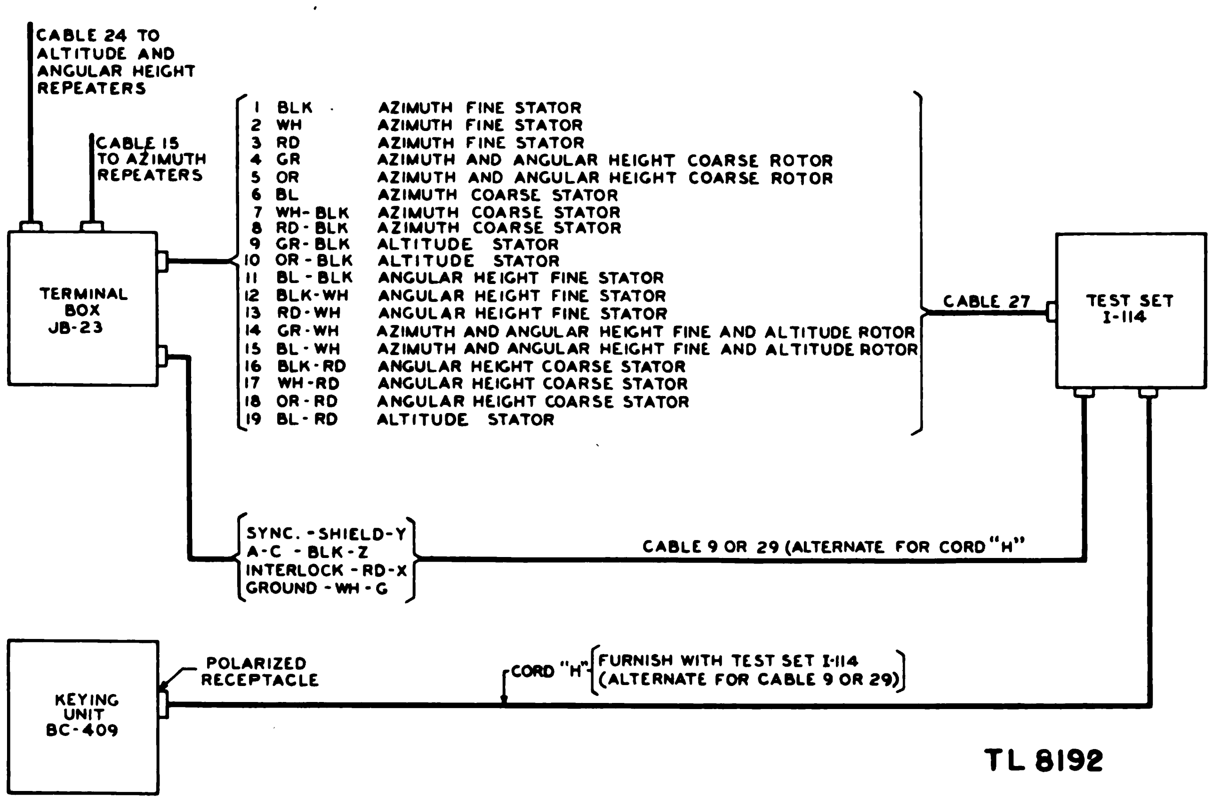


Figure 56. Synchronous repeater, Test Set I-114; connections for repeater tests.

Repeater under test	*Change in reading*
Coarse azimuth	3,200 mils
Fine azimuth	200 mils
Fine angular height	200 mils
Altitude	5,000 yards

(6) To measure the a-c voltage at the test set on boxes having serial number 244 or higher, set the voltmeter switch in the VM position. On test sets having serial number 243 or lower, plug cord J into the jack on the instrument panel, set the voltmeter switch in the VAC position, and touch the instrument clip of this cord to some part connected to the ground system, such as the grounded terminal of the unused a-c receptacle of the test set.

d. *Other Uses of Test Set I-114.* Test Set I-114 is intended primarily for testing repeaters, but it has several other uses. Plug cord J into the jack on the test set instrument panel for all of the following applications of the test set.

(1) TO MEASURE VOLTAGES OF 150 VOLTS OR LESS (TEST SETS HAVING SERIAL NUMBER 243 OR LOWER). Connect the alligator clips of cord J across the voltage to be measured, and set the voltmeter switch in the VM position.

(2) TO CHECK FOR GROUNDED CABLE LEADS. Connect alternating current to the test set as shown in figure 56 (cable 27 need not be connected); set the voltmeter switch in the VAC position; and operate the toggle switch on the test set. Touch the insulated alligator clip of cord J to the lead in question. If the voltmeter does not deflect, the lead is not grounded. If the voltmeter deflects, note the reading. Move the voltmeter switch to the VM position and note the voltmeter reading. If the two readings are the same, the lead is grounded through little or no resistance. If the first reading is less than the second, the lead is grounded through a resistance path.

(3) TO CHECK FOR CROSSED CABLE LEADS.

(a) Connect alternating current to the test set as shown in figure 56 (cable 27 need not be con-

nected); set the voltmeter switch in the VAC position; and operate the toggle switch. Disconnect both ends of the lead under test.

(b) On test sets having serial number 244 or higher, connect the uninsulated alligator clip of cord J to one of the cable leads. Then touch the insulated alligator clip to each of the other leads of the cable, observing whether the test set voltmeter deflects as any of the leads are touched. If the voltmeter does not deflect, none of the leads in the cable is crossed with the lead to which the uninsulated clip of cord J is connected. A deflection indicates crossed leads. Continue in this manner until tests have been made with the uninsulated clip of cord J connected to each of the other leads in the cable.

(c) On test sets having serial number 243 or lower, connect ground to one of the cable leads by Test Cord CD-503. Then touch the insulated alligator clip of cord J to each of the other leads of the cable, observing whether the test set voltmeter deflects as any of the leads are touched. If the voltmeter does not deflect, none of the leads in the cable is crossed with the grounded lead. A deflection indicates crossed leads. Continue in this manner with ground connected to each of the other leads in the cable.

(4) TO CHECK FOR CONTINUITY OF A LEAD.

(a) Connect alternating current to the test set as shown in figure 56 (cable 27 need not be connected); set the voltmeter switch to the VAC position, and operate the toggle switch. Disconnect both ends of the lead under test.

(b) On test sets having serial number 244 or higher, connect one of the alligator clips of cord J to one end of the lead and the other alligator clip to the other end of the lead. If the voltmeter does not deflect, the lead is open. If the voltmeter deflects, note the reading. Then move the voltmeter switch to the VM position and again not the voltmeter reading. If the two readings are the same, or practically the same, the lead is continuous and of low resistance.

(c) On test sets having serial number 243 or lower, connect ground to one end of the leads under test by Test Cord CD-503. Then connect the insulated clip of cord J to the other end of the lead. If the voltmeter does not deflect, the lead is open. If the voltmeter deflects, note the reading. Then touch the insulated clip of cord J to ground and again note the voltmeter reading. If the two readings are the same, the lead is continuous and of low resistance.

c. Maintenance. (1) Before using this test set, make sure that the voltmeter reads zero when no connections are made to the test set. The voltmeter needle may readily be positioned at zero, if necessary, by a screwdriver adjustment at the pivot of the needle. Usually no other maintenance work on this test set will be required.

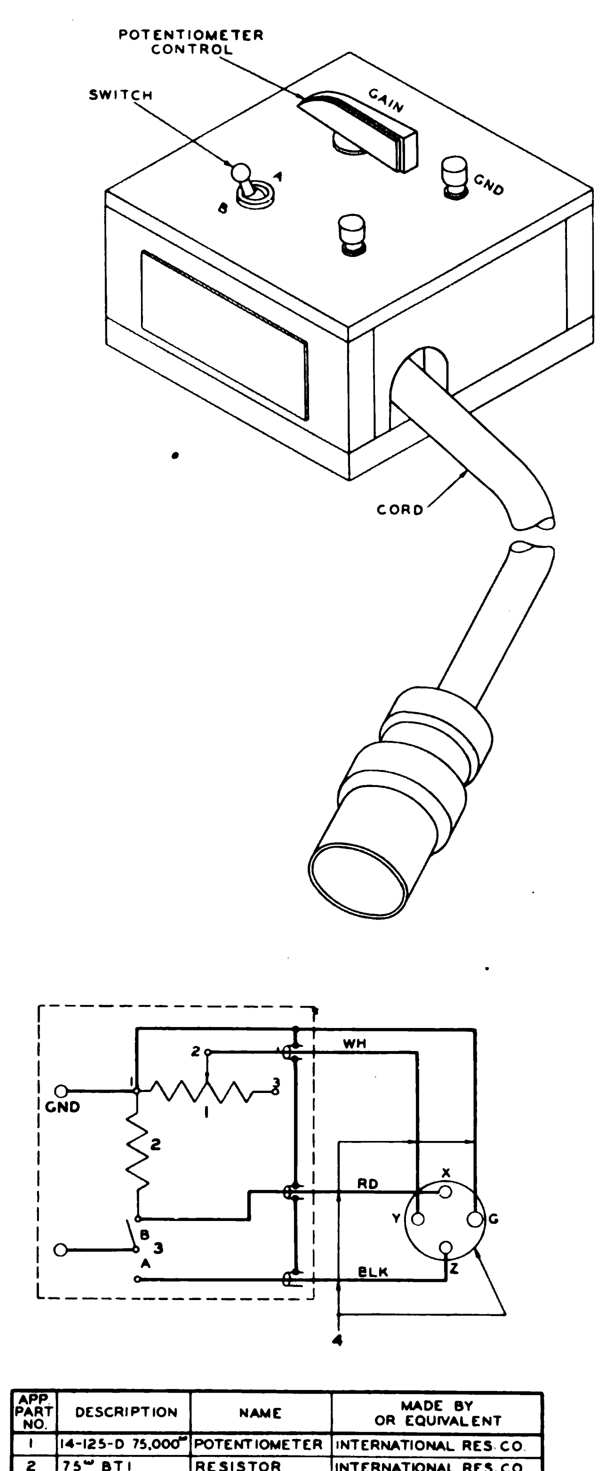
(2) Check the accuracy of the voltmeter occasionally, by connecting the voltmeter to a known voltage of 110 or 120 volts alternating current and noting whether the meter indicates the correct voltage. Then, when voltage measurements are made with the test set, the error, if any, may be added or subtracted from the value indicated to get the correct voltage.

(3) Refer to figure 55 for a schematic diagram of the test set.

163. RECEIVER OUTPUT BOXES, TEST SETS BC-671 AND BC-708-A.

a. The function of the receiver output box is to provide a means for connecting the output of Receiver BC-406 to a test oscilloscope. The receiver can then be tested and aligned. Figures 57 and 58 show the circuit schematic diagrams and equipment arrangements for Receiver Output Boxes BC-671 and BC-708-A respectively. Each box is equipped with a variable resistor, a fixed resistor, and a toggle switch. The variable resistor simulates the sensitivity control normally located in Oscilloscope BC-412-A. The fixed resistor takes the place of a similar resistor in Oscilloscope BC-412-A and completes the plate circuit of the switching amplifier in Receiver BC-406.

b. The toggle switch controls the switching of the "hot" lead which is connected to the high terminal of the vertical deflection plates of the test oscilloscope. In one position, the high terminal of the test oscilloscope is connected to the output of the switching amplifier, which normally is connected



APP. PART NO.	DESCRIPTION	NAME	MADE BY OR EQUIVALENT
1	14-125-D 75,000ω	POTENTIOMETER	INTERNATIONAL RES. CO.
2	75ω BT1	RESISTOR	INTERNATIONAL RES. CO.
3	NO. 1236	SWITCH	INSULINE CORP. OF AMERICA
4	ESO-681743-3	CORD ASSEM.	WESTERN ELECTRIC CO

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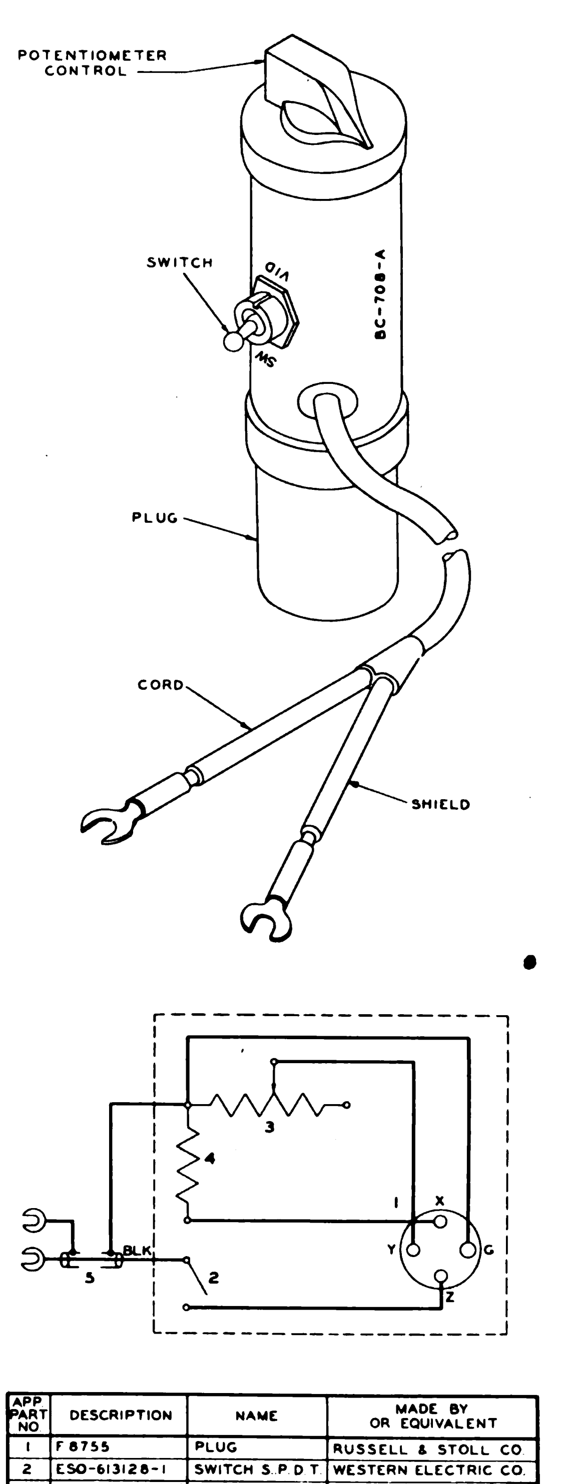
Figure 57. Receiver Output Box BC-671.



APP. PART NO.	DESCRIPTION	NAME	MADE BY OR EQUIVALENT
1	F 8755	PLUG	RUSSELL & STOLL CO.
2	ESO-613128-1	SWITCH S.P.D.T.	WESTERN ELECTRIC CO.
3	TYPE J 75,000ω STRAIGHT TAPER	POTENTIOMETER	ALLEN-BRADLEY CO.
4	75ω BT 1/2	RESISTOR	INTERNATIONAL RES CO
5	ESO-681922-4	CORD ASSEM.	WESTERN ELECTRIC CO.

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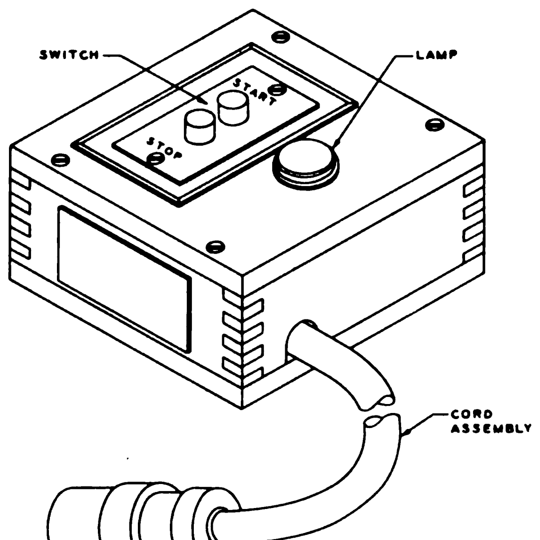
Figure 58. Receiver Output Box BC-708-A.



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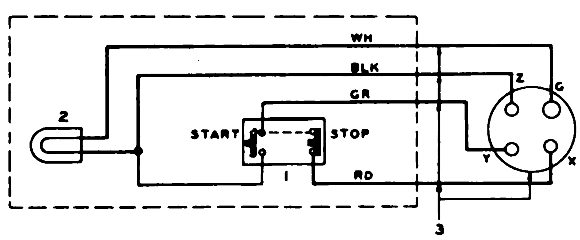

APP. PART NO.	DESCRIPTION	NAME	MADE BY OR EQUIVALENT
1	NO. 1615F	SWITCH	ARROW HART & HEGEMANN CO.
2	56 MAZDA LAMP 6 WATTS	LAMP	GENERAL ELECTRIC CO.
3	ESO-681743-1	CORD ASSEMBLY	WESTERN ELECTRIC CO.

