WAR DEPARTMENT TECHNICAL MANUAL
TM 11-2627

TUBE TESTER I-177

WAR DEPARTMENT *3 AUGUST 1944*

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WASHINGTON 25, D. C., 3 AUGUST 1944.

TM 11-2627, Tube Tester I-177, is published for the information and guidance of all concerned.

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BY ORDER OF THE SECRETARY OF WAR:

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The Adjutant General.

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X

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

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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, crow-bars, 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*—Meters, controls, panels.

2. *Cut*—Cables and all wiring.

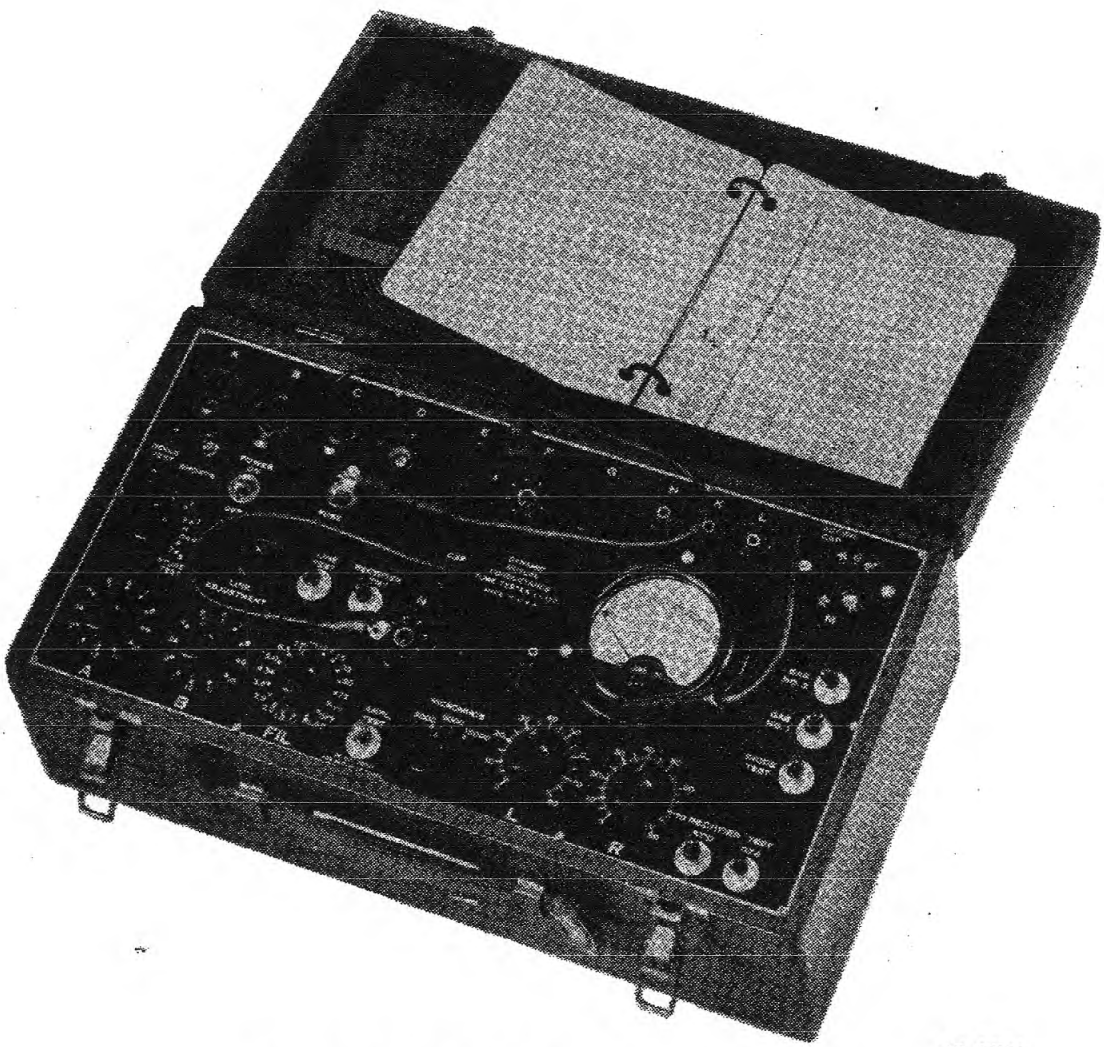
3. *Burn*—Resistors, capacitors, all technical manuals, instruction books, tube charts.