Figure 59. Rectifier remote control Test Box BC-670-B.

to the spread amplifier of Oscilloscope BC-412-A. With the toggle switch in this position, the test oscilloscope will indicate the character of the spread voltage secured from the switch amplifier.

c. When the toggle switch is in the other position, the vertical terminals of the test oscilloscope are connected across the output of the video stages of the receiver. The trace which appears on the test oscilloscope is the signal output of the receiver.

d. Receiver Output Box BC-708-A is provided with a cord assembly for connection to the test oscilloscope; whereas Receiver Output Box BC-671 is furnished with a set of terminals which must be connected to the test oscilloscope. Instructions for the connection and operation of these test sets are given in the manual covering maintenance of the receiver.

164. REMOTE CONTROL TEST BOX BC-670-B.

a. Test Box BC-670-B is provided for remote-control operation of the high-voltage circuit of Rectifier RA-38 at its panel. The unit is a small box with a STOP and START switch, a red pilot light, and a 3-foot cable terminated in a four-pole plug. The circuit arrangement is shown in figure 59.

b. In order to operate the rectifier during normal operation, the interlock circuits in the radio set must be closed and the RECTIFIER START button at the keyer must be operated. It is sometimes more practical, however, to use remote-control Test Box BC-670-B, which provides those functions of the keyer necessary to turn on the rectifier high-voltage circuit. For example, when maintenance work is being performed on the rectifier, it may be necessary to turn the rectifier on and off repeatedly. Since the keyer is located approximately 150 feet from the rectifier, a 300-foot trip would have to be made every time the rectifier was turned on. By removing cable 22 from the REMOTE CONTROL CABLE receptacle at the rectifier control panel, and inserting the plug of the test box, the rectifier high-voltage can be controlled by the test box.

c. Test Box BC-670-B can also be used as a trouble-shooting device. Trouble in the interlock circuit can be localized to the rectifier or keyer interlocks.

d. When Test Box BC-670-B is used, do not apply the high voltage unless the filaments of the transmitter tubes are lit and the radio set is prepared for the application of high voltage. If the PLATE CONTROL handwheel at the rectifier is turned to its maximum counterclockwise position (minimum setting), high voltage cannot be applied to the modulator and transmitter.

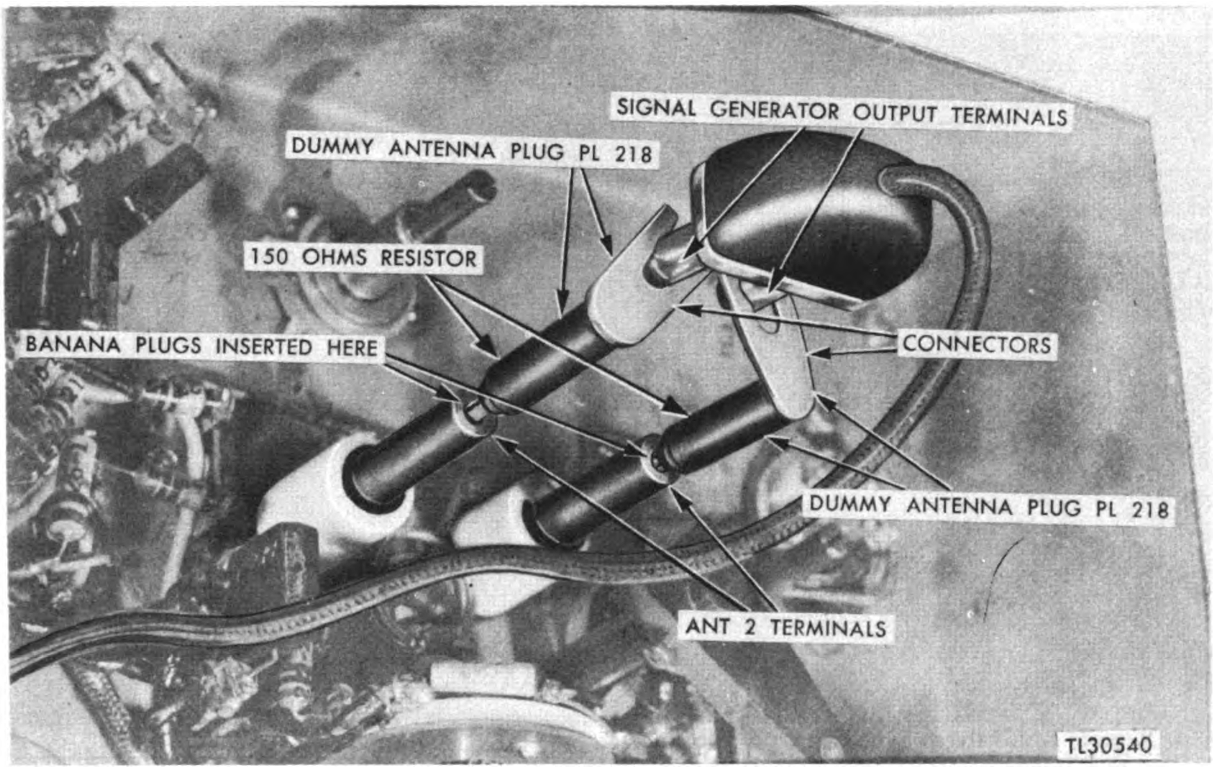

Figure 60. Plug PL-218, test connections.

165. PLUG PL-218.

a. Plug PL-218 contains a 150-ohm carbon resistor. Two of these plugs are used as an impedance-matching device when Receiver BC-406-A is aligned or tested by means of the r-f signal generators provided with the test equipment. Figure 60 illustrates the use of these plugs. Each one is connected in series with each leg of the signal-generator output terminals and the receiver antenna terminals. A schematic diagram is shown in figure 61.

b. The signal-generator output cable terminates in a resistance of approximately 30 ohms, while the antenna impedance of the receiver is 300 ohms for each channel. A perfect impedance match therefore requires an impedance-matching resistor equal to 300 ohms minus 30 ohms, or 270 ohms. Since the receiver is designed to operate from a balanced-input line, the impedance-matching resistance is equally divided in each leg of the line. This calls for 135 ohms in series with each leg. In actual practice, 150 ohms resistance is inserted in each leg.

c. The two 150-ohm resistors are arranged with connectors which can be joined to the signal-generator output terminals. The other end of each of these series resistors terminates in a "banana" plug, which can be inserted into the receiver antenna terminals. When used with Signal Generator I-126, Measurements model 78-B, the plug connectors must be filed to fit the output terminals of the signal generator.

166. SCREEN M-352.

a. Screen M-352 is a wire-mesh screen in a wooden frame. It is used as a shield and reflector when the buried-tweeter method is used to align the antennas of Radio Set SCR-268-(*). The arrangement of the screen on Modulator BC-423 (tweeter) is shown in figure 62.

b. Small openings in the screen permit it to be placed over the tweeter without touching the dipole. The wooden frame supports the screen in a fixed position above the tweeter case and below the dipole antenna.

c. When burying the tweeter, make sure that the top of the tweeter is flush with the ground and that

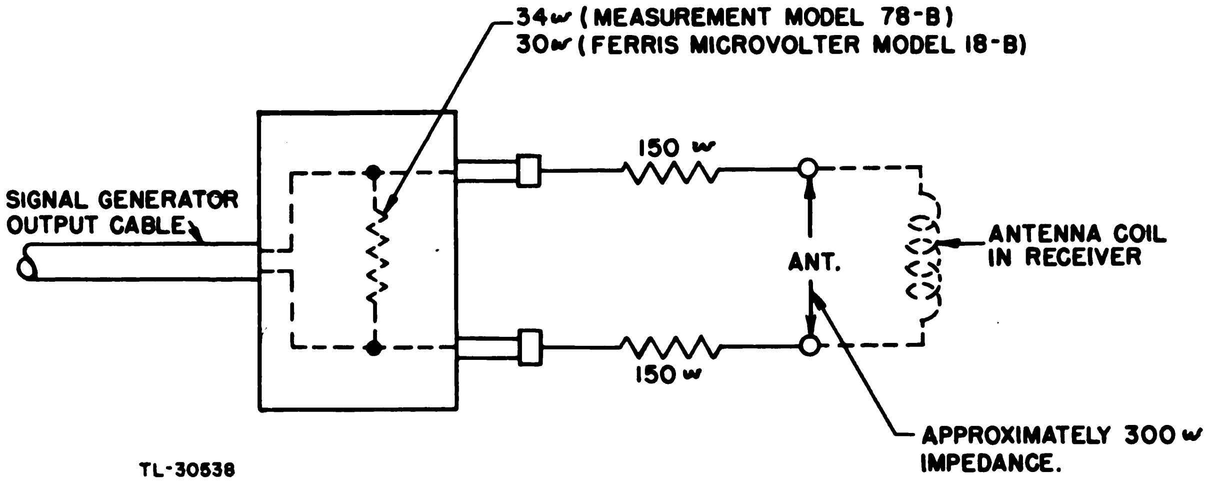

Figure 61. Plug PL-218, schematic diagram of test connections.

the dipole projects above the surface. The tweeter dipole must be parallel to the plane of the antenna array of the radio set.

d. Remove both halves of the tweeter dipole, and place the screen flat on the tweeter case and on the earth. Replace the dipole so that both halves project above the screen without touching it. Make sure that the wooden frame on the tweeter screen rests *squarely* on the tweeter case. Connect the tweeter case to the screen and the screen to a metal ground stake placed behind the tweeter as shown in figure 62.

167. SIGHT M-351.

a. Function. Sight M-351 (peepsight) consists of an eyepiece and crosshairs set in a bar which is fastened to a mounting that includes an elevation and azimuth adjustment mechanism. Reference pointers for elevation and azimuth are provided. The mounting is fastened by means of a pivot screw to a support which is used to mount the complete peepsight assembly. Figure 63 shows the location and method of mounting the peepsight on radio sets equipped with wooden antennas. Figure 64 illustrates the method of mounting the peepsight on radio sets equipped with metal antennas. When the peepsight is properly adjusted, the aerial target being tracked by the radio set should center exactly between the horizontal and vertical bars of the sight when the radio set is on the target. Before adjusting the peepsight, make sure it is mounted securely.

b. Normal Adjustment. Normal adjustment consists of setting the elevation and azimuth thumbscrews of the sight so that, when the radio set is focused on or tracking a known target, the peepsight lines up with the target. This adjustment is generally used when the adjustments of the antennas, receivers, etc., of the radio set are satisfactory and it is desired to make the line of sight (optical axis) agree with the electrical axis of the radio set. That is, normal adjustment is made after the receiving antennas are aligned.

c. Adjustment to Coincide with Mechanical Axis. When normal adjustment cannot be applied, the peepsight may be adjusted so that the optical axis coincides with the mechanical axis of the antennas. This is not an accurate method, however, because the electrical axis of the radio is seldom exactly the same as the mechanical axis. For this reason, normal adjustment must always be made if possible. To adjust the peepsight axis of the radio set, proceed as follows (subpars. *d* and *e* below).

d. Peepsight Adjustment in Azimuth with Mechanical Axis. (1) Select an object at a distance, such as a house or other object on the horizon. Set the antennas at their minimum angular-height position and rotate the mount in azimuth until the object can be seen by sighting through the transposition (feed) lines of the antennas from one end of the system to the other. In this way, the antennas will be positioned so that the end-to-end axes of the

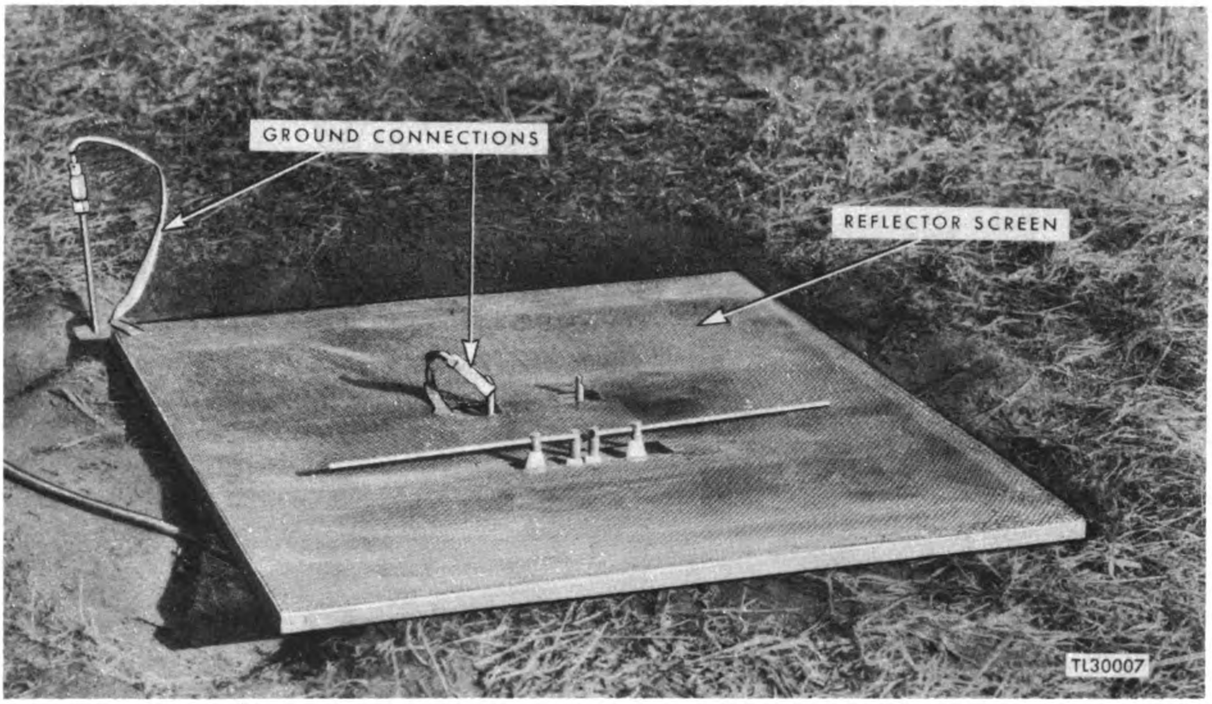

Figure 62. Arrangement of screen on buried tweeter.

dipoles point directly at the object; that is, the end of the antenna-mounting beam is pointing toward the target. If, because of variations in the antennas, a definite line of sight cannot be obtained, suspend two plumb bobs from the top receiving dipoles of the azimuth antenna, one for each end dipole. Then use the cords attached to the plumb bobs as a guide in aiming the antennas at the object selected. This latter method assumes that the top dipoles are perfectly aligned with respect to the rest of the azimuth antenna system. If the top dipoles are out of alignment, use some other pair of dipoles, such as the second row from the top. In sighting the antennas in this manner, it must be assumed that some dipoles will not be exactly parallel to others in the system; but an effort must be made to point the average dipole of the azimuth system at the object selected.

(2) When the antenna system is pointing at the object, make a note of the reading on the azimuth ring of the mount. Then turn the azimuth handwheel so that the antennas are rotated 1,600 mils (90°). Adjust the peepsight with the azimuth thumbscrew so that the object selected is sighted exactly between the vertical bars of the sight. To permit sighting on the object, it may also be necessary to position the sight in angular height temporarily, with either the elevation handwheel or the elevation thumbscrew. Note whether the azimuth pointer on the sight lines up with the reference mark. If not, loosen the pointer mounting screws and reposition the pointer as required.

e. Peepsight Adjustment in Angular Height with Mechanical Axis. (1) This adjustment presupposes that the trailer mount has been previously leveled.

(2) For wooden antennas, position the elevation antenna at zero angular height, or so that the long crossarms are exactly perpendicular. For metal antennas, place the reflector frame in a perpendicular position. If temporary changes in the elevation-stop mechanism are necessary to permit placing the antennas in this position, place the antennas at the lowest angular height permitted by the elevation-handwheel stop mechanism. Unbolt the housing over the elevator-stop mechanism and permit it to rest on the elevation handwheel. Observe the angular height counter reading as the antennas are brought to a perpendicular position.

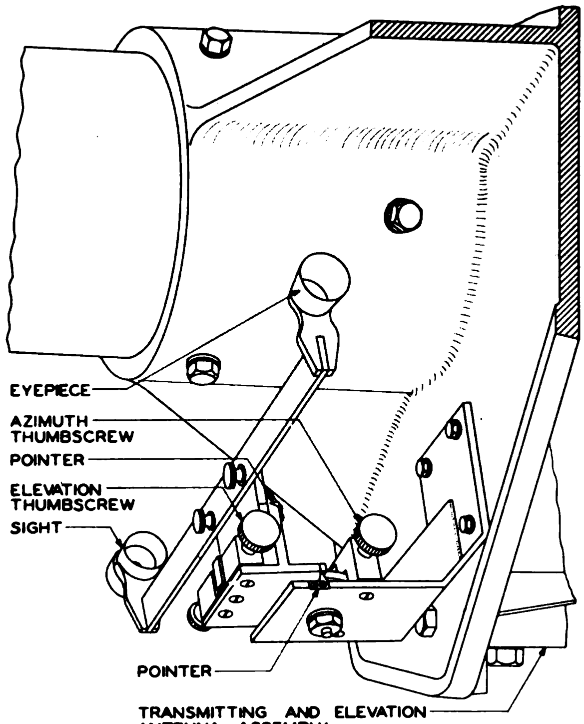

Figure 63. Sight M-351, mounted, with wooden antenna.