4. *Bury or scatter*—Any or all of the above pieces after destroying their usefulness.

DESTROY EVERYTHING

SAFETY NOTICE

THE PRESENCE OF HIGH VOLTAGES IN THIS EQUIPMENT IS DANGEROUS TO LIFE. OPERATING PERSONNEL MUST EXERCISE EXTREME CARE. SAFETY REGULATIONS AND CAUTION NOTICES WHICH APPEAR THROUGHOUT THIS MANUAL MUST BE OBSERVED AT ALL TIMES. MAKE TESTS EXACTLY AS DIRECTED. PERSONNEL NOT FAMILIAR WITH THE SERVICING OF HIGH-VOLTAGE CIRCUITS SHOULD NEVER MAKE TESTS INVOLVING SUCH CIRCUITS.



TL-14593

Figure 1. Tube Tester I-177 with cover raised.

SECTION I

DESCRIPTION

1. PURPOSE. Tube Tester I-177 is an instrument used to test and measure mutual conductance values of vacuum tubes. The purpose of this manual is to acquaint the repairman with the construction, operating principles, maintenance, and use of this instrument.

2. TUBE TESTER I-177 (fig. 1).

a. This instrument is furnished both as an individual unit or as a part of Test Set I-56-K. As a part of Test Set I-56-K it fits into a compartment of Carrying Case CS-130. The weights and dimensions of the tube tester and carrying case are given below.

Equipment	*Dimension (in.)*			*Weight (lb.)*
	Height	*Width*	*Depth*	
Tube Tester I-177	5¾	15½	8½	15.75
Carrying Case CS-130	14¾	20½	9¾	25.6

b. Tube Tester I-177 is fundamentally a dynamic mutual conductance tube tester designed to provide either REPLACE-GOOD readings or mutual conductance values in micromhos for Signal Corps and commercial receiving tubes and small transmitting tubes. Noise tests of tubes can be made by connecting the input of a radio receiver to two NOISE TEST jacks. An extra topcap lead permits testing of transmitting tubes having plate connections to envelope topcaps. Special switches are provided for making gas tests of tubes. Mutual conductance values of tubes can be measured in three ranges: 0-3,000 micromhos, 0-6,000 micromhos and 0-15,000 micromhos. The tube tester operates on 105- to 125-volt, 60-cycle alternating current. Tube testing data is given in a loose-leaf booklet attached to the inside of the cover of the instrument. The power cord is wound on brackets on the inside of the cover.

SECTION II

OPERATION

3. PRELIMINARY INSTRUCTIONS.

Before handling Tube Tester I-177, read the operating instructions carefully. This is a delicate electrical instrument containing a meter and parts that can easily be damaged by mishandling. Pay particular attention to caution notices.

CAUTION: After testing tubes *always* set all controls to off or safety positions as indicated in the following table. Tubes may be burned out if inserted in test sockets before the controls have been properly set.

Control	*Safety position*
POWER	OFF
SHORT-TUBE TEST	1
LINE ADJUSTMENT	Extreme counterclockwise
A	1
B	1
FIL	OFF
MICROMHOS	15,000
L	80
R	80

4. SHORTS TEST.

a. Make sure all controls are in safety positions (par. 3).

b. Plug the power cord of the tester into a suitable a-c power outlet (105 to 125 volts).

c. Determine the type number of the tube to be tested, and locate this type number in the column headed Tube Type on the loose-leaf test data cards fastened inside the cover of the instrument. If the tube is marked

with Signal Corps nomenclature, use the table in section V or the table on the back of the first card in the tester to determine the commercial equivalent.

d. Set selector switch A to the number indicated in column A.

e. Set selector switch B to the number indicated in column B.

f. Set selector switch FIL to the number indicated in the column headed Fil. volts.

g. Insert the tube in the socket indicated in the column headed Socket Letter.