CAUTION: Do not allow the counter to read less than zero.

(3) If the reading reaches zero before the antennas are perpendicular, reset the angular-height counter for a greater reading by means of the angular-height vernier adjustment on the counter (it will be necessary to loosen the adjacent setscrew to do this). Use a carpenter's level to determine when the crossarms are in the required position. All crossarms may not be exactly parallel to each other, but an effort must be made to strike an average between the four crossarm members. For metal antennas, place an average part of the reflector frame in the perpendicular position.

(4) The easiest way to adjust the sight for angular height is to select an object known to be at the same elevation above sea level as the sight and then to adjust the sight to permit sighting on the object by turning the elevation thumbscrew. Sometimes an object at the desired level may be selected by reference to a contour map of the locality. This reference point may also be obtained by means of the gun director or a surveyor's level or transit.

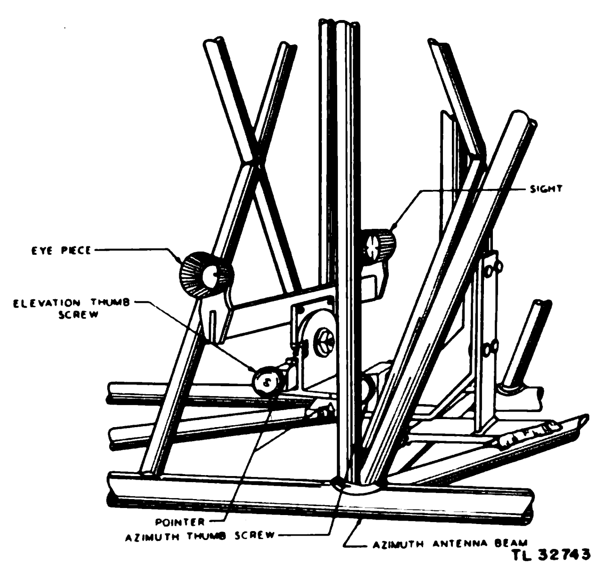

Figure 64. Sight M-351, mounted, with metal antenna.

(5) Lacking a reference point known to be at the required level, select a light-colored distant object which seems to be at about the same elevation as the radio set. Rotate the mount in azimuth, and adjust the sight in angular height so that the sight is lined up with object selected. Then rotate the column 180° (3,200 mils) in azimuth and see whether the object selected is in the line of sight when looking through the sight in the opposite-to-normal direction. A more accurate job of sighting backwards through the site may be done if a piece of nontransparent adhesive tape, with a peephole about $1/16$ inch in diameter through it, is mounted over the sight with the hole centered between the bars. If the object used as a reference does not line up, adjust the elevation thumbscrew so as to sight on the object again, noting particularly the number of turns, or parts of a turn, of the thumbscrew. Then turn the thumbscrew back exactly half this number of turns. The sight is now adjusted so that the line of sight is parallel with the mechanical axis of the elevation antenna.

(6) If the elevation-stop-mechanism adjustment has been disturbed, rebolt the stop-mechanism housing in place. Readjust the elevation-stop mechanism after the equipment is oriented.

168. PLUG PL-217.

a. Plug PL-217 is a four-pole Everlok male plug, used to close the interlock system when Keying Unit BC-409 or BC-409-A is being tested (fig. 65). Terminals Y and G are connected together. When used, the plug is inserted in the keyer receptacle labeled TO MODULATOR.

b. During normal operation of the radio set, the interlock circuit originates in the transmitter, extends through the keyer, and is completed to ground in the modulator. When the keyer is removed from the radio set and tested, an a-c voltage is supplied to the keyer interlock circuit. The interlock circuit to ground is completed through Plug PL-217 instead of through the interlock in the modulator.

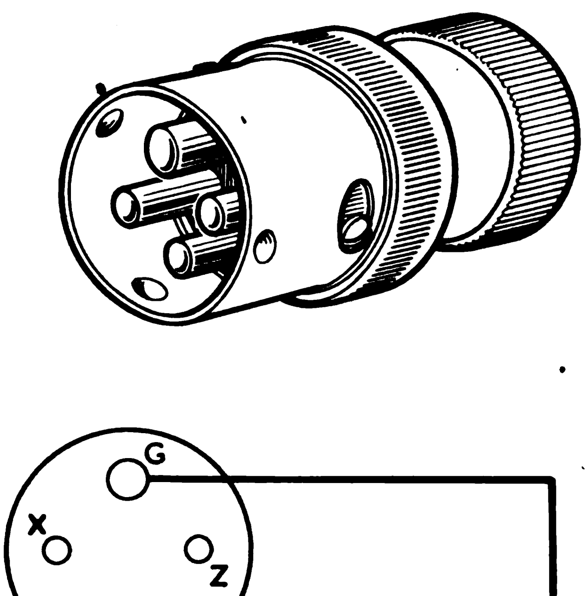

Figure 65. Plug PL-217

169. POLARIZED OUTLET BOX BC-672-B. This unit is used as a source of polarized a-c power when the components of the radio set are being serviced. Without a polarized source, short circuits would occur, since the primaries of the power transformers are grounded at one end. A proper connection of the source of power to the primary of the transformer requires that the live side of the source of power be connected to the ungrounded end of the primary and that the ground side of the source of power be connected to the grounded end of the primary. A view of the polarized outlet box is shown in figure 66. It consists of a small box with four polarized outlets and a cable with a polarized plug.

170. CALIBRATOR I-168.

a. Calibrator I-168 is a 3-tube, crystal-controlled oscillator generating a frequency of 4,098.3 cycles. It is used to check and calibrate the frequency of the oscillator in Keying Units BC-409 and BC-409-A. For a complete description of the calibrator, see TM 11-1128 which has been published previously.

b. The output of the calibrator is applied to one pair of deflection plates of a test oscilloscope; the synchronous-frequency output voltage of the keyer is applied to the other pair of deflecting plates. The horizontal sweep circuit of the test oscilloscope is not used. If the horizontal and vertical deflections are adjusted to equal amplitudes by the two amplifier-gain controls on the oscilloscope, and if both input voltages are of the same frequency, the resultant image will remain stationary and have an elliptical, circular, or linear shape.

c. If the frequency of the keyer is slightly different, either higher or lower than that of the calibrator, the pattern will be in motion, appearing like a disk rotating in space. This means that the oscillator in the keyer must be recalibrated.

d. Test connections for checking the synchronous frequency of the keyer by use of Calibrator I-168 are shown in figure 67. Test Set I-115 need not be connected for this particular test.

171. RANGE CALIBRATORS I-108, I-158, AND I-178.

a. Range Calibrator I-108 is an 8-tube unit for calibrating Range Units BC-436-A and BC-436-B. It compares the range indicated on devices mechanically coupled to the range unit with the actual range as indicated by electrical relationships observed on the test oscilloscope. In this manner the accuracy of the range unit can be checked.

b. Range Calibrators I-158 and I-178 are improved range calibrators similar to Range Calibrator

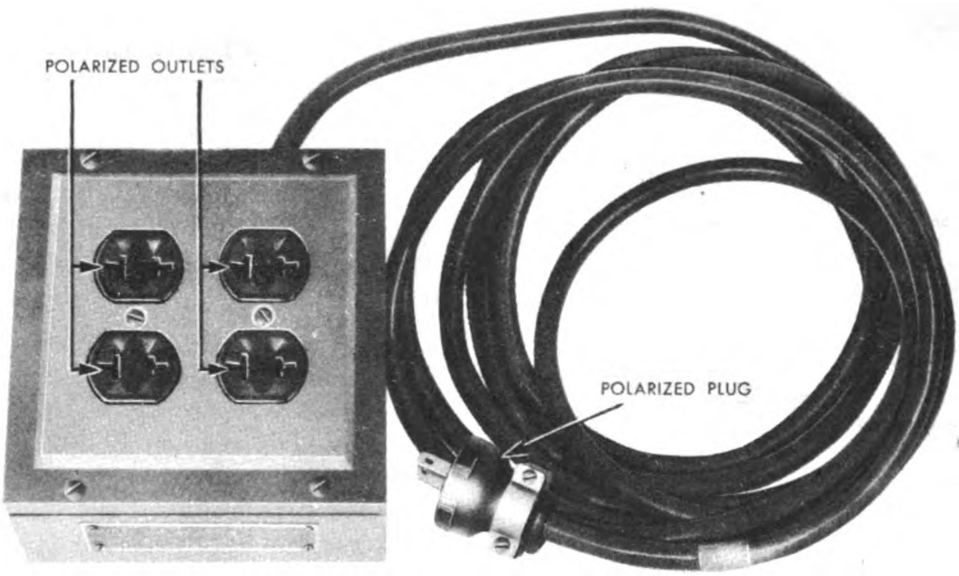

Figure 66. Polarized Outlet Box BC-672-B.

I-108. Although the mechanical layout and electrical circuits are slightly different, these three calibrators perform the same function. The cables supplied with Range Calibrators I-108 and I-178 are interchangeable with one another, but the cables supplied with Range Calibrator I-158 are not interchangeable with those supplied for Range Calibrators I-108 and I-178.

c. Schematic spare parts, and detailed operating instructions for calibrating Range Unit BC-436-A and BC-436-B by means of the range calibrators are given in the manuals supplied with these instruments. TM 11-1104 is supplied with Range Calibrator I-108; an instruction book without a TM number is provided with Range Calibrator I-158. TM 11-1051 is furnished with Range Calibrator I-178. In addition, TM 11-1106-B and TM 11-1106-C include detailed instructions for the operation of Range Calibrator I-108.

172. FREQUENCY METER BC-438.

a. Although the frequency meter is considered as part of the Radio Set SCR-268-(*), this meter is actually a highly-specialized test instrument. The function of Freqeuncy Meter BC-438 is to accurately measure frequencies between 195 and 215 megacycles. It is employed to check the frequency and the stability of the frequency of Transmitter BC-407-A. It may be used also as a high-frequency signal generator for other test purposes.

b. This meter consists essentially of a calibrated variable oscillator and a crystal oscillator which generates an exact and extremely stable frequency. The crystal oscillator frequency is used to set the meter at its 205-megacycle calibration point, preparatory to making the measurement. Frequency measurements are then made by adjusting the variable oscillator until its frequency is the same as that of the signal-to-be-measured. The actual frequency of the

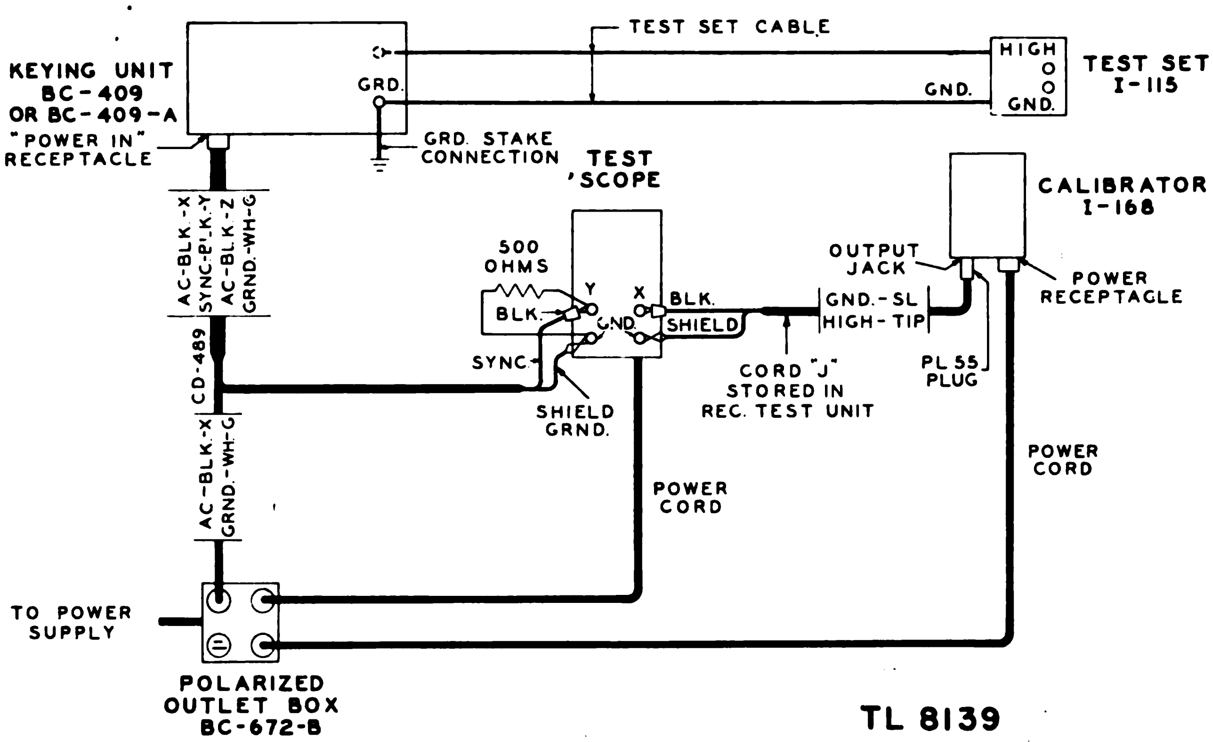

Figure 67. Test connections for synchronous-frequency test.

signal is determined by reference to a calibration chart provided with the meter.

c. A discussion of circuit theory, and the use of Frequency Meter BC-438 is given in TM 11-1106-B and TM 11-1106-C.

173. MODULATOR BC-423 (TWEETER).

a. The tweeter is supplied with Radio Set SCR-268-(*). This piece of test equipment simulates the functions of Keyer BC-409, Modulator BC-435-A, and Transmitter BC-407-A; these components being turned off when the tweeter is used. It is essentially a device for generating and radiating a signal, the frequency of which can be varied. This signal is useful in adjusting and testing the receiving antennas and receivers of the radio set.

b. The tweeter receiver a-c power through Cord CD-520, cable 29, which is plugged into the keyer receptacle of the terminal box in place of cable 9. The tweeter also transmits a synchronizing pulse to the oscilloscopes in place of the pulse ordinarily transmitted by the keyer.

c. For detailed information on Modulator BC-423, consult TM 11-1106-B and TM 11-1106-C.

SECTION XXVI
MOISTUREPROOFING AND FUNGIPROOFING

174. GENERAL. Failures commonly occur when Signal Corps equipment is operated in tropical areas where temperature and relative humidity are extremely high. The following problems are typical:

a. Resistors and capacitors fail.

b. Electrolytic action takes place in coils, chokes, transformer windings, etc., causing eventual breakdown.

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

d. Moisture forms electrical leakage paths on terminal boards and insulating strips, causing flashovers and crosstalk.

e. Moisture provides leakage paths between battery terminals.

175. 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-resistant and fungi-resistant varnish applied by means of a spray gun. For general instruction in the spray method of moistureproofing and fungiproofing refer to TB Sig-13. A brief description of the principal steps follows:

a. All repairs and adjustments necessary for the proper operation of the equipment are made.

b. Equipment to be processed is thoroughly cleaned of all foreign matter such as dirt, dust, rust, fungus, oil, and grease.

c. Equipment is partially disassembled and certain points, such as relay contacts, open switches, air capacitors, sockets, and bearings are covered with masking tape.

d. Equipment is thoroughly dried by heat to dispel moisture which the circuit elements have absorbed.

e. All circuit elements and all parts of the equipment are sprayed or painted with three coats of moistureproofing and fungiproofing varnish.

f. The equipment is given a final operational check; radio sets receive a 24- and 36-hour aging period before alignment, when time permits.

176. ANALYZER, SUPREME NO. 592.

a. Disassembly. (1) Remove screws holding battery-compartment cover in place.

(2) Remove cover of battery compartment.

(3) Loosen screws in back of instrument case which hold bracket for C batteries.

(4) Remove C batteries and bracket as well as A batteries; do not disconnect batteries from leads.

(5) Remove instruction book from cover of instrument.

b. Masking. Mask face of instrument panel with paper and masking tape.

c. Coating. Spray inside and outside of case, leather handle, batteries, and battery lead.

d. Partial Reassembly. Replace battery and cover to battery compartment.

e. Further Disassembly. (1) After removing masking from face of instrument, remove screws holding instrument in case.

(2) Remove instrument from case as far as wiring to battery compartment will permit.

f. Coating. (1) Spray inside of instrument compartment.

(2) Brush-coat all surfaces at rear of instrument except movable parts and electrical contacts of selector switches, push-button type.

> CAUTION: *Keep coating material and vapors away from meter-viewing window of instrument!*

177. ANALYZER I-167, WESTON MODEL 772.

a. Disassembly. (1) Remove four screws in face plate and lift out instrument.

(2) Remove wooden plate holding down two C-batteries.

(3) Remove screws holding A battery in case.

(4) Remove A battery from case.

(5) Remove C batteries from case.

b. Masking. (1) Mask movable contacts of selector switches.

(2) Mask back of OHMMETER-ADJUSTER potentiometer (fig. 6).

c. Coating. Spray all surfaces on back of instrument, batteries, battery leads, wooden plate for holding C batteries, inside and outside of wooden case, and leather handle.

> CAUTION: Keep spray and vapors away from meter window.

178. ANALYZER I-153, PRECISION MODEL 856.

a. Disassembly. (1) Remove the six screws holding instrument in case.

(2) Remove instrument from case.

(3) Loosen battery clamps.

(4) Remove instrument and batteries.

b. Masking. Mask switch contacts.

c. Coating. (1) Spray back surfaces of instrument.

(2) Spray batteries and leads.

(3) Spray inside and outside of wooden case.

179. TUBE CHECKER, SUPREME MODEL 504-A.

a. Disassembly. (1) Open cover of wooden case.

(2) Remove instruction book.

(3) Remove power cord from its compartment.

(4) Remove screws holding instrument in case.

(5) Remove instrument from case.

(6) Loosen battery clamp and remove battery.

b. Masking. (1) Mask glass surface of rectifier tube.

(2) Mask rear of wirewound potentiometer.

(3) Mask rear of tube sockets mounted on front panel.

(4) Mask movable parts and contact points on push-button selector switches.

(5) Mask contacts of the two wafer-type selector switches.

(6) Mask holes on back of paper-chart housing.

(7) Mask rear of noise-test receptacles.

c. Coating. (1) Spray as completely as possible rear of instrument, battery, leads (battery), and inside and outside of wooden case.

(2) Spray leather handle of case.

> CAUTION: Keep spray and vapors away from meter window.

180. TUBE CHECKER I-157, PRECISION MODEL 920.

a. Disassembly. (1) Remove screws on face-plate which hold instrument in case.

(2) Remove instrument from case.

(3) Loosen battery clamp and remove battery and leads.

(4) Loosen bracket holding neon bulb (shorting indicator); remove bulb felt cushion.

b. Masking. (1) Mask neon-bulb socket.

(2) Mask paper chart.

(3) Mask all switch contacts.

(4) Mask wirewound LINE ADJUSTMENT potentiometer (fig. 15).

(5) Mask glass surfaces of glass vacuum tubes.

(6) Mask glass bulb of pilot lamp.

(7) Mask rear of tube sockets mounted on front panel.

(8) Mask contact surfaces of wirewound adjusting rheostat.

(9) Mask push-button selector switch.

(10) Mask electrical contacts on acorn-tube adapters.

c. Coating. Spray all surfaces on rear of instrument, acorn-tube adapters, battery, battery leads, and wooden case.

CAUTION: Keep spray and vapors away from viewing windows.

181. TUBE CHECKER I-180, HICKOK MODEL 540.

a. Disassembly. (1) Remove screws holding instrument and tube chart in case.

(2) Remove instrument and tube chart from case.

(3) Remove voltmeter from case after removing mounting screws.

b. Masking. (1) Mask glass envelope of rectifier tube 83.

(2) Mask rear of rectifier potentiometer 117N7.

(3) Mask rear of MICROMHOS switch.

(4) Mask contacts of all jack push-button switches.

(5) Mask all wafer-type switches.

(6) Mask moving parts, contact, and rear of FIL switch.

c. Coating. (1) Spray all surfaces on rear of instrument.

(2) Spray inside of case. (Keep spray away from cables.)

(3) After reassembling instrument, spray exterior of case and leather handle.

182. OSCILLOSCOPE, SUPREME MODEL 546.

a. Disassembly. (1) Remove screws around edge of front panel and two screws from bottom of case.

(2) Remove chassis from case.

(3) In wooden-case model, remove metal perforated plate from rear of case after removing screws holding it in place.

b. Masking. (1) Mask glass surfaces of glass vacuum tubes.

(2) Mask wafer-type switch.

c. Coating. (1) Spray top, bottom, and rear of chassis.

(2) Spray or brush leather handle on case.

(3) On wooden-case model, spray inside and outside of wooden case.

CAUTION: Keep spray and vapors away from viewing screen of cathode-ray tube.

183. OSCILLOSCOPE I-134, DUMONT MODEL 224.

a. Disassembly. (1) Remove cover to front panel.

(2) Remove the two screws from rear of case.

(3) Remove the seven roundheaded screws in top and side edges of front panel. Do not remove the four flat-head screws.

(4) Loosen power cord and pull chassis from case.

b. Masking. (1) Mask glass surfaces of glass vacuum tubes and bulbs.

(2) Mask edges of all potentiometers and rheostats.

(3) Mask the six wafer-type switches.

(4) Mask neck of cathode-ray tube.

(5) Mask both ends of coaxial cable connector mounted in lower edge of front panel.

c. Coating. Spray all top, rear, and bottom surfaces of chassis.

CAUTION: Keep spray and vapors away from viewing screen of cathode-ray tube.

184. OSCILLOSCOPES, RCA MODEL 155-A AND RCA MODEL 155-B.

a. Disassembly. (1) Remove the two screws from rear of case.

(2) Pull chassis out of case from the front.

b. Masking. (1) Mask glass surfaces of all glass vacuum tubes.

(2) Mask all wafer-type switches.

(3) Mask around sides and rear of AMPLIFIER OFF-ON switch.

c. Coating. Spray all top, rear and bottom surfaces of the chassis.

> CAUTION: Keep spray and vapors away from viewing screen of cathode-ray tube.

185. SIGNAL GENERATOR I-126, MEASUREMENTS MODELS 78-B AND 78-C.

a. Disassembly. (1) Open wooden case.

(2) Remove screws around edge of instrument panel.

(3) Remove instrument from its metal case.

(4) Remove bolts holding metal instrument case in plywood carrying case.

(5) Remove metal instrument case.

b. Masking. (1) Mask edge of metal strip where contact is made between instrument chassis and its case.

(2) Mask both sides of scale-viewing window.

(3) Mask projecting parts of microvolt cylindrical slide.

(4) Mask the two output-meter-calibration trimmer capacitors.

(5) Mask glass surfaces of the vacuum tubes.

(6) Mask tuning windlass and string belt on left rear side of front panel.

c. Coating. (1) Spray all surfaces on top, rear, and bottom of chassis.

(2) Spray inside and outside of wooden carrying case.

(3) Dip, brush, or spray cotton-braid-covered external lead cord.

> CAUTION: Keep spray and vapors away from output meter window.

186. SIGNAL GENERATOR, FERRIS MODEL 18-B.

a. Disassembly. (1) Remove screws holding rear cover plate in position.

(2) Remove rear cover plate.

(3) Remove the two screws holding rectangular copper shield in place, and remove this shield.

(4) Remove the two screws holding large cylindrical shield over second acorn tube, and remove this shield.

(5) Remove the four screws from right side of case (as viewed from rear) and the four screws in bottom right side of case.

(6) Remove power-filter subassembly and power-supply chassis.

(7) Remove the nuts holding covers on the four chokes on power-filter subassembly, and remove these covers.

b. Masking. (1) Mask back of microvolts potentiometer.

(2) Mask glass surfaces on the two vacuum tubes and small glow lamp, all on the power-supply chassis.

(3) Mask back of O ADJ. wirewound rheostat.

(4) Mask opening to right of acorn-tube mounting through which the large variable air capacitor can be seen.

(5) Mask contacts of coil selector on cylinder to left of acorn-tube mounting.

(6) Mask back of power-filter subassembly mounting plate and the position inside case where this plate makes electrical contact.

c. Coating. (1) Spray as completely as possible all articles and surfaces inside case, the complete power chassis, and the filter subassembly.

(2) Coat, by spraying, brushing, or dipping, the cotton-braid-covered lead cord extending from front panel.

187. AUDIO OSCILLATOR, SUPREME MODEL 563.

a. Disassembly. (1) Remove the ten screws around edge of front panel.

(2) Remove the four screws from bottom of case.

(3) Remove chassis from case.

b. Masking. (1) Remove cans covering the four choke coils.

(2) Mask frequency-selector variable air capacitor, and gears which actuate rotor of the capacitor.

(3) Mask all contacts of POWER OFF-ON switch.

(4) Mask CAL. ADJ. variable air capacitor.

(5) Mask contacts of ZERO-PILOT INDICATOR switch.

c. Coating. (1) Spray top and bottom of chassis.

(2) Spray or brush leather carrying strap.

188. AUDIO OSCILLATOR I-151, HICKOK MODEL 198.

a. Disassembly. (1) Remove screws holding instrument in case.

(2) Remove instrument from case.

(3) Remove plate covering transformer on top of chassis.

b. Masking. (1) Mask glass surfaces of glass vacuum tubes.

(2) Mask contacts of push-button switch.

(3) Mask bearing of shaft connected to cylindrical dial.

(4) Mask small trimmer capacitor underneath edge of chassis.

(5) Mask lamp bulbs.

(6) Mask rear edge of range-selector switch.

c. Coating. (1) Spray all surfaces on top, rear, and bottom of chassis.

(2) Cover completely the cylindrical dial.

CAUTION: Keep spray and vapors away from viewing window and variable air capacitor.

189. THERMOCOUPLE, WESTON MODEL 425; METER 507.

a. Disassembly. None required.

b. Masking. Mask glass viewing windows, leaving 1/8-inch margin around edge.

c. Coating. Spray all exterior surfaces.

190. THERMOCOUPLE, WESTON TYPE D; OUTPUT METER M-322.

a. Disassembly. (1) Remove screws holding on cover plate of thermocouple case.

(2) Remove cover plate and replace screws in their holes.

(3) Remove one dipole from thermocouple case.

(4) Open wooden case to meter.

(5) Remove meter from case after removing mounting screws.

b. Masking. Mask glass viewing window of meter., leaving 1/8-inch margin around edge unmasked.

c. Coating. (1) Dip thermocouple housing in the coating composition.

(2) Spray exterior of meter and mounting plate.

(3) Spray inside and outside of wooden case.

191. REMOTE CONTROL BOX BC-670-B.

a. Disassembly. (1) Remove the eight wood screws from rear of wooden case.

(2) Remove rear wooden plate after loosening cable clamp.

b. Masking. Mask all cable and wiring inside case.

c. Coating. Spray interior of box and cover.

d. Unmasking. Remove masking from leads.

e. Reassembly. Replace rear cover.

f. Coating. Spray exterior of box, covering all surfaces.

192. POLARIZED OUTLET BOX BC-672-B.

a. Disassembly. (1) Remove the eight wood screws from rear of wooden case.

(2) Loosen cable clamp.

(3) Remove rear cover plate.

b. *Masking.* (1) Mask cable and rubber-covered leads inside box.

(2) Mask the four outlets on front of box.

c. *Coating.* Spray inside of wooden case and inside of back cover.

d. *Unmasking.* Remove masking from cable and rubber-covered leads.

e. *Reassembly.* Replace rear cover of box.

f. *Coating.* Spray exterior of box.

193. RECEIVER OUTPUT TEST SET BC-708-A.

a. *Disassembly.* Remove the six screws holding housing in place and remove housing for potentiometer, switch, etc.

b. *Coating.* Spray all surfaces on interior of unit except in plug where contact prongs are located.

194. RANGE CALIBRATOR I-108.

a. *Disassembly.* (1) Unscrew knurled knobs holding chassis in case.

(2) Slide chassis out of case.

(3) Remove cans covering the three choke coils.

b. *Masking.* Mask phone jacks.

c. *Coating.* (1) Spray top and bottom of the chassis.

(2) Spray paper labels, one in chassis compartment, the other in cable compartment.

195. SYNCHRONOUS REPEATER, TEST SET I-114.

a. *Disassembly.* (1) Remove wooden cover.

(2) Remove cables from cable compartment.

(3) Remove instrument from case.

b. *Masking.* (1) On front panel, mask prongs on the 4-conductor receptacles, the 2 prongs on the 2-conductor receptacle, and all of the 19-conductor connector.

(2) Mask toggle switch, phone jack, and glass meter window, leaving 1/8-inch margin around edge of window.

c. *Coating.* (1) Spray all surfaces of instrument.

(2) Spray inside and outside of case.

196. KEYER LOAD, TEST SET I-115.

a. *Disassembly.* (1) Remove cover plate.

(2) Remove four screws holding capacitor mounting.

(3) Remove capacitor.

(4) Remove resistor bank.

b. *Masking.* (1) Mask stand-off insulator bushings on capacitor.

(2) Mask shorting-contact bar.

(3) Mask contact bars attached to capacitor terminals.

(4) Mask all resistors.

c. *Coating.* Spray all surfaces of capacitor, capacitor mountings, cover plate, resistor mounting, and wooden case.

SECTION XXVII
SUPPLEMENTARY DATA

197. TESTING CAPACITORS.

a. When testing components of Radio Set SCR-268-(*) for defects, it is often necessary and desirable to check the capacitors for leakage or open or short circuits. Although open circuits sometimes occur in paper-type capacitors due to the metal terminal tab pulling away from the tinfoil plates, this trouble is rare. The usual trouble in capacitors is a short circuit or leakage caused by the break-down of the dielectric between the plates. This applies only to capacitors of the tinfoil-paper or mica type, inasmuch as the dielectric film of wet electrolytic capacitors is "self-healing." Electrolytic capacitors, however, are not used in the radio set and therefore will not be discussed.

b. The insulation resistance, or permissable leakage, of paper and mica capacitors is expressed in megohms per microfarad. A good 1-microfarad capacitor has an insulation resistance of at least 100 megohms. Since the insulation resistances of paper and mica capacitors of similar voltage ratings are inversely proportional to their capacitance, a 0.1-microfarad capacitor has 10 times the resistance of a 1-microfarad capacitor, that is, 1,000 megohms. It is therefore not practical to use the ohmmeter method for measuring leakages in paper or mica capacitors unless an exceptionally high-reading megohmmeter is available. However, the ohmmeter may be used to obtain a *kick* indication.

c. In this method, remove one end of the capacitor from its circuit before attempting to check it. This is done because the capacitor is usually across some other circuit element. When an ohmmeter is connected across a good paper or mica capacitor, the needle will flick over slightly and gradually drop back to zero. This shows that the capacitor has taken a charge and is not leaky or shorted. If the needle does not go back to zero, the capacitor is leaky and should be replaced.

d. Tinfoil-paper filter capacitors may also be tested for break-down by several other methods. One of the simplest is to disconnect the capacitor from the circuit and apply from 90 to 400 volts direct current directly to its terminals, by means of a d-c supply or the plate prong of a tube in the low-voltage section of one of the components, such as the receiver or oscilloscope. The voltage applied to the capacitor should not exceed its rated voltage. Immediately after charging, disconnect the capacitor and short-circuit its terminals with an insulated cord or screwdriver. This should produce a flash, the size of the flash depending on the capacitance of the capacitor, and the voltage used for charging. If the capacitor has a short circuit between its plates, no charge will be stored by them, and no flash will be produced.

e. This type of capacitor may also be tested for leakage by charging it and noting the intensity of the flash when it is discharged. Recharge it, disconnect it from the charging circuit, and discharge it 5 minutes later. If the resulting flash is much less intense than before, it is evident that leakage exists between the capacitor plates.

f. In the following method, a high d-c potential is applied to the capacitor in series with a d-c voltmeter to check for low insulation resistance or abnormal leakage. As before, the d-c potential can be obtained from the plate prong of a tube in the low-voltage section of one of the components. Voltage to be applied to the capacitor should not exceed its rated voltage.

(1) Arrange the analyzer as a d-c voltmeter and select the voltmeter range that indicates the greatest deflection for the d-c voltage available.

(2) With the power supply off, connect the d-c voltmeter across the d-c supply, observing polarity. Connect the positive terminal to the plate prong and the negative terminal to chassis or ground.

(3) Insert the capacitor to be tested in series with one of the leads.

(4) Turn on the power supply. A momentary deflection due to the charge of the capacitor will be indicated on the d-c meter.

(a) If the capacitor is good, the needle pointer will return rapidly to the zero voltage mark.

(b) If the meter pointer remains considerably above the zero mark, the capacitor has abnormal leakage.

(c) If the meter pointer remains at the indicated value of the voltage measurement obtained initially, the capacitor is shorted.

(d) If no meter deflection is obtained, the capacitor is open or the capacitance is too low to indicate a noticeable meter deflection when charged.

> CAUTION: After this test is completed, always *first* disconnect the negative test lead from the circuit *before* turning off the power supply, to prevent slamming of the needle pointer due to the discharge of the capacitor under test. (Turn off the power supply and then discharge the capacitor.) Never leave a charged capacitor lying around. Always discharge it before putting it away.

g. Radio-frequency bypass capacitors of small capacitances (10 micromicrofarads or larger) are difficult to check for continuity and often cause considerable trouble in the r-f and i-f circuits and also when used as bypasses. These capacitors may be checked for continuity by means of an audio oscillator and test oscilloscope as follows:

(1) Connect the audio oscillator and the test oscilloscope and adjust their controls to obtain a large sine wave of approximately 10,000 cycles per second on the oscilloscope screen.