NOTE: When inserting or removing a loctal or acorn tube from a socket, handle the tube as gently as possible. Tube pins pass directly through the glass seals and excessive force will crack the glass. A slight sidewise pressure applied to a loctal tube will release the lock and permit easy removal of the tube from the socket.

h. If the tube has a topcap, attach the clip of the CAP lead to the cap. For acorn tubes, use the ACORN CAP lead and clip. For tubes having a star in the Notations column (such as 807, 871, etc.), connect the plate topcap of the tube to the upper left contact of 6-pin socket C with the 12-inch lead having a clip and banana plug.

i. Set POWER switch to ON position.

j. To adjust the line voltage, press and hold down the LINE TEST button and turn the LINE ADJUSTMENT knob until the meter pointer is exactly at the LINE TEST position (at 1,500, not at the ? on the scale); then release LINE TEST button.

k. After allowing at least 30 seconds for the tube to warm up, turn the SHORT-TUBE TEST switch slowly from position 1 to positions 2, 3, 4, and 5 successively while tapping the tube with a finger and watching the SHORTS neon lamp. If the neon lamp burns continuously or glows during tapping in any of the five positions, the tube contains shorted electrodes and should be discarded without further testing (to prevent damage to the meter) unless an exception is noted on the test data card. Disregard a momentary flash of the neon lamp while the switch is being turned from one position to the next, since this is due to charging of a capacitor in the lamp circuit.

NOTE: Before discarding the tube, refer to the Notations column on the test data card to see if the tube being tested normally appears to

be shorted on certain positions of the switch. Thus, for the 1LN5, the notation "Short on 4-5" on the card means that the neon lamp will normally glow at positions 4 and 5 for good tubes. This tube has no shorts if the neon lamp stays out for positions 1, 2, and 3.

l. On tubes having several sections, the shorts test need be made only once.

5. QUALITY TEST.

a. Test the tube for shorts by following the complete procedure given in paragraph 4. If the tube is shorted, discard it without making further tests.

b. If the tube is not shorted, turn the SHORT-TUBE TEST switch to the TUBE TEST position. Do not change any of the other controls used for the shorts test.

c. Set potentiometer L to the number indicated in column L on the test data card.

d. Set potentiometer R to the number indicated in column R.

e. Set the MICROMHOS range switch at 3,000.

f. Press the button indicated in the Press column on the test data card, and read the meter on the RED-GREEN scale.

g. Normally, if the pointer stops in the GREEN sector the tube is good; if in the RED sector, the tube is defective and should be discarded. If the pointer stops in the ? sector, the tube is usable for a few more hours but should be replaced soon. For tubes in the Notations column having a note such as "OK over 160" (for example, type 40), read the meter on the 0-3,000 micromhos scale. Tubes reading higher than the value given in the Notations column are good. Good diode sections may read in the portion of the RED scale marked DIODES O.K. Only diodes reading to the left of this section (to the left of A in REPLACE on the scale) should be considered defective.

CAUTION: Do not press the red AMPL. TEST button while testing rectifier tubes. When testing small diodes, do not press either the AMPL. TEST or a RECTIFIER TEST button, because the high voltage would damage the delicate cathode. Press only the DIODE TEST button as called for on the test data card.

h. If a tube is listed two or more times on the test data card, it has two or more sections requiring individual tests, or has two input grids (for example, 6A8 pentagrid converter) requiring separate dynamic tests.

Remove the tube from the socket after the first test is completed. Then repeat the quality test in paragraph 5 for each additional listing in turn. The shorts test should be made *only* for the first listing, however. The tube section covered by a listing is identified in the Notations column on the test data cards.

6. MEASURING MUTUAL CONDUCTANCE. This procedure gives a mutual conductance reading in micromhos for an amplifier tube or amplifier section, instead of a RED-GREEN reading.

a. Test the amplifier tube or section for shorts by following the complete procedure given in paragraph 4. If the tube is shorted, discard it without making further tests.

b. If the tube is not shorted, turn the SHORT-TUBE TEST switch to the TUBE TEST position. Do not change any of the other controls used for the shorts test.

c. Set potentiometer L at G_M (replaces 60 on dial).

d. Set potentiometer R to the number indicated in column R on the test data card.

e. Set the MICROMHOS range switch to an appropriate range for measuring the value given in the Mut. Cond. column on the test data card.

f. Press the button called for in the Press column, and read the meter on the scale to which the MICROMHOS switch is set. This reading is the mutual conductance of the tube in micromhos under the element voltage conditions provided by the tube tester.

g. If a tube is listed two or more times on the test data card, remove the tube from its socket after the first test. Then repeat all tests except the shorts test for the next listing, as if testing another tube.