(2) Place the capacitor under test in series with the hot lead to the test oscilloscope. A sine wave should be observed, the amplitude of which may or may not be diminished by the impedance of the capacitor being tested. The presence of the sine wave indicates continuity through the capacitor.

(3) Decrease the frequency of the audio oscillator (to 1,000 cycles per second if necessary) and observe that the amplitude of the sine wave decreases. A decrease indicates that the capacitor is not shorted and that it should function correctly in its circuit. If the amplitude of the sine wave does not decrease even at frequencies as low as 20 cycles per second, the capacitor is either shorted or of too large a capacitance (5,000 microfarads or greater) to constitute an appreciable impedance.

(4) If no sine wave was observed in step (2), the capacitor is probably open. To make sure, adjust the audio oscillator to its highest frequency and increase the gain of both the audio oscillator and test oscilloscope. If the sine wave still does not appear, the capacitor is definitely open.

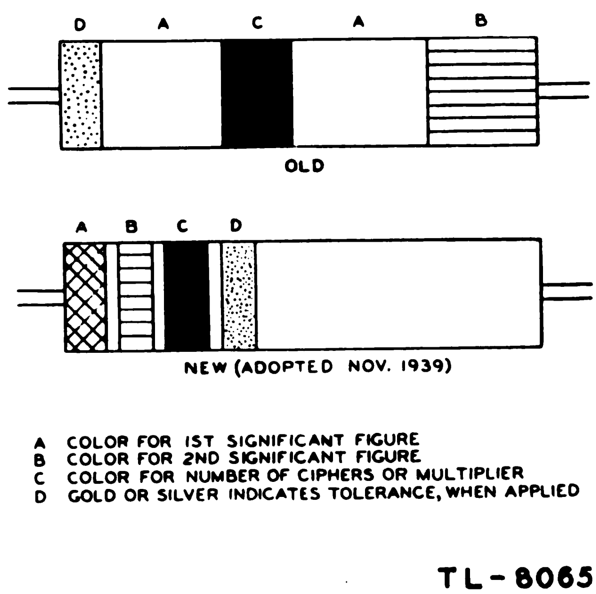

Figure 68. R.M.A. resistor color code.

198. RESISTOR COLOR CODE.

a. The R.M.A. (Radio Manufacturers Association) standard color code for small carbon-type resistors is as follows (fig. 68).

TABLE XI

Color	Significant figure	Multiplier	Tolerance (percent)
Black	0	1	
Brown	1	10	
Red	2	100	
Orange	3	1,000	
Yellow	4	10,000	
Green	5	100,000	
Blue	6	1,000,000	
Violet	7	10,000,000	
Gray	8	100,000,000	
White	9	1,000,000,000	
Gold			± 5
Silver			±10
No Color			±20

b. For example:

Ohms	Color code
75,000	Violet (7), green (5), orange (x 1,000)
4,300	Yellow (4), orange (3), red (x 100)
250	Red (2), green (5), brown (x 10)
75	Violet (7), green (5), black (x 1)

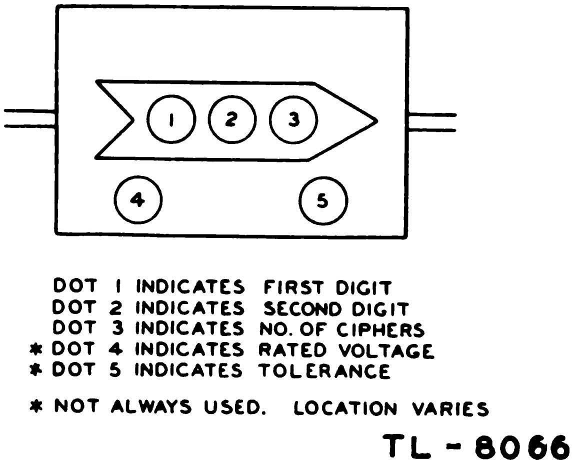

Figure 69. Capacitor color code.

199. CAPACITOR COLOR CODE.

a. General. Small mica capacitors are generally marked on the body with three colored dots to indicate the capacitance rating. The voltage rating and capacitance tolerance may also sometimes be indicated by additional dots or by color bands, though generally this information is not shown. This color code, which is similar to the standard R.M.A. resistor color code is as follows:

TABLE XII

Color	Numeral in determining capacitance	Rated voltage (if given)	Tolerance, percent (if given)
Black	0		
Brown	1	100	1
Red	2	200	2
Orange	3	300	3
Yellow	4	400	4
Green	5	500	5
Blue	6	600	6
Violet	7	700	7
Gray	8	800	8
White	9	900	9
Gold		1,000	
Silver			±10
No color		500	±20

b. Capacitance Markings. The three colored dots are arranged in a line counting from left to right with the capacitor held so the words on the case are right side up or, if an arrow appears on the case, so the arrow points to the right. The capacitance is expressed in micromicrofarads ($\mu\mu f$). The first two dots indicate the first two digits of the capacitance, and the third dot indicates the number of ciphers that follow the first two digits. For example, $0.00025\mu f = 250\mu\mu f$. The markings for this capacitance would be: red (2), green (5), brown (one cipher). Other examples are:

$0.000025\mu f = 25\mu\mu f$ = red, green, black.
$0.00005\mu f = 50\mu\mu f$ = green, black, black.
$0.0004\mu f = 400\mu\mu f$ = yellow, black, brown.
$0.002\mu f = 2{,}000\mu\mu f$ = red, black, red.
$0.01\mu f = 10{,}000\mu\mu f$ = black, brown, orange.

c. *Markings for Rated Voltage.* Where the rated voltage is indicated by color code, this is generally done by a fourth dot somewhere on the case or by a color band.

d. *Markings for Tolerance.* Some manufacturers may indicate the percentage tolerance on the capacitance rating by means of a fifth dot or by a second color band either to the right of the rated voltage marking or, if the rated voltage is not indicated, near the right side of the case of the capacitor.

e. *Special Markings.* (1) The preceding discussion is intended to illustrate the system of marking used on the general run of small mica capacitors appearing as original and spare equipment on the radio set. Different manufacturers, however, sometimes use variations in the system, especially in the method of designating the rated voltage and tolerance by color code on the case. Also, the third digit of a capacitance will not always be a cipher, for example, 375 and 1750$\mu\mu$f, and different methods may be used by various manufacturers to handle the situation. A knowledge of the manufacturer's marking system may be required to identify the capacitor type in question, if a replacement must be secured from a local source of supply and if the required information is not printed on the case of the capacitor.

(2) The capacitance of small molded-paper capacitors may or may not be indicated by the above system. A knowledge of the system used is necessary to identify positively capacitors of this type.

200. PARTS LIST FOR TEST EQUIPMENT RC-68 (FOR RADIO SETS SCR-268 AND SCR-268-A).

NOTE: Order replacement parts by stock number, name, and description.

Signal Corps stock No.	*Name of part, description, use*	*Mfr. No.*[a]	*Drawing or specification No.*	*Quan. per major unit*
3F4067	ANALYZER: 25,000 ohm-per-volt dc; 1,000 ohm-per volt ac. Multirange volt-, ohm-, and ammeter.	1	Supreme model 592.	1
	BOOK: log and diary. Ledger.	2	National Blank Book Co. No. 38.	1
3E1487	CORD CD-487: 6-foot, 2-conductor; composed of No. 18 AWG, stranded, rubber-covered, type SJ; with a 3-pole male plug No. 8013, Everlok, R & S, or equal, on one end and a polarized plug cap No. 9941, as made by Harvey Hubbell Inc., or equal, on the other end. Used to supply power to Radio Receiver BC-406.	3	ES-D-7677-C, group 1.	1
3E1488	CORD CD-488: 12-foot, composed of 3 No. 18 AWG, stranded, shielded, rubber-covered, type SJ conductors; with a 4-pole male plug No. 8158, Everlok, R & S, on each end. One conductor opened 5 feet from one end, with the conductors connected to a crocodile clip which is covered with a black rubber insulator; the clips are No. 85 and the insulators are No. 87; as made by the Mueller Electric Co., or equal. Used to connect output of Radio Receiver BC-406 to input of Oscilloscope BC-412-A while on Trailer K-28.	3	ES-D-7677-C, group 2.	1
3E1489	CORD CD-489: 6-foot, 2-conductor, and a 6-foot, single-conductor. The 2-conductor is of No. 18 AWG, stranded, rubber-covered, type SJ; and the single-conductor, No. 18 AWG, stranded, shielded, rubber-covered, type SJ. Both are connected on one end to a 4-pole female plug No. 8028, Everlok, R & S, or equal. The free end of the single-conductor is skinned, tinned, and connected to a crocodile clip No. 85, with black rubber insulator No. 85, both as made by Mueller Electric Co., or equal. The shield	3	ES-D-7678-C, group 2.	1

[a]See paragraph 201, List of Manufacturers.

Signal Corps stock No.	Name of part, description, use	Mfr. No.[a]	Drawing or specification No.	Quan. per major unit
	is twisted, tinned, and connected to a crocodile clip No. 85, as made by the Mueller Electric Co., or equal. The 2-conductor is connected at its free end to a polarized plug cap No. 9941, as made by Harvey Hubbell Inc., or equal. Used to supply power to Keying Unit BC-400, and to obtain synchronous voltage.			
3E1490	CORD CD-490: 12-foot, 2-conductor, and 16-foot, single-conductor. The 2-conductor is of No. 18 AWG, stranded, rubber-covered, type SJ. The single conductor is of No. 18 AWG, stranded, shielded, rubber-covered, type SJ. The 2-conductor and the single-conductor are connected on one end to a 4-pole male plug No. 8018, Everlok, R & S, or equal. The 2-conductor is connected at the other end to a polarized plug cap No. 9941, as made by Harvey Hubbell Inc., or equal. The other end is connected to a Plug PL-55. Used to supply power to Oscilloscope BC-412-A. The synchronous sweep voltage is obtained from Radio Modulator BC-423.	3	ES-D-7678-C, group 1.	1
3E1491	CORD CD-491: 6-foot, 3-conductor; No. 18 AWG, stranded, individually shielded, rubber-covered, type SJ; or 3 single-conductors, No. 18 AWG, stranded, shielded, rubber-covered, type SJ, taped together at several points. Each end or group of ends connected to a 4-pole male plug No. 8018, Everlok, R & S, or equal. Used to connect output of Radio Receiver BC-406 to input of Oscilloscope BC-412-A while in a test position.	3	ES-D-7677-C, group 3.	1
3E1502.1	CORD CD-502.1: 28-inch, single-conductor, No. 18 AWG, stranded-braid rubber-covered (S.B.R.C.) type SJ; with crocodile clips No. 85 and rubber insulators No. 87, as made by Mueller Electric Co., or equal, on the ends. The cord has 2 red rubber insulators. Used to short the interlock systems while servicing the components and also as general utility cord.	3	ES-D-7676-C, group 1, item 1.	1

[a]See paragraph 201, List of Manufacturers.

Signal Corps stock No.	Name of part, description, use	Mfr. No.[a]	Drawing or specification No.	Quan. per major unit
3E1502	CORD CD-502: 28-inch, single-conductor; No. 18 AWG, S.B.R.C., type SJ; with crocodile clips No. 85, and black rubber insulators No. 87 as made by Mueller Electric Co., or equal, on the ends. Used to short the interlock systems while servicing the components and also as general utility cord.	3	ES-D-7676-C, group 2, item 1.	1
3E1503.1	CORD CD-503.1: 102-inch, single-conductor; No. 18 AWG, S.B.R.C., type SJ; with crocodile clips No. 85 and red rubber insulators No. 87, as made by Mueller Electric Co., or equal, on the ends. Used to short the interlock systems while servicing the components and also as general utility cord.	3	ES-D-7676-C, group 1, item 2.	1
3E1503	CORD CD-503: 102-inch, single-conductor; No. 18 AWG, S.B.R.C., type SJ; with crocodile clips No. 85 and black rubber insulators No. 87, as made by Mueller Electric Co., or equal, on the ends. Used to short the interlock systems while servicing the components and also as general utility cord.	3	ES-D-7676-C, group 2, item 2.	1
3E1504.1	CORD CD-504.1: 150-inch, single-conductor; No. 18 AWG, S.B.R.C., type SJ; with crocodile clips No. 85 and red rubber insulators No. 87, as made by Mueller Electric Co., or equal, on the ends. Used to short the interlock systems while servicing the components and also as general utility cord.	3	ES-D-7676-C, group 1, item 3.	1
3E1504	CORD CD-504: 150-inch, single-conductor; No. 18 AWG, S.B.R.C., type SJ; with crocodile clips No. 85 and black rubber insulators No. 87, as made by Mueller Electric Co., or equal, on the ends. Used to short the interlock systems while servicing the components and also as general utility cord.	3	ES-D-7676-C, group 2, item 3.	1
3E1505	CORD-CD-505: 50-foot, 2-conductor, No. 18 AWG, rubber-covered, type SJ; with a double T-slot polarized plug cap at one end, and a polarized plug cap on the other. The cord connector is No. 7084 and the plug cap is No. 9941, as made by Harvey Hubbell Inc., or equal. Used as general utility extension cord.	3	ES-D-7678-C, group 3.	1

[a]See paragraph 201, List of Manufacturers.

Signal Corps stock No.	Name of part, description, use	Mfr. No.[a]	Drawing or specification No.	Quan. per major unit
3E1518	CORD CD-518: 6-foot, 2-conductor; No. 18 AWG, S.B.R.C., rubber-covered, type SJ; a 3-pole female plug No. 8023, Everlok, R & S, or equal, on one end and a polarized plug cap No. 9941, as made by Harvey Hubbell Inc., or equal, on the other end. Used to supply power to Range Unit BC-436-A.	3	ES-D-7676-C, group 4.	1
3E1519	CORD CD-519: 6-foot; composed of two 6-foot lengths of single conductor, No. 18 AWG, shielded, rubber-covered, type SJ. One pair of ends connected to a 4-pole female plug No. 8028, Everlok, R & S, or equal. The other ends, shields, and conductors are connected to 4 crocodile clips. The rubber insulators (1 black, 1 red) are placed over the clips, connected to the conductors. The crocodile clips are No. 85 and the insulators are No. 87, both as made by Mueller Electric Co., or equal. To introduce and obtain the phase-shifted sine-wave voltage from Range Unit BC-436-A. Sine wave is introduced through one lead and is shifted in phase and fed through the other.	3	ES-D-7676-C, group 3.	1
3E1520	CORD CD-520: 250-foot, 4-conductor; No. 18 AWG; one conductor shielded, rubber-covered, type SJ. A 4-pole male plug No. 8158, Everlok, R & S, or equal, on one end; and a 4-pole female plug No. F-6855, Everlok, R & S, or equal, on the other. Formerly cable 29. Used to supply power to Radio Modulator BC-423 and to transfer the synchronous voltage from Radio Modulator BC-423 to the units on Trailer K-28-A while adjusting antennas.	3	ES-D-8743-B	1
3F4069A	TUBE AND SET CHECKER: With acorn-tube adapter, for testing low-power vacuum tubes.	1	Supreme model 504.	1
3F3455.1-1	SIGNAL GENERATOR: Ultra-high frequency, for repair of Radio Receiver BC-406.	4	Microvolter, Ferris model 18-B.	1
3F910-8	THERMAL METER M-322: Thermocouple, r-f; 0-100 ma; panel mounting case, bakelite. Used in testing Radio Transmitter BC-407-A and its antenna.	5	Weston model 425.	2

[a]See paragraph 201, List of Manufacturers.

Signal Corps stock No.	Name of part, description, use	Mfr. No.[a]	Drawing or specification No.	Quan. per major unit
3F3565	OSCILLATOR: Audio, beat-frequency.	1	Supreme model 563.	1
3F3642	OSCILLOSCOPE: 3" cathode-ray tube; for testing and repairing.	1	Supreme model 546.	1
2C7598-A	REMOTE CONTROL BOX BC-670-A: Contains a stop-start switch, cordage, and proper plug for use with rectifier. Used with Rectifier RA-38 to provide a means of control at the rectifier.	3	ES-D-7675-D, group 1, and ES-D-8897-A.	1
2C7598-B	REMOTE CONTROL BOX BC-670-B: same as above.	3	ES-D-7675-D, group 1, and ES-D-8897-A.	1
2Z7372-B	OUTLET BOX TEST SET BC-672-B: Consists of polarized receptacles and connecting cord. Used to supply polarized a-c power for components when they are being serviced. Short circuits would occur with an unpolarized source.	3	ES-D-7675-D, group 2, and ES-D-8897-A.	1
3F4423-A	TEST UNIT BC-673-( ): Used to test Tube VT-127 and to remove grid contamination by baking the grid.	3	Specifications SCL-435 and 271-1520.	1
3F4452-708A	TEST SET BC-708-( ): Consists of an Everlok plug and a metal sleeve which contains a gain control, a 75-ohm carbon resistor, and a toggle switch. Used as an output test set while testing and aligning Radio Receiver BC-406. Used in conjunction with a test oscilloscope.	3	ES-D-7675-D, group 3, and ES-D-8897-A.	1

[a]See paragraph 201, List of Manufacturers.

201. TEST EQUIPMENT RC-68, LIST OF MANUFACTURERS.

Mfr. No.	Name and address
1	Supreme Instrument Co., Greenwood, Mass.
2	National Blank Book Co., Holyoke, Mass.
3	Espey Manufacturing Co., New York, N. Y.
4	Ferris Instrument Co., Boonton, N. J.
5	Weston Electrical Inst. Corp., Newark, N. J.

202. SPECIFICATIONS AND LIST OF TUBES IN TEST EQUIPMENT RC-68.

a. Signal Generator, Ferris No. 18-B.

Tube complement:

1 ea 5Y3GT.
1 ea 76.
2 ea 955.
1 ea 1055-A neon lamp.

Specifications:

Frequency range: 3.5 to 150 mc in 5 ranges.
Modulation frequency: 500 cps at 30 percent.
Output voltage: variable, 1-100,000 microvolts.
110-120 volts, 60 cycles.
Dimensions: 14½" x 10" x 6".
Weight: Approximately 35 lb. net, approximately 40 lb. packed.

b. Tube Tester, Supreme No. 504-A.

Tube complement:

1 ea 71-A.
1 ea T-4½ neon lamp.

Specifications:

Tests tubes with filaments from ¾ to 117 volts.
Measures a-c volts in 5 ranges to 1,000 volts.
Measures d-c volts in 7 ranges to 2,500 volts.
Measures d-c current in 7 ranges to 10 amperes.
Measures resistance in 5 ranges to 20 meg.
Battery complement: 1 Burgess 2FBP, 1½ volts,
Accuracy, d-c: 2 percent.
Accuracy, a-c: 3 percent.
Dimensions: width, 11¾"; length, 11½"; depth, 6".
Weight: 15½ lb. net, 19 lb. packed.
110-133 volts, 60 cycles, 25 watts.
Supplied with acorn-tube adapter and test leads.

c. Analyzer, Supreme No. 592.

Dimensions: height, 6⅜"; width, 8½"; depth, 4½".
Weight: 11 lb. net, 16 lb. packed.
Sensitivity: 25,000 ohms per volt dc, 1,000 ohms per volt ac or dc.
A-c volts: 0-7-35-140-350-700-1,400.
D-c volts: 0-7-35-140-350-700-1,400.
D-c current: 0 to 70 microamperes; 0-350 ma; 0 to 14 amp.
Resistance: 0 to 50 meg in 6 ranges.
Battery complement: 4 Burgess Uni-Cell No. 1, 1½ volts; 1 Eveready Minimax No. 482, 45 volts.

d. Oscilloscope, Supreme No. 546.

Tube complement:

2 ea 80.
2 ea 6C6.
1 ea 885.
1 ea 906, cathode-ray tube (C.R.T.).

Specifications:

110-120 volts, 60 cycles, 50 watts.
1-ampere fuse.
Dimensions: height, 11½"; width, 7¼"; depth, 13¼".
Weight: 22 lb. net, 30 lb. packed.
Frequency response of amplr: 20-75,000 cps.
Frequency range of timing axis: 15 to 30,000 cps.

e. Oscillator, Supreme No. 563.

Tube complement:

2 ea 6SK7.
2 ea 6C5.
1 ea 6X5.

Specifications:

Frequency range: 30 to 15,000 cps.
Output impedance: 0-250-500-5,000 ohms.
Output voltage: 125 milliwatts.
110-120 volts, 60 cycles, 35 watts.
Dimensions: height, 9"; width, 13¼"; depth, 7½".
Weight: 17 lb. net, 19 lb. packed.

203. PARTS LIST FOR TEST EQUIPMENT RC-68-A (FOR RADIO SET SCR-268-B).

NOTE: Order replacement parts by stock number, name, and description.

Signal Corps stock No.	Name of part, description, use	Mfr. No.[a]	Drawing or specification No.	Quan. per major unit
3F1772	ANALYZER I-167: 20,000-ohm-per-volt dc., 1,000-ohm-per-volt ac. Multirange volt-, ohm-, and ammeter.	5	Weston model 772 (Precision No. 856 also supplied.)	1
	LEDGER BOOK: used as a log and diary.	6	Boorum & Pease No. 38.	1
3F2440-108	RANGE CALIBRATOR I-108: An 8-tube unit complete with 6 test cords. Used in conjunction with Range Unit BC-436-A and BC-436-B. With it, it is possible to determine the errors in range at several points of the total range with the particular keying frequency being used.	7	SCL-442	
3E1487	CORD CD-487: 6-foot, 2-conductor; composed of No. 18 AWG, stranded, rubber-covered, type SJ; with a 3-pole plug No. 8013 Everlok, R & S, or equal, on one end, and a polarized plug cap No. 9941, as made by Harvey Hubbell Inc., or equal, on the other end. Used to supply power to Radio Receiver BC-406.	7	ES-D-7677-C, group 1.	1
3E1488	CORD CD-488: 12-foot; composed of 3 No. 18 AWG, stranded, shielded, rubber-covered, type SJ conductors; with a 4-pole male plug No. 8158, Everlok, R & S, on each end. One conductor opened 5 feet from one end, with conductors connected to a crocodile clip which is covered with a black rubber insulator, the clips are No. 85 and the insulators are No. 87, as made by the Mueller Electric Co., or equal. Used to connect output of Radio Receiver BC-406 to input of Oscilloscope BC-412-A, while on Trailer K-28.	7	ES-D-7677-C, group 2.	1
3E1489	CORD CD-489: 6-foot, 2-conductor, and a 6-foot, single-conductor; the 2-conductor is of No. 18 AWG, stranded, shielded, rubber-covered, type SJ. Both are connected on one end to a 4-pole female plug No. 8029, Everlok, R & S, or equal. The free end of the	7	ES-D-7678-C, group 2.	1

[a]See paragraph 204, List of Manufacturers.

Signal Corps stock No.	Name of part, description, use	Mfr. No.[a]	Drawing or specification No.	Quan. per major unit
	single-conductor is skinned, tinned, and connected to a crocodile clip No. 85, with a black rubber insulator No. 87, both as made by Mueller Electric Co., or equal. The shield is twisted, tinned, and connected to a crocodile clip. The 2-conductor is connected at its free end to a polarized plug cap No. 9941, as made by Harvey Hubbell Inc., or equal. Used to supply power to Keying Unit BC-409, and to obtain synchronous voltage from oscillator in the keyer.			
3E1490	CORD CD-490: 12-foot, 2-conductor, and 16-foot, single-conductor; the 2-conductor is of No. 18 AWG, stranded, rubber-covered, type SJ. The single-conductor is of No. 18 AWG, stranded, rubber-covered, type SJ. The 2-conductor and the single-conductor are connected on one end to a 4-pole male plug No. 8018, Everlok, R & S, or equal. The 2-conductor is connected at the other end to a polarized plug cap No. 9941, as made by Harvey Hubbell Inc., or equal. The other end is connected to Plug PL-55. Used to supply power to Oscilloscope BC-412-A. The synchronous sweep voltage is obtained from Radio Modulator BC-423, through Plug PL-55.	7	ES-D-7678-C, group 1.	1
3E1491	CORD CD-391: 6-foot, 3-conductor; No. 18 AWG, stranded, type SJ; or 3 single-conductors, No. 18, stranded, shileded, rubber-covered, type SJ; tapped together at several points; each end or group of ends connected to a 4-pole male plug No. 8018, Everlok, R & S, or equal. Used to connect output of Radio Receiver BC-406 to input of Oscilloscope BC-412-A while both are in a test position.	7	ES-D-7677-C, group 3.	1
3E1502.1	CORD CD-502.1: 28-inch, single-conductor; No. 18 AWG, S.B.R.C., type SJ; with crocodile clips No. 85 and rubber insulators No. 87, as made by Mueller Electric Co., or equal, on the ends. The cord has 2 red rubber insulators. Used to short the interlocks systems while servicing the components and also as general utility hook-up cord.	7	ES-D-7676-C, group 1, item 1.	1

[a]See paragraph 204, List of Manufacturers.

Signal Corps stock No.	Name of part, description, use	Mfr. No.[a]	Drawing or specification No.	Quan. per major unit
3E1502	CORD CD-502: 28-inch, single-conductor; No. 18 AWG, S.B.R.C., type SJ; with crocodile clips No. 85 and black rubber insulators No. 87, as made by Mueller Electric Co., or equal, on the ends. Used to short the interlocks systems while servicing the components and also as general utility hook-up cord.	7	ES-D-7676-C, group 2, item 1.	1
3E1503.1	CORD CD-503.1: 102-inch, single-conductor; No. 18 AWG, S.B.R.C., type SJ; with crocodile clips No. 85 and red rubber insulators No. 87, as made by Mueller Electric Co., or equal, on the ends. Used to short the interlock systems while servicing the components and also as general utility hook-up cord.	7	ES-D-7676-C, group 1, item 2.	1
3E1503	CORD CD-503: 102-inch, single-conductor; No. 18 AWG, S.B.R.C., type SJ; with crocodile clips No. 85 and black rubber insulators No. 87, as made by Mueller Electric Co., or equal, on the ends. Used to short the interlock systems while servicing the components and also as general utility hook-up cord.	7	ES-D-7676-C, group 2, item 2.	1
3E1504.1	CORD CD-504.1: 150-inch, single-conductor; No. 18 AWG, S.B.R.C., type SJ; with crocodile clips No. 85 and red rubber insulators No. 87, as made by Mueller Electric Co., or equal, on the ends. Used to short the interlock systems while servicing the components and also as general utility hook-up cord.	7	ES-D-7676-C, group 1, item 3.	1
3E1504	CORD CD-504: 150-inch, single-conductor; No. 18 AWG, S.B.R.C., type SJ; with crocodile clips No. 85 and black rubber insulators No. 87, as made by Mueller Electric Co., or equal, on the ends. Used to short the interlock systems while servicing the components and also as general utility hook-up cord.	7	ES-D-7676-C, group 2, item 3.	1
3E1505	CORD CD-505: 50-foot, 2-conductor; No. 18 AWG, S.B.R.C., rubber-covered, type SJ; with a double T-slot polarized cord connector at one end and a polarized plug cap on the other. The cord connector is No. 7084 and the plug cap is No. 9941, as made by Harvey Hubbell Inc., or equal. Used as a general utility extension cord.	7	ES-D-7678-C, group 3.	1

[a]See paragraph 204, List of Manufacturers.

Signal Corps stock No.	Name of part, description, use	Mfr. No.[a]	Drawing or specification No.	Quan. per major unit
3E1518	CORD CD-518: 6-foot, 2-conductor; No. 18 AWG, S.B.R.C., rubber covered, type SJ; with a 3-pole female plug No. 8023, Everlok, R & S, or equal on one end and a polarized plug cap No. 9941, as made by Harvey Hubbell Inc., or equal, on the other end. Used to supply power to Range Unit BC-436-A while in a test position.	7	ES-D-7676-C, group 4.	1
3E1519	CORD CD-519: 6-foot; composed of two 6-foot lengths of single-conductor; No. 18 AWG, shielded, rubber-covered, type SJ. One pair of ends connected to a 4-pole female plug No. 8028, Everlok, R & S, or equal. The other ends, shields and conductors are connected to 4 crocodile clips. The rubber insulators (1 black, 1 red) are placed over the clips, connected to the conductors. The crocodile clips are No. 85 and the insulators are No. 87, both as made by Mueller Electric Co., or equal. Used to introduce and obtain the phase-shifted sine-wave voltage from Range Unit BC-436-A. Sine wave is introduced through one lead, and is shifted in phase and fed through the other.	7	ES-D-7676-C, group 3.	1
3E1520	CORD CD-520: 250-foot, 4-conductor; No. 18 AWG; one conductor shielded, rubber-covered, type SJ; 4-pole male plug No. 8158, Everlok, R & S, or equal, on one end, and a 4-pole female plug No. F-6855, Everlok, R & S, or equal, on the other end. Used to supply power to Radio Modulator BC-423 and to transfer the synchronous voltage from Radio Modulator BC-423 to the units on Trailer K-28 while adjusting the receiving antennas.	7	ES-D-8843.	1
3E1728	CORD CD-728: 50 feet long. Used with Thermocouple and Meter M-322 to measure field strength.	7	ES-690563-1.	1
3F3825	SIGNAL GENERATOR I-126-B: ultra-high frequency. Used when adjusting Radio Receiver BC-406.	8	Measurements model 78-B.	1
3F3870	SIGNAL GENERATOR I-126-B: ultra-high frequency. Used when adjusting Radio Receiver BC-406.	8	Measurements model 78-C.	1

[a]See paragraph 204, List of Manufacturers.

Signal Corps stock No.	Name of part, description, use	Mfr. No.[a]	Drawing or specification No.	Quan. per major unit
3F35665	OSCILLATOR I-151: audio, resistance capacitance type; frequency range 20-20,000 cycles; power output impedance, 15 to 5,000 ohms; accuracy of calibration, 2% on 1 cycle.	9	Hickok model 198 or equal.	1
3F4452-703-A	OSCILLOSCOPE: 3" cathode-ray tube. Used to observe waveshapes and as an output indicator when aligning the radio receivers.	10	RCA model 155-B.	1
3F3640-134( )	OSCILLOSCOPE I-134: same as above.	11	Dumont model 224-A.	
2Z7226-217	PLUG PL-217: 4-pole Everlok plug, with 2 of its terminals shorted. The plug is inserted into a receptacle on Keying Unit BC-409 in order that the interlock circuit will be closed. Used when testing Keying Unit BC-409.	7	ES-D-7678-C, group 4.	1
2Z7226.218	PLUG-PL-218: dummy antenna plugs, 150 ohms each. Used in series with the output of the signal generator when aligning radio receiver with uhf signal generator.	7		3
3Z8270	SCREEN M-352: a wire mesh screen in a wooden frame. Used as a shield and reflector between the Radio Modulator BC-423 case and its dipole antenna when the buried tweeter method of aligning antennas is used.	12	ES-D-8856-A.	1
7A1757	SIGHT M-351: a "peep" sight. Used to sight targets when orientating the radio set. Must be used with Radio Modulator BC-423, Screen M-352, and Cord CD-520 or Cord CD-506.	13	ES-D-8806-A, 8607-A, 8608-A, 8609-A.	1
3F4114	TEST SET I-114: used to test cable No. 27 and the 5 synchronous repeaters contained in the radio set. Contains one 0-150-volt a-c meter.	7	ES-D-8613, 8635, 8636, 8637, 8657.	1
3F4115	TEST SET-I-115: containing an isolating capacitor, and resistors which serve as load and as voltage dividers. This is connected to the output of Keying Unit BC-409 and, with a test oscilloscope, the waveshape and peak voltage may be observed.	7	ES-D-8404, 8405, 8406, 8407, 8408.	1

[a]See paragraph 204, List of Manufacturers.

Signal Corps stock No.	Name of part, description, use	Mfr. No.[a]	Drawing or specification No.	Quan. per major unit
2C7598B	REMOTE CONTROL TEST SET BC-670-B: contains a stop-start switch and a plug. The plug is inserted into the receptacle on the panel of Rectifier RA-38, so that the rectifier may be controlled at the rectifier panel.	7	ES-D-7675-D, group 1, and ES-D-8897-A.	1
3F4045-671A	TEST SET BC-671 OUTPUT BOX RECEIVER: contains a sensitivity control and a load resistor. Used with Radio Receiver BC-406. The output of the receiver is connected to the test set and the test set in turn is connected to a test oscilloscope.	7	ES-D-7675-B.	1
3F4452-703A	RECEIVER OUTPUT BOX BC-708-A: similar to BC-671 but in a square box.			1
2Z7372-B	TEST SET BC-672-B: contains polarized outlets and a cable with a polarized plug. Used as a source of polarized a-c power when servicing the components. Without a polarized source, short circuits would occur.	7	ES-D-7675-B, group 2, and ES-D-8897-A.	1
3F910-8	THERMOCOUPLE AND METER M-322: an external type thermocouple, with facilities for mounting dipole rods. A length of cable and a meter permit the erection of the dipole with thermocouple at a distance away from the transmitting antenna and observation of the reading at the mount trailer. This is supplied with a meter case, cord, and dipole rods. Consists of: Meter Case CH-148, Cord CD-728, two 11- by ⅜-inch copper tubing.	5 7	Weston type D thermocouple and model 507 meter.	1
3F5690	TUBE CHECKER I-157: a low-power tube tester with provision for testing acorn tubes.	14	Precision model 920.	1

[a]See paragraph 204, List of Manufacturers.