7. GAS TEST. This procedure determines whether or not an amplifier tube contains too much gas.

a. Carry out the shorts test procedure given in paragraph 4. If dealing with a multisection tube, the shorts test and gas test must be made on an amplifier section. The gas test does not apply to diode sections or to rectifiers.

b. Set potentiometer L at G_M (replaces 60 on dial).

c. Set the MICROMHOS range switch at 3000.

d. Hold down the GAS NO. 1 button and adjust potentiometer R until the meter reads 100 micromhos on the 0-3000 scale.

e. While holding down GAS NO. 1 button, press GAS NO. 2 button.

If the meter pointer moves upward more than one scale division, the tube contains too much gas for satisfactory operation. If the pointer movement is less than one division, the tube can be considered sufficiently free from gas.

NOTE: If the pointer cannot be brought down to 1000 micromhos by adjusting potentiometer R, set R at 82, note the position of the pointer, and press GAS NO. 2 button to see if the pointer moves upward more than one scale division. In some cases it may be necessary to let the tube warm up for a few minutes before making the gas test, since the tubes may develop gas only after filament current has been on for a period of time.

8. NOISE TEST. This procedure detects intermittent contacts between tube electrodes during the shorts test, even though the shorts are too brief to be detected by the neon SHORTS lamp.

a. After completing the conventional shorts test in paragraph 4, connect the NOISE TEST jacks on the panel of Tube Tester I-177 to the antenna and ground terminals of a radio receiver.

b. With the radio receiver turned on, with volume advanced, and with the tube tester still set as in paragraph 4*k*, tap the tube while turning the SHORT-TUBE TEST switch slowly from position 1 to 5. Loud static noises coming from the loudspeaker indicate intermittent shorts between electrodes, and mean that the tube is bad.

9. TESTING CATHODE-RAY INDICATOR TUBES. Since the function of these tubes is to indicate rather than amplify, conventional mutual conductance or quality tests cannot be made. Test data is therefore given on the last test data card rather than in numerical sequence, and is repeated here in greater detail. No shorts tests are made. The meter and controls L, R, and MICROMHOS are not used in this test. The procedure checks only the opening and closing action of the eye.

a. Turn on the tube tester and adjust the line voltage as in paragraph 4*j*.

b. Set the FIL switch at the correct filament voltage (2.5 for the 2E5 tube; 6.3 for tube types starting with 6).

c. For 2E5, 6AB5, 6E5, 6G5, 6H5, 6N5, and 6U5 tubes, set selector switch A at 12, set selector switch B at 3, and press the red AMPL. TEST button. The eye should open. Release the button, set selector switch B at 2. and again press the AMPL. TEST button. The eye should now close if the tube is good.

d. For 6AD6 and 6AF6 tubes, set selector switch B at 8, set selector switch A at 2, and press the red AMPL. TEST button. Eye No. 1 should

open, and eye No. 2 should close. Release the button, set selector switch A at 3, and again press the AMPL. TEST button. Eye No. 2 should open and eye No. 1 should close if the tube is good.

10. TESTING PILOT LAMPS.

a. To check a pilot lamp or other type of lamp having a miniature base, set selector switch FIL to the correct voltage for the lamp. This voltage is generally marked on the lamp base.

b. Turn ON the POWER switch, adjust line voltage as instructed in paragraph 4*j* and hold the lamp in the center of socket D. If the lamp lights with normal brilliancy, it is good; if it does not light, it is bad.

11. SERVICING RADIO EQUIPMENT WITH TUBE TESTER I-177. Almost all receiving tubes and the lower-powered transmitting tubes may be tested with Tube Tester I-177. The repairman should be thoroughly familiar with the operation of the tube tester as outlined in previous paragraphs of this section before attempting to make any tests.

a. Receiver Tubes. Test all tubes in the receiver for internal shorts and for quality. Install new tubes in place of those found to be defective. To prevent replacing a tube in the wrong socket, check one tube at a time.

b. Transmitter Tubes. Test all tubes that can be handled by Tube Tester I-177 and check the remaining tubes by replacing them one at a time with good tubes of the same type, noting the effect on the transmitter performance.

WARNING: Voltages high enough to cause death on contact are used in transmitters. Before touching any part of a transmitter circuit or attempting to remove a tube from the transmitter or its power supply, *turn off all power.* Discharge capacitors and ground exposed circuit components with a tool having a well-insulated handle. Remove shorts and grounds after a repair has been made or a tube replaced, before applying power to the transmitter.

SECTION III

FUNCTIONING OF PARTS

12. GENERAL. Individual circuits of Tube Tester I-177 are presented and described below as they function for the various types of tests made with this instrument. The circuit diagrams in this section are included primarily for a better understanding of this equipment, and therefore have been simplified in some instances. These diagrams must not be used for unauthorized repairs.

13. LINE TEST (fig. 2). Pushing the LINE TEST button connects the meter of the tube tester in series with the type 83 rectifier across a secondary winding of the power transformer, with suitable series and shunt resistors 75 and 74 in this calibrating circuit so the meter will receive a d-c voltage proportional to the a-c voltage across the transformer primary. Factory calibration is such that, when 200-ohm LINE ADJUSTMENT rheostat 47 in series with the power transformer primary is adjusted so the meter pointer is exactly at 1500 (near the center of the scale), the a-c input voltage of the transformer is exactly 93 volts, the value at which the instrument was designed to operate. A small automobile-type lamp 20 is included in the transformer primary circuit as the FUSE LAMP to protect the entire instrument from dangerous overloads. It will burn out during an overload. Setting the FIL. switch to the rated filament voltage value of a tube, followed by the setting of the LINE ADJUSTMENT

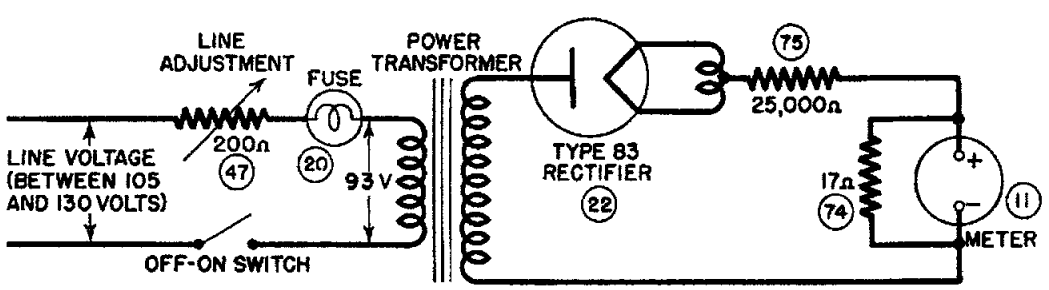


Figure 2. Tube Tester I-177, simplified line test circuit.

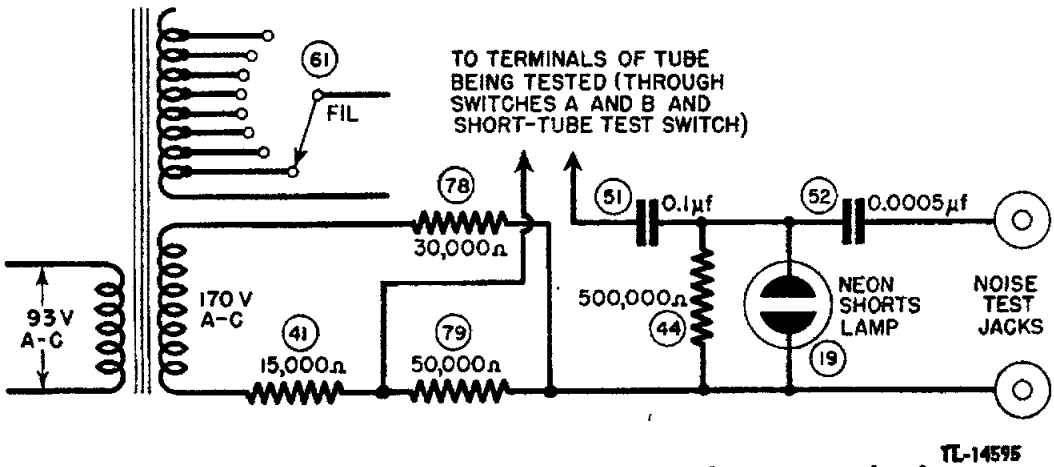


Figure 3. Tube Tester I-177, simplified noise and shorts test circuit.