204. TEST EQUIPMENT RC-68-A, LIST OF MANUFACTURERS.

Mfr. No.	Name and address
5	Weston Electrical Inst. Corp., Newark, N. J.
6	Boorum & Pease, Brooklyn, New York.
7	Western Electric Co., Kearney, New Jersey.
8	Measurements Corp., Boonton, New Jersey.
9	Hickok Electrical Inst. Co., Cleveland, Ohio
10	Radio Corp. of America, Camden, N. J.
11	Dumont Laboratories Inc., Passaic, N. J.
12	Parker Engineering Products Co., N. Y. C.
13	H. S. Zebley, Asbury Park, New Jersey.
14	Precision Apparatus Co., Elmhurst, L. I.

205. SPECIFICATIONS AND LIST OF TUBES IN TEST EQUIPMENT RC-68-A.

a. R-F Signal Generator, Measurements No. 78-B.

Tube complement:

1 ea 9002. 1 ea 7L7.
1 ea 7Y4. 1 ea VR 150-30.
1 ea 7C5.

Specifications:

Frequency range: 15-25 mc; 195-225 mc.
Modulation: 400 or 8,200 cps at 30 percent.
Dimensions: width, 13"; height, 10"; depth, 7".
Weight: 25 lb. net, 29 lb. packed.
Output impedance: 34 ohms.
Output voltage: variable, 1 to 100,000 microvolts.

b. Audio Signal Generator, Hickok No. 198.

Tube Complement:

1 ea 6SJ7. 1 ea 6V6.
1 ea 6X5. 1 ea 6SN7.

Specifications:

Frequency range: 20 to 20,000 cps.
Output impedance: 0-10-250-500-5,000 ohms.
Dimensions: width, 12½"; height, 10¼"; depth, 6½".
Weight: 17 lb. net, 22 lb. packed.

c. Oscilloscope, RCA No. 155-B.

Tube complement:

2 ea 6C6. 1 ea 884.
1 ea 906 C.R.T. 2 ea 80.

Specifications:

Frequency response of amplifiers: 20-90,000 cps.
Frequency range of timing axis: 15-22,000 cps.
Deflection sensitivity at amplifier inputs: 0.5 volts per inch.
Deflection sensitivity at C.R.T. inputs: 20 volts per inch.
110-120 volts, 50-60 cycles, 50 watts.
Dimensions: height, 14⅜"; width, 8", depth, 14¼".
Weight: 21 lb. net, 50 lb. packed.
1½-amp fuse.

d. Oscilloscope I-134, Dumont No. 224.

Tube complement:

1 ea 3GP1 C.R.T. 1 ea 6J5.
2 ea 6AG7. 1 ea 6Q5G.
1 ea 6AC7. 1 ea CD-2005 neon lamp.
1 ea 6SN7GT. 1 ea 80.
1 ea 6SG7. 1 ea 6V6.
1 ea 5Z3. 1 ea 6SJ7.

Specifications:

Frequency range of amplr: 20 to 2,000,000 cps.
Frequency range of timing axis: 15 to 30,000 cps.
Deflection sensitivity at amplifier inputs: 0.4 volts per inch.
Deflection sensitivity at C.R.T. inputs: 25 volts per inch.
115 volts, 60 cycles, 150 watts.
2-amp fuse.
Dimensions: 14⅛" x 8⅜" x 15⅛".
Weight: 49 lb. net, 60 lb. packed.

e. Tube Checker I-157, Precision No. 920.

Tube complement:

1 ea 80.
1 ea G-10 neon lamp.

Specifications:

Tests tubes from 1-volt to 120-volt filaments.
Tests for shorts.
Measures a-c and d-c volts in 6 ranges to 3,000 volts.
Measures d-c current in 5 ranges to 12 amperes.
Measures resistance in 4 ranges to 10 meg.

Dimensions: 12" x 13" x 6".
Weight: approximately 15 lb. net, 21 lb. packed.

f. Analyzer I-167, Weston No. 772.

Dimensions: 15⅛" x 5⅛" x 8¾".
Weight: 8½ lb. net, 10 lb. packed.
Sensitivity: 20,000 ohms-per-volt dc; 1,000 ohms-per-volt ac.
Voltage range: 0-2.5-10-50-250-1,000 ac or dc.
Current range: 0-0.1-1-10-50-250 ma; 0-1-10 amp.
Resistance range: 0-3M-30M-3 meg-30 meg.
Db range: —14 to +54.
2 Burgess No. 5540, 7½-volt batteries.

g. Analyzer I-153, Precision model 856.

Weight: approximately 7 lb. net, 9 lb. packed.
Dimensions: 9" x 10" x 6¼".
Sensitivity: 20,000 ohms-per-volt dc and 1,000 ohms-per-volt ac or dc.
Voltage range: 0-3-12-60-300-600-1,200-6,000 volts ac or dc.
Current range: 0-60-300 microamperes; 0-3-30-120-600 ma; 0-12 amp dc.
Ohm range: 0-6M-600M-60 meg.
Db range: —12 to +70.
1 Eveready No. 950, 1½-volt battery.
1 Burgess No. 4156, 22½-volt battery.
Type of meter: 50 microamperes; 4½" square.
Accuracy: 2% dc — 3% ac.

h. Range Calibrator I-108.

Tube complement:

1 ea 5W4.
1 ea 6C5.
5 ea 6SJ7.
1 ea 6FS.

Specifications:

Dimensions: 12 13/64" x 10 13/64" x 13 15/32".
Weight: 50 lb. net, 55 lb. packed.
120 volts, 60 cycles.
1¼-amp fuse.

206. SPECIFICATIONS AND LIST OF TUBES, TUBE CHECKER I-180, HICKOK MODEL 540.

Tube complement:

1 ea 5W4 or 5Y3GT.
1 ea 83.

Specifications:

Tests tubes with filaments from 1 to 117 volts.
Dynamic mutual conductance test.
Provision to test acorn-type tubes.
115 volts, 50 cycles.
Dimensions: width, 14¾"; height, 13"; depth, 6".
Weight: 16 lb. net, 22 lb. packed.

207. VACUUM TUBE CHARACTERISTICS OF RADIO SET SCR-268-(*).

a. Description and Function.

Type number	Mfr. code No.*	Type†	Base diag. No.‡	Heater Volts	Heater Amp	Description	Component used on	Function
VT-65	6C5	M	2	6.3	0.3	Detector amplifier triode	Keyer	1st synchronizing amplifier
							Calibrator	Frequency multiplier
VT-66	6F6	M	3	6.3	0.7	Power amplifier pentode	Tweeter	2d audio amplifier
							Range Unit	2d or 3d amplifier
							Keyer	1st pulse amplifier 2d synchronizing amplifier
							Calibrator	Pulse amplifier
VT-86-B	6K7GT	G	5	6.3	0.3	Triple-grid super control amplifier	Frequency meter	Oscillator
VT-91	6J7	M	5	6.3	0.3	Triple-grid detector amplifier	Tweeter	Audio amplifier Oscillator
VT-94-D	6J5GT	G	2	6.3	0.3	Detector amplifier triode	Frequency meter	Oscillator
VT-96	6N7	M	6	6.3	0.8	Class B twin amplifier	Receiver	Switching amplifier Switching oscillator
VT-107-A	6V6GT	G	3	6.3	0.45	Beam power amplifier	Signal generator	Oscillator
							Frequency meter	Audio amplifier
							Dumont test oscilloscope	Amplifier

*All tubes of RCA manufacture except VT-127-A, VT-129, and VT-130, which are Eimac; VT-166 which is Western Electric; and 3GPI/2537A-3, which is Dumont.

†Tubes marked G are glass, those marked M are metal.

‡Refers to diagrams of figure 70.

Type number	Mfr. code No.*	Type†	Base diag. No.‡	Heater		Description	Component used on	Function
				Volts	Amp			
VT-112	1852 or 6AC7	M	9	6.3	0.45	Television amplifier pentode	Oscilloscope	Synchronizing amplifier
							Dumont oscilloscope	Amplifier
VT-115	6L6	M	3	6.3	0.9	Beam power amplifier	Oscilloscope	Pulse generator Sweep generator Right amplifier Left amplifier Pulse amplifier Pulse amplifier
							Keyer	Second pulse amplifier Second pulse amplifier
VT-116	6SJ7	M	9	6.3	0.3	Triple-grid detector amplifier	Receiver	Second detector Video amplifier
							Oscilloscope	Spread amplifier Sweep amplifier
							Range unit	First and second amplifier
							Keyer	Oscillator Overdriven amplifier Pulse generator
							Signal generator	Oscillator
							Calibrator	Frequency multiplier Amplifier No. 1 Amplifier No. 2

*All tubes of RCA manufacture except VT-127-A, VT-129, and VT-130, which are Eimac; VT-166 which is Western Electric; and 3GPI/2537A-3, which is Dumont.

†Tubes marked G are glass, those marked M are metal.

‡Refers to diagrams of figure 70.

Type number	Mfr. code No.*	Type†	Base diag. No.‡	Heater		Description	Component used on	Function
				Volts	Amp			
VT-116	6SJ7	M	9	6.3	0.3	Triple-grid detector amplifier	Calibrator	Overdriven amplifier Pulse generator
							Dumont test oscilloscope	Amplifier
VT-117	6SK7	M	9	6.3	0.3	Triple-grid super control amplifier	Receiver	First i-f amplifier Second i-f amplifier Third i-f amplifier Fourth i-f amplifier
VT-120	954	G	11	6.3	0.15	Detector amplifier pentode, acorn type	Receiver	First r-f amplifier Oscillator First r-f amplifier Second r-f amplifier Mixer
VT-121	955	G	12	6.3	0.15	Detector amplifier oscillator, acorn type	Receiver	Oscillator
							Tweeter	Oscillator
VT-129	304TL	G	15	5	13	Multiple-unit triode	Modulator	Modulator
VT-130	350TL	G	16	5	10.5	Heavy-duty triode	Modulator	Rectifier
	250-R	G	16	5	10.5	Heavy-duty triode	Modulator	Rectifier
VT-151-B	6A8GT	G	18	6.3	0.3	Pentagrid converter	Frequency meter	Detector
VT-202	9002	G	20	6.3	0.15	Detector amplifier oscillator, midget type	Microvolter	Oscillator

*All tubes of RCA manufacture except VT-127-A, VT-129, and VT-130, which are Eimac; VT-166 which is Western Electric; and 3GPI/2537A-3, which is Dumont.

†Tubes marked G are glass, those marked M are metal.

‡Refers to diagrams of figure 70.

Type number	Mfr. code No.*	Type†	Base diag. No.‡	Heater		Description	Component used on	Function
				Volts	Amp			
	6SF5	M	30	6.3	0.3	Diode-super-control amplifier pentode	Receiver	Switch oscillator
VT-231	6SN7	M	21	6.3	0.6	Twin-triode amplifier	Signal generator	Phase inverter
	6C6	G	22	6.3	0.3	Triple-grid detector amplifier	RCA test oscilloscope	Amplifier
VT-94	6J5	M	2	6.3	0.3	Detector amplifier triode	Dumont test oscilloscope	Amplifier
VT-247	6AG7	M	24	6.3	0.65	Video power amp. amplifier pentode	Dumont test oscilloscope	Amplifier
VT-231	6SN7GT	G	21	6.3	0.6	Twin-triode amplifier	Dumont test oscilloscope	Amplifier
VT-211	6SG7	M	26	6.3	0.3	H-f amplifier pentode	Dumont test oscilloscope	Amplifier
	7L7	M	28	6.3	0.3	Triple-grid amplifier	Microvolter	Amplifier
	7C5	G	29	6.3	0.45	Beam power amplifier	Microvolter	Amplifier

*All tubes of RCA manufacture except VT-127-A, VT-129, and VT-130, which are Eimac; VT-166, which is Western Electric; and 3GPI/2537A-3, which is Dumont.

†Tubes marked G are glass, those marked M are metal.

‡Refers to diagrams of figure 70.

x.	Plate resistance (ohms)	Trans. conductance (micromhos)	Load resistance (ohms)	Total harmonic distortion (percent)	Max. signal power output (watts)	Cathode resistor (ohms)
	10,000	2,000				
2			7,000	9	4.5	440
	600,000	1,650				
	1,000,000	1,225				
	7,700	2,600				
			8,000	8	10	
6	77,000	3,750	8,500	12	5.5	
	1,000,000	9,000				160
.6			4,500	11	6.5	220
	1,000,000	1,650				
	800,000	2,000				
	1,000,000	1.400				
	11,400	2,200				
	260,000	550				
	11,400	2,200				
	66,000	1,500				
	7,700	2,600				
	1,000,000	1,225				
	7,700	2,600				
9	130,000	11,000	10,000	7	3	
	7,700	2,600				
	1,000,000	4,000				
	1,000,000	3,100				
6	77,000	3,750	8,500	12	5.5	

ʼperating characteristics as rectifiers					
With capacitor input filter			With choke input filter		
A-c ltage plate volts)	Plate supply impedance (ohms)	Max. d-c output current (ma)	A-c plate voltage per plate (rms volts)	Input choke inductance (henrys)	Max. d-c output current (ma)
50	50	125	500	5	125
'50	50		500	6	100
·50	150	225	550	3	225
		7.5			
·25	150	70	450	8	70
50	.75	225	550	3	225
25	150	60	450	10	60

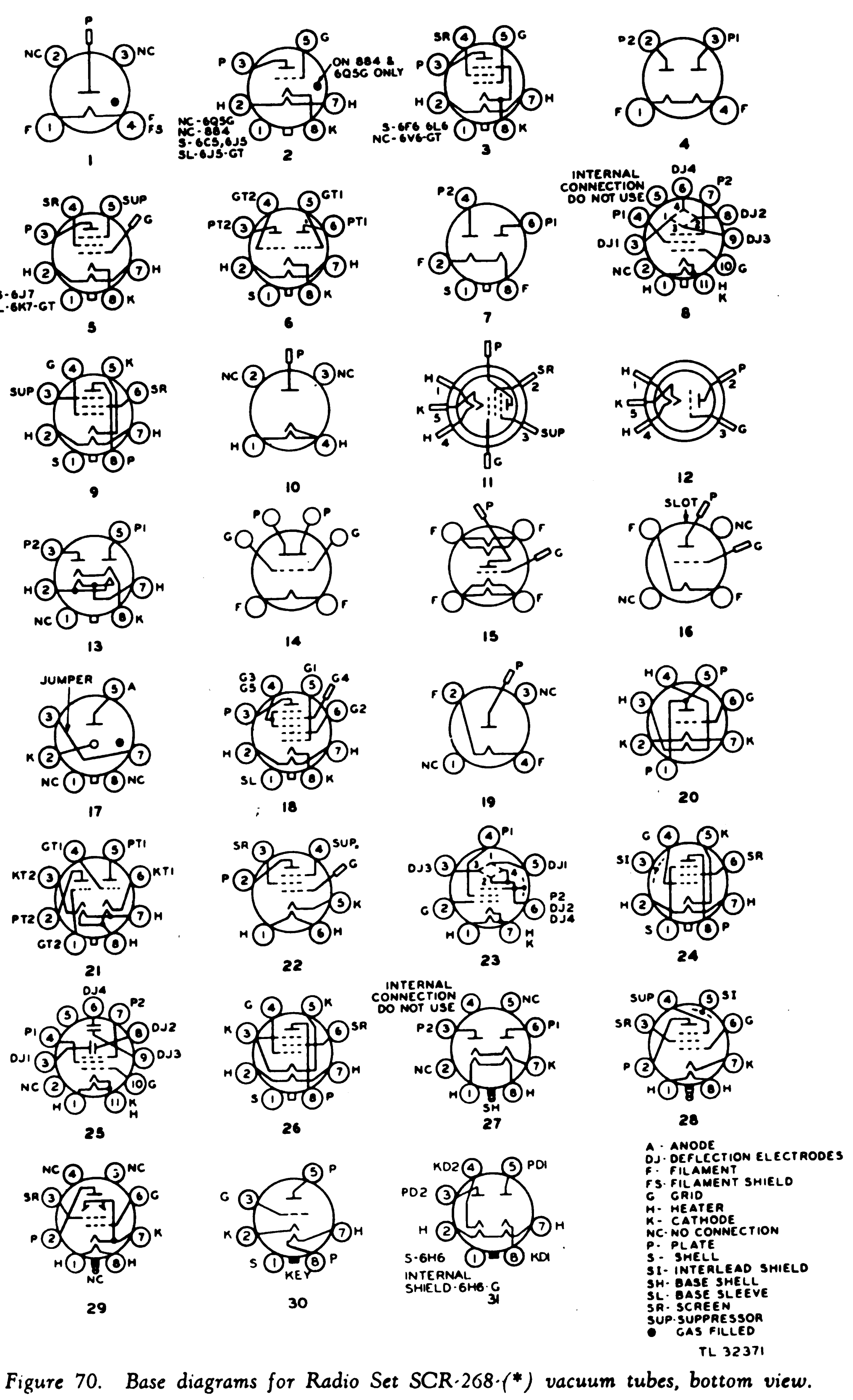

Figure 70. Base diagrams for Radio Set SCR-268-(*) vacuum tubes, bottom view.