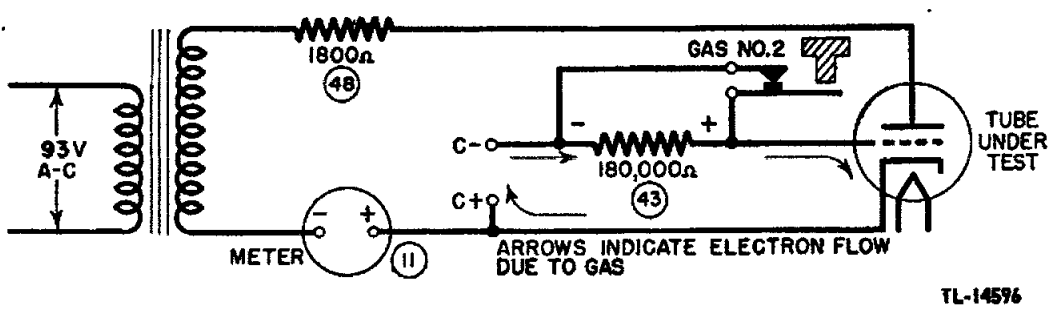


Figure 4. Tube Tester I-177, gas test circuit.

control, provides the correct filament voltage. For filament voltages of 12.6 volts and less, the switch places a center-tapped resistor in the filament circuit for use as a cathode return terminal.

14. SHORT TEST (fig. 3). Turning the SHORT-TUBE TEST switch through positions 1, 2, 3, 4, and 5 connects various pairs of tube electrodes in turn across the test terminals of the circuit. Tubes having shorts between elements complete the circuit and apply transformer voltage to neon SHORTS lamp 19, causing it to glow. Good tubes do not complete the circuit, and the lamp does not glow. Switches A and B (not shown) provide the proper tube socket connections for the tube under test, and the FIL. switch connects the tube filament to the correct tap on the filament winding.

15. NOISE TEST (fig. 3). This circuit is also used for making a noise test of vacuum tubes. With the antenna and ground terminals of a radio receiver connected to the NOISE TEST jacks, any intermittent short between tube electrodes momentarily permits alternating voltage from the power transformer to be applied to the neon lamp, causing a brief oscillation that will be reproduced as an audible signal in the receiver speaker.

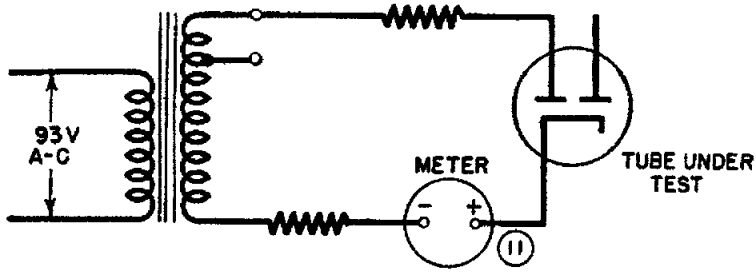


Figure 5. Tube Tester I-177, simplified rectifier test circuit.

16. GAS TEST (fig. 4). Pressing GAS NO. 1 button applies definite values of plate and grid voltages to the tube under test, causing a definite value of plate current to flow. Pressing GAS NO. 2 button inserts 180,000-ohm resistor 43 in the grid circuit. If the grid bias voltage source is sending current through the grid circuit due to gas in the tube, this current develops a voltage drop across resistor 43 that reduces the negative bias, causing a corresponding increase in the plate current being measured by the meter. A tube with negligible gas gives less than a scale division of plate current increase when GAS NO. 2 button is depressed.