208. SUMMARY OF FORMULAS.

a. D-c Circuits.

(1) $E = IR, \quad I = \frac{E}{R}, \quad R = \frac{E}{I}.$

(2) $I_{total} = I_1 = I_2 = I_3 = \ldots$ (series circuit).

(3) $I_{total} = I_1 + I_2 + I_3 + \ldots$ (parallel circuit).

(4) $E_{total} = E_1 + E_2 + E_3 + \ldots$ (series circuit).

(5) $E_{total} = E_1 = E_2 = E_3 = \ldots$ (parallel circuit).

(6) $Power_{(watts)} = IE = I^2R = \frac{E^2}{R}.$

(7) $R_{total} = R_1 + R_2 + R_3 + \ldots$

(8) $R_{equivalent} = \dfrac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots}$ (resistors in parallel).

(9) $R_{equivalent} \quad \dfrac{R_1 \times R_2}{R_1 + R_2}$ (two resistors in parallel).

b. A-c Circuits

(1) $E = IZ, \quad I = \frac{E}{Z}, \quad Z = \frac{E}{I}.$

(2) $Z(ohms) = \sqrt{R^2 + (2\pi fL - \frac{1}{2\pi fC})^2}$

(3) X_L (ohms) $= 2\pi fL$ (inductive reactance)

(4) X_c (ohms) $= \dfrac{1}{2\pi fC}$ (capacitive reactance).

(5) $E_L = IX_L, \quad E_c = IX_c$ (pure reactive circuits).

(6) $I_L = \dfrac{E}{X_L}, \quad I_c = \dfrac{E}{X_c}$ (pure reactive circuits).

(7) $L_{total} = L_1 + L_2 + L_3 + \ldots$ (inductors in series).

(8) $L_{equivalent} = \dfrac{1}{\frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} + \ldots}$ (inductors in parallel).

(9) $C_{total} = C_1 + C_2 + C_3 + \ldots$ (capacitors in parallel).

(10) $C_{equivalent} = \dfrac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \ldots}$ (capacitors in series).

(11) $C_{equivalent} = \dfrac{C_1 \times C_2}{C_1 + C_2}$ (two capacitors in series).

c. Miscellaneous.

(1) Frequency in cycles per second: $f = \dfrac{300{,}000{,}000}{\lambda}.$

(2) Frequency in cycles per second: $f = \dfrac{1}{2\pi\sqrt{LC}}.$

f = frequency in cycles. C = farads.
λ = wavelength in meters. 2π = 6.28.
L = henrys.

209. GLOSSARY OF TERMS.

Acorn tube. An acorn-shaped vacuum tube designed for u-h-f receiver circuits. The tube has low electron-transit time and low interelectrode capacitance because of close spacing and small size of electrodes.

Align. To adjust the tuned circuits of a receiver or transmitter for maximum signal response.

Ammeter. An instrument for measuring the flow of current or electrons in amperes.

Ampere (Amp). The basic unit of current or electron flow.

Amplification. The process of increasing the strength of a signal.

Amplification factor. The ratio of change in plate voltage to a change in grid voltage in a vacuum tube, with all other electrode voltages and plate current constant.

Amplifier (amplr). A device used to increase the signal voltage, current, or power, generally composed of a vacuum tube and suitable circuit called a stage. It may contain several stages in order to obtain desired gain.

Amplitude. The maximum value of an alternating voltage or current, measured in either the positive or negative direction.

Amplitude distortion. The changing of a waveshape so that it is no longer proportional to its original form. Also known as harmonic distortion.

Analyzer. A device used for electrical trouble analysis, combining voltmeter, ohmmeter, ammeter, and output-meter function into one test set.

Anode. A positive electrode; the plate of a vacuum tube.

Attenuation. The reduction in the strength of a signal.

Audio amplifier. Any device that amplifies signals having frequencies within the audio range.

Audio frequency (af; a-f). A frequency which can be detected as a sound by the human ear. The range of audio frequencies extends approximately from 20 to 20,000 cycles per second.

Baseline. The horizontal trace observable on the screen of an oscilloscope when no input is applied to the vertical deflection plates and the sweep circuit is operating.

Beat frequency. A frequency resulting from the combination of two different frequencies. It is numerically equal to the difference between or the sum of these two frequencies.

Bias. The average d-c voltage maintained between the cathode and control grid of a vacuum tube.

Blocking capacitor. A capacitor used to block the flow of direct current while permitting the flow of alternating current.

Buffer amplifier. An amplifier used to isolate the output of an oscillator from the effects produced by changes in voltage or loading in following circuits.

Bypass capacitor. A capacitor used to provide an alternating-current path of comparatively low impedance around a circuit element.

Capacitance. The property of two or more bodies which enables them to store electrical energy in an electrostatic field between the bodies.

Capacitor. Two electrodes or sets of electrodes in the form of plates, separated from each other by an insulating material called the dielectric.

Carrier. The r-f component of a transmitted wave upon which an audio signal or other form of intelligence can be impressed.

Cathode. The electrode in a vacuum tube which is the source of electron emission.

Cathode-ray tube (C.R.T.). A tube used in oscilloscopes to provide a visible pattern of electronic variation.

Choke. A coil which impedes the flow of alternating current of a specified frequency range because of its high inductive reactance at that range.

Continuity. The indication of a complete electrical circuit.

Crystal oscillator. An oscillator circuit in which a crystal is used to control the frequency and to reduce frequency instability to a minimum.

Current. Flow of electrons; measured in amperes.

Cycle. One complete positive and one complete negative alternation of a current or voltage.

Decibel (db). The standard unit of comparison between two quantities of electrical or acoustical power.

Degeneration. The process whereby a part of the output signal of an amplifying device is returned to its input circuit in such a manner that it tends to cancel the input.

Detection. The process of separating the modulation component from the received signal.

Dielectric. An insulator; a term applied to the insulating material between the plates of a capacitor.

Diode. A two-electrode vacuum tube containing a cathode and a plate.

Diode detector. A detector circuit employing a diode tube.

Dipole. A pair of radiating elements of equal length, placed end to end, and usually energized at the two adjacent ends.

Distortion. The production of an output waveform which is not a true reproduction of the input waveform. Distortion may consist of irregularities in amplitude, frequency, or phase.

Effective value. The equivalent heating value of an alternating current or voltage, as compared to a direct current or voltage. It is 0.707 times the peak value of a sine wave. It is also called the *rms* value.

Electric field. A space in which an electric charge will experience a force exerted upon it.

Electrode. A terminal at which electricity passes from one medium into another.

Electrolyte. A water solution of a substance which is capable of conducting electricity. An electrolyte may be in the form of either a liquid or a paste.

Electrolytic capacitor. A capacitor employing a set of plates immersed in an electrolytic solution.

Electromagnetic field. The field of influence which an electric current produces around the conductor through which it flows.

Electron. The smallest quantity of negative charge. Also the smallest particle of matter. Electrons associated with equal numbers of protons form atoms.

Electron emission. The liberation of electrons from a body into space under the influence of heat, light, impact, chemical disintegration, or potential difference.

Electrostatic field. The field of influence between two charged bodies.

Farad. The unit of capacitance.

Feedback. A transfer of energy from the output circuit of a device back to its input.

Field. The space containing electric or magnetic lines of force.

Field intensity. Electrical strength of a field.

Filament. An element within a vacuum tube in the form of a metal wire heated by the current passing through it.

Filter. A combination of circuit elements designed to pass a definite range of frequencies, attenuating all others.

Fixed bias. A bias voltage of constant value, such as one obtained from a battery, power supply, or generator.

Fluorescence. The property of emitting light as the immediate result of electrical bombardment.

Fly-back. The portion of the time base during which the spot is returning to the starting point. This is usually not seen on the screen of the cathode-ray tube, because of blanking action.

Frequency. The number of complete cycles per second existing in any form of wave motion; such as the number of cycles per second of an alternating current.

Frequency distortion. Distortion which occurs as a result of failure to amplify or attenuate equally all frequencies present in a complex wave.

Gain. The ratio of the output power, voltage, or current to the input power, voltage, or current, respectively.

Galvanometer. An instrument designed to detect the presence of direct current in an electrical circuit.

Gas tube. A tube filled with gas at low pressure in order to obtain certain desirable characteristics.

Getter material. Material used to absorb gas in vacuum tubes.

Grid current. Current which flows between the cathode and the grid whenever the grid becomes more positive than the cathode.

Grid leak. A high resistance connected across the grid capacitor or between the grid and the cathode to provide a d-c path from grid to cathode and to limit the accumulation of charge on the grid.

Ground. A metallic connection with the earth to establish ground potential. Also, a common return to a point of zero *r-f* potential, such as the chassis of a receiver or a transmitter.

Harmonic. A multiple of a fundamental frequency. (The second harmonic is twice the frequency of the fundamental or first harmonic.)

Henry (h). The basic unit of inductance.

Impedance. The total opposition offered to the flow of an alternating current. It may consist of any combination of resistance, inductive reactance, and capacitive reactance.

Inductance. The property of a circuit which tends to oppose a change in the existing current and is present only when the current is changing.

Induction. The act or process of producing voltage by the relative motion of a magnetic field across a conductor.

Inductor. A circuit element designed so that its inductance is its most important electrical property; a coil.

In phase. Applied to the condition that exists when two waves of the same frequency pass through their maximum and minimum values of like polarity at the same instant.

Intensify. To increase the brilliance of an image on the screen of a cathode-ray tube.

Interelectrode capacitance. The capacitance existing between the electrodes in a vacuum tube.

Intermediate frequency (i.f.; i-f). The fixed frequency to which all *r-f* carrier waves are converted in a superheterodyne receiver.

Inverse peak voltage. The highest negative voltage reached between the plate and cathode of a rectifier tube.

Ion. An atom which has lost one or more electrons and therefore is positively charged.

Ionization. The breaking of atoms into ions.

Kilocycle (kc). One thousand cycles; generally used to indicate 1,000 cycles per second.

Lag. The amount one wave is behind another in time; expressed in electrical degrees.

Lead. The opposite of *lag*. Also, a wire or connection.

Leakage. The electrical loss due to poor insulation.

Load. The required output power; or, the impedance to which energy is being supplied.

Loading. The excessive shunting of current through a voltmeter when that voltmeter is applied across an electrical circuit.

Magnetic field. The space in which a magnetic force exists.

Matched impedance. The condition which exists when two coupled circuits are so adjusted that their impedances are equal.

Megohm (meg). One million ohms.

Mho. The unit of conductance.

Milliampere (ma). One-thousandth of an ampere.

Mixer. A vacuum tube or crystal and suitable circuit used to combine the incoming and local-oscillator frequencies to produce an intermediate frequency.

Modulation. The process of varying the amplitude (amplitude modulation), the frequency (frequency modulation), or the phase (phase modulation) of a carrier wave in accordance with other signals in order to convey intelligence. The modulating signal may be an audio-frequency signal, video signal as in television), or electrical pulses or tones to operate relays, etc.

Multielectrode tube. A vacuum tube containing more than three electrodes associated with a singe electron stream.

Multiplier. A resistor used in series with a voltmeter movement to increase the range of voltages measured by it.

Multiunit tube. A vacuum tube containing within one envelope two or more groups of electrodes, each associated with separate electron streams.

Mutual conductance. *See* Transconductance.

Mutual inductance. A circuit property existing when the relative position of two inductors causes the magnetic lines of force from one to link with the turns of the other.

Negative feedback. *See* Degeneration.

Neon bulb. A glass bulb containing two electrodes in neon gas at low pressure.

Ohm. The unit of electrical resistance.

Ohmmeter. A direct - current - operated meter calibrated to read resistance in ohms.

Open circuit. A circuit which does not provide a complete path for the flow of current.

Oscillator. A circuit capable of converting direct current into alternating current of a frequency determined by the constants of the circuit. It generally uses a vacuum tube.

Oscilloscope. An instrument for showing, visually, graphical representations of the waveforms encountered in electrical circuits.

Overload. A load greater than the rated load of an electrical device.

Peak value. The maximum instantaneous value of a varying current, voltage, or power. It is equal to 1.414 times the effective value of a sine wave.

Pentode. A five-electrode vacuum tube containing a cathode, control grid, screen grid, suppressor grid, and plate.

Phase difference. The time in electrical degrees by which one wave leads or lags another.

Phase inversion. A phase difference of 180° between two similar waveshapes of the same frequency.

Plate. The principal electrode in a tube to which the electron stream is attracted. *See* Anode.

Positive feedback. *See* Regeneration.

Potentiometer. A variable voltage divider; a resistor which has a variable contact arm so that any portion of the potential applied between its ends may be obtained.

Push-pull circuit. A push-pull circuit usually refers to an amplifier circuit using two vacuum tubes in such a fashion that when one vacuum tube is operating on a positive alternation, the other vacuum tube operates on a negative alternation.

Radio frequency (rf; r-f). Any frequency of electrical energy capable of propagation into space. Radio frequencies normally are much higher than sound-wave frequencies.

Radio-frequency amplification. The amplification of a radio wave by a receiver before detection, or by a transmitter before radiation.

Reactance. The opposition offered to the flow of an alternating current by the inductance, capacitance, or both, in any circuit. Its symbol is X.

Rectifier. A device used to change alternating current to unidirectional current.

Regeneration. The process of returning a part of the output signal of an amplifier to its input circuit in such a manner that it reinforces the grid excitation and thereby increases the total amplification.

Resistance. The opposition to the flow of current caused by the nature and physical dimensions of a conductor.

Resistor. A circuit element whose chief characteristic is resistance; used to oppose the flow of current.

Resonance. The condition existing in a circuit in which the inductive and capacitive reactances cancel.

Rheostat. A variable resistor.

rms. Abbreviation of root mean square; the effective value. In a sine wave, it is 0.707 times the maximum value.

Saturation. The condition existing in any circuit when an increase in the driving signal produces no further change in the resultant effect.

Saturation point. The point beyond which an increase in either grid voltage, plate voltage, or both produces no increase in the existing plate current.

Screen grid. An electrode placed between the control grid and the plate of a vacuum tube to reduce interelectrode capacitance.

Secondary. The output coil of a transformer.

Sensitivity. The degree of response of a circuit to signals of the frequency to which it is tuned.

Short circuit. A low-impedance or zero-impedance path between two points.

Shunt. Parallel; a parallel resistor placed in an ammeter to increase its range.

Sine Wave. An a-c wave that varies uniformly from zero to maximum value in one direction, comes back to zero, builds up to a maximum in the opposite direction, and again comes back to zero.

Sinusoidal. Varies as a sine wave.

Space charge. The negative charge existing in the space between the cathode and plate in a vacuum tube, formed by the electrons emitted from the cathode in excess of those immediately attracted to the plate.

Standing wave. A distribution of current and voltage on a transmission line formed by two sets of waves traveling in opposite directions, and characterized by the presence of a number of points of successive maximums and minimums in the distribution curves.

Sweep circuit. The part of a cathode-ray oscilloscope which provides a time-reference base.

Synchronous. Happening at the same time; having the same period and phase.

Thermocouple ammeter. An ammeter which operates by means of a voltage produced by the heating effect of a current passed through the junction of two dissimilar metals. It is used for r-f measurements.

Transconductance. The ratio of the change in plate current to the change in grid voltage producing this change in plate current, while all other electrode voltages remain constant.

Transformer. A device composed of two or more coils, linked by magnetic lines of force, used to transfer energy from one circuit to another.

Triode. A three-electrode vacuum tube, containing a cathode, control grid, and plate.

Vacuum-tube voltmeter. A device which uses either the amplifier characteristic or the rectifier characteristic of a vacuum tube or both to measure either d-c or a-c voltages. Its input impedance is very high, and the current used to actuate the meter movement is not taken from the circuit being measured. It can be used to obtain accurate measurements in sensitive circuits.

Video amplifier. A circuit capable of amplifying a very wide range of frequencies, including and exceeding the audio band of frequencies.

Volt (v). The unit of electrical potential.

Voltage divider. A resistor connected across the output of a power source, with a mechanical provision for connecting the local load circuits across all or part of the resistor to obtain the desired voltage.

Voltage doubler. A method of increasing the voltage by rectifying both halves of a cycle and causing the outputs of both halves to be additive.

Voltage regulation. A measure of the degree to which a power source maintains its output-voltage stability under varying conditions.

Watt (w). The unit of electrical power.

Wave. Loosely, an electrical impulse, periodically changing in intensity and traveling through space. More specifically, the graphical representation of the intensity of that impulse over a period of time.

Waveform. The shape of the wave obtained when instantaneous values of an a-c quantity are plotted against time in rectangular coordinates.

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