17. RECTIFIER TEST (fig. 5). This circuit is used for making emission tests of standard full-wave rectifiers, diodes and 0Z4 tubes. An a-c voltage of definite value is applied between a cathode and plate of the tube under test, through resistors and the meter. The total resistance and the voltage are set automatically to the correct values for a GOOD-REPLACE meter reading when selector switches A and B are set at the positions specified on the test data card for the tube being tested. As an example, one plate of a four-prong full-wave rectifier is connected into the circuit when selector A is set at position 1. The second plate is connected into the circuit when selector A is set at 3. The special pushbutton for 0Z4 rectifier tubes provides a higher plate-cathode voltage than is used for heater or filament-type rectifiers, with a resistor in the circuit to limit the current if the tube elements are shorted. The special pushbutton for diodes provides a lower voltage than for regular tubes. It also provides a protective series resistance.

18. QUALITY TEST FOR AMPLIFIER TUBES (fig. 6).

a. The mutual conductance (g_m) of an amplifier-type vacuum tube, also called the grid-plate transconductance, is an expression representing the efficiency of performance of a tube as indicated by the *change in plate current* ($\triangle I_p$) divided by the *change in grid voltage* ($\triangle E_g$). The relation is generally written $g_m = \triangle I_p / \triangle E_g$. The value is expressed in micromhos

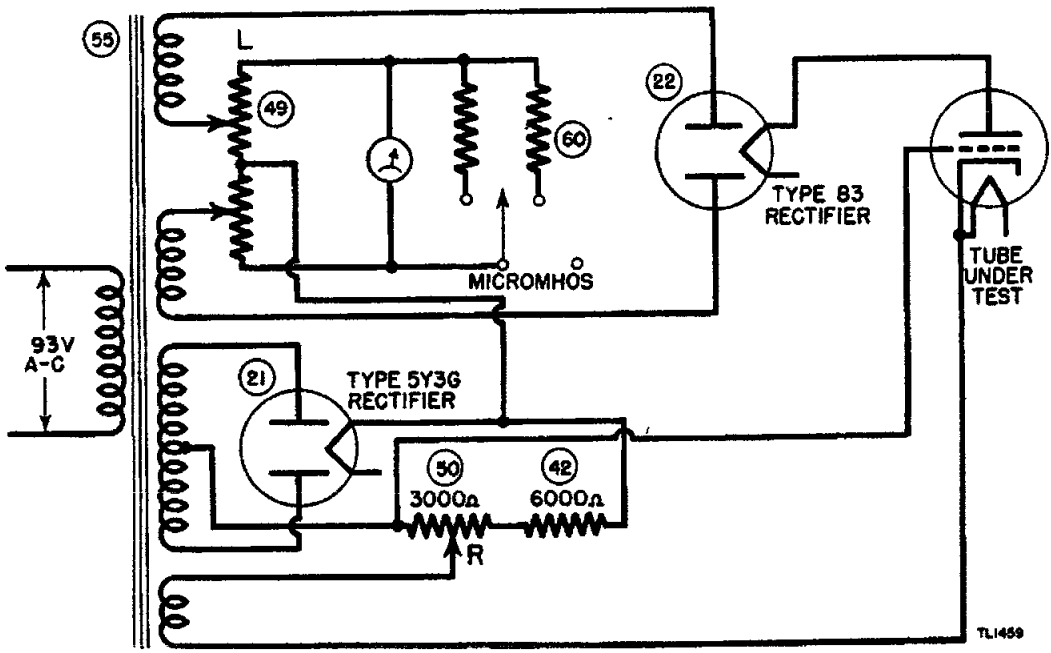


Figure 6. Tube Tester I-177, simplified quality test circuit.

and is a performance indication because it shows how effective a tube is in converting a small change in grid voltage (grid signal) to a large change in plate current. The mutual conductance values given on the test data cards are those supplied by tube manufacturers, and can be checked directly with Tube Tester I-177 by setting its controls for mutual conductance measurements. These values also form the basis for the dynamic quality tests during which the controls are adjusted so that the meter automatically reads GOOD if the mutual conductance is satisfactorily near the rated value for a particular tube.

b. For the RED-GREEN quality test based upon dynamic mutual conductance or for measurement of the mutual conductance value directly, the proper d-c grid voltage for the tube under test is supplied by a full-wave rectifier circuit using a 5Y3G tube. Setting potentiometer R at the value called for on the test data card adjusts this negative bias voltage to the correct value for the particular tube under test.

c. An alternating voltage of 4.7 volts rms, obtained from a separate secondary winding on the power transformer, acts in series with the grid bias as required for this type of test. This voltage alternately swings the grid in positive and negative directions from the d-c bias value, thereby producing the grid-voltage change ($\triangle E_g$) required for a dynamic test.

d. The plate voltage for the tube under test is supplied by another full-wave rectifier circuit, using a type 83 tube. The return lead contains the meter circuit which serves to measure the plate-current change ($\triangle I_p$). The meter circuit consists essentially of dual potentiometer L shunted across the meter. Adjusting control L on the panel adjusts the effective shunt

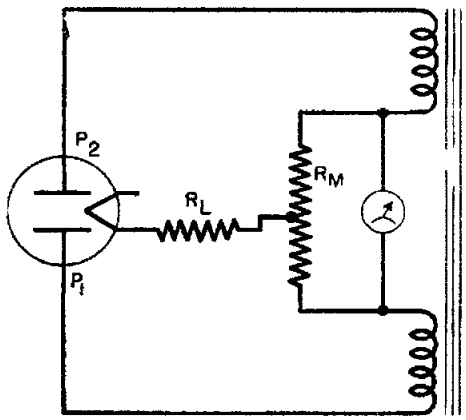


Figure 7. Tube Tester I-177, rectifier diagram illustrating theory.

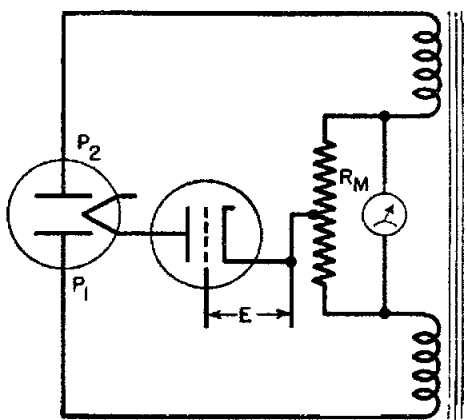


Figure 8. Tube Tester I-177, simplified mutual conductance test circuit.

resistance so the meter pointer will read in the GREEN section of the scale if the tube under test is good. Pressing the AMPL. test button completes the circuit as just outlined, and the meter then reads the quality of the tube.

19. THEORY OF OPERATION OF QUALITY TEST CIRCUIT.

a. Examine first the simple full-wave rectifier circuit shown in figure 7. The two power transformer secondary windings have their inner ends connected to a direct-current milliammeter. Across the milliammeter is a center-tapped resistor R_M. The load is shown as a resistance R_L, connected between the center tap and the rectifier filament as in any full-wave rectifier circuit. When rectifier plate P_2 is positive, electron flow is through the upper half of R_M, and the meter tends to deflect in one direction. When P_1 is positive, electron flow is through the lower half of R_M, and the meter tends to deflect in the other direction. With the load resistance fixed and equal forces acting on the meter in both cases, the meter stays at zero because it cannot follow variations at the power line frequency.

b. If the vacuum tube to be tested is substituted for the fixed load resistance, and a fixed bias E is applied to the tube as in figure 8, the meter will still read zero because a vacuum tube under steady-state conditions acts like a fixed resistance.

c. If an a-c potential is applied to the grid of the tube under test in addition to the d-c bias, the circuit becomes equivalent to that employed for quality and mutual conductance tests in Tube Tester I-177. When this a-c potential swings the grid positive, the plate current of the tube is increased, and when the plate-cathode resistance is correspondingly lowered, more current flows through R_M and the deflecting force on the meter is greater

than before. When the grid swings negative on the other half-cycle, the resistance of the tube under test is increased and the deflecting force on the meter is less. With unbalanced currents on adjacent half-cycles and consequent unequal forces on the meter, the meter reading becomes proportional to the difference in currents. Since this difference is created by the a-c grid potential, the meter indicates the plate-current changes produced by the applied grid voltage change, or in other words, the meter indicates mutual conductance.

20. MUTUAL CONDUCTANCE MEASUREMENTS. For mutual conductance measurements, the MICROMHOS switch places additional fixed shunt resistors across the meter as required for the three ranges